SOMALI REGION PASTORAL AND AGRO-PASTORAL RESEARCH INSTITUTE (SoRPARI)

PROCEEDINGS OF 2018-2021, SoRPARI's RESEARCH REPORT

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Somali Region Pastoral and Agro-Pastoral Research Institute (SoRPARI)
Proceedings of 2021/22, SoRPARI research report

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Year, 2013 E.C
Tel: 0257753123|757097|757049
Fax: 0257753122
P.O.Box: 398, Jigjiga, Ethiopia

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Preface

Realizing the key role that it plays in the national economy; the Ethiopian government has given due emphasis to the agricultural sector development. The Agricultural and Rural Development Policy and Strategy of the country which was designed nearly a decade and half ago, has highly emphasized the important role of agriculture as a means of ensuring rapid economic growth, enhancing benefits to the people, eliminating food aid dependency, and promoting the development of a market-oriented economy. Guided by this national policy and strategy, different consecutive national plans, programs and projects focusing on the development of the agriculture sector has been implemented and is being implemented throughout the country. In addition to this, our country is designed 10 years strategic plan of which agriculture sector is once recognized as backbone for the national economy. It is believed that, in achieving and implementing these and other national plan, the role of research is expected than ever as it did in the previous plans and research component is added in these national plans.

The aim of the research component is to adapt or generate agricultural technologies, undertake pre-extension demonstration of proven technologies, produce source technologies that would serve as a base for large scale technology multiplication and enhance capacity of the research systems to improve technology supply. Being one of the implementing institutions, the Somali Region Pastoral and Agro-Pastoral Research Institute (SoRPARI) is conducting various technology adaptation and generation, research report proceedings, source technology multiplication and capacity building activities.

SoRPARI is therefore working on generating/adapting technologies suited to the agro-ecologies of the region and demonstrating them in close collaboration with farmer research and extension groups. SoRPARI also supplies source technologies by multiplying them in the mandate areas on farmers field, to address problems related to seed shortage and the like. As part of the agricultural growth program, SoRPARI had a total of 28 main research activities selected for this particular proceeding since the reform that mainly collected from crop, livestock, food science, mechanization and range research directorates. Demonstration of generated or introduced technologies and their multiplication needs serious attention from the stakeholders working in the agricultural system.

The Technical Advisory Committee (TAC)

Message from Director General

Mr. Mohammed Sharif

Director general of SoRPARI

Research is an advanced stage of study undertaken to discover or establish facts or principles. In agriculture, it involves finding solutions to farmer's problems through systematic experimental procedures. The contemporary agricultural sector faces many new challenges, from new crop and animal diseases to the impacts of climate change. Yet these challenges can often be combatted with new and improved technologies developed through scientific research. In addition to addressing large-scale trends, the research can often solve problems encountered by small-scale agricultural producers – with tangible benefits. For instance, low production of crops, livestock and fish can be overcome by turning to newly developed varieties and breeds. Or better nutrition and food sufficiency can be attained by diversifying diets. Yet in many developing countries, the connection between this research and agricultural development is weak. There is little investment in agriculture-focused research as the immediate impacts are easy to overlook. Therefore, it is important to establish an institute which engaged in research activities and link stakeholders and end user to the different agricultural technologies.

Somali Region Pastoral and Agro-pastoral Research Institute (SoRPARI) was established in 2002 G.C, and effective since 2011 G.C, with objectives of changing the livelihood of pastoralists and agro-pastoralists by introducing, adapting, generating, popularizing and disseminating livestock, forage, crop, natural resource and related technologies. The institute commitment and efforts towards equipping the regional agricultural sector with improved agricultural technologies, and information knowledge are the basic corner stone of its mandate to the region. The institute, through well-orchestrated efforts, had delivered a number of technologies, information and knowledge to pastoral and agro-pastoral communities of the region. By mid-years of its working experience, the institute had faced a lot of challenges which reached up to risking the existence of the institute. Since the reform that happened by 2018 G.C. in our country particularly our region, the institute have been getting the usual support from government and different partners which help its restorage.

Tremendous and tangible changes have been achieved starting from the reform especially since 2021G.C. Some of the major achievement done by the institute are, successful implementation of the so called "Job Evaluation and Grading JEG", completing agro-ecological characterization of the region, opening of two new research directorates (Food science and Nutrition Research Directorate, Technology multiplication and Seed Research directorate), Re-establishment of "Technical Advisory Committee TAC", preparation of different guidelines (Research legislation and Seed management guideline), revising the ten years strategic plan. It is also the year where we have conducted board meeting for the first time in which 2014 E.C. annual report & 2015 E.C. plan and the above-mentioned documents were got approval. The institute become successful when it comes restoring its partnership with different government and non-government stakeholders to reach its end users. We have been working with Mercy corps, LLRP, GIZ, EAIR, ATI and other partners on different mega and mini research projects. To mention some of the projects we work with partners, "Farm system characterization" with EAIR, "PAPREG and other Project" with LLRP, "Nutrition and crop related research" with Mercy corps. Therefore, we believe that, all activities done by the institute and in collaboration with different partners should reach different stakeholders and end users.

As part of its mandate and disseminating finalized research works to stakeholders and end users, the institute has been collected different manuscript from the different research directorates to prepare proceeding where research works of 2011 to 2013 E.C. have been included. In this particular proceeding, 33 manuscripts which were done in the area of crop. livestock, rangeland, soil & water, agricultural mechanization and food science & nutrition are included. The data obtained in those research works will help government and NGOs partners, stakeholder, researchers as baseline to further include in their different future activities.

Lastly, SoRPARI is always grateful to regional top leaders, both federal and regional agricultural sector bureaus, different NGOs/partners for their support and believing our institute as their potential partners. I as director general and in the name of the institute, we keep promise to enhance our partnerships and actively engaged in all kind projects and activities that change the livelihood pastoral and agro-pastoral community. To all stakeholders, researchers and other interest group, I wish you to enjoy reading of the proceeding and using as baseline for your future developmental projects and research works.

By the end, my especial thanks go to Technical Advisory Committee (TAC) for their compilation and production of this proceeding and their help in all technical aspects of the institute. I would also like to acknowledge researchers, directorates for their commitment and contribution to the reality of this proceeding.

I thank you.

Mohammed Sharif Ali

SoRPARI Director General

Message from Deputy Director General

Mr. Jimaale Ahmed Yusuf
Deputy Director general of SoRPARI

Somali Regional State is endowed with huge natural resources like rivers, vast rangelands, suitable land for crop and forage production, diversified forests and wild live. Most of the population depends on livestock production, crop farming and small-scale trade. Camel, cattle, sheep and goats are the major domestic animals that provide food and income to this pastoral and agro pastoral communities of the region. For the effective utilization these and other natural resources, the research institute plays great role to improve the livelihoods of pastoral and agro-pastoral communities.

The Somali Region Pastoral and Agropastoral Research Institute (SoRPARI) was established in 2002 by Proclamation No. 31/2002, as the first regionally coordinated agricultural research system in the region. SoRPARI was established with a mission to deliver and popularize agricultural technologies, knowledge and information in a participatory and integrated way for all the pastoral and agro-pastoral communities in the Somali Regional State and similar communities in other regions of Ethiopia in general.

In the past four and half years (since mid of 2018 G.C.) SoRPARI has made much efforts to deliver improved technologies through adapting, generating and improving the existing ones, in line with this, the research institute accomplished different research projects, generated different technologies, knowledge and/ or information in the areas of livestock, crops, soil & water conservation, range lands & Agro-forestry, agricultural mechanizations, food science &

Nutrition and Socio-economic that are crucial in improving the livelihood of the Pastoral and Agro-Pastoral communities and strengthen the production and productivity of the agricultural sector in the Region.

Some of the major achievements including researches by the institute include; Developed 10-year strategic plan of SoRPARI that is aligned the 10-year strategic plan of Ethiopian Institute of Agriculture Research (EIAR) and finally endorsed by Board of Directors, 9 improved forage species constituting of grasses, legumes and fodder trees have been tested, selected, diffused for rain fed and irrigated areas and released to reach both pastoral and Argo-pastoral communities of the region, large scale low land irrigated national wheat production pilot and demonstration was planted in Gode, Adadle and Beeraano woredas with the support of federal stockholders (FDRE Ministry of Agriculture, EIAR and Agricultural Transformation Institute), a number of Cereals; Rice-Nerica1, Nerica2, Nerica4, Nerica6, Nerica14, wheat (Fentale 2, Kings Bird, amibara etc) varieties were improved and already reached the pastoral and agro-pastoral communities, Range land recovery and conservation has been treated with holistic range land approach on an area covered by invasive species mostly Prosopis juliflora, Community-based area enclosure for threatened species Yeheb, Cordeauxia edulis plant rehabilitation in its habitat has been done, Agro-ecological characterization & land capability evaluation and farm characterization research were implemented and many others.

SoRPARI would like to take this opportunity to publish 33 manuscripts compiled and implemented in the year 2018 - 2020. The manuscripts were collected from Crop researches, livestock researches, agricultural mechanization researches, Food science researches, Soil and Water researches and Rangeland researches.

Finally, Agriculture sector is the Somali region's main economic contributor. While the sector has shown improvements recently, there is still huge potential in the region to generate value through a focused agricultural program. Somali Pastoral and Agro pastoral Research Institute would like to see our key stakeholders and other researchers to use this proceeding as baseline, technology transfer, policy input and for further dissemination to the end users through extension system.

By the end, I would like to acknowledge researchers, directorates for their commitment and contribution to the reality of this proceeding. My especial gratitude goes to Technical Advisory

Committee (TAC) for their compilation and production of this proceeding and their help in all technical aspects of the institute.

I thank you

Jimaale Yusuf

Deputy Director General

Message from Technical Advisory Committee (TAC) chairperson

Mr. Abdulkarim Mohammed Ali
TAC Chairperson

Somali Region Pastoral and Agro-pastoral Research Institute (SoRPARI) was established in 2002 G.C, and effective since 2011 G.C, with objectives of changing the livelihood of pastoralists and agro-pastoralists by introducing, adapting, generating, popularizing and disseminating livestock, forage, crop, natural resource and related technologies. The institute commitment and efforts towards equipping the regional agricultural sector with improved agricultural technologies, and information knowledge were the basic corner stone of its mandate to the region.

SoRPARI conducted a wide range of researches both introduced and tested of intensive crops and forages rangelands over many years and released various suitable technologies, others introduced and adapted, (for both riverine and rain fed farming systems). The institute, through well-orchestrated efforts, had tried to deliver a number of technologies, information and knowledge to pastoral and agro-pastoral communities of the region. Although different events such as conference, workshops, field days and some others were prepared, having well organized scientific report and some other pintables material options are not yet in place. On the other hand, a lot of new technologies has been adapted, developed, re-engineered by the institute which need to be reach to the concerned stakeholders and end users through different mechanism which well-organized system. In similar fashion, modification and improvement has been made on some of the previously released technologies which still need systematic means to reach the end users. For this reason, the institute has organized “Technical Advisory committee” to run all its activities systematically and to have productive scientific report.

The technical advisory committee (TAC) was established in June 15/2022 (Sane 8/2014 E.C.) with initiation from director general of the institute Mr. Mohammed Sharif Ali to actively engaged in and lead the technical activities of the institute. The committee is established to provide service such as Proposal & Research (ongoing and completed) review, Organizing different events at regional, national and international level in collaboration with concerned directorates and stakeholders, Preparation of different printable/compile report, Research related capacity building, Monitoring & Evaluation on the technical part of project and research, Journal development and Other special technical advice and task based on the request from top management.

As part of disseminating finalized research works to stakeholders and end users, the TAC has been collected different manuscript from the different research directorates to prepare the 2nd proceeding where research works of 2011 to 2013 E.C. have been collected. In this particular proceeding, six research directorates submitted their research works namely crop (14 manuscripts), Livestock (6 manuscripts), Agricultural mechanization (4 manuscripts), Food Science (2 manuscripts), Rangeland (4 manuscripts) and soil & water (3 manuscripts). Totally, 33 manuscripts have been included under this proceeding.

Last but not list, TAC is always grateful to top management, directorates, center managers, researchers for their help and insightful contribution to the preparation of 2nd proceeding. By this TAC will keep its promise in preparing other proceedings and serving SoRPARI community in all aspects of technical assistance. By the end, I wish you to enjoy reading of the proceeding and using as baseline data for your future research work and keeping your cooperation as usual.

Abdulkarim Mohammed Ali
TAC Chair Person

SOMALI REGION PASTORAL & AGRO-PASTORAL RESEARCH INSTITUTE (SoRPARI)

LIVESTOCK & FORAGE RESEARCH DIRECTORATE




1. On-station evaluation of straws and stovers with urea to increase utilization in Somali Region

Daniel Seyoum Esheta[1*] and Woldegebriel Tesfamariam[2]
Tel: - +251920688458[1]
E-mail:- danielsyyoum101@gmail.com[1],
[1]Animal Nutritionist, Somali Region Pastoral and Agro-pastoral Research Institute (SoRPARI), Jigjiga, Ethiopia.
[2]Animal Nutritionist, Ethiopian Institute of Agricultural Research (EIAR), Addis Ababa, Ethiopia.

Abstract

Wheat straw (WS), barley straw (BS), sorghum Stover (SS), and maize Stover (MS) were subjected to different times of ensiling and urea treatment levels in order to identify the most effective ensiling time and urea treatment level to attain preferable nutritional aptitude. Both straws and stovers were treated with 0.40 and 0.50 g concentration levels of urea solution dissolved in 0.8 L of water and sealed plastic sheet for one to four weeks. Accordingly, to the general observation at the time of opening, there was no mold growth, appeared golden brown in color, and had soft consistency with a strong ammonia smell ensuring the effectiveness of the treatment. The chemical analyses and IVDMD were done at HRCL. The results showed that the urea level had a no-significant effect on all chemical compositions and IVDMD for all urea-treated straws and stovers. Therefore, treatment with 40 g urea may be more economical. On the other hand, negative and significant ($P<0.001$) correlations existed between IVDMD and fiber fractions for all treatments. While other quality parameters, IVDMD and CP, were strongly correlated ($r=0.90$) ($P<0.01$) for WS and BS. The results also revealed that the treatment duration on both straws and stovers should be 28 days.

Key words: *Treatment, ensiling time, chemical analysis, digestibility, crop residues*

Introduction

Ethiopia has the largest cattle population in Africa with an estimated 56.71 million heads of animals. Out of this total cattle population, the female cattle constitute about 55.45% and the remaining 44.55% are male cattle (CSA, 2015). According to SRS BoFED, currently the region has also huge livestock population estimated to be 26.8 million of which cattle (20%), sheep (33%), goat (36%), camel (10%) and equines (1%), contributing considerably to the national economy and the livelihood of the people. Regardless of their number, however, the productivity per head is usually low mainly because of inadequate year-round nutrition, unimproved genetic resources and prevalence of diseases and parasites.

Under-nutrition, due to inadequate or fluctuating nutrient supply, is a major constraint limiting the productivity of the livestock, leading to high mortality of animals, longer parturition intervals and substantial weight loss, particularly during the dry season in most parts of the region. At this period most of the animals depend on matured herbage, aftermath grazing and crop residues, which are usually, low in protein, digestible energy and minerals (Seyoum and Zinash, 1998) which may result in lowered animal performance. Residues of cereals and pulses account for about 26% of the total feed utilized and ranked second to grazing (64%) in mixed crop- livestock production system of Ethiopia (CSA, 2004). It is also estimated that above 18.5 million metric tons of crop residues are annually produced in the country (Azage et al., 2002), out of which 70% is utilized for livestock feeding dominated by cereal straws.

Crop residues are generally characterized by low nutritive value, but have potential degradability as high as 80%, but are low in actual digestibility rarely exceeding 50% due to close association of carbohydrates with lignin (Jackson, 1977). However, poor quality roughages such as straws have the potential for improving animal feeding by employing different strategies.

Urea treatment has most practical significance in the tropics by acting both as an alkali and as a source of nitrogen to roughages inherently low in protein, resulting in a successful improvement in digestibility and intake of these feeds. During treating, the ammonia gas acts upon the fiber and favours the release of soluble carbohydrates and energy for cellulolytic bacteria growth, enhancing efficient utilization of roughages. Moreover, urea application is relatively easy, less toxic and effective (Ibrahim and Schiere, 1989).

The inputs needed for effective urea treatment should not follow blanket recommendation, as this is mainly influenced by the environmental conditions under which the treatment is carried out. However, under most tropical condition, 40 or 50 g of urea per kg of straw dissolved in as much as 1 kg of water has been used for urea treatment of roughages. Depending on the level of technology and the economy of the farmer, the ensiling vat for straw treatment with urea can vary from a simple pit to concrete silos. Dark brown color of the straw with strong smell of ammonia and soft consistency are indicators of effective urea treatment (Mascarenhas- Ferreira *et al*., 1989).

Fafan Zone is among the dominant cereal-based farming practiced in SRS, where crop and livestock production are well integrated. Crop residue is utilized as livestock feed either as stubble grazing or is collected and used for stall feeding of livestock mostly during the dry season.

Agro-pastoralists accept that fibrous straws and stovers from cereal grain crops are a poor feed resource because their crude protein (CP) content is low and fiber levels are high. When offered to livestock both dry matter intake and palatability are low. However, these residues are often the only livestock feed available in smallholder mixed crop and livestock systems, especially in areas characterized by a defined dry season. This suggests that if these materials were used optimally, so that a small improvement in the nutritive value was obtained, there would be a marked reduction in dry season feeding stress in livestock in the region.

The production and utilization of treated straw and stovers as supplementation to animals is feasible to improve the nutritional values and the productivity of farm animals. The present paper reports a laboratory experiment carried out to determine the effects of urea concentration and duration of ensiling treatment on chemical composition of straws and stovers by increasing digestibility, palatability and crude protein content. Therefore, experiment was carried out to evaluate and identify the most effective time of ensiling and urea treatment level to attain preferable nutritional aptitude.

MATERIALS AND METHODS

The experiment was conducted at Somali Region Pastoral and Agro-Pastoral Research Institute compound at Jigjiga. At higher elevation area and lower altitude of the study area the average monthly temperature varies between 16 to 20°C and 22 to 26°C, respectively, whereas the mean annual temperature is 21°C. The average annual rainfall ranged from 300 to 500 mm (MOARD- PADS, 2004).

Feed collection (WS, BS, MS and SS)

Wheat straw (WS) and barley straw (BS) were collected after grain harvest from Tulu Gulled farmers. Sorghum Stover (SS) and maize Stover (MS) adequate for the experiment were collected from crop producing areas of Jigjiga surrounding. The collected residues (straw and Stover) destined for treatments were sun-dried and stored without leaf-loss.

Urea treatment of the straw and Stover

The straws and stovers were treated with 0.40 and 0.50 g concentration levels of urea solution prepared according to the result of MacMillan (1992) and Ibrahim and Schiere (1989), that is, each amount of urea were dissolved in 0.8 L of water.

After the sacks were sealed with air-tight plastic sheet, it was left unopened from one week up to four weeks. By the end of treatment period, the sacks were opened and the straw was aerated for 24 h and oven dried at 65°C for another 24 h. Finally, all the samples were taken to Holleta Research Center Nutrition Laboratory (HRCL) for chemical analyses. In addition, untreated straw and stover samples were also taken and pre-dried for parallel chemical analyses.

A two factor factorial design was used for the experiment. There were eight treatment combinations (two urea treatment at each of four durations of ensiling) and three replicate ensiled crop residues plastic sacks per treatment combination. This design was used for each crop residues (that is, wheat straw, barley straw, maize Stover and sorghum Stover).

Chemical analysis

Dry matter (DM), ash and Kjeldahl-nitrogen were determined according to the AOAC methods (AOAC 1990). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Van Soest and Robertson (1985). Crude protein (CP) was calculated as N × 6.25. All the analyses were run in triplicates.

Table 1. Chemical composition (%DM) of WS as affected by levels of urea and treatment duration.

Straw		DM	CP	NDF	ADF	OM	ADL	Ash	IVDMD
	Untreated	93.42	3.91	79.65	56.2	91.23	9.74	8.77	45.24
	Effects of Urea level								
	40 g Urea	92.19^{a}	5.26^{a}	68.36^{a}	52.22^{a}	91.74^{a}	8.19^{a}	8.26^{a}	58.56^{a}
	50 g Urea	92.27^{a}	5.54^{a}	67.32^{a}	51.12^{a}	91.81^{a}	8.18^{a}	8.19^{a}	59.42^{a}
Wheat									
	Effect of treatment duration								
	week	93.30^{a}	4.65^{b}	71.48^{a}	54.48^{a}	91.46^{d}	9.35^{a}	8.54^{a}	57.45^{c}
	week	92.15^{b}	4.77^{b}	69.68^{b}	52.88^{b}	91.67^{c}	8.43^{b}	8.33^{b}	57.84^{bc}
	week	92.10^{b}	5.87^{a}	66.23^{c}	49.88^{c}	91.82^{b}	7.87^{b}	8.18^{c}	59.04^{b}
	week	91.38^{b}	6.30^{a}	63.98^{d}	49.43^{c}	92.15^{a}	7.10^{c}	7.85^{d}	61.63^{a}

[ab]Means in the same column within each treatment factor bearing the same superscript are not significantly different at the 5% level. CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin DM: Dry matter; IVDMD: in vitro dry matter digestibility. Source: Authors

In vitro dry matter digestibility procedure

In vitro dry matter digestibility (IVDMD) of each samples were determined by the method of Tilley and Terry (1963). The rumen fluid was obtained from rumen fistulated animals kept at Holleta Research Station.

Data analysis

Data for *in vitro* DM digestibility were analyzed using the General Linear Models (GLM) procedure of the SAS program (SAS, 2002). Analyses followed a 2 × 4 factorial arrangement with amount of urea treatment and duration of ensiling as the main effects. Correlation among the different nutritional parameters was done. Means was separated using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

General observations

In the present experiment, two straws (wheat and barley) and two stovers (maize and sorghum) were treated with either 50 g urea or 40 g urea, regarded as two different urea levels and four durations of ensiling (7, 14, 21 and 28 days).

At the time of opening, there was no mould growth observed in each duration which leads to spoilage of the straws and stovers. The strength of NH_3 smell and the soft consistency was increased from the 1st to the 4th opening of the ensiled treated straws and stovers. All the treated crop residues were changed to golden brown on the 21st And 28th days of opening. Therefore, from the general observation, indicators ensuring that the urea treatments were effective (Mascarenhas-Ferreira et al., 1989).

Effects of urea level on WS and BS

The urea level had no-significant (P>0.05) effect on all chemical compositions for both urea treated straws (Tables 1 and 2). IVDMD was not also influenced by the concentration of urea. Therefore, treatment with 40 g urea may be more economical if it has good effect on intake of straws by the ruminant.

Effects of treatment duration on WS and BS

The CP content of WS increased significantly (P<0.05) over the treatment time, especially between 14th to 21st days. NDF fraction of the cell wall constituents was significantly (P<0.05) decreased between all treatment durations (7, 14, 21 and 28 days) from 71.48 to 63.98%, respectively. Both CP and ADF of the WS were not significantly (P>0.05) affected by the treatment time after 21 days (Table 1). Similar changes were observed in CP of WS following urea treatment (Getahun, 2006; Cakmak et al., 1996; Gao, 2000). However, the CP content of treated WS observed in this study was lower than that previously reported (Rehrahie, 2001). This reduction in CP was probably caused by volatile N loss while ventilating during sampling and drying before analysis.

Extending treatment time of the WS from 14 to 21 days did not affect the IVDMD and ADL (P>0.05), but further extending from 21 to 28 days significantly (P<0.05) increased the

IVDMD from 59.04 to 61.63% and decreased ADL from 7.87 to 7.10% (Table 1). Rough calculations showed that, urea treatment improved digestibility of WS by 36% (from 45.24 to 61.63%).

In case of BS, urea-treatment significantly ($P<0.05$) increased CP content from 4.4 to 6.75% before and after

Table 2. Chemical composition (%DM) of BS as affected by levels of urea and treatment duration

Straw		DM	CP	NDF	ADF	OM	ADL	Ash	IVDMD
	Untreated	93.2	4.4	76	49	90.7	9.81	9.3	46.34
					Effects of Urea level				
	40 g Urea	92.58^{a}	5.53^{a}	73.61^{a}	47.00^{a}	91.43^{a}	8.59^{a}	8.58^{a}	51.40^{a}
	50 g Urea	92.46^{a}	5.66^{a}	73.13^{a}	46.78^{b}	91.47^{a}	8.38^{a}	8.53^{a}	51.98^{a}
Barley									
					Effect of treatment duration				
	1st week	92.64	4.54^{d}	75.65^{a}	48.43^{a}	90.80^{c}	9.41^{a}	9.21^{a}	47.34^{d}
	2nd week	92.09	4.86^{c}	74.20^{ab}	47.27^{b}	90.88^{c}	9.00^{b}	9.13^{a}	48.83^{c}
	3rd week	92.47	6.23^{b}	72.56^{bc}	46.64^{c}	91.43^{b}	8.30^{c}	8.58^{b}	54.78^{b}
	4th week	92.90	6.75^{a}	71.07^{c}	45.24^{d}	92.70^{a}	7.23^{d}	7.30^{c}	55.81^{a}

^{ab}Means in the same column within each treatment factor bearing the same superscript are not significantly different at the 5% level. CP: Crude protein; NDF: neutral detergent fibre; ADF: acid detergent fiber; ADL: acid detergent lignin; DM: dry matter; IVDMD: *in vitro* dry matter digestibility. Source: Authors

Table 3. Chemical composition (%DM) of MS as affected by levels of urea and treatment duration.

Stover		DM	CP	NDF	ADF	OM	ADL	Ash	IVDMD
	Untreated	91.62	7.21	79.47	55.87	92.1	10.62	7.9	43.89
	Effects of Urea level								
	40 g Urea	91.94^{b}	7.99^{a}	77.31^{a}	53.08^{a}	93.34^{a}	9.86^{a}	6.66^{a}	49.65^{a}
	50 g Urea	92.40^{a}	8.21^{a}	76.75^{a}	52.12^{a}	93.35^{a}	9.58^{a}	6.65^{a}	50.83^{a}
Maize									
	Effect of treatment duration								
	week 1	91.44^{b}	7.45^{c}	79.03^{a}	54.48^{a}	92.57^{c}	10.30^{a}	7.44^{a}	44.81^{b}
	week s d	91.70^{b}	7.61^{c}	78.53^{a}	52.88^{ab}	92.74^{c}	10.56^{a}	7.27^{a}	49.82^{ab}
	3rd week	92.60^{a}	8.23^{b}	77.23^{b}	52.10^{bc}	93.20^{b}	9.75^{b}	6.80^{b}	51.25a
	4th week	92.94^{a}	9.10^{a}	73.33^{c}	50.93^{c}	94.89^{a}	8.29^{c}	5.11^{c}	55.10a

^{ab}Means in the same column within each treatment factor bearing the same superscript are not significantly different at the 5% level. CP: Crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin DM: Dry matter; IVDMD: *in vitro* dry matter digestibility. Source: Authors

Treatment, and NDF contents were significantly ($P<0.05$) decreased between 7 and 28th days of treatment durations from 75.65 to 71.07%, respectively. ADF and ADL fractions of the cell wall constituents were significantly ($P<0.05$) decreased between all treatment durations (7, 14, 21 and 28 days) from 48.43 to 45.24%

and from 9.41 to 7.23%, respectively (Table 2). Treatment means of IVDMD of the BS were also significantly ($P< 0.05$) different at all treatment durations.

The IVDMD of BS was improved by 9.47% units when compared between untreated and treated. The increased IVDMD of urea treated straw could be explained by the improved concentration of digestible nutrients; by the enhanced accessibility of cell wall constituents to microbial digestion due to the disrupting effect of urea NH_3 on the chemical arrangement of cell wall constituents

And by dissolving out lignin which is believed to hinder the microbial digestion (Theander, 1981).

Effects of urea level MS and SS

There was no significant (P>0.05) effect of urea level on the chemical composition and also IVDMD of urea treated MS and SS (Tables 3 and 4).

Effects of treatment duration on MS and SS

The results on chemical composition of MS value illustrated that the CP and OM content significantly increased (P<0.05) and NDF and ADL fractions of the cell wall constituents were significantly (P<0.05) decreased as the treatment duration advanced at 21st and 28th days (Table 3). Urea treatment improved the CP content of MS by about 26% (from 7.21 to 9.1%). On the other hand, the mean values of IVDMD showed significantly increase (P<0.05) from 7 to 28 days of treatment duration. Also digestibility of MS was improved by 11.21% units between untreated and treated from 43.89 to 55.1%, respectively.

At 7, 14 and 21 days of treatment duration, the CP content of the SS was not significantly increased (P>0.05), the 28th days treatment duration were significantly (P< 0.05) different from the rest of the durations (Table 4). However, the CP increment between 21 and 28 days was 1.21% units compared to the 0.19% units between 7 and 21 days. Thus, the rate of CP increment appeared to slow down between 7 and 21 days of treatment duration. ADF and ADL were significantly (P<0.05) reduced between all treatment duration. The IVDMD were significantly increased (P<0.05) between 7 and 28 days but not between 7 and 14 or 21 and 28 days of treatment duration.

Table 4. Chemical composition (%DM) of SS as affected by levels of urea and treatment duration.

Stover		DM	CP	NDF	ADF	OM	ADL	Ash	IVDMD
Sorghum	Untreated	93.75	5.63	80.26	53.25	87.29	11.54	12.71	42.32
	Effects of Urea level								
	40 g Urea	93.10^{a}	6.00^{a}	77.15^{a}	52.56^{a}	88.23^{b}	10.85^{a}	11.78^{a}	50.31^{a}
	50 g Urea	92.93^{b}	6.15^{a}	76.90^{a}	52.38^{a}	88.37^{a}	10.76^{a}	11.63^{b}	50.46^{a}
	Effect of treatment duration								
	1st week	93.24^{a}	5.66^{b}	79.42^{a}	53.20^{a}	87.72^{d}	11.33^{a}	12.28^{a}	49.72^{b}
	2nd week	93.34^{a}	5.75^{b}	78.53^{a}	52.71^{b}	87.88^{c}	10.91^{b}	12.13^{b}	50.19^{b}
	3rd week	92.87^{b}	5.85^{b}	76.34^{b}	52.23^{c}	88.54^{b}	10.64^{c}	11.47^{c}	50.73^{a}
	4th week	92.61^{c}	7.06^{a}	73.82^{c}	51.73^{d}	89.07^{a}	10.33^{d}	10.94^{d}	50.90^{a}

[ab]Means in the same column within each treatment factor bearing the same superscript are not significantly different at the 5% level. CP: crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin; DM: dry matter; IVDMD: *in vitro* dry matter digestibility.

Source: Authors

Table 5. Correlation coefficients of chemical composition and *in vitro* DM digestibility of WS.

Correlation	DM	CP	NDF	ADF	ADL	OM	IVDMD
CP	-0.72*	1					
NDF	0.86**	-0.95***	1				
ADF	0.80*	-0.95***	0.96***	1			
ADL	0.96***	-0.87**	0.95***	0.92**	1		
OM	-0.91**	0.90**	-0.97***	-0.90**	-0.97***	1	
IVDMD	-0.80*	0.90**	-0.94***	-0.84**	-0.88**	0.95***	1

CP: Crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin OM: Organic matter; IVDMD: *in vitro* dry matter digestibility; * P<0.05, **P<0.01, *** P<0.001.

Source: Authors

Correlation coefficient between nutritive value and *in vitro* DM digestibility of different crop residues

Correlation analysis for WS and BS

In urea treated WS and BS with different amount of urea and duration, Tables 5 and 6 present the correlation between the DM, CP, NDF, ADF, ADL, OM and IVDMD.

Negative correlations were detected between IVDMD and fiber fractions (ADF, NDF and ADL) for both WS and BS. Numerous evidences (Van Soest et al., 1991; McDonald et al., 1995; Buxton, 1996) indicated that high cell wall constituents also set a limit to potential feed intake by physical fill effect as well as by reducing the digestibility of feeds.

The correlation coefficient between the CP and cell wall contents such as NDF, ADF and ADL indicated negative values of -0.95, -0.95 and -0.87 and -0.97, -0.93 and -0.95 for WS and BS, respectively. While other quality parameters such as IVDMD and CP were correlated with correlation coefficient value of r=0.90 (*P<0.01*) for WS and r=0.99 (*P<0.001*) for BS.

Table 6. Correlation coefficients of chemical composition and in vitro DM digestibility of BS.

Correlation	DM	CP	NDF	ADF	ADL	OM	IVDMD
CP	0.49	1					
NDF	-0.41	-0.97***	1				
ADF	-0.37	-0.93***	0.96***	1			
ADL	-0.52	-0.95***	0.96***	0.98***	1		
OM	0.62	0.90**	-0.90**	-0.93***	-0.97***	1	
IVDMD	0.43	0.99***	-0.95***	-0.91**	-0.92**	0.86**	1

CP: Crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin OM: Organic matter; IVDMD: *in vitro* dry matter digestibility; * P<0.05, **P<0.01, *** P<0.001.

Source: Authors

Table 7. Correlation coefficients of chemical composition and in vitro DM digestibility of SS.

Correlation	**DM**	**CP**	**NDF**	**ADF**	**ADL**	**OM**	**IVDMD**
CP	-0.82*	1					
NDF	0.92**	-0.90**	1				
ADF	0.89**	-0.85**	0.97***	1			
ADL	0.85**	-0.81*	0.94***	0.99***	1		
OM	-0.96***	0.87**	-0.98***	-0.97***	-0.95***	1	
IVDMD	-0.85**	0.70	-0.89**	-0.96***	-0.97***	0.92**	1

CP: Crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin; OM: organic matter; IVDMD: *in vitro* dry matter digestibility; * P<0.05, **P<0.01, *** P<0.001.

Source: Authors

Table 8. Correlation coefficients of chemical composition and in vitro DM digestibility of MS.

	DM	**CP**	**NDF**	**ADF**	**ADL**	**OM**	**IVDMD**
CP	0.90**						
NDF	-0.84**	-0.98***					
ADF	-0.91**	-0.86**	0.85**				
ADL	-0.86**	-0.95***	0.98***	0.80*			
OM	0.80*	0.96***	-0.99***	-0.79*	-0.96***		
IVDMD	0.89**	0.83*	-0.84**	-0.95***	-0.79*	0.81*	1

CP: Crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin; OM: organic matter; IVDMD: *in vitro* dry matter digestibility; * P<0.05, **P<0.01, *** P<0.001.

Source: Authors

Correlation analysis for MS and SS

In the urea treated MS and SS with different amount of urea and duration, Tables 7 and 8 present the correlation between the DM, CP, NDF, ADF, ADL, OM and IVDMD. The positive correlation was observed between IVDMD and CP levels in both MS and SS, but not statistically significant for SS. Negative and significant (P<0.05) linear correlations were observed between IVDMD and fiber fractions (NDF, ADF and ADL), respectively, for both MS and SS.

Conclusions

The goal of this study was to determine the most effective ensiling time and urea treatment amount for achieving preferred nutritional aptitude.

Therefore, the commencement of urea treatment of straws and stovers resulted in no mold growth, a golden brown hue, a soft consistency, and a strong ammonia odor, indicating that the treatment was effective. It also improves the nutritive value of the treated crop residues, in terms of total content and *in vitro* digestibility.

On the basis of the current findings, it can be stated that the urea level had no effect on the chemical compositions and IVDMD for all urea-treated straws and stovers. As a result, treatment with 40 g urea may be more cost-effective. The study also found that if the ambient temperature is between 16 and 20°C, the treatment period for both straws and stovers should be 28 days.

Finally, urea treatment is recommended technologies for resource poor smallholder agro-pastoralists who cannot afford the use of commercial supplementation. However, to generate more information supporting the current result, further work is suggested in supplementation of urea treated straws and stovers based feeding for livestock's

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2. Assessment on major indigenous knowledge's of milk and milk products handling and processing in pastoral and agro-pastoral production system in Jigjiga Woreda of Ethiopia Somali Region

Daniel Seyoum[1], Tel: - +251920688458[1]E-mail:- danielsyyoum101@gmail.com[1],

Animal feed and nutrition Research program

Somali Region Pastoral and Agro-pastoral Research Institute (SoRPARI)

ABSTRACT

The study was conducted in Jigjiga woredas of Somali Regional State, with the general objectives of assessing the major indigenous knowledge and traditional milk and milk products and preservation methods. Two kebeles, Fafan and Hadow that have milk production potential were purposively selected and used for the study. The average family size of the study area was 7.3. The study area has a mean livestock population of 9.39Tropical Livestock Units (TLU) per household. Almost all villages of the producer's respondents are well aware of colostrum's feeding for the new born animals and understand the beneficial effect on health of the young. Milk is consumed either as fresh or in fermented form in the current study; the majority of the milk produced is sold in both kebeles. Plastic bucket is the major container used for milking and sale dairy products in the study area. With regard to milk fermentation, the majority of the respondents use wooden container. The use of plastic and traditional containers can be a potential source for the contamination of milk by bacteria because it is impossible with practical cleaning but none of the respondents mentioned problem in regarding to difficulty of cleaning. Instead they proudly said wooden containers have its own advantage in improving flavor and shelf life on their milk. The most common technique of washing milk utensils is by putting plant leaves of Berkaketi(Lantana camara) together with water and shaking for some times and finally rinsing with water. Moreover, they rub milk utensils not only for washing but also flavoring milk containers. On the other hand, Woob is the most common woody plants species used to add flavor to churning material by boiling its stem cover (bark) with water into the container before putting the milk.Balanitesglabra (Kadiin Somali), Oleaafricana (Agarsein Somali) and Acacia etbaica (Sogsogin Somali) are the most frequently used plant species for smoking milk vessels in the study areas. Besides, Acacia nilotica and Acacia brevespica are used when they miss the others. And also, Acacia brevespica is used for smoking milk containers only for camel in the study area. The majority of the respondents used Acalyphafruticosa to keep butter for longer period of time and to add flavor. The average shelf life of raw milk was 2.45 days at an ambient temperature. The estimated milk post-harvest loss per week in this study is 11.85 and 16.33% for Hadow and Fafan, this was mainly attributed by rejected from sale. The major points of milk sale for dairy products in Fafan sell fresh milk to collectors (76.3%), individuals (62.5%) and at kiosk (65.0%), while the sale for fresh milk in Hadow were (6.3%) to individuals, 90 percent to collectors and at the farm gate (3.8%). The average estimated time to milk delivery was 45.53 and 34.22 minutes in Hadow and Fafan, respectively. An average price of 10.2 and 16.4 Birr/liter for fresh whole milk and 46 and 60.7 Birr/kg for butter were reported for the wet and dry seasons, respectively. The lower price of fresh milk and butter price in wet season than dry season may be attributed to the surplus milk production during wet season in the study area. The research revealed some challenges or constraints involved in milk production, processing, marketing and consumption of the study areas. Low milk yield, poor quality of feeds, feed shortage, poor market infrastructure and unavailability of smallscale milk processing equipment's are the most important constraints associated with milk production. Area.

Key Words: *indigenous knowledge, milk, handling, processing, production*

INTRODUCTION

Post-harvest loss of milk and dairy products estimated at about 40% reported to cost the eastern African countries over 90 million USD annually (www.fao.org). A large amount of milk produced in tropical countries is converted into processed products such as butter and cottage type cheese or some kinds of fermented or concentrated product that have longer shelf life (Chamberlain, 1990). Milk is a major component in human diet all over the world, but it also serves as a good medium of the growth of many microorganisms, especially pathogenic bacteria (Mannane *et al*., 2007). The number and types of micro-organisms in milk immediately after milking are affected by factors such as animal and equipment cleanliness, season, feed and animal health. In Ethiopia the climate is hot for most of the year and under such conditions the raw milk spoils easily during storage unless it is cooled but cooling systems are not feasible in some parts of the country especially in the rural areas (O'Mahoney and Peters, 1987). In addition, there are post-harvest losses associated with poor handling, contamination, low level of technology applied in the conservation of milk to extend its shelf life and lack of market (Felleke, 2003).

Post-harvest loss is a major problem of the dairy sector in tropical countries. The high temperature coupled with the absence of cooling facilities and inadequate transportation means hasten the spoilage of the milk produced in this area (O'Mahoney and Peters, 1987). In Ethiopia the rural milk production system accounts for about 97 % of the total milk production in the country where it is difficult to transport the raw milk to the market area or to the processing plant due to poor infrastructure (Staal and Shapiro, 1996). Only about 5 % of the milk will be reached to the market area and the rest of the milk will be processed at the farm into different dairy products. Significant amounts of milk will be spoiled due to the absence of cold storage facility such as refrigeration. However, the proportion of milk spoiled due to several reasons is not studied well and documented at a country level. No comprehensive information is available on the level of post-harvest milk loss, which can help to devise different intervention methods to minimize the loss. To mitigate post-harvest milk loss different methods have been practiced by small scale milk producing and processing households. Milk processing is one of the mitigation system used to minimize the loss of raw milk especially in areas where infrastructure is underdeveloped to sale the raw milk. Assessment of the quality of traded milk and milk products has shown that value addition through small-scale processing is important for income generation and reduction of post-harvest losses (Lusato, 2006). Fumigation of milk handling equipments using different herbs is another alternative for minimizing post-harvest loss. On the other hand, adding plant materials directly to the milk products is also used by small scale milk producers and processors in order to alleviate the problem of milk and milk products spoilage before consumption. However, there are other means of post-harvest milk loss mitigation systems which should be studied, documented and introduced to other parts of the country.

The abundance of carbohydrates, proteins, and fats combined with the neutral pH supports and encourages a microbial ecology that can be both diverse and highly variable (Micaela and Kathryn, 2001). Milk is recognized as a highly perishable foodstuff easily subjected to microbial contamination which can vary widely with milk-handling practices (James, 2002). Microbial growth and metabolism shortens the shelf life of milk by producing undesirable changes in aroma and taste attributes that influence consumer acceptability of the products (Fromm and Boor, 2004). Unhygienic production, poor handling and undesirable practices such as addition of water or other substances introduce the bacteria or germs and that cause the spoilage of milk and its products. Various forms of microbiological spoilage are preventable to a large degree by a wide range of preservation techniques, most of which act by preventing or inhibiting microbial growth (Grahame, 1996).

In Ethiopia, the milk produced in most of the smallholder farms is either sold and/or consumed as fresh, fermented milk and products such as butter and cottage type cheese (O’Connor, 1994; O’Mahoney, 1988). Traditional milk and milk products preservation methods can play significant role in optimizing the shelf life of milk products. In traditional milk processing system of the country there are different plant materials that are being used either to improve the taste and flavor of the milk products and/or to increase the shelf life of milk products. For instance *Oleaafricana* and *Balanitesgalabra* are major tree species used to smoke milk vessels in Shinile and Jigjiga areas of Estern Ethiopia (Eyasu, 2007). So far there were some efforts to test different chemicals, plant materials and extracts as preservative of milk and milk products. However, these efforts were concentrated in the central parts of the country and peripheral as well as most of the rural areas of the country were not addressed in such kinds of study. The impact of the plant materials on the organoleptic, microbial as well as compositional quality needs to be investigated and documented. The level of inclusion and the mode of preparation of the preservatives and alternative ways of use by modifying traditional preservation methods should be studied in order to improve the preservative efficiency. The general objective of the study was by assessing the major indigenous knowledge and traditional milk and milk products and preservation methods to increase productivity. Therefore, the specific objectives of the present study are:

- ✓ To review available documents on post-harvest handling practices and losses of milk and milk products
- ✓ To identify causes and level of milk product losses during production, processing and handling as well as mitigation system in different parts of the country
- ✓ To investigate available traditional preservation technologies and to collect plant materials used for milk preservation and processing in different localities and study their antimicrobial properties
- ✓ To enhance market opportunity for value added dairy products through devising product diversification techniques

MATERIALS METHODS

Sampling technique and Data collection

The study was conducted in Jigjiga woreda of Somali region. Based on their accessibility and availability of logistics, Fafan and Hadow milk shade Kebeles were selected to conduct the study. A semi-structured questionnaire were prepared in English and tested in the pilot areas and necessary adjustments were made. Enumerators were selected from SoRPARI and training was organized for one day to brief them on the ways of data collection. Then, formal surveys were conducted by interviewing the responsible family member of the selected household of milk producers, collectors, processors, supermarkets/kiosks, and consumers. Therefore, from each segment of value chain, milk producers (40), processers (10), supermarkets (10), retailers (10) and consumers (10) were interviewed in the study. In addition plant materials used for fumigation/smoking, flavoring, preservation, cleaning and other purposes were identified from the above mentioned areas.

Data Analysis

Descriptive statistics were employed for qualitative data using Statistical Procedures for Social Sciences (SPSS) version 13.0 (SPSS, 2004), for quantitative data.

RESULTS AND DISCUSSION

Household characteristics

The average family size of the study area was found to be 6.7 and 7.8 for Fafan and Hadow kebeles, respectively with an overall mean of 7.3persons per family. The average family size was lower than that reported for Afdem district (13.17) (Fikirte, 2008) and Gursum district (9.34) (Helen, 2009) and similar with that reported for the Hamer and Bena-Tsema districts (7.3) Admasu (2006).The high family size might be associated with the cultural practice of polygamy for most of the pastoralists of the study area.

Herd Structure

As indicated in the Tables 1 that on the average there were larger number of cattle's than, goats and sheep's and camels per household in the study area. According to the Tropical Livestock Units (TLU) result, the study area has a mean livestock population of 9.39 TLU per household.

Table 1. Overall species composition of herds in the study area

Animal type	Number of animals	Mean ± SD	Population (TLU[a])	TLU/HH
Cattle				
Lactating Cows	277	3.5± 2.4	221.9	2.77
Dry cows	173	2.2± 2.4	138.7	1.73
Heifers	197	2.5±2.0	98.7	1.23
Bull	144	1.8 ± 1.8	158.4	1.98
Oxen	32	0.4 ± 0.8	35.2	0.44
Camel	51	0.6± 1.1	51.0	0.64
Sheep and Goats	536	6.7± 9.1	48.2	0.60
Total			752.1	9.39

[a] One Tropical Livestock Unit (TLU) = 250 kg which is equivalent to one camel (ILCA, 1992), 1.1 Oxen or 1.1 Bulls or 0.8 Cows or 0.5 Heifers or 0.09 sheep/goat (Gryseels (1988) as sited by Solomon (2004))SD= Standard Deviation, HH=Household

The proportion of cows in the total cattle herd in the current study was 55 percent. This figure is in agreement with what was report by Derese (2008) where the proportion of cows in the total herd was 52 percent in West Shoa Zone, Oromia region. The proportion of milking cows accounted for 61.5 percent of the total cows in the herd in the study area.

Major Purpose of Colostrum

Nowadays in most villages of the producer's respondents are well aware of colostrum's feeding for the new born animals and understand the beneficial effect on health of the young. As an increasingly common practice, the days of colostrum feeding or days of colostrum milk not used by the households were presented in the table below (Table 2). However, most respondents stated that days of colostrum feeding are often determined by the status of the mother. If the dam calves for first time (new mother), the dam will not be milked for 7-8 days and if the dam calves more than one time, the dam will not be milked for 1-3 days.

Table 2. Days of colostrum's milk not used by HH in Fafan and Hadow kebeles

Days from calving	Fafan (N=40)		Hadow (N=40)	
	N	%	N	%
1	5	12.9	6	16.1
2	4	9.7	3	6.5
6	1	3.2	12	29.0
7	25	61.3	17	41.9
>7	5	12.9	3	6.5

Milk Production and Utilization

Milk Utilization

To the 3 million pastoral population livestock are vital to survival and food security. The share of milk in the diet of pastoralists ranges from 25 to 76% of the total food consumption. This figure varies according to season and ethnic group (ESAP, 2002).Milk is consumed either as fresh or in fermented form in the current study; the majority of the milk produced is sold both in Fafan and Hadow kebeles (Table 3). This indicates that the objective of milk production in the study area is generation of cash income through sale of fresh milk. Small proportion of the total milk produced is allocated for butter making because of the high demand for fresh milk and low production of milk yield.

The total milk production from these study sites were estimated to be 6.21 liters per HH per day, of which, 46.55% was sold, 27.7 % left for household consumption,16.05 % to calves and 8.55% processed mainly into butter. However, the total milk production of the country is very low.

Table 3. Proportion of daily milk utilized in Fafan and Hadow kebeles

Daily milk utilization	**Proportion of fresh milk**		
	Fafan kebeles	**Hadow kebeles**	**Overall (%)**
For market	43.1	50.0	46.55
For family consumption	29.8	25.6	27.7
For butter production	8.8	8.3	8.55
For calf feeding	16.0	16.1	16.05

Labor Allocation in Dairying

Divisions of labor among family members with respect to dairy activities in Fafan and Hadow kebeles are indicated in Tables 4. In the current study, dairying offers more opportunities for females to be closely involved in the daily management than other family members. This is consistent with the finding of Kedija*et al*. (2008) who reported that women members of the family engaged in dairy farm activities in Mieso district, Oromia Regional State. Most of the respondents reported that the majority of the milking and dairy product processing activities are performed by women in both Fafan and Hadow kebeles. Only7.5 %of the respondents indicated that husbands are take part in milking and milk handling activities in Fafan but all of them lost their wife by death.

Table 4. Percentage of family members' participation on milk post-harvest activities in Fafan and Hadow kebeles

Activity Description	Fafan (N=40)		Hadow (N=40)	
Milking	**N**	**%**	**N**	**%**
Husband	3	7.5	0	0.0
Wife	37	92.5	40	100
Both wife &husband	0	0.0	2	3.8
Daughters	10	23.8	16	40.0
Milk handling				
Husband	3	7.5	0	0.0
Wife	37	92.5	40	100
Husband and wife	0	0.0	0	0.0
Daughters	3	7.5	16	40.0
Milk processing				
Husband	0	0.0	0	0.0
Wife	37	92.5	40	100
Wife and daughters	15	37.5	16	40.0
Marketing				
Husband	0	0.0	0	0.0
Wife	37	92.5	40	100
Both wife &husband	0	0.0	0	0.0
Daughters	7	16.3	16	40.0

Milk Handling Practices

Containers used for Milking and Milk Fermentation

Table 5 shows the different containers used for milking and milk fermentation produced in the study area. Plastic bucket is the major container used for milking and sale dairy products in the study area. Most of the respondents (77.5 %) in Fafan and 82.5% in Hadow use plastic bucket for milking. Furthermore, 15.0percent of the respondents in Fafan and 13.8% in Hadow use wooden container for milking. With regard to milk fermentation, the majority of the respondents (63.8%) in in Fafan and 60.0% in Hadow use wooden container while 31.3and 35 percent use plastic bucket in Hadow and Fafan kebeles, respectively. The use of plastic and traditional containers can be a potential source for the contamination of milk by bacteria because it is impossible with practical cleaning systems to remove all milk resides and deposits from the milk contact surfaces, but none of the respondents mentioned problem in regarding to difficulty of cleaning. Instead they proudly said wooden containers have its own advantage in improving flavor and shelf life on their milk. Only few respondents use metallic container for both milking and milk fermentation.

Table 5. Material used for milking and milk fermentation in the study area (percentage of the respondents)

	Fafan (N=80)				Hadow(N=80)			
	Milking		Milk Fermentation		Milking		Milk Fermentation	
	N	%	N	%	N	%	N	%
Plastic bucket	62	77.5	25	31.3	66	82.5	28	35.0
Wooden container	12	15.0	51	63.8	11	13.8	48	60.0
Metallic container	6	7.5	4	5.0	3	3.8	4	5.0

Cleaning and Smoking Milk Vessels

The respondents who practice fumigation and cleaning practices of milk utensils in the study area are indicated in Table 6. Almost all the respondents practice smoking and washing the utensils used for processing of milk. The most common technique of washing is by putting plant leaves of *berkaketi*(*Lantana camara*) together with water and shaking for some times and finally rinsing with water. Moreover, they rub milk utensils not only for washing but also flavoring milk containers.

Table 6.Fumigation and cleaning practices of milk utensils in the study area

S. No	HHs practicing	Fafan (N=80)		Hadow (N=80)	
		N	%	N	%
1	Fumigating milk equipment's	78	97.5%	80	100%
Reason for fumigation					
2	Flavor impartation	78	97.5%	80	100%
3	Shelf life increment	78	97.5%	80	100%
4	Both	78	97.5%	80	100%
5	Do you rub for washing and flavoring milk containers?	80	100%	80	100%

Balanitesglabra, *Acacia etbaica* , *Oleaafricana*, *Acacia nilotica*, *Solanumincanum*, *Acacia brevespica*, *Canthiumbogosensis*, *Lantana camara* and *Premnaresinosa*are commonly used tree and shrub species for cleaning up and smoking of milking utensils (Table 7). *Lantana camara*(*Berkaketi* in Somali) is the most common plant species used to clean milk vessels. Woob in Somali (Unidentified) is the most common woody plants species used to add flavor to churning material by boiling its stem cover (bark) with water into the container before putting the milk.

Balanitesglabra (*Kadiin* Somali), *Oleaafricana* (Agarsein Somali) and *Acacia etbaica* (Sogsogin Somali) are the most frequently used plant species for smoking milk vessels in the study areas. These plants are used to impart good flavor to the milk and milk products. Besides, it is claimed that they are known to increase the shelf life of milk when used. This report is consistent with the report of (Eyasu, 2007) in Shinile and Jigjiga area. *Acacia Nilotic a*nd *Acacia brevespica* are used for smoking milk containers when they miss the others. On the contrary, *Acacia brevespica* used for smoking milk containers only for camel in the study area.

In the study area, the majority of the respondents reported washing and smoking of milking utensils with different indigenous plant species is a common practice for both flavor impartation and shelf life increment.

Table 7. Plants used for cleaning and smoking of milk utensils in the study area

S.No	**Local name**	**Scientific name**	**Purpose**	**Fafan %**	**Hadow %**
1	Kadi	*Balanitesglabra*	Smoking	100	100
2	Sogsog	*Acacia etbaica*	Smoking	71.3	81.3
3	Agarse	*Oleaafricana*	Smoking	100	100
4	Maraa	*Acacia nilotica*	Smoking	31.3	33.8
5	Kariir	*Solanumincanum*	Smoking	43.8	52.5
6	Warsamay	*Acacia brevespica*	Smoking	22.5	33.8
7	Timir-lojir	*Canthiumbogosensis*	Smoking	0	47.5
8	Jacjacle	*Premnaresinosa*	Smoking	0	36.3
9	Berkaketi	*Lantana camara*	Cleaning	100	100
10	Woob	Unidentified	Cleaning	57.5	63.8

N = number of respondents (80 respondents from each district).

Acalyphafruticosa (*Dhigri*in Somali) and Wheat and Sorghum flour were the most commonly used butter preservatives in the studied areas (Table 8). 95% of the women in Hadow and 92.5% in Fafan district used *Acalyphafruticosa* to keep butter for longer period of time and to add flavor.

Table 8. Plants used for butter preservation in the study area

Local Name	**Common name**	**Scientific name**	**Fafan (N=80)**		**Hadew (N=80)**	
			N	**%**	**N**	**%**
Dhigri	-	*Acalyphafruticosa*	74	92.5	76	95
Deqik	Wheat flour	-	61	76.3	50	62.5
Deqik	Sorghum flour	-	61	76.3	50	62.5

Milk cooling mechanism

This milk can be contaminated by microorganisms at any point from production to consumption. The microbial load of milk is a major factor in determining its quality. It indicates the hygienic level exercised during milking, that is, cleanliness of the milking utensils, condition of storage, manner of transport as well as the cleanliness of the udder of the individual animal (Spreer, 1998; Gandiya, 2001). The manners of handling milk from production till marketing were considered. The fresh milk produced in the area is not subjected to any cooling mechanism like refrigeration to reduce milk temperature except a small number of respondents in Fafan. However, it was noticed that most of the respondents put the containers in Coldwater and also put wet cloth on the milk equipment in order to cool and keep its freshness.

Table 9. Type of cooling mechanism used in the study area

	Fafan (N=80)		Hadow (N=80)	
	N	%	N	%
Refrigeration	15	18.75	0	0
Putting in cold water container/flowing/	29	36.25	34	42.5
Putting wet cloth container	36	45	46	57.5

Shelf Life of raw milk in the Study Area

Table 10 shows the shelf life of milk or duration of milk fermentation produced in the study area. The shelf life of raw milk was found to be 2.1 and 2.8 days in Fafan and Hadowkebeles, respectively at an ambient temperature or by local cooling mechanism. In general, the shelf life of the raw milk produced in the study area differs from the findings of other workers. This could have been due to the difference in handling practices and traditional techniques used to preserve dairy products in the study area and elsewhere.

Table 10. Reported shelf life (days) of raw milk in the study area

Study areas	N	Min	Max	Mean	SD
Fafan	80	1	3	2.1	0.72
Hadow	80	1	3	2.8	1.69

SD= Standard Deviation

Level of Milk Production, Processing and Consumption

Table 11 summarizes the weekly estimated amount of milk produced, processed and consumed, and also the total value of estimated milk post-harvest loss per week in form of rejected and dumped milk for both kebeles. The estimated milk post-harvest loss per week in this study is 16.06 and 20.57% for Hadow and Fafan, this was mainly attributed by rejected from sale.

Table 11. Level of milk production, processing and consumption and estimated amount of post-harvest loss in Hadow and Fafan

Variables	**Hadow**		**Fafan**	
	Mean	**SD**	**Mean**	**SD**
Weekly milk production (Lit)	43.45	3.48	40.79	2.42
Amount of milk sold per week (Lit)	21.72	2.4	18.1	2.8
Amount of milk consumed per week (Lit)	11.27	0.73	12.2	1.53
Amount of milk rejected from sale per week (Lit)	4.04	2.41	5.4	7.22
Amount of milk dumped per week (Lit)	1.11	0.19	1.26	0.33
Amount of milk donated to neighbors per week (Lit)	1.69	0.51	1.63	2.31
Amount of milk processed per week (Lit)	3.62	0.74	2.2	0.74
Amount of butter produced per week (Kg)	0.14	3.4	0.1	5.11
Estimated Milk post-harvest loss per week	***11.85%***		***16.33%***	

SD= Standard Deviation

Marketing of Milk and Milk Products

In the current study, most producers practice informal marketing system. The major points of milk sale for dairy products in the study area are collectors or retailers, individuals, at kiosk and at the farm gate (Table 12). The producer in Fafan sell fresh milk to collectors (76.3%), individuals (62.5%) and at kiosk (65.0%), while the sale for fresh milk in Hadow were 6.3 percent to individuals, 90 percent to collectors and at the farm gate (3.8%). In Fafan kebeles, most producers sale their fresh whole milk on the transportation road to individuals in Fafan town. The dairy products sold in the study area are fresh whole milk, butter and *Ergo*. Most of the respondents in these areas do not sell butter and *Ergo* but selling of fresh milk in these areas is a common practice.

Table 12. Major point of milk sale in the study area

	Fafan (N=80)		Hadow (N=80)	
	N	**%**	**N**	**%**
At the farm gate	4	5	3	3.8
At kiosk	52	65.0	0	0
To individuals	50	62.5	5	6.3
To cooperative	13	16.3	0	0
To collectors	61	76.3	72	90
Directly to processors	5	6.3	0	0

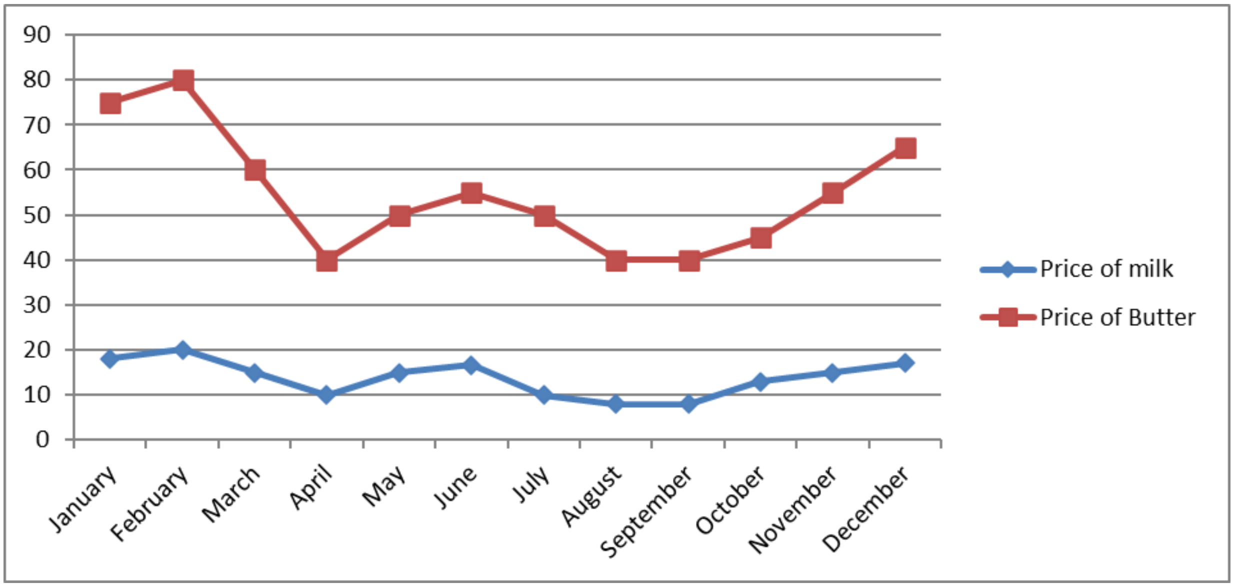
Milking was mostly performed twice a day in all the study area. However, there were exceptions to this, during the dry seasons milking operation is limited to once per day. Milk is transported to the major point of milk sale on foot or by donkey. The average estimated time to milk delivery from farm to the major point of milk salewas45.53and 34.22 minutes in Hadow and Fafan, respectively.

Table 13. Estimated time for milk delivery after milking (min) in the study area

Time of milking	Fafan (N=80)					Hadow (N=80)				
	N	**Min**	**Max**	**Mean**	**SD**	**N**	**Min**	**Max**	**Mean**	**SD**
Morning	40	15	55	30.47	12.68	40	10	80	45.53	21.10
Afternoon	40	20	60	37.97	14.55	40	10	80	45.53	21.10

The price of milk and butter sold in the study areas are shown in Figure 1. An average price of 10.2 and 16.4 Birr/liter for fresh whole milk and46 and 60.7 Birr/kg for butter were reported for the wet and dry seasons, respectively in the study area. The average price of fresh whole milk observed in the current study is much higher than that reported by Alganesh (2002) who indicated that an average price of 2.8 and 2.9 Birr/liter for fresh whole milk during the rainy and dry seasons, respectively in eastern Wollega . The same author reported that the average price of butter was 15.4 and 27.78 Birr/kg for the rainy and dry seasons, respectively in eastern Wollega.

Figure 1. Price (Birr) of fresh milk and butter in the study area over the year (2016/2017)



In this study the price of fresh milk and butter price is higher during dry season than wet season in both Fafan and Hadowkebeles. This may be attributed to the surplus milk production during wet season in the study area.

Milk rejection problem

Reasons for not selling fresh whole milk in Fafan and Hadow kebeles are indicated in Table 14. Among the reasons reported by the respondents are spoilage, udder disease, adulteration and low market demand are major causes for rejection and downgrading of milk in the local community. The loss associated with downgrading of milk and milk products, which is important income generating commodity, is considerable.

Table 14. Major reason for rejection of raw milk in the study area

Milk Rejection	Fafan (N=80)		Hadow(N=80)	
	N	%	N	%
Milk rejection problem				
Yes	18	22.5	29	36.25
No	62	77.5	51	63.75
Major reasons for milk rejection				
Spoilage	17	21.3	28	35.0
Udder disease	17	21.3	22	27.5
Adulteration	18	22.5	22	27.5
Law fat content of milk	8	10.0	6	7.5
Low market demand	18	22.5	27	33.8

On the contrary, spoilage of dairy products due to long distance to market is limited in the area mainly because of minimum estimated time for milk delivery after milking in the study area. A major problem faced by producers was lack of cooling facilities, which consequent spoilage of the milk. When this occurred, producers were not sale all milk and they are forced to consumer to donate to neighbors before it spoiled. Accordingly, this study revealed that major possible reasons for milk spoilage problem next to lack of cooling facilities are poor milk handling practices and cleaning problem. In addition, some respondent claimed that mixing of milk which was previously milked with the new one can be possible reason for milk spoilage problem.

Table 15. Major possible reasons for milk spoilage problem in the study area

	Fafan (N=80)		Hadow(N=80)	
	N	%	N	%
Poor milk handling practices	53	66.3	55	68.8
Long distance to market	2	2.5	14	17.5
Use of inappropriate containers	8	10.0	11	13.8
Lack of cooling facilities	65	81.3	80	100
Cleaning problem	43	53.8	47	59

Further, spillage of milk and udder infection problem (*Gofle*in Somali) of cattle increases the potential level of losses from the producer. Mostly the milk from infected udder used to feed for calves and pet animals or they discard it. Most of the respondents were believed that letting the calves to suckle until the cattle recover from infected udders the best method to decrease loss. Spillage losses were very low in the study area.

Table 16. Spillage and udder infection problem and fate of milk from this problem in the study area

	Fafan (N=80)		Hadow (N=80)	
	N	%	N	%
Spillage	6	7.5	5	6.3
Udder infection problem	44	55.0	37	46.3
• **Fate of milk from infected udder**				
Dispose	6	7.5	3	3.8
Use for calves & pet animals	38	47.5	34	42.5

Identified Causes of milk post-harvest losses

Most post-harvest loss of milk and milk product are associated with poor handling, contamination, the level of technology applied in the conservation of milk to extend its shelf life and lack of market (FAO, 2001).

Overall, the commonest reason for post-harvest losses due to milk spoilage was unhygienic practices especially originating from the farm. In the current study area post-harvest losses are high due to unhygienic practices, improper milking procedure and lack of cooling facilities which cause spoilage problem.

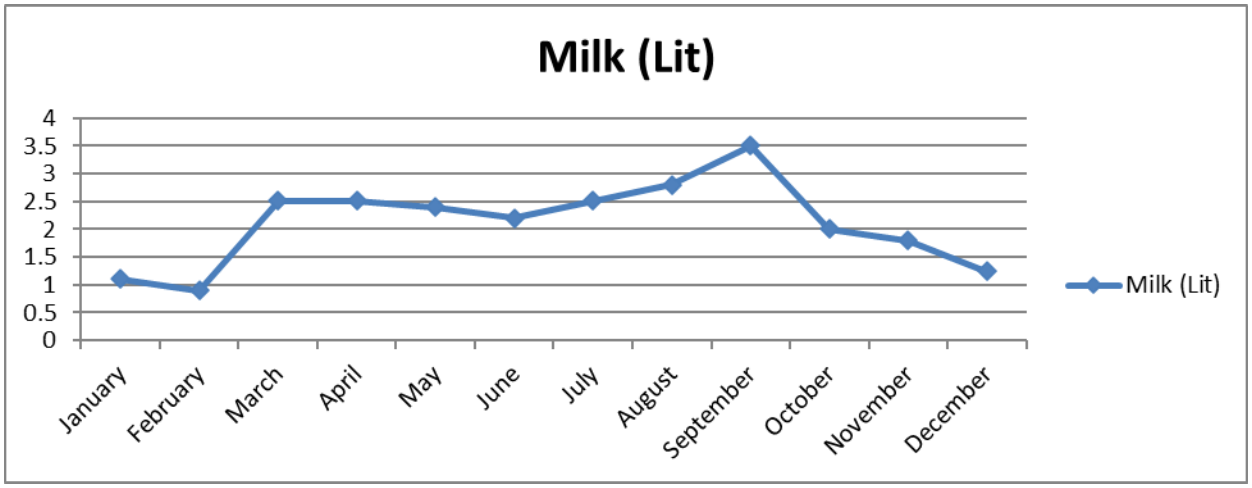
Table 17. Post-harvest loss problems in Hadow and Fafan kebeles

Problem	**Fafan**		**Hadow**	
	N=80	**%**	**N=80**	**%**
Spoilage problem	36	45.0	41	51.3
Cool milk after milking	28	35.0	22	27.5
Use teat dip solution after milking	25	31.3	18	22.5
Check udder and fore milk	33	41.3	34	42.5
Check abnormal appearance of milk	52	65.0	44	55.0
Dry teats thoroughly	8	10.0	6	7.5
Prepare separate clean milking place	47	58.8	36	45
Follow proper order of milking	44	55.0	37	46.3

Forced consumption

Forced consumption arises when milk that would otherwise be sold has to be consumed at the farm because of lack of markets. Losses arising from forced consumption result in reduced value of liquid milk and the level of loss fluctuates depending on changes in milk supply and demand. In this study, it has been estimated that an overall average of 2.12 liter farm milk goes to forced consumption, which is 2.8lit during the wet season, mainly due to insufficient market outlets for the excess milk.

Figure 2. Forced consumption of milk in the study area over the year (2016/2017)



Constraints of Milk Production, Marketing, Consumption and Processing

The most important constraints associated with milk production as prioritized by the sample respondents of the study areas are low milk yield, poor quality of feeds, feed shortage, poor market infrastructure and unavailability of small scale milk processing equipment's (Table 18). This finding is in agreement with Kedija*et al*. (2008) who stated that the feed scarcity and access to transport or poor market infrastructure as a major problem.

Table 18. Production constraints in the study area

	Fafan		Hadow	
	N	**%**	**N**	**%**
Low milk yield	77	96.55	72	89.66
Poor quality of feeds	52	65.52	47	58.62
Feed shortage	63	79.31	55	68.97
Low price of milk	8	10.34	19	24.14
Poor market infrastructure	41	51.72	47	58.62
Labor shortage	22	27.59	25	31.03
Low milk quality/rejection	11	13.79	22	27.59
unavailability of small scale milk processing equipment's	47	58.62	33	41.38

According to the respondents, the major constraints to milk processing in the study areas are: Poor market infrastructure, low milk yield and unavailability of small scale milk processing equipment's (Table 19).

Table 19. Processing constraints in the study area

	Fafan		Hadow	
	N	%	N	%
Low milk yield	39	48.28	44	55.17
Low price of milk	14	17.24	19	24.14
Poor market infrastructure	44	55.17	50	62.07
Labor shortage	28	34.48	22	27.59
Low milk quality	28	34.48	25	31.03
Unavailability of small scale milk processing equipment's	55	68.97	74	93.10

The existing constraints with references to marketing are in the form of poor market infrastructure, insufficient milk production and related problems. These constraints constitute a barrier between urban demand and rural supply. The perishability of milk means that producers who cannot sell raw milk within a few hours of milking due to poor market infrastructure must either process it or cool it. When cooling and processing facilities are limited, production is discouraged.

Table 20. Marketing constraints in the study area

	Fafan		Hadow	
	N	%	N	%
Low milk yield	55	68.97	58	72.41
Low price of milk	30	37.93	28	34.48
Poor market infrastructure	61	75.86	66	82.76
Labor shortage	28	34.48	25	31.03
Low milk quality/rejection	36	44.83	41	51.72
Unavailability of small scale milk processing equipment's	44	55.17	30	37.93

Most producers with limited production capacity, however, increased consumption of their own production is not sufficient to compensate for the income losses. So, major income source constitute one of the most important consumption constraints in the study area.

Table 21. Consumption constraints in the study area

	Fafan		Hadow	
	N	%	N	%
Low milk yield	22	27.59	30	37.93
Major income source	55	68.97	61	75.86
Low quality	14	17.24	19	24.14

The interaction of these constraints affects the overall milk production in the areas. Therefore, to alleviate these problems integrated work should be done with close participation the Zonal and Woreda Offices of Agriculture and the researcher.

Summary and Conclusions

The present study was conducted in two representative kebeles of Jigjiga woreda, Somali Regional State, with the objectives of identifying causes and level of milk product losses during production, processing and handling as well as mitigation system, to investigate available traditional preservation technologies and to identify plant materials used for milk preservation and processing in different localities to generate information that helps to make informed decisions by milk producers, collectors, processors, supermarkets/kiosks, and consumers concerned with dairy production. Descriptive statistics were used.

The average family size of the study area was 7.3. The average livestock holding per household were larger number of cattle's than, goats and sheep's and camels per household in the study area. According to the Tropical Livestock Units (TLU) result, the study area has a mean livestock population of 9.39 TLU per household. The proportion of cows in the total cattle herd was 55 percent. The proportion of milking cows accounted for 61.5 percent of the total cows in the herd in the study area. Almost all villages of the producer's respondents are well aware of colostrum's feeding for the new born animals and understand the beneficial effect on health of the young. However, most respondents stated that days of colostrum feeding are often determined by the status of the mother. If the dam calves for first time (new mother), the dam will not be milked for 7-8 days and if the dam calves more than one time, the dam will not be milked for 1-3 days.

Milk is consumed either as fresh or in fermented form in the current study; the majority of the milk produced is sold both in Fafan and Hadowkebeles. This indicates that the objective of milk production is generation of cash income through sale of fresh milk. Small proportion of the total milk produced is allocated for butter making because of the high demand for fresh milk and low production of milk yield.

Dairy activities offer more opportunities for females to be closely involved in the daily management than other family members. The majority of the milking and dairy product processing activities are performed by women in both kebeles.

Plastic bucket is the major container used for milking and sale dairy products in the study area. Most of the respondents use plastic bucket for milking. With regard to milk fermentation, the majority of the respondents use wooden container. The use of plastic and traditional containers can be a potential source for the contamination of milk by bacteria because it is impossible with practical cleaning but none of the respondents mentioned problem in regarding to difficulty of cleaning. Instead they proudly said wooden containers have its own advantage in improving flavor and shelf life on their milk.

The most common technique of washing milk utensils is by putting plant leaves of Berkaketi(*Lantana camara*) together with water and shaking for some times and finally rinsing with water. Moreover, they rub milk utensils not only for washing but also flavoring milk containers. On the other hand, Woobis the most common woody plants species used to add flavor to churning material by boiling its stem cover (bark) with water into the container before putting the milk.

Balanitesglabra (*Kadiin* Somali), *Oleaafricana* (Agarsein Somali) and *Acacia etbaica* (Sogsogin Somali) are the most frequently used plant species for smoking milk vessels in the study areas. These plants are used to impart good flavor to the milk and milk products. Besides, *Acacia nilotica* and *Acacia brevespica* are used when they miss the others. And also, *Acacia brevespica* is used for smoking milk containers only for camel in the study area. The majority of the respondents used *Acalyphafruticosa* to keep butter for longer period of time and to add flavor.

The fresh milk produced in the area was subjected to local cooling mechanism, by putting the containers in cold water and also put wet cloth on the milk equipment in order to reduce milk temperature and keep its freshness. The average shelf life of raw milk was 2.45 days at an ambient temperature.

The estimated milk post-harvest loss per week in this study is 11.85 and 16.33% for Hadow and Fafan, this was mainly attributed by rejected from sale.

The major points of milk sale for dairy products in Fafan sell fresh milk to collectors (76.3%), individuals (62.5%) and at kiosk (65.0%), while the sale for fresh milk in Hadow were (6.3%) to individuals, 90 percent to collectors and at the farm gate (3.8%). In Fafan kebeles, most producers sale their fresh whole milk on the transportation road to individuals. The dairy products sold in the study area are fresh whole milk, butter and *Ergo*. Milk is transported to the major point of milk sale on foot or by donkey. The average estimated time to milk delivery was 45.53 and 34.22 minutes in Hadow and Fafan, respectively. Therefore, spoilage of dairy products due to long distance to market is limited.

An average price of 10.2 and 16.4 Birr/liter for fresh whole milk and 46 and 60.7 Birr/kg for butter were reported for the wet and dry seasons, respectively. The lower price of fresh milk and butter price in wet season than dry season may be attributed to the surplus milk production during wet season in the study area.

Among the reasons reported by the respondents are spoilage, udder disease, adulteration and low market demand are major causes for rejection and downgrading of milk in the local community. Accordingly, this study revealed that major possible reasons for milk spoilage problem next to lack of cooling facilities are poor milk handling practices and cleaning problem. In addition, some respondent claimed that mixing of milk which was previously milked with the new one can be possible reason for milk spoilage problem.

Further, udder infection problem (*Gofle*in Somali) of cattle increases the potential level of losses from the producer. Mostly the milk from infected udder used to feed for calves and pet animals or they discard it. Spillage losses were very low in the study area. In the current study area post-harvest losses are high due to unhygienic practices, improper milking procedure and lack of cooling facilities which cause spoilage problem. Losses' arising from forced consumption has been estimated that an overall average of 2.12 liter farm milk, which is 2.8lit during the wet season, mainly due to insufficient market outlets for the excess milk.

The research revealed some challenges or constraints involved in milk production, processing, marketing and consumption of the study areas. Low milk yield, poor quality of feeds, feed shortage, poor market infrastructure and unavailability of small-scale milk processing equipment are the most important constraints associated with milk production. The major constraints to milk processing in the study areas are: Poor market infrastructure, low milk yield and unavailability of small scale milk processing equipments. The existing constraints with references to marketing are in the form of poor market infrastructure, insufficient milk production and related problems. Most producers with limited production capacity, however, increased consumption of their own production is not sufficient to compensate for the income losses. So, major income source constitutes one of the most important consumption constraints in the study area. The interaction of these constraints affects the overall milk production in the areas.

Recommendations

- Training of farmers on how to ensure good quality milk with improved milk handling practices, milk marketing, etc. is important.
- Marketing problem is one of the major blocks for the development of the dairy sector. Therefore, along increased milk production, improvement of the marketing system in the area needs due attention. For example, group approaches like farmers' milk marketing group, which makes path for regular dispatch of milk is an important step forward and therefore should be established.

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3. Investigation of Severe Silent Outbreak of Camel Abortion in Mayomuluko Districts, Erer Zone, Somali Region, Ethiopia.

Muhumed Ali Farah [1], Muhumed Ali [2], Abdu Salam [3]
Abdi Malik [4] and Ahmed Dek[5]
Tel: +251911024107[1]
Animal health research program, Somali Region Pastoral and Agro-Pastoral Research Institute (SoRPARI)

ABSTRACT

A questionnaire based survey and a cross-sectional study was conducted from October 2017 to October 2019 on randomly selected 50 individual she-camel owners and 100 she-camels (50 for blood smear and 50 for serological examinations) from the study area with the aim of investigating Investigation of Severe Silent Outbreak of Camel Abortion in Mayomuluko District, Erer Zone, Somali Region, Ethiopia. From the studied district five kebele namely Bulbul, Harjano, jiidamissa, degmayo and 3rd kebele in Mayumulukho Town were randomly selected. The word camel is derived from the Greek word "kremal, which is meaning running". Camel is an important component of the desert ecosystem from time immemorial and is recognized as the "Ship of the desert, Humans depend on this animal not just for meat, milk and hide but also as one of the most important mode of transport in the desert where impossible other means of transportation, Camel is one of the large ruminants reared by 70 % of Somali pastoral community depending on their livelihood in the semi-arid hardship land they live and it is the only animal can provide milk for their children and elders during summer time when other livestock are in danger due to shortage of feed and water. Despite the important camel as a potential animal food security provider is neglected for centuries, until now it has no single vaccine produced to protect them from different diseases affecting them except camel pox vaccine which is recently produced and is in experimental stage and not yet evaluated its efficiency in mass vaccination, there many diseases killing camel not yet identified. e g camel respiratory disease syndrome (95/96), camel posterior paralysis since (1974), camel killer disease, (2005), etc., even bacterial diseases which their vaccine available in this country not yet adjust dosage for camel, like Anthrax and Pasteurella vaccines which are the only two vaccines use for camel against their infection with bacterial diseases and not yet adjust dosage for camel but use cattle dosage.

Key words*: Camel Abortion, Ethiopia, Investigation, Mayomuluko, Nogob Zone, Outbreak, Somali region*

INTRODUCTION

The Somali regional state of Ethiopia lies in the arid and semi- arid ecological zones of the country, the majority of the population in this region of Ethiopia depend on direct or indirect livestock on livestock and their products for their livelihood. According to the (IPS, 1999-2000.year) livestock population estimated sheep (9,053,000.heads), goats (8,547,000.heads), camels (2, 032,000.heads), cattle (3,746,000 Heads) and donkeys (213,000.heads). This region, together with Afar and Boerne lowlands, is known for its large number of Camel (Camelidae-Dromedary) population. Over the past two decades, camels have begun in the region recognition for their food producing potential animal in the arid and semi- arid areas. Their vital role in supporting human populations in some of the poorest and frequently drought- stricken areas of the world, such as the Horn of Arica, has now been widely acknowledged (Hjort Af Ornas, 1988).

The devastating African drought in (1984) and one that occurred (in this year 2011G.C in Horn Africa as well as that happened in 2009 E.C), generally and specially Somali pastoralists demonstrated that camel ownership could give pastoralists a competitive edge and an excellent chance for survival in similar crises. Whereas entire herds of cattle, sheep succumbed to the arid conditions. Camel populations survived relatively un scathed Consequently, due to that reason some pastoral groups with deep –rooted traditions of cattle herding , such as Borena in south east of Ethiopia and Samburu in northern Kenya, started to acquire camels (Spreling, 1987), a fact which has come to the attention of development agencies and international organizations.

Most pastoralists and some agro-pastoralists of the Ethiopia Somali Regional State depend on camel for their meat and milk requirements, particularly during the severe dry periods. Camels are also sources of income for many households as they are sailing live animal and their milks are gaining market in the big cities and even some people exported to Arab countries, further that camel milk got number of medicinal value as wrote Professor Yagille (2011G.C in Jigjiga camel conference), at the moment some people in Jigjiga town got permission to export camel milk to Somaliland and from there other people export to abroad especially some Gulf Countries). In addition, camels are considered as a corner stone of social organization in the Region (Bekele, 2002). Therefore, camels play vital role in the food- security for pastoral community living in areas where climatic and drought vagaries are very common. Although camels are resistant to drought conditions comparing with other livestock like cattle and sheep and has natural resistant to deadly diseases like Rinder pest in cattle, African horse in equine, blue tongue disease in sheep and Mucosal disease, etc., they are not free from constraints that reduce their survival and productivity. The constraints can vary from one place to another depending on environment, climatic condition, and social factors, diseases have been indicated as one of the major problems of camel production in camel rearing regions of Ethiopia like camel killer disease (2005 G.C), camel respiratory disease syndrome (1996/7G.C) and camel posterior paralysis (1973/4 G.C), these diseases not yet identified, (Teshome *et al*., 2003, Cattle, 1999, Tefera and Gebreah, 2001). However, information on diseases and other camel production constraints are few and limited to certain villages and districts due to poor infrastructure, lack of attention and nature of mobility in pastoral communities. Therefore, the objective of this study was designed to generate information on camel production constraints in the two districts (Mayomuluko and Kubi), particularly with the emphasis on camel abortion disease prevalence, is any specific gestation period more abortion occur, is certain age of pregnancy she camel more sensitive to the disease causing abortion and what about Economical loss related with the disease.

Study Methodology

Description of the Study Areas

Nogob (Somali: Nogob), formerly known as Fik, is a zone in Somali Region of Ethiopia. Nogob Zone is bordered on the south by Godey, on the southwest by Afder Zone, on the west and northwest by the Oromia Region, on the north by Fafan, on the east by Jerar, and on the southeast by Korahay Zone at 8°08'17.0" North latitude; 42°17'36.4" East longitude. About 403 km East of Addis Ababa. Nogob zone has 9 woredas including Fik, Segeg, Garbo, Lagahida, Salehad, Hamero, duhun, Meyumuluku, Qubi and Goljano. Among these Mayomuluko was purposefully selected and considered as the study areas of this research project. Of the total kebeles of the Mayomuluko district 5 kebeles were randomly selected namely Jidamissa, Degmayo, Harajano, Bulbule and the 03 Kebele of Mayomuluko town.

Ethiopia Somali Regional State MAP, look at Location of the studied areas (Mayomuluko District)

Mayomuluko is located northwest part of the Ethiopia Somali Regional State, Oromia Regional state in the north, and west of them, ERRE River in the east and south Hamaro district. Its altitude more or less is in between1600-1700 M.S.L (IPS). Annual rainfall is 560- 600 mm. Temperature in general is in between 25 - 35c in different season. Human activities are pure pastoralists. They rear camel, goats, sheep and cattle. Areas composed of scattered mountains, hells, valley, vegetation forge, bushes and accaicia trees which catch each other on the to making permanent shades under them and it is suitable breeding for different biting flies like: Tabanus groups, Stomxys, Hippopocida, Horse flies, different types of mosquitoes like(normal mosquitoes) transmits human malaria Culicoides ,Migges,etc),usually transmit number of viral diseases like Rift valley fever, Three sickness disease, blue tongue, to study for camel abortion

Tabanus group which transmit trypanosomes to camel mechanically

Study Design and Sampling Methods

Cross-sectional study design was employed. Accordingly, five kebeles were randomly selected to be studied for camel abortion. In each one of the five kebele we selected 4 household of camel owners randomly without considering, their herd size. Thus, Total HHS we selected in the five kebeles was 20 HHS (4HHs x 5 kebeles). Number of participants people were selected randomly from the 20HHS making the total interviewed people from the five kebele as 50 persons (10

HHS x 5 kebeles) where all of them were men. Total camel we bled randomly in each herd were 100 samples (20 HHS x 5 camel (from in each HHS). Among these, 50 samples were examined in field for the presence of Trypanosoma species, while we kept other 50 sample for Brucella test to be done in the laboratory (zonal veterinary laboratory in Jigjiga), during blood collection we follow strictly conventional veterinary procedure methods for blood collection under aseptic condition procedures.

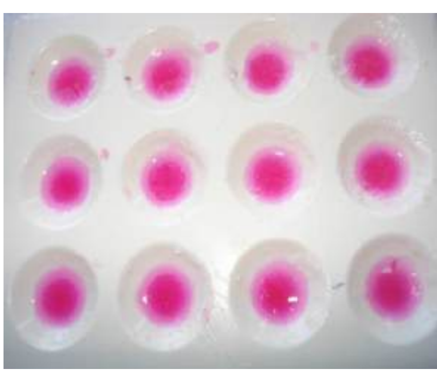
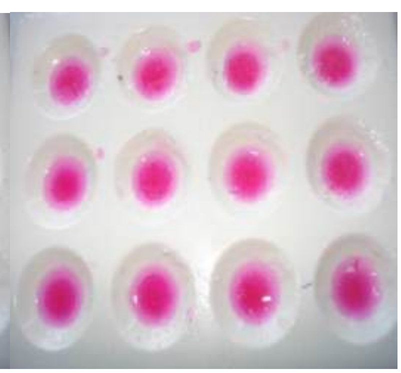
Blood Examination for Trypanosome Infestation

We prepared wet blood films from that we collected from jugular vain and examined under sun light Microscope in the field on the spots in each day during our work in the field. Thick and thin films (fixed in methanol, stained with giemsa 10 %, kept for staining 30 minutes in it, washed out with water, dried up, examined under microscope power 100, using immersion oil, searching in each film for 5 minutes or 100 field microscope). Fortunately, the 50 blood samples we examined we did not find any positive case for T.evans and that finding minimized possibility involving Trypanosomiasis as a primary causative agency for camel abortion

Serology Studying

The test that we have used in this study was screen test, the Rose Bengal plat test. The procedure that we were followed for doing Rose Bengal plate test was as follows:-

- ✓ We collected blood samples from 10 herds, dispersed into five kebel, in each kebel two herds and we bled 5 animals from in each herd, so that, the total of animals we collected blood samples were 50 animals,
- ✓ By using Rose Bengule Plat test, we mixed 30 micron of brucella antigen with 30 micron of serum sample we collected from Mayumulukho district aborted camels in different gestation period(2-12months0
- ✓ Using special wood prepared for the test (could be plastic) mixing together for 2minutes in each test
- ✓ Then we read the result and we found all the samples we collected from Mayumulukho were negative for the disease we were suspected before (brucella) and here is the plate we used for the tests



RESULTS AND DISCUSSION

The 50 she camel owners interviewed, were hold 1674 she camels with herd size of ranging from 1- 100. Among these 802 (47.9%) were pregnancy, while 872 (52.1%) were dry she camels. Of the pregnancy she camels due to different reasons, 548 (68.3%) were aborted and the remaining 254 (31.6%) she camels were give birth normally for the last two years (Chart 1- 5). On the other hand chi2 test analysis of potential risk factor, the herd size at animal level in relation to abortion had revealed statistically significant association ($P<0.05$) (Table. 1). However in this study the abortion was higher in those she camels with small herd size unlike to the results of previous research studies who reported in contrary to the result of the current study. This may be due to the proportion of sample size different across the herds (Table .1)

Table 1. Occurrence of Abortion in She Camels Based on Herd Size Different By Chi2 Test Analysis

Variables		**No. of pregnancy she camels recorded**	**No. of she camels aborted, %**	χ^2	**P-value**
Herd size	Small herd	335	244 (72.8)	13.7	0.001
	Medium herd	178	130 (73..0)		
	Large herd	289	174 (60.2)		

Furthermore, from examined animals in the field some clinical signs were observed, including yellowish fetal membrane, congested eyes. Moreover, calves body usually also edematous at the delivery time and sometimes difficult to be delivered. All drugs we tried failed to save calved (pen-strep, oxytetracycline, tetracycline, etc), as well as. Traditional medicine also failed. When we moved pregnancy she camel before deliver 20-30 days caves delivered would survive. Sometimes, Usually calves born in normal health condition but after drank colostrum become sick and would die within 2-3 days, pastoral , camel herders believed that causative agent was lantana camera and they reasoned, when they moved pregnancy she camels at 8-9 gestation period from lantana camara habitat and delivered in an area not existed of lantana camara calves born there would survive, but if they kept number of pregnancy she camel in the lantana camara habitat calves born would die, until now there was no any remedy available for this problems and it would wait when somebody brought new would discover and solved Lantana camara problem in the future, when lantana Camara no followers. Seeds or leaves calves borne usually would survive but vice -verse would happen if there were seeds, leaves and flowers.

Chart 1. Degmayo Area

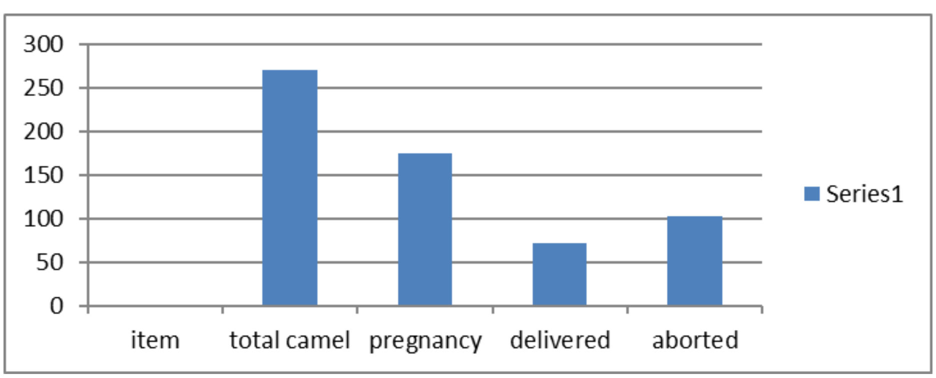


Chart 2. Jiidamissa Area

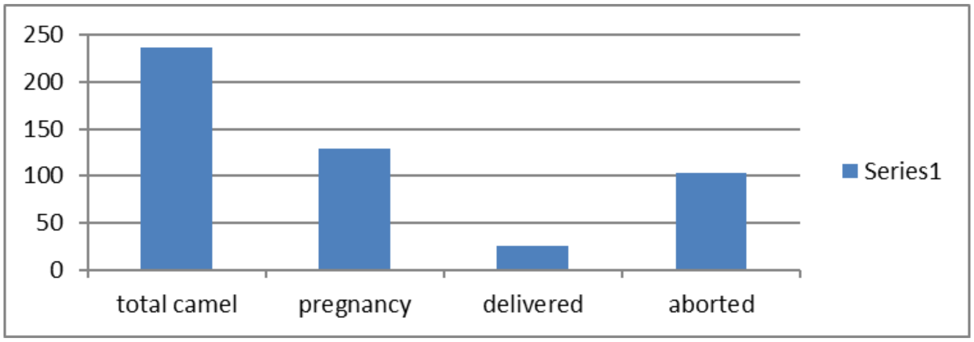


Chart 3. Bulbule Area

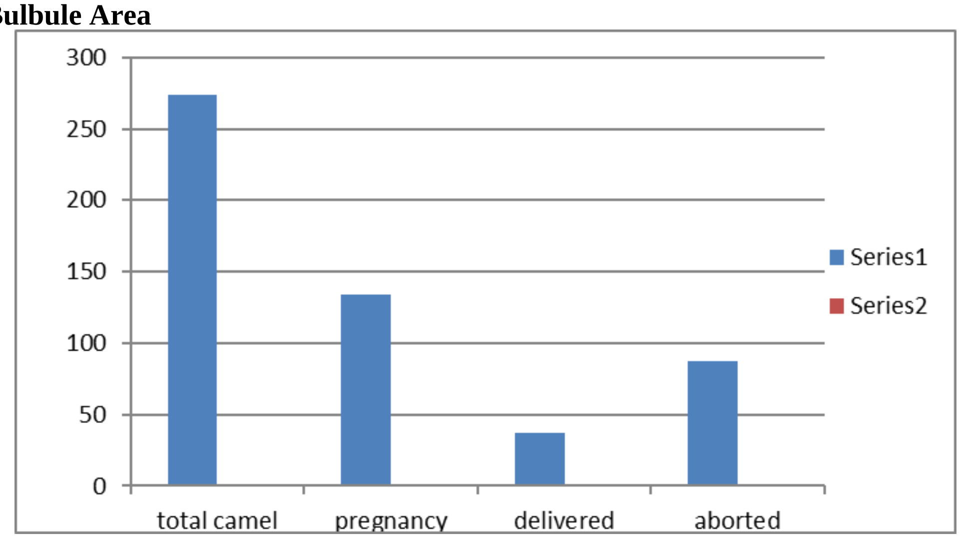


Chart 4. Harajano Area

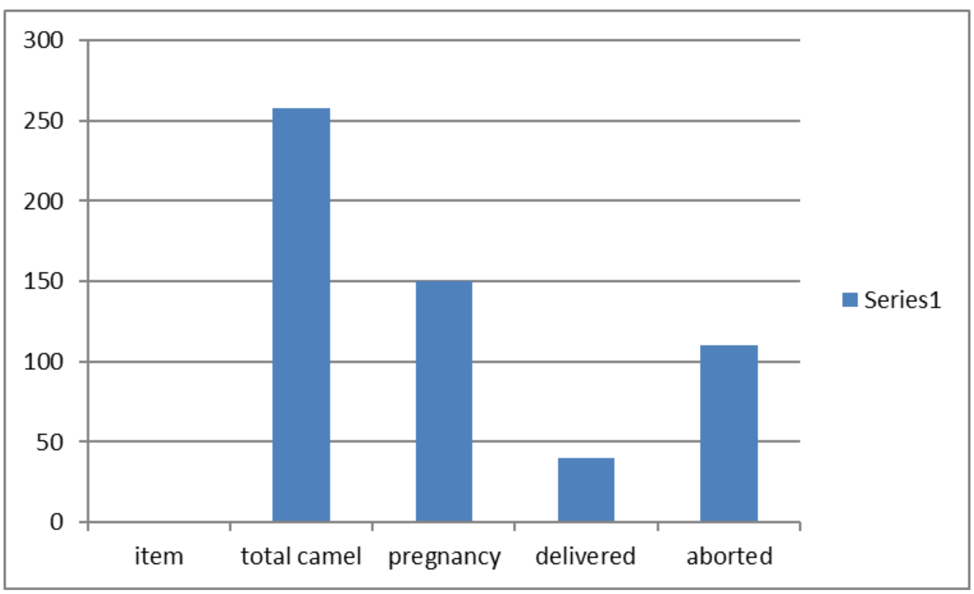
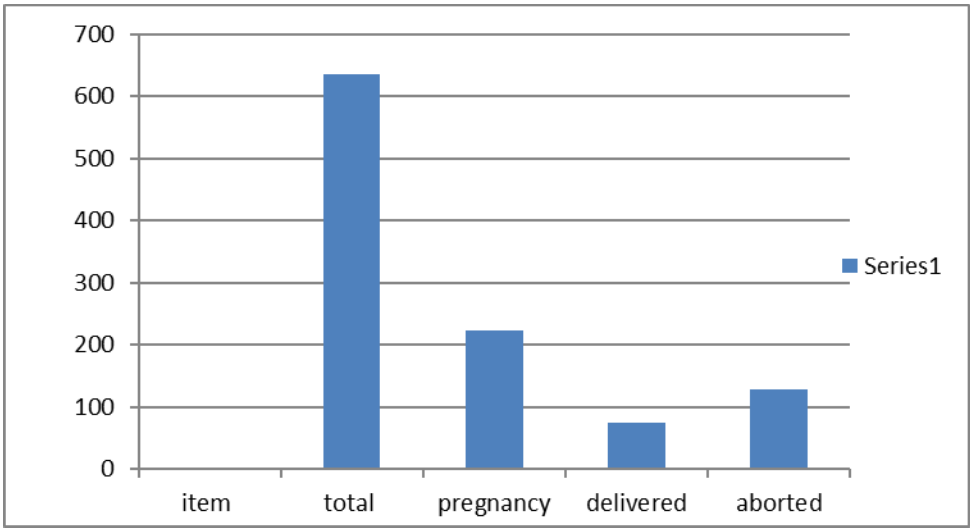


Chart 5. Kebele 03 of

Mayomuluko town



If we look back despondences got from the 50 camel owners during discussion with them about camel health problems encountered in their areas in the last two years (2016-2017 G.C), which included huge camel abortion(see the five tables) in different gestation period of pregnancy she camels (5%, 85%. 10%) 2-3month, 7-10 month and 10 -12month respectively, considering there were not retained placenta seen with camel aborting, existing mineral deficiency which forced camel to chow old bones, plastic backs, etc. and causing disease like botulism which is not common to happen in camels, present huge different types of mosquitoes which included (Cullicoides and Midgges) which both of them can transmit number of viral diseases like Rift valley fever, Blue Tongue and three day sickness diseases, keeping in mind there were parallel human sickness during camel abortion in -Mayumulukho, especially those five areas we visited, which included (Severe coughing, fever, shivering, severe headache, vomiting, pain in muscles, and joints, photophobia, off food. Usually these clinical symptoms used to continuous for 4-7 days and person usually in most cases revering, finding negative 50 camels we examined for trypanosomes infestation, as well as finding negative another 50 samples which we tested for Brucella disease using Rose Bengul test.

This finding result indicate that Brucella disease and Trypanosoma Evansi were not the primary agent causing severe silent outbreak of camel abortion in Mayomuluko district, considering different symptoms seen aborting camels in field condition which more less very similar when happened severe outbreak of RVF in Kenya after heavy rains occurred as reported by Scott (1963G.c), also in Egypt reported by Imam et, al (1978 G.C) and EISE(1981G.C) they were able to isolate virus (RVF) from a health, naturally infected dromedaries.

On other hand experimental infections with the RVF virus have induced No clinical symptoms in non – pregnant dromedaries (DAVIES, *et*, *al*, 1985, G.c) but caused abortion for pregnant dromedaries as well as with parallel human health problems occurred during camel abortion, keeping in mind that ,also could be participated camel abortion mineral deficiency which forced camel to chew old bones, threw away old plastic bakes, stones, and leaded to occur new disease which is not commonly happen in camel (Botulism). After whole, these finding results for camel abortion investigation in Mayomuluko District we recommend to be re-tested with other reagents like viral Antigens the 50 serum samples which we found negative for Brucella disease and kept in the deep fridge at the Zonal veterinary laboratory in Jigjiga town.

Skin disease predisposed by mineral deficiency in HARAJANO area





During discussion with different camel owners in the five location we visited as showed in the above figure mentioned LANATA CAMARA causing high mortality rate of camel calves direct after birth 2-3 days.

Camel Miss- Management in the Study Area

In this area, while we were discussing with camel herders we realized majority of camel owners give their camel common salt in estate of soil content salt, also, they do not take their camel to wells content salt water like wells available in Sagag district or others, their areas has not bushes content salt**,** 90% of camel get water from pond, or Erer River, many of their camels lose their teeth so early due to drinking cold soft water from pond or river ,and that forced camel in Mayomuluko and Kubi , to chew small stones, old bones, threw away old Jernigan's, and any plastic backs they found in front of them, etc. in order to compensate missing things which is mineral**.** When we asked why they do not watering their camel from wells and not taking at least two times a year into wells content salt water, simply saying most of camel owners now a days were sheep flock owners or cattle herders and they do not know camel management and that is why they give their camel common salt in estate of soil content salt or taking to wells content salt water like cattle management. Due to mineral deficiency camel start to chew small stones, old bones and other items and that brought new disease not common in camel before which is botulism like that affect cattle when they chewed old bones in the early rainy season in certain places like in Jerar zone and part of Fafan zone of Somali Region. Possible solution for camel chewing old items like stones, plastic backs, we advised camel herders live in those areas as following: Has to be provided soil content salt once in each two month; Watering camels from wells instant of ponds (warm water) as possible**;** Taking camel two times in a year to wells content salt water (like Bulale well, or others) like it. If they do that camel will stop to chew stones or bones as they are doing now.

Diseases Affecting Camels in Mayomuluko District

According to the responses got from 50 camel herders interviewed they mentioned the following diseases: 1-Baterial diseases like Anthrax, qanje, different types of pneumonia, pasturella, and other diseases like twisting neck, nervous disorder, tick paralysis, mange mites, rabies disease, external parasites,,etc. 2-New disease they called *Kaligidi cune*/ *Suuqe,* affects camels grazed in swamp area, like when Shebelle River flooded seasonally in certain places like in east *Iimay, qalaafo, mustaxil,* etc and water stay in flooded areas number of months, usually found Paramphistomum larvae hanging on grazes and animals take with grazes causing later on (3-4months) disease that called Paramphistomiasis, symptoms they mentioned to us like Paramphistomum infestation and they added no respond to normal Anthelminthic, at last infected animal become blend and dye. Number of those people who told us this new disease for their camel we advised them to deworm their sick animal with tetraclozone tablet which one tablet enough 150kg/body weight.

Camel Abortion

As we heard before camel abortion has been going on in the last three years, according to the camel herders, abortion occur in any time of camel gestation period which is at least 12months in normal gestation period and all ages of she camels pregnancy, mainly in hot and shortage of feed time (*xagaa*) and they arranged per cent of abortion camel as follows: 2-3 months pregnancy (5 %); 7-10 month pregnancy (85 %); 10 -12 month pregnancy (10 %) still birth and died.

Clinical Symptoms Seen Aborted She Camel In Field Condition:

In this study some of the respondents claimed that they see just after the she camels aborted (2-3 month pregnancy) while some others said that they see conditions like normal delivering, softening pelvic cavity, udder putting with Milk in it, moving alone from the other herd, etc. in she camels with 8-10 month pregnancy. Similarly, she camels with 10 – 12 months pregnancy show all aforementioned conditions, but deliver alive calves which usually dye after few hours or days. Consequently, these she camels remain in lactating stage till they become pregnancy again and dry up again. Moreover, more than 90% of the aborted she camel did not show any retained placenta and very few animals; died. As camel herders claimed, abortion in she camels occur mainly when there is hot climate and shortage of feed and after bitten camel by different flies as well as huge mosquitoes.

Human Cases in the Study Area.

During camel abortion, parallelly there were human sicknesses with clinical symptoms of severe coughing, fever, shivering, severe headache, vomiting, and pain in muscles, and joints, photophobia and in appetite. Usually these clinical symptoms used to continuous for 4 -7 days and person usually in most cases recovering.

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4. Participatory On-farm Evaluation and Demonstration of Improved Forage Legume and Grass at Gursum Woreda, Somali Regional state, Ethiopia

Abdi Mohamed Ali[1], Daniel Siyum Eshatu[2]Tel
Tel - +251915006131[1], +251920688458[2]
E-mail:- Abdicade9921@gmail.com[1] , danielsyyoum101@gmail.com[2],
Animal Feed & Nutrition Program, Livestock & Forage Research Directorate, Somali Region Pastoral and Agro-Pastoral research Institute (SoRPARI)

Abstract

Livestock development and production is constrained and challenged by feed shortage. Forage innovation is proposed to minimize feed shortage for the livestock sector. Participatory evaluation and demonstration of both forage grass and legume forage crops namely Panicum Maximum, Rhodes grass, Cinchrus cilliaris and Medicago sativa and Caw pea small were undertaken under agro-pastoralist area under irrigated condition in fafan dry river irrigated area. Agro pastoralists FRG/PRG group formation and problem identification under taken prior to the implementation of demonstration activity. Land preparation, sowing and overall husbandry was undertaken based on the agronomic recommendation so far developed by SoRPARI Research Institute the whole forage cultivation activity undertaken by the members of FRG/PRG. Variety evaluation in participatory way and organization of field days was undertaken, to collect the perception of agro-pastoralists towards the productivity of each forage crops and to create linkage for further adoption of the technology. From herbaceous grasses panicum maximum is found to be better in plant height, early maturity and higher fresh and dry matter yield. Rhodes grass is found to be late in maturity but with better biomass yield followed by panicum antidotal but cinchrus cilliaris is found to be tolerant to stress but with lower dry matter. From herbaceous legumes Caw pea small is found to be superior in early maturing and biomass yield however due to the possibility of multiple harvests from Medicago sativa the annual biomass yield and cost of production is found to better for Medicago sativa. Agro pastoral perception collected indicated that among the tested forage varieties from grasses interms of biomass yield, early maturing, ease of establishment, multiple harvest and nature of purpose as well a resistance to stress Panicum ranked first followed by Rhodes there by cinchrus species, from leguminous species Caw pea small is found to be better in most of agro-pastoralists evaluation criteria but due to the possibility of multiple harvest without replanting and due to feed preference from domestic animals Medicago sativa is found to be superior feed and selected as best forage crop. From the above participatory variety evaluation work it's found that most of the parameters agro-pastoralists use to select variety have similarity with scientific criteria.

Key words: *Farmer research group, participatory variety evaluation, herbaceous grasses, herbaceous legumes.*

Introduction

Ethiopia" one of the largest populated countries in Africa, is expected to have a human population of about 130 million by the year 2030 (Alemneh, 2003). It is reported that of the total population in the country, 85% lives in the rural areas mainly engaged in the agricultural sector. Agriculture remains the mainstay of the country's economy. It contributes 46 percent to gross domestic product (GDP) and 85 percent to export commodities; it also supports the agriculture-based industrial sectors, which encompasses about 70 percent of large and medium scale industries (Setotaw, 2007).

Livestock is an important sector of agriculture in the Ethiopia. It has the largest livestock population in Africa. The livestock sub sector contributes about 18 percent to the total gross domestic product, 40 percent of the agricultural GDP and 19 percent of the national export earnings (Setotaw, 2007). Moreover, the sector contributes a lot in the manure production, fuel for fire, means of transportation and animal traction particularly in the rural part of the country, which is often very difficult to include these contributions to the total GOP. Although the livestock sector of Ethiopia is great in size with significant potential contribution to economic and social development and growth, its current contribution is much below expectation and fails to meet the demand for livestock services and products.

Somali Region is one of Ethiopia’s largest regions with a biggest portion (more than 85%) of its population dependent on livestock for their livelihood (Tesfaye and Hailu, 1997; Ahmed 2003). Being an integral part of the agricultural production system, livestock husbandry practiced in the region can categorically be divided into migratory pastoralists and sedentary system. The former system comprise the bulk of the livestock resources while the sedentary system is dominant in the scattered villages inhabited by subsistent crop mainly sorghum and maize producing farmers. Depending chiefly on crop residues, sedentary livestock farmers are oriented towards milk production for household consumption and marketing.

In pastoral areas of Somali regional state environmental degradation, water scarcity, increasing human and livestock population, and expansion of crop cultivation have contributed to a reduction in the quantity and quality of productive rangeland (IPS, 2002). Moreover, there is a marked seasonality in the quantity and quality of forage available. In the wet season, the community used to have enough fodder available to feed their livestock. Increasing resource base shrinkage due to farm encroachment and land degradation has minimized this prospect making feed shortage the reality of wet season too. In the dry season, the challenge is hillier. The meager amount of forage available is characterized by low protein and high fiber content causing a decline in weight and milk production. These factors combined with poor animal and human health, place enormous stress on the traditional pastoral and land management practices. As a result the productivity and economic contribution of the huge livestock population do not definitely much their number.

As a part of its effort to address feed shortage, Somali Region Pastoral and Agro-pastoral Research Institute (SoRPARI) introduced and tested the adaptability of numerous promising forage species so far and identified adaptive improved forage (grasses and legumes) for both the rain fed and irrigated agro-ecologies of the region. Seeds of some of the best performing forage species have been disseminated to various Farmers Research Groups (FRGs), cooperatives and individual Agro pastoralists. Forage technology dissemination has been started 15 years before with the then Farmers Research Groups (FRGs), cooperatives and individual Agro pastoralists. Therefore, the adoption and sustainable growing of the technology requires more to be done and identifying the factors that constrain the adoption decisions is important. The purpose of this project was to increase FRGs farmers' participation on improved forage seed and improve adoption of forage crop technologies in pastoral and agro-pastoral areas.

Materials and Methods

The research site was the villages of aroaska, golmarodi and kubijaro which are under gursum werada. Gursum district is located in the western side Jigjiga town of Somali regional state. The maximum and minimum temperature of the wereda ranges 20-28^{o}C respectively and annual rainfall ranges 200-600mm and topography of the woreda is 200-1600m a.s.l. respectively. The wereda is composed of fourteen kebele and the majority populations of the wereda are pastoralist and agro-pastoralist who depends on livestock for their livelihood.

Team from FILRDC jointly with woreda administration and woreda livestock and pastoral development office identified intervention kebelles and from selected kebelles a FRG/PRG which comprises twenty one (21) members inclusive women's were formed. Information sharing and discussion forums organized, problem identification and ranking undertaken in participatory way. Based on the identified problems possible interventions identified. Among the problem identified feed shortage and lack of skills in production of high yield improved forage crop varieties are the high ranking.

Participatory approach was employed to provide farmers with a number of forage legumes and fodder grasses species for experimentation and selection. Five forage crop varieties that was recommended by SoRPARI for both rain fed and irrigated areas of Somali region namely Alfalfa (*medicago sative*), Caw Pea small, Panicum maximum, Buffale grass (*cincherus cilliaris*), and Rhodes grass (*calloris gayan*) have been selected and used as an experimental crop. Prior to the implementation of participatory on-farm evaluation and demonstration practical training organized and all FRG/PRG members trained on forage husbandry.

The implemented forage species adaptive research varieties along Fafan dry river basin of Gursum district were designed by researchers, but were carried out under farmer's own management. These varieties were single replicate of all forage legumes and grasses selected for participatory on-farm variety evaluation. Land preparation and sawing was undertaken by members of the FRG/PRG based on the agronomic recommendation of each forage crops. Based on this the spacing of 40cm distance between rows, spacing between plants were 10cm for caw pea small and no spacing for other forage crop. Seedling rate for each excremental crop is 8kg/ha for Rhodes, Buffle and Alfalfa, 6kg for Panicum maximum and 25kg/ha for caw pea small. Establishment phase irrigation frequency of 6 to 8 days was used and after well-establishment two weeks irrigation frequency were practiced for all forage crop. Other agronomic practices like weeding, and pest management, and other related activities also considered as a routine activity during experimental period.

Each forage species trial on each FRG farmer member's field was a single replicate of two forage legume and three fodder grasses species, i.e., a single replicate of RCBD. Varieties on each of the twenty one farmer's field were randomized separately. Each forage varieties were grown on a net plot size of 10mX10m consisting all legume and grass species. The varieties were implemented in three different kebelle in the district and all of the varieties were planted in same day. All the varieties were grown under farmer's own management level.

Descriptive data on agronomic traits such as Planting date, Days to 50% crop emergence, Days to flowering, Days to harvest, Plant height from five plants/plot, Total green matter weight/plot (kg), Total air dried matter weight/plot (kg), Total green matter weight/ha (tons), Total air dried matter weight/ha (tons) and Dry matter percent. And also non-parametric data on farmer's preference for the forage species were collected FRG/PRG level from farmers that implement the varieties and during farmer's participatory pre harvest and post-harvest evaluation of the varieties during farmer's field days through focus group discussion. Half of the plot (5mX10m) has been used to collect the above data's and the remaining half plots used to collect seed yield.

The data were subjected to two-way analyses of variance using statistical procedures. The Least Significant Difference (LSD) test was used for mean separation when the analyses of variance indicated the presence of significant difference.

Result and Discussions

Growth characters of forage legume

Averaged overall farmers plots the analyses of variance displayed that, species difference among the forage legumes significantly affected days to flowering, days to harvest and plant height, in contrast days to 50% crop emergence was not significantly affected by species difference among the forage legumes at 5% level of significance (Table 1).

"Alfalfa"/Lucerne/ (*Medicago Sativa* L.) was recorded the highest days to flowering, where as "Cowpea small" was recorded the least days to flowering (Table 1). Compared to each other of the forage legumes were found to be significantly different in mean number of days to flowering with "Cowpea small" requiring significantly least number of days to flower suggesting to be early flowering than Alfalfa, in contrast "Alfalfa" required a significantly highest mean days to flowering suggesting that it flowers late compared to the cow pea small. The highest mean days to the first harvest (62.40days) were recorded by "Cowpea small", where as the least mean days (47.50days) to get the first harvest was recorded by "Alfalfa". This significant difference in the number of days to the first harvest among the forage legume species was due to genetic differences that exist among the species, which in turn resulted to difference in the rate of dry matter production and accumulation. Walter *et al*. (2002).

The highest mean plant height (60cm) during the first harvest was recorded by "Cowpea small", where as the least mean plant height (42.9cm) during the first harvest was recorded by “Alfalfa” (Table 1).

Table 1.Means growth characters and dry matter yield as affected by species differences among the forage legumes species.

Treatments	DTCE	DTF	DTFH	Pl.H (cm)	TGMWPH (tons)	TADMWPH (tons)	DMP (%)
Alfalfa	3.00	51.90	47.50	42.9[a]	6.4	1.58[b]	24.7[c]
Cowpea small	3.00	42.00	62.40	60.0	28.0	6.10[d]	21.79
LSD (0.05)	NS	2.30	1.83	3.39	3.37	3.51	1.11

Values with the same letters are not significantly different at ($P \leq 0.05$)
DTCE=days to crop emergence, DTF=days to flowering, DTFH=days to first harvest, Pl.H=plant height, TGMWPH=total green matter weight per hectare, TADMWPH= total air-dried matter weight per hectare and DMP=dry matter percent.

When all mean values for total green matter weight per hectare of all forage legume species were compared to each other at ($p \leq 0.05$), it was found that “Cowpea small” was produced a significantly highest mean total green matter weight per hectare, in contrast “Alfalfa” was produced a significantly least mean total green matter per hectare (Table 1).

The highest mean total air-dried matter weight (6.10tons/ha) was harvested from “Cowpea small”, where as the least mean total air-dried matter weight of (1.58tons/ha) was harvested and recorded for “Alfalfa” (Table 1). Caw pea small showed statistically significantly better biomass yield as compared to Medics. Past research result indicated that species like Medics are naturally perennials and they can produce much more biomass than Caw pea small due to the possibility of multiple harvest. However, Caw pea small needs sowing seeds after harvest and maximum of three harvests per year is possible. Plant height measurement result indicated that Caw pea small is superior in height than medics. Date to first physiological maturity indicated that Caw pea small needs less date to attain physiological maturity than medics.

The highest mean dry matter percent (24.7%) was obtained from the air-dried total green matter per hectare that was produced by “Alfalfa”, in contrast the least dry matter content percent (21.79%) was recorded for “Cowpea small”. When the mean dry matter content in percentage values of the forage legumes species were compared to each other “Alfalfa” recorded a significantly highest mean dry matter percentage, where as “Cowpea small” produced a significantly least dry matter from air dried total green matter weight harvested per a hectare, at (p≤0.05)(Table 1). The significant difference in total green matter weight per hectare was due to species difference that exists among the forage legumes species, which in turn brought physiological and morphological differences that affected the rate of dry matter production per unit of time of a given species.

Forage grasses Growth characters

Averaged overall farmers plots, the analyses of variance exhibited that species difference among the fodder grasses were significantly affected growth characters such as days to 50% crop emergence, days to flowering, das to first harvest and plant height at 5% level of significance (Table 2).

The highest mean value for days to 50% crop emergence (4 days) was recorded for "Rhodes grass", where as the least mean days (3.00days) to 50% crop emergence was recorded for "penicum maximum". But the mean difference between "Panicum" and "buffle grass" were not significantly different (Table 2).

Table 2. Means of growth characters and dry matter yield as affected by species differences among the fodder grasses.

Treatments	DTCE	DTF	DTFH	Pl.H (cm)	TGMWPH (tons)	TADMWPH (tons)	DMP (%)
Buffalo grass	3.90^{b}	38.3^{c}	78.4	1.34^{f}	23.4^{h}	7.56^{i}	33.3
Panicum	3.20^{a}	35.8^{c}	57.1^{d}	2.04^{f}	13.3	4.34	34.7
Rhodes grass	4.00^{b}	53.9	74.7	1.91^{g}	23.8^{h}	7.43^{i}	34.5
LSD (0.05)	0.36	6.27	8.03	23	3.17	1.10	3.88

Values with the same letters are not significantly different at (P≤0.05)

DTCE=days to crop emergence, DTF=days to flowering, DTFH=days to first harvest, Pl.H=plant height, TGMWPH=total green matter weight per hectare, TDMWPH= total dry matter weight per hectare and DMP=dry matter percent.

Averaged overall farmers plots on which the mother trials were implemented at (P≤0.05) the highest mean number of days (53.9days) to flowering was recorded by "Rhodes grass" in contrary the least mean days (35.8days) to flowering was recorded for "Panicum"(Table 2). The mean values for the number of days to the first harvest for fodder grasses species when averaged overall the farmers plots, "Rhodes grass", was recorded the highest mean days to the first harvest, in contrast, "Penicum" was recorded the least mean number of days to the first harvest (Table 2). Compared to each other "penicum maximum" was recorded a significantly least mean days to the first harvest, where as “Rhodes grass”, was recorded a significantly highest mean days to reach to the growth stage when first harvesting to be undertaken (Table 2). This significant difference in the number of days to the first harvest among the fodder grasses species was due to genetic differences that exist among the species, which in turn resulted to difference in the rate of dry matter production and accumulation. Walter *et al*. (2002). The increase in mass of a plant due to the products of assimilation (production rate, or productivity), expresses the increase in dry matter per unit time (day, week) during the period of production.

The highest mean plant height was recorded for “Penicum Maximum”, where as the least mean plant heighet when averaged overall farmers plots (FRG/PRG trials) was recorded for “Buffle grass” at ($p \leq 0.05$). Compared to other species “Penicum maximum” was recorded a significantly highest mean plant height, where as “Buffle grass” produced significantly the least mean plant height, but also “Rhodes grass” was recorded a non-significantly different plant height from that of “Panicum maximum” at ($p \leq 0.05$)(Table 2). The difference in plant height among the fodder grass species was due to physiological and morphological differences that existed among the species, which was resulted due to genotypic difference among the species.

Conclusion and Recommendation

The approach was found that the FRG are effective and efficient approaches in generating, evaluating and disseminating forage technologies. Participatory on-farm research requires active participation of major stockholders particularly DA’s & farmers. Though it is yet at start, it was made possible to increase farmers’ level of understanding participatory and knowledge about production of improved forage seed (Forage Legumes & Grasses). This has increased their interest and confidence to engage in improved forage seed production. Knowledge and Technique of site DA’s has also improved. Different stakeholders like non-FRG farmer members were made aware of the possibility of producing improved forage seed production in the local area. Fafan integrated livestock development research Centre used this approaches as means to address the technology adoption of the various forage technologies so far developed. The following lessons were drawn from the experience with forage technology participatory evaluation using FRGs:

- The beneficiaries of the FRG project have practically gained adequate knowledge, understanding and skill of improved forage feed and seed production techniques and utilization.

- Research-extension agro-pastoralists linkage at the grass root level and stakeholders' participation in research and extension activities was improved.
- It's found efficient and effective approach in addressing research and technology extension issues since it utilizes both scientific and indigenous knowledge systems.
- The approach helped in developing sense of ownership technology development activities and provided the means for feedback on technologies generated and disseminated.
- The experience of the project beneficiaries in improving the animal productivity through improved forage feeding has motivated other farmers in the vicinity.

Recommendations

- Based on the experience and achievement attained in this project extending the program to other vulnerable households in other Kebeles of Gursum Woreda other Woredas of the Zone is required to minimize hazards of drought and mitigate the impact of drought
- Incorporating range land rehabilitation programs in the future similar project is vital in improving the livelihood of the pastoral and agro pastoral community**.**

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5. On-farm demonstration and pre-scaling up of Beef fattening technologies to attain market weight under semi-intensive feeding systems in Gursum Woreda, SRS

Daniel Seyoum[1], Aden Omer [2], Hassan Abdurahman [3] and
Ahmed A [4]
Tel: - +251920688458[1], +251915004263[2], +251915189064[3]
E-mail:- danielsyyoum101@gmail.com[1], abdirahman2018a@gmail.com[3]
Animal Feed & Nutrition Program, Livestock & Forage Research Directorate,
Somali Region Pastoral and Agro-pastoral Research Institute (SoRPARI) & Jigjiga University

Abstract

This activity was conducted at Gursum woreda of Somali Regional State of Ethiopia with the objective of demonstrating and pre-scaling up of feeding technological options for fattening beef cattle to model agro-pastoralists engaged in beef finishing at this woreda. A total of twenty agro-pastoralists (10 female and 10 male), each having at least five male Ogaden cattle breed with the same age (1.8-2 years) were selected from the agro-pastoralist herd groups have been selected to participate in this activity based on their previous engagement in fattening activities and their willingness to participate in the activity. The selected agro-pastoralists were randomly assigned to one group, while providing them with a supplementary feeding technological option made of ration constituting of Wheat bran (49.5%), Noug Cake (49.5%) and common salt (1%) for beef finishing group. Beneficiary agro-pastoralists, DAs and livestock experts were given trainings on improved small ruminant fattening techniques and feeding management of the experimental animals as awareness creation and capacity building. Experimental feed was introduced to beef cattle at 0.6kg/head/day with gradual increment within ten days period. Initial live body weights have been measured and recorded prior to the experiment and weight gains were monitored through fortnight live body weight measurement and recording for a period of sixteen weeks (56 days). Data were analyzed using ANOVA and GLM procedure of SAS (2002). There has been a significantly (P<0.05) different in mean live body weights before and after the experiment. The average initial body weight was 231.15kg whereas the average final body weight was 273.58 kg and the average total weights gain was42.43 kg. On the other hand, Average daily weight gains were 353.58g/*h/day and there were no significant difference (P>0.05) in final body weight and total weight gain between the entire agro-pastoralist group. The partial budget analysis shows that the average gross return and net return were the highest as compared to on-station with same breed. In this study highest additional profit (5,690.54ETB) and the highest net return of (2,860.25ETB/h/120days)on average was obtained from the beef fattening at on-farm conditions. Somali beef cattle's perform better when supplemented with concentrate after day time grazing.*

Keywords: *Demonstration, Pre-scale up, Beef, Fattening, Technologies.*

INTRODCUTION

Ethiopia has the largest cattle population in Africa with an estimated of 56.71 million heads of animals. Out of this total cattle population, the female cattle constitute about 55.45 percent and the remaining 44.55 percent are male cattle (CSA, 2015). With their large number and diversity of products, cattle contribute more to the national economy than any other livestock species. They provide about 45% of all domestic meat consumption with small surplus which generates export income mainly from the sell of live animals. However, the earning from export of live animals and processed meat is very small as compared to the potential of the country.

Ethiopia has the lowest levels of beef production per animals. Only 8kg of beef is produced annually per head of cattle and the national per capita meat yield from cattle is 108 kg (FAO, 2004). To improve this scenario, various research activities have been undertaken in different parts of the country. The recent study on evaluation of feeding options on indigenous Somali beef cattle to attain export market weight (SoRPARI, 2009) indicated that strategic supplementation with agro-industrial by products mainly a supplementary ration made of 49.5% Noug cake,49.5% wheat bran and 1% common Salt for beef was found to be the most economical way of attaining the highest weight gains of 300kg in 120 days' time and also the result indicated breeds have a better potential to attain export market weight at an earlier age. Therefore, this project was aimed to disseminate and popularization of those outsmarted improved beef fattening technology through scaling-up activities in Gursum District.

The objective of the project was to demonstrate and pre-scaling up cattle fattening technologies on indigenous Somali beef cattle breeds to attain the required market weight of 300kg.

Material and Method

Description of study area and agro-pastoralist selection

Sheep fattening demonstration and scaling up activity were conducted in Gursum district, which is about 46 km in the western side of Jigjiga town and located adjacent to the main road from Jigjiga to Harar. The rainfall pattern of the area is bi-modal amounting to an average of 750 ml and extending from March to April and the long rain season from June to September. The mean annual temperature is 21 ^{o}C, with a mean minimum and maximum temperature of 14 c^{o} and 28c ^{o}, respectively.

A total of twenty agro-pastoralists (10 female and 10 male), each having at least five male Ogaden cattle breed with the same age (1.8-2 years) were selected from the agro-pastoralist herd groups which are found around the selected area.

Agro-pastoralists Selection

In addition to the twenty agro-pastoralists, eight enumerators (researchers), two extension agents and two experts from the district agricultural bureau were trained on the method and level of feeding improved feeds to fatten male cattle's. Training manual on beef fattening and management practices, which was translated in Somali language, were prepared and distributed for all trainees for future reference.

Feeding and Experimental animal management

The agro-pastoralists were asked to bring their selected beef cattle's to Fafan center that is five beef per agro-pastoralists and a total of one hundred beef cattle's included in this study. On the first day of arrival to center all the animals were treated against internal and external parasites.

The feed ingredient which is the mixture of Nougcakes(NC) and wheat bran(WB) were purchased from local market around Adama.The ration was computed as per SoRPARI fattening result and the ration were prepared and mixed at "Mizan Poultry and Animal Feed Processing" located at Adama.finally,transported and stored in well-protected and ventilated storage in the Fafan research center.

The concentrate mixture was 49.5%NC, 49.5%WB and 1% common salt. All the experimental animals were fed diet for15days'adaptation period and 120 days of

experimental period. During the experimental period's, all the animals were allowed to graze freely for 8 hrs. Per day and the supplementation given at the evening.
At the beginning and end of the experiment price were estimated by forming a panel of three local live beef cattle dealers and the average estimate were used for the economic analysis. Partial budget analyses were used to analyze the profitability of beef finishing. Live weight of the animals were measured at ten days interval after over-night fasting. During this phase data on the performance of the technologies and perception of agro-pastoralists towards the technologies were also collected. The mean daily live weight gain was calculated by regressing live weight on days of feeding. General linear mode of SAS system (2002) used for analysis of data collected.

Beef fattening demonstration and pre-scaling up activities were implemented in collaboration with JJU by targeting agro-pastoralists who own beef cattle's. It was also designed to reach other non-participant agro-pastoralists and pastoralists through field days to facilitate the learning process and to popularize the technologies. Therefore, a total of 15 male and 15 female agro-pastoralists were invited.

Results and Discussion

Effect of supplement intake

Average daily supplement were adjusted according to ten days interval body weight gain of the animals in the entire group. This indicate that the animals consumed the same in the entire group and there was no significant difference ($P>0.05$) in supplement intake. The supplement was given to the animals based on the recommendation and on average 0.6 kg/h/day was given for all experimental animals.

Reponses of Beef cattle's to the supplementation

The responses of beefs to the supplementation in all agro-pastoralist were indicated in table 1. All the experimental animals performed better in all the groups. The average initial body weight was 231.15kg whereas the average final body weight was 273.58 kg and the average total weights gain was 42.43 kg.

Average daily weight gains were 353.58g/h/day and there were no significant difference ($P>0.05$) in final body weight and total weight gain between the entire agro-pastoralist group.

The average daily weight gains of supplemented on-farm were lower than the on-station result, which were360.7g/h/day. This can be due to management level of the agro-pastoralists.

Table 22.LSM ± SE of on- farm beef cattle fattening performance

Variables	**Mean ± SE**
IBW (kg)	231.15± 4.34
FBW (kg)	273.58± 3.86
TWG (kg)	42.43± 2.47
ADG (gm)	353.58 ± 3.11

IBW (Initial Body Weight), FBW (Final Body Weight), TWG (Total Weight Gain), ADG (Average Daily Gain)

Economics of supplementation

Table 2 indicates partial budget analysis of Somali beef cattle fattening at on-farm condition. The highest live weight gain was obtained at all livestock's as levels of supplementation was the same for all, this levels was the recommended levels for Somali beef cattle's at on-station. The partial budget analysis shows that the average gross return and net return were the highest as compared to on-station with same breed. In this study highest additional profit (5,690.54ETB) and the highest net return of (2,860.25ETB/h/120days)on average was obtained from the beef fattening at on-farm conditions.

Table 23.LSM ± SE of economic feasibility of on-farm beef fattening

Variables	**Mean ± SE**
I price (birr)	2,761.58 ± 128.33
F price (birr)	8,452.13 ± 140.85
Gross profit (birr)	5,690.54 ± 152.03
Net profit (birr)	2,860.25 ± 13.52

I (Initial), F (Final)

Agro-pastoralists' perception toward the Technologies

Somali beef cattle's perform better when supplemented with concentrate after day time grazing.

Conclusion and recommendation

From this result one can conclude that supplementing Somali beef cattle's with concentrate at on-farm condition was resulted with fast growth rate and the animals can be brought to their slaughtering body weight at their early ages. Supplementing these animals with concentrate was also resulted with highest net return. From this we can conclude that Somali beef cattle are a potential breed which can be exploited by supplementing concentrate. Therefore, doing additional scaling-up activities will help agro-pastoralists and private investors to have full information on the technologies developed and become benefited.

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6. On-Farm Demonstration and Pre-Scaling Up of Black Head Somali Sheep and Long Eared Somali Goats Fattening Technologies to Attain Market Weight Under Semi-Intensive Feeding Systems in Gursum Woreda, SRS

Muhyadin Mohamed [1] Daniel Seyoum[2], Hassan Abdurrahman [3] and Ahmed A [4]

Tel: -+251915752889 +251920688458[1], , +251915189064[3]

E-mail:- danielsyyoum101@gmail.com[1]

Animal Feed & Nutrition Program, Livestock & Forage Research Directorate,

Somali Region Pastoral and Agro-pastoral Research Institute (SoRPARI) & Jigjiga University

ABSTRACT

This activity was conducted at Gursum woreda of Somali Regional State of Ethiopia with the objective of demonstrating and pre-scaling up of feeding technological options for fattening Black Head Somali Sheep and Long Eared Somali Goat yearlings to model agro-pastoralists engaged in small ruminant finishing at this woreda. Twenty model agro-pastoralists having ten BHS and LESG yearlings (Five from each spp) have been selected to participate in this activity based on their previous engagement in fattening activities and their willingness to participate in the activity. The selected agro-pastoralists were randomly assigned to two groups (i.e. BHS finishing group and LESG finishing group), while providing them each with a supplementary feeding technological option made of ration constituting of Wheat bran (49.5%), Noug Cake (49.5%) and common salt (1%) for BHS finishing group and a ration constituting of Wheat bran (24.5%), Noug Cake (74.5%) and common salt (1%) for LESG finishing group. Beneficiary agro-pastoralists, DAs and livestock experts were given trainings on improved small ruminant fattening techniques and feeding management of the experimental animals as awareness creation and capacity building. Experimental feed was introduced to BHS and LESG yearlings at 0.6kg/head/day with gradual increment within ten days period. Initial live body weights have been measured and recorded prior to the experiment and weight gains were monitored through fortnight live body weight measurement and recording for a period of eight weeks (56 days). Data were analyzed using ANOVA and GLM procedure of SAS (2002). There has been a significantly (P<0.05) different in mean live body weights before and after the experiment. The overall mean initial live body weights, final live body weights, total weight gains and daily weight gains were found to be 15.99±.34kgs, 24.15±.46kgs, 8.17±.31kgs and 14.09±.005gm of live weights, respectively. Accordingly, the economic benefits model agro-pastoralists obtained after selling their finished BHS & LESG was very high. Therefore; these two feeding technological options are recommended for scale up at larger scale.

Keywords: *Demonstration, Pre-scale up, BHS, LESG, Fattening, Technologies.*

INTRODUCTION

In Ethiopia sheep & goats form important economic, social and cultural functions and represent an important component of the mixed farming systems in the highland & extensive pastoral and agro-pastoral production in the lowland. Their contribution for income generation, food supply and financial security for the rural population is well documented. They require small initial investments; have the ability to utilize fibrous feed materials and need much shorter recovery periods to increase flock sizes following a severe drought; have faster growth rates (potential marketability in shorter time), ease of integration with other crop-based farming systems and greater environmental adaptability as compared to large ruminants.

The estimated numbers of sheep and goats in Ethiopia is about 29.33 and 29.11 million, respectively (CSA, 2015). The market supply of sheep & goat originates in small numbers from highly dispersed small producers that supply non-homogenous animals to local markets. Presently, due to the low productivity of the animals and the absence of market-oriented production systems, the volume of marketed surplus is very low. Because of poor link of producers and other actors in the chain to the critical support services, live animals supplied to the market by pastoralist and farmers do not meet the quality attributes required by diverse market actors.

The export market obviously demands sheep that weigh up to 25 to 30 kg at yearling age while most indigenous shoat breeds are commonly slaughtered at around yearling age when their body weights are 18-20 kg (IAR, 1991). Moreover, abattoirs' report indicated that the market has been constrained by lack of consistent and uniform supply of the required weight at younger age.

Feed and water scarcity in quality and quantity is among noted production constraints along the value chain. Feed production covers requirements only in exceptional good years; the deficit reaching 35% in normal years and 70% in bad years (FAO, 2005). Therefore, developing feeding packages that support the existing traditional production and the emerging private producers and exporter is the timely intervention for increased production and productivity to meet the demand for meat and live animal export market.

To improve this scenario, various research activities have been undertaken in different parts of the country. Various attempts have been made during the last couples of decades to develop technology and generate information to avert these problems and improve production and productivity.

Much of the technologies and knowledge generated so far have been confined to on-station experimentation and lacked participatory evaluation to facilitate technology or knowledge transfer. The result of recent study on evaluation of feeding options on indigenous blackhead Somali Sheep and long eared Somali goats to attain export market weight (Un-published) indicated that strategic supplementation with agro-industrial by products mainly a supplementary ration made of 50% Noug cake and 50% wheat bran for sheep and 75% Noug cake and 25% wheat bran for goat was found to be the most economical way of attaining the highest weight gains of 30kg in 120 days' time and also the result indicated breeds have a better potential to attain export market weight at an earlier age. Therefore, this project is aimed to disseminate and popularization of those outsmarted improved shoat fattening technology through scaling-up activities in Gursum District.

With this background, this project was carried out with the objective to demonstrate and pre-scaling up fattening technologies for black head Somali Sheep and long eared Somali goat yearling to attain standard market weight of 30kg within 120 days.

MATERIALS AND METHODS

Description of the study area

This demonstration and pre-scaling up research activity was conducted in Gursum district, which is about 46 km in the western side of Jigjiga town and located adjacent to the main road from Jigjiga to Harar. The rainfall pattern of the area is bi-modal amounting to an average of 750 ml and extending from March to April and the long rain season from June to September. The mean annual temperature is 21^{o}C, with a mean minimum and maximum temperature of 14^{o}C and 28^{o}C, respectively.

Site and Agro-pastoralists Selection

Site Selection

As a target area, Gursum district of Fafan Zone of Ethiopian Somali Region was selected for the implementation of the activity due to the existence of small ruminant fattening practices in the area and presence of agro-pastoralists' cooperatives engaged in livestock fattening business as livelihood diversification mechanisms.

Agro-pastoralists Selection

Selection of model agro-pastoralists participating in this demonstration research activity was based on agro-pastoralists' willingness to participate, their previous knowledge of practicing small ruminant fattening who have 10 male black head Somali sheep and long eared Somali goat yearlings (5 from each species) and genuineness and transparency to share innovations to other agro-pastoralists. Consequently, 20 model agro-pastoralists (10 male and 10 female) were selected from the study area.

The selected agro-pastoralists were randomly assigned to two treatments by drawing lot: control and finishing group. Shoats in the finishing group were provided a supplementary for a period of 120 days while the control group were maintained only on grazing. The formulation of the finishing ration for sheep and goat was based on a ration constituting of Wheat bran (49.5%), Noug cake (49.5%) and common salt (1%) and Wheat bran (24.5%), Noug cake (74.5%) and common salt (1%), respectively.

Feeding and Experimental Animals Management

Feed was introduced gradually with increment within ten days period. Weight gain was monitored and input costs for each individual shoat has been recorded for economic analysis. The selected animals were vaccinated against common diseases and treated for internal and external parasites and diagnosis and prevention of diseases related with fattening before the start of supplementary feeding were made. At the beginning and end of the experiment price was estimated by forming a panel of three local live shoat dealers and the average estimate has been used for economic analysis. Partial budget analysis was used to analyze the profitability of shoat finishing. The actual market price of the experiment feed was taken for the economic analysis. Live weight of the animals was measured at ten days interval after over-night fasting and mean daily live weight gain has been calculated by regressing live weight on days of feeding.

Data Analysis

The data was subjected to analysis of variance (ANOVA) in a randomized complete block design using the general linear model (GLM) procedure of the statistical analysis system using the statistical software SAS (2002). Means were separated using Duncan's Multiple Range Test (DMRT).

RESULT AND DISCUSSION

Awareness Creation

Training was the main approach employed to create awareness about the technological option being demonstrated among the pastoralists in order to capacitate the agro-pastoralist beneficiaries, DAs and small ruminant fattening experts ‘knowledge and skill. A multi-disciplinary team constituting of animal production, socio-economic and extension, animal nutrition and breeding researchers from Jigjiga University (JJU) and Somali Region Pastoral and Agro-pastoral Research Institute (SoRPARI) jointly carried out the training and capacity building activity.

A total of 34 participants constituting of 20 beneficiary agro-pastoralists (16 females & 4 males), 6 woreda DAs and experts (all male) and 8 technical assistants (all male) have taken part in the training.

Feeding Technology

A supplementary feeding technological options formulated from mixing available feed ingredients (Wheat bran and Noug cake) in to two levels of energy (i.e. medium 10.0 and high 11.5 MJ ME/kg DM) and one level of protein (15% CP) were used in this project for finishing indigenous black head Somali sheep and long eared Somali goats at the agro-pastoralists hands. A supplementary finishing ration made of Wheat bran (49.5%), Noug Cake (49.5%) and common salt was prepared for sheep and a supplementary ration made of Wheat bran (24.5%), Noug Cake (74.5%) and common salt (1%) was prepared for goats. Feeding regiments started with 0.6kgs of body weights with increments in ten days interval. Chemical analysis of the feeds has been done prior to the commencement of the trail and the following table shows the chemical composition of the feeds.

Table 1. Chemical composition of feed ingredients

Types of feed	DM	ASH	NDF	ADF	CP	IVDMD
Wheat Bran	91.06	4.30	40.89	17.59	16.93	81.10
Noug Cake	92.91	7.56	36.28	31.29	34.19	65.69
Average	**91.83**	**9.14**	**37.16**	**20.59**	**21.51**	**78.78**

Weight Gains

Prior to the start of the feeding experiment, initial live body weights of all the experimental sheep and goats were taken and recorded. Up on the completion of the feed adaption period of two weeks, the feeding trail commenced and live weights of experimental animals were taken on fortnight bases at Fafen Research Center for a period of 8 weeks (56 days). Table 2 shows mean liveweight gains of the experimental throughout the study period.

Table 2. Goats Mean Liveweight Gains

S/N	Households/Study Group	Mean Liveweight Gains of Experimental Animals							
		Mean Initial Live Weight before experiment		Mean Final Live Weight (Kgs)		Mean Total Weight Gains (kgs)		Mean Daily Weight Gains (gr)	
		N	Mean	N	Mean	N	Mean	N	Mean
1.	Hamdia Ali	5	16.3±1.94	5	23.3±2.4	5	7.03±.79	5	12.55±.01
2.	Saynaba Omer	5	16.7±1.73	5	23.2±1.84	5	6.59±1.4	5	11.77±.02
3.	Hali Abdi	5	18.01±.68	5	25.8±.75	5	7.7±.82	5	13.89±.01
4.	Halimo Mohammed	5	15.41±1.5	5	21.5±1.42	5	6.16±.78	5	11.00±.01
5.	Hali Hassen	5	20.11±1.79	4	29.2±2.45	4	9.15±1.18	4	16.34±.02
6.	Hinda Abdi	5	14.27±.86	4	25.1±2.98	4	10.85±2.9	4	19.37±.05
7.	Mohammed Mowlid	5	15.11±2.17	4	21.3±2.6	4	6.25±1.1	4	11.16±.20
8.	Habsa Abdi	5	16.27±1.65	5	24.9±1.9	5	8.7±.84	5	15.54±.01
9.	Halimo Ibrahim	5	14.53±.85	3	22±.47	3	7.53±1.07	3	13.45±.02
10.	Ahmed Aden	5	17.55±2.1	5	23.6±1.99	5	6.08±.66	5	10.86±.01
11.	Maryan Abdi	5	14.35±1.73	4	23.2±2.35	4	8.9±.78	4	15.89±.01
12.	Rukiya Mohammed	5	18.03±1.76	5	26±1.41	5	7.97±1.86	5	14.23±.03
13.	Badal Mohammed	5	17.35±.86	5	27.6±3.1	5	10.2±3.02	5	18.30±.05
14.	Safiya Aw-moálin	5	13.66±.75	5	21.3±1.17	5	7.63±.67	5	13.64±.01
15.	Halimo Ahmed	5	17.18±2.8	4	25.7±2.6	4	8.56±1.09	4	15.29±.02
16.	Nimo Mohammed	5	16.52±2.27	4	26±1.58	4	9.47±.85	4	16.92±.01
17.	Abdi Yusuf	5	16.77±1.46	4	27.7±1.77	4	10.9±1.46	4	19.51±.02
18.	Ardo Hirsi	5	13.61±.52	4	20.62±.37	4	7.01±.33	4	12.52±.006
19.	Asha Abdi	5	13.43±1.13	5	20.3±.97	5	6.89±.50	5	12.30±.009
20.	Hinda Mohammud	5	13.98±.82	5	24.56±1.46	5	10.58±.81	5	18.89±.01
	`Total	**99**	**15.99±.34**	**90**	**24.15±.46****	**90**	**8.17±.31**	**90**	**14.09±.005**

As shown in Table 2, the overall mean initial live body weights, final live body weights, total weight gains and daily weight gains of the experimental goats in the agro-pastoralists hands was found to be 15.99±.34 kgs, 24.15±.46 kgs, 8.17±.31 kgs and 14.09±.005 gm of live body weight respectively. A significantly ($P<0.05$) different and higher live body weights have been observed after the end of the experiment.

Table 3. Tests of Within-Subject Effects of Live Weight

Tests of Within-Subjects Effects							
Measure: MEASURE_1							
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Weight Difference	Sphericity Assumed	2978.288	1	2978.288	710.434	**.000**	.910
	Greenhouse-Geisser	2978.288	1.000	2978.288	710.434	**.000**	.910
	Huynh-Feldt	2978.288	1.000	2978.288	710.434	**.000**	.910
	Lower-bound	2978.288	1.000	2978.288	710.434	**.000**	.910
Weight Difference * Household	Sphericity Assumed	108.739	19	5.723	1.365	**.174**	.270
	Greenhouse-Geisser	108.739	19.000	5.723	1.365	**.174**	.270
	Huynh-Feldt	108.739	19.000	5.723	1.365	**.174**	.270
	Lower-bound	108.739	19.000	5.723	1.365	**.174**	.270
Error (weight Difference)	Sphericity Assumed	293.455	70	4.192			
	Greenhouse-Geisser	293.455	70.000	4.192			
	Huynh-Feldt	293.455	70.000	4.192			
	Lower-bound	293.455	70.000	4.192			

As shown in the above statistical table of within-subject effects of live weight gains, there has been a significant ($P<0.05$) effect of feeding technology on live weights of the animals. However, there has not been a significant ($P>0.05$) effect of within-subject effects between households.

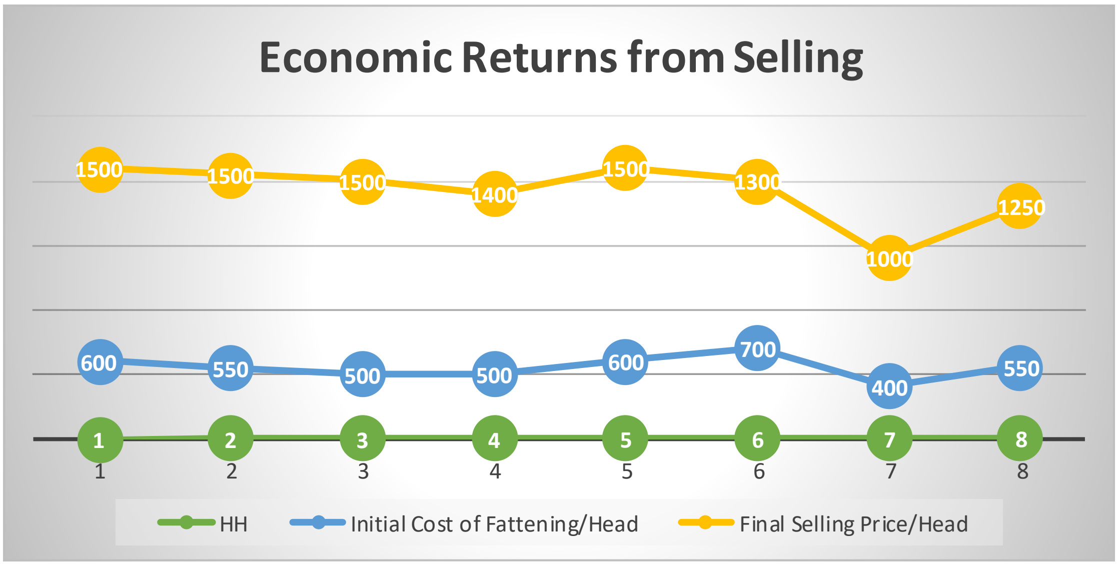
Agro-pastoralists' Feedback on Feeding Technologies

Two Focus Group Discussions (FGD); 1 FGD with each of the project beneficiaries (Sheep and Goat) constituting of 8 beneficiaries have been done at Fafan Research Centre and thorough discussions have been made regarding how they made use of the feeding technology and the role the technology had on improving their livelihoods.

The beneficiaries said that they used to face challenges as they tried practicing fattening or finishing small ruminant for sale due to feed scarcities in their locality and their limited knowledge and skills towards utilization of improved feeds and feeding management also hampered their fattening practices.

In terms of the advantages they obtained from adopting the feeding technological options, the beneficiaries said that apart from the knowledge and skill improvement the feeding technology also had an economical and or livelihood improvement as the net returns obtained from sales of the fattened animals was high as compared to their previous scenarios. The following graph shows the net returns they obtained from small ruminant sales after the experiment.

Fig. 1. Economic Returns after Selling Fattened Sheep & Goats



Conclusion and Recommendation

In spite of the inevitable variability in management and husbandry practices between model agro-pastoralists in the study area, a promising live body weight gains have been obtained for finishing black head Somali sheep yearlings fed with a supplementary feeding ration constituting of Wheat bran (49.5%), Noug cake (49.5%) and common salt (1%) with in eight weeks (56 days) period under agro-pastoralist management condition. Similarly, a promising live body weight gains have been obtained for finishing long eared Somali goats fed with a supplementary feeding ration constituting of Wheat bran (24.5%), Noug cake (74.5%) and common salt (1%) under agro-pastoralist management condition.

The shorter duration, less effort and labor requirement of fattening small ruminant using these feeding technological options; and above all, the better economic returns the agro-pastoralists obtained from selling of their finished animals after using this fattening technology boosted the awareness of other agro-pastoralists in the study area. Consequently, resulted higher demand for large scale scaleup of the technologies in the area.

Hence, it is recommended that this fattening technological option be further scaled up to other agro-pastoralists in the study area and other similar ecologies and or production systems in the region.

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SOMALI REGION PASTORAL & AGRO-PASTORAL RESEARCH INSTITUTE (SoRPARI)

CROP RESEARCH DIRECTORATE




Part I. Cereal crops

1. Adaptation Trail of Improved Hybrid Maize (Zea Mays L.) Varieties under Rain fed and Irrigation Condition in SRS.

Yohannes Seyoum, Khalid Ibrahim, Abdi Hussen

Somali region pastoral and agro-pastoral research institute (SoRPARI), Jigjiga, Ethiopia

Corresponding Author: E-mail: yohanes1195@gmail.com

Abstract

Maize is one of a major crop in Ethiopia in production, consumption and income generation for both resource constrained men and women. Although, productivity of maize in Ethiopia is showing increment in recent years, productivity in Somali region is still low compared to the national and regional average. The experiment was conducted at lowland areas of Somali region namely Godey and Dollo-ado research station in 2019/20 cropping seasons. The study was done with the objectives to evaluate the performance of hybrid maize varieties for their adaptability, high yielder and to recommend variety/ies for the study areas and similar agro-ecologies. The experiment was conducted with Randomized Complete Block Design with three replications. There was significance variation in hybrid maize varieties for the traits evaluated. The highest mean grain yield (7116.45 and 5884.44 kg ha-1) was obtained from variety MH140 in both Jigjiga, and Dolo-ado. Respectively. Besides, variety BH546 had no statistical difference from high mean grain yield recorded variety MH140 in Jigjiga and it also had no statistical difference from low mean grain yield recorded variety Melkasssa 2 in Dolo-ado. Thus, it can be concluded that hybrid maize varieties MH140 resulted the highest yield across location followed by BH546.22 and BH547. Therefore, variety MH140 were selected for both locations and variety BH546.22 and BH547 were selected as second alternative recommendation for Jigjiga and Dolo ado locations, respectively. Therefore, for sustainable maize production in the study area these varieties had been recommended and need to be demonstrated with local varieties to users along with their improved production packages.

Keywords: hybrid maize, adaptability, grain yield

Introduction

Maize (*Zea mays* L.) is an important cereal and fodder crop which occupies a pivotal role in the world economy (White and Johnson, 2003). It is widely adaptable to various climatic and soil conditions; the crop can be affected when exposed to extreme environmental factors during its growing period. Environmental factors expected with climate change and the potential for more extreme temperature events will impact the crop productivity. Pollination is one of the most sensitive phonological stages to extreme heat across all species and during this developmental stage the production would greatly affect.

The major impact of environmental stress was during the reproductive stage of development and in all cases grain yield in maize was significantly reduced by as much as 80-90% from a normal regime. Stress effects are increased by scarcity of water and excess soil water demonstrating that understanding the interaction of heat and water will be needed to develop more effective adaptation strategies to offset the impacts of greater heat extreme events correlated with a changing climate (Jerry and John, 2015). Since there is a rapid increase in climate change, there is a need to develop high yielding genotypes with tolerance to various environmental stresses.

Maize is a major crop in Ethiopia and worldwide, its production and yield stability are greatly affected by environmental factors. Improving abiotic stresses in maize has become one of the top priorities for maize breeding programs. Most of the peoples of the Somali National Regional State mainly earn their livelihood from livestock; they practice crop production as well. Maize is the major crop cultivated and predominant in the region. Knowledge on the background of environmental stresses for source of genotypes which can be effectively used as parents to develop potentially high yield and good agronomic traits with adaptation to different stress conditions. Therefore, improved hybrid varieties were tested under rain-fed and irrigation condition in SRS with the objective of selecting best performed and high yielding varieties among the improved hybrid maize varieties with good biomass yield in the study area.

Materials and Methods

The trail was conducted at the experimental station of Jigjiga, Gode and Dollo-ado Pastoral and Agro-pastoral Research Center of SoRPARI in Somali region. The experimental materials were included ten hybrid maize (MH140, BH540, BH660, MH130, MHQ138, BH543, BH546, BH661, BH140 and BH547**)** varieties. The trail was carried out in Randomized Complete Block Design (RCBD) with three replications. The plot size was 22.5 m^2 (5m length x 4.5 width) with inter-row and intra-row spacing's of 0.75 m and 0.25 m, respectively. Agronomic practices were applied based on location recommendation. Plant height, ear height, grain yield, biomass, thousand seed weight, number of rows per ear, number of kernels per ear and pest reaction data were collected and subjected for individual and combing analysis of variance by PROC GLM procedure of SAS version 9.2, (SAS Institute Inc., 2008). Treatment differences were separated by least significant difference (LSD) at $P \leq 0.05$.

Result and Discussion

The analysis of variance result revealed that there was significant difference among varieties on grain yield parameter in Jigjiga, Dolo-ado and but not in Jereti location. The highest mean grain yield (7116.45 and 5884.44 kg ha^{-1}) were obtained from variety MH140 in both Jigjiga, and Dolo-ado. Respectively. Besides, variety BH546 had no statistical difference from high mean grain yield recorded variety MH140 in Jigjiga and it also had no statistical difference from low mean grain yield recorded variety Melkasssa 2 in Dolo-ado. The possible reason for the observed differences could be variation in their genetic traits. This study is in line with those of Mosisa and Habtamu (2007), who evaluated different improved maize varieties and reported that variation of mean grain yield across environments.

Table 1. Mean grain yield of Hybrid maize varieties per locations

Entry no	Variety name	Jigjiga	Dolo ado	Combined
1	BH546	**5762.22**	3219.11	**4490.67**
2	BH547	5307.11	**4449.33**	**4878.22**
3	BH661	5712.89	3183.56	4448.22
4	MH140	**7116.45**	**5884.44**	**6500.44**
5	GIBE.3 ((check)	4753.33	3430.22	4091.78
6	Melkasa.2 (check)	5118.66	2390.22	3754.44
	Mean	5628.45	3759.48	4693.96
	LSD	1394.00	1208.30	863.52
	CV (%)	13.61	17.66	15.28

Conclusion and Recommendation

Using improved varieties of hybrid maize could make an important contribution to increase Agricultural production and productivity in areas like Somali region where there is low practice of using improved technologies such as improved crop varieties. To this end, the use of improved hybrid maize technologies such as improved varieties could be one of the alternatives to improve productivity by small farmers. During the field implementation, eight improved Hybrid maize varieties were used. According to the results of analysis of variance, grain yield trait evaluated was revealed significant statistical variation. Hybrid maize variety BH-140 gave the highest grain yield across location followed by BH-546 and BH-547, while Melkasa.2 (check) variety showed the smallest grain yield. Thus, it can be concluded that hybrid maize varieties MH140 resulted the highest yield across location followed by BH546.22 and BH547. Therefore, variety MH140 were selected for both locations and variety BH546.22 and BH547 were selected as second alternative recommendation for Jigjiga and Dolo ado locations, respectively. Therefore, for sustainable maize production in the study area these varieties had been recommended and need to be demonstrated with local varieties to users along with their improved production packages.

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2. Adaptation Trail of Improved Hybrid Maize (Zea Mays L.) Varieties under Irrigation Condition in Godey Woreda, Shabelle Zone, Somali Regional State (SRS), Ethiopia

Hassen Iskeen, Abdikadir Shekh Abdurahman

Somali region pastoral and agro-pastoral research institute (SoRPARI), Jigjiga, Ethiopia

Corresponding Author: E-mail: hassennour99@gmail.com

Abstract

Six Maize genotypes were planted in RCBD with three replications with plot size of 22.5 m^2 (5m length x 4.5 width) with inter-row and intra-row spacing's of 0.75 m and 0.25 m, respectively, by furrow irrigation to evaluate adaptation performance of Maize genotypes and identify high yielding and heat tolerant genotypes adapted to Godey in order to enhance the net national crop production in general and product diversification in Godey in particular in the near future. The analysis of variance showed that genotypes included in the test differed highly and significantly at (p=0.05) probability level for all traits, except days to 50% emergence. Maize grain yield mean value comparison or mean separation result indicated that the genotype BH-547 is superior compared to others with 44.22 quintals grain yield per hectare followed by BH-546 and BH-5661 genotypes with 41.91 and 40.37 quintals grain yield per hectare value. Based on the productivity standard the superior genotype BH-547 scored 47.4% yield advantage over the national (30 qt/ha) maize average productivity.

Keywords: varieties, adaptation, and performance

Introduction

Maize (Zea mays L) is one of the worlds' three primary cereal crops. It occupies an important position in world economy and trade as a food, feed and industrial grain crop. Maize holds a unique position in world agriculture as a food, feed for livestock and as a source of diverse, industrially important products. It accounts for 15-56% of the total daily calories of people in developing countries, and is currently produced on nearly 100 million hectares in 125 developing countries and is among the three most widely grown crops in 75 of those countries (FAOSTAT, 2010). Maize is the most important food security crop for Ethiopia, as it is for many other countries in sub-Saharan Africa. The average annual rate of growth in area and yield has been increasing over the last four decades (FAOSTAT, 2008). Maize is one of the most important cereal crops in Ethiopia, ranking second in area coverage after teff and first in total production (CSA, 2013).

Maize is a major staple food crop grown in diverse agro-ecological zones and farming systems, and consumed by people with varying food preferences and socio-economic backgrounds in Sub-Saharan Africa (Feeding Africa 2015). The central role of maize as a staple food in Sub-Saharan Africa is comparable to that of rice or wheat in Asia, with consumption rates being the highest in eastern and southern Africa. An estimated 208 million people in Sub-Saharan Africa depend on maize as a source of food security and economic wellbeing. Maize occupies more than 33 million ha of Sub-Saharan Africa's estimated 200 million ha of cultivated land. Considering the low average maize grain yields that are still pervasive in farmers' fields, meeting the projected increase demand for maize grain in Africa presents a challenge (Feeding Africa 2015). Therefore, this study was initiated with the objective to evaluate adaptation performance of Maize genotypes thereby to identify high yielding and heat tolerant genotypes adapted to Godey, Somali regional state in order to enhance the net national crop production in general and product diversification in Godey in particular in the near future.

Materials and Methods

The trail was conducted at the experimental station of Gode Pastoral and Agro-pastoral Research Center of SoRPARI in Somali region. The experimental materials were included five hybrid maize and one local (BH546, BH547, BH661, MQ138, Melkasa 6Q and local**)** varieties. The trail was carried out in Randomized Complete Block Design (RCBD) with three replications. The plot size was 22.5 m^2 (5m length x 4.5 width) with inter-row and intra-row spacing's of 0.75 m and 0.25 m, respectively. Agronomic practices were applied based on location recommendation. Days to 50% emergence, days to 50% tasseling, days to 50% silking, days to 90% maturity, plant height, ear length, grain yield, thousand seed weight data were collected and Analysis of variance was performed as per the methods described by Gomez and Gomez (1984) using GenStat 15th software for randomized complete block design and treatment mean comparison is done by Fisher's list significance difference (LSD) at 5%.

Result and Discussion

Days to 50% Emergence

The analysis of variance (ANOVA) showed that varieties had no significant effect on days to 50% emergence (Appendix Table 1 at the end this manuscript).

Days to 50% Tasseling

Days to 50% tasseling was highly significant (P<0.01) affected due to various maize varieties (Appendix Table 1). Significantly the longest period (48) days to 50% tasseling were recorded at BH546, BH547, BH5661 and MQ138. The shortest (40.67) days to tasseling was recorded at Melkasa 6Q, However, it was statistically at par with local variety (Table 1). This could be due to genetic difference of the varieties in adapting the environment may vary days to tasseling. This result agrees with that of Dilnesaw *et al*. (2018) who reported that the existence of wide variation among genotypes for days to flowering.

Days to 50% Silking

The present result revealed that days to 50% silking was highly significantly affected due to various maize varieties (Appendix Table 1). Significantly the longest period (51) days to 50% silking were recorded at BH546, BH547, BH5661 and MQ138. The shortest (44) days to silking was recorded at local variety, However, it was statistically at par with Melkasa 6Q (Table 1). This may be due to fact that varieties varied in their genetic make-up which affected days to silking. Similar results were also reported by Zinaw *et al*. (2019) who reported that the existence of wide variation among genotypes for days to silking.

Days to 90% Physiological Maturity

Days to 90% physiological maturity was highly significant (P<0.01) affected due to various maize varieties (Appendix Table 1). Significantly the longest duration (103) days to 90% physiological maturity were recorded at BH547 and MQ138 followed by BH5661(99.67), while local variety was recorded as the shortest (103.6) days to 90% physiological maturity with same days to BH546 and Melkasa 6Q (Table 1). The possible reason for the observed differences could be variation in their genetic makeup. These findings corroborate with the results reported by Zinaw *et al*. (2019) who reported that the existence of wide variation among genotypes for days to maturity.

Table 1: Main effect of varieties on days of 50% emergence (DE), days of 50% tasseling (DF), days to silking (DS) and days of 90% physiological maturity (DPM)

Treatments	**Parameters**			
	DE	**DT**	**DS**	**DPM**
BH546	6^a	48^b	51^b	93^a
BH547	6^a	48^b	51^b	103^b
BH5661	6^a	48^b	51^b	99.67^b
MQ138	6^a	48^b	51^b	103^b
Local	6^a	41.33^a	44^a	93^a
Melkasa 6Q	6^a	40.67^a	44^a	93^a
LSD (0.05)	Ns	0.99	1.36	4.28
CV (%)	13.6	1.2	1.5	2.4

NS = Non-significant, LSD = Least Significant Difference at 5% level of significance, CV (%) = Coefficient of variation in %; Means in column and followed by the same letters are not significantly different from each other

Ear length

The present result revealed that ear length of plant was highly significantly (P<0.01) affected due to various maize varieties (Appendix Table 2). The tallest plants were observed in BH-547 (35.07cm) followed by MQ138 and BH5661with height of 33.93 and 32.73 cm, respectively and the lowest was observed in local (30.20) (Table 2). The possible reason for the observed differences could be variation in their genetic makeup. These results are in accordance with that of Daniel (2014), who also reported significant genetic differences for ear length among maize genotypes

Plant Height

The present result revealed that height of plant was highly significantly (P<0.01) affected due to various maize varieties (Appendix Table 2). The tallest plants were observed in BH-546 (211.0cm) followed by Melkasa 6Q and BH-661 with height of 207.9 and 202.9 cm, respectively and the shortest was observed in local (171.5) (Table 2). This may be due to fact that varieties varied in their genetic make-up which affected plant height. This is in agreement with Daniel (2014), who evaluated different improved maize varieties and reported that plant height varied among maize varieties.

Thousand Kernel Weight

Analysis of the data revealed that thousand kernel weight of plant was highly significantly (P<0.01) varied among the tested varieties of maize (Appendix Table 2). The highest thousand kernel weight was recorded at variety BH5661 (233.3), However, it was statistically at par with local and Melkasa 6Q varieties with weight of 233.3 and 226.7 gram, respectively and the lowest was observed in BH546 (203.3) (Table 2). This could be that genetic-make difference of the varieties which caused the weight difference. Zinaw *et al*. (2019) who reported that mean hundred kernel weight varied from 36.33 to 40.67 g.

Grain yield

Analysis of the data revealed highly significantly (P<0.01) variations among the tested varieties of maize for grain yield (Appendix Table 2 at the end of this manuscript). The highest grain was noticed at variety BH-547 (4422) followed by BH-546 (4191) which remained superior among all others genotypes under study, while the lowest recorded in local (2904) (Table 2). The possible reason for the observed differences could be variation in their genetic makeup. This is in agreement with Zinaw *et al*. (2019) who reported that mean Grain yield among five maize genotypes varied from 1.61 to 5.36 tons per hectare.

Table 2: Main effect of varieties on ear length (EL), plant height (PH), grain yield (GY) and thousand kernel weight (TKW)

Treatments	**Parameters**			
	EL	**PH**	**GY**	**TKW**
BH546	31.27ab	211.5c	4191c	203.3a
BH547	35.07d	201.5bc	4422c	223.3bc
BH5661	32.73bc	202.9bc	4037bc	233.3c
MQ138	33.93cd	192.5b	3111a	210ab
Local	30.20a	171.5a	2904a	233.3c
Melkasa 6Q	31.40ab	207.9bc	3698b	226.7c
LSD (0.05)	2.05	15.79	480.9	14.07
CV (%)	3.5	4.4	7.1	3.5

NS = Non-significant, LSD = Least Significant Difference at 5% level of significance, CV (%) = Coefficient of variation in %; Means in column and followed by the same letters are not significantly different from each other

Conclusion and Recommendation

The analysis of variance showed that genotypes included in the test differed highly and significantly at (p=0.05) probability level for all traits, except days to 50% emergence. Maize grain yield mean value comparison or mean separation result indicated that the genotype BH-547 is superior compared to others with 44.22 quintals grain yield per hectare followed by BH-546 and BH-5661 genotypes with 41.91 and 40.37 quintals grain yield per hectare value. Based on the productivity standard the superior genotype BH-547 scored 47.4% yield advantage over the national (30 qt/ha) maize average productivity. Therefore, from this study it can be concluded that genotypes BH-547 which scored the first superior grain yield per hectare mean value and excellent yield advantage over the national maize productivity shall be recommended for commercial production at Godey and similar environments and soil types.

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Appendix

Appendix Table1: Mean square values of ANOVA of Maize varieties for phenological parameters

Source	Df	Days to emergence	Days to tasseling	Days to silking	Days to maturity
Block	2	0.66	1.66	1.66	5.55
Varieties	5	0.00ns	39.33**	39.2**	75.55**
Error	10	0.66	0.3	0.56	5.55

** Highly significance at P<0.01, * significant of 0.05 at p<0.05, ns: non-significant at p> 0.05 level of significance.

Appendix Table 2: Mean square values of ANOVA of Maize varieties for yield component and yield

Source	Df	Ear length	Plant height	Grain yield	Thousand kernel weight
Block	2	3.80	264.01	65861	13.50
Varieties	5	10.015**	628.77**	378107*	463.33**
Error	10	1.27	75.29	69864.	59.83

** Highly significance at P<0.01, * significant of 0.05 at p<0.05, ns: non-significant at p> 0.05 level of significance.

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3. Evaluation of adaptability and yield performance of quality protein maize (*Zea mays* l) varieties at Hadegala district of Siti zone, Somali regional state, Ethiopia

Tadeos Shiferaw

Somali region pastoral and agro-pastoral research institute (SoRPARI), Jigjiga, Ethiopia

Corresponding Author: E-mail: tadu1352@gmail.com

Abstract

The experiment was conducted on SoRPARI research farm at Hadegala research center which is located at Hadegala woreda of Siti zone Somali region state eastern Ethiopia. The study was performed to evaluate of adaptability and yield performance of maize varieties. The treatment consisted of five improved varieties namely Melkassa 2, MH 138 Q, Melkassa 6Q and MH 140 were planted on (4.5m x 7.5m) plots at spacing of 75 cm x 25 cm. The experiment was laid in RCBD with three replications. Data on plant height, Number of ear plant/plant, 1000 grain weight and grain yield were recorded. The analysis of variance showed that there were highly significant (P<0.01) differences among varieties for grain yield, biomass and other parameters among maize varieties. The highest plant height of 202 cm was recorded from MH 138 Q. The variety MH 138 Q gave the highest grain yield (1022 kgha^{-1}). Thus, variety Melkassa 2 was superior in terms of bio mass yield yielded 464 kg/ha. It is, therefore suggested that since the study is a single season experiment for the area to have reliable data on maize varieties the experiment must be repeated by including other promising varieties.

Keywords: quality protein maize, grain yield evaluation, varieties

Introduction

Maize (*Zea mays* L.) is one of the three most important cereal crops in the world together with wheat and rice in terms of area of production. The global maize production area 176 million hectares while that of wheat 216 million hectare and that of rice at 184 million hectares in 2012 (FAO, 2012). Maize is one of the most important cereal crops grown in the Ethiopia (Kinfe *et al*., 2017). The total annual production and productivity exceeds all other cereal crops. In terms of area coverage, it is only super passed by tef Eragrostis tef (Zucc.) Trotter. Considering its importance, wide adaptation, total production and productivity, maize is regarded as one of the high priority food security crops in Ethiopia, the second-most populous country in sub-Saharan Africa after Nigeria (CSA, 20114).

Ethiopia's current average national maize yield is 3.43 metric tons per hectare whereas the developing and developed countries average yields are 2.5 and 6.2 metric tons per hectare, respectively (CSA, 2015). Maize also occupies a strategic position in the food security of Ethiopia as in several countries in sub-Saharan Africa and the vision portends the intention of the government to transform the agricultural sector from a rural based economy to commercial and industry-oriented sector in order to boost agricultural productivity, enhance food security and self-sufficiency. But there are some problems that hinder its production and productivity like lack of high yielder and stable improved genotypes, drought, change in soil fertility, inappropriate agronomic practices, soil erosion, decreasing applications of manure-based compost as a result of a government policy prohibiting farmers from collecting fodder from forests leading to reductions in the number of livestock per farm, and low adoption of new maize varieties with higher potential yield released by the national maize breeding programmers.

The significant proportion of maize in Ethiopia is produced in both the low land and highland areas and its considerable variation in the grain yield is observed depending up on the variety, fertilizer use, rainfall pattern, frequency of tillage, plant density and the like. In Ethiopia, maize is also grown at four different maize agro ecology zones (MAEZs) that are classified mainly based on altitude and precipitation: high altitude sub humid (1800-2400 m.a.s.l), mid-altitude sub-humid (1000-1800 m.a.s.l), low altitude sub-humid (<1000 m.a.s.l) and low-moisture stress (500-1800 m.a.s.l)

Maize is currently grown across 13 agro-ecological zones, which together cover about 90 percent of the country. Moreover, it is an increasingly popular crop in Ethiopia: The area covered by improved maize varieties grew from five percent of total area under maize cultivation in 1997 to 20 percent in 2006 (CSA, 2006). Maize cultivation is also a largely smallholder phenomenon in Ethiopia. The small-scale farmers that comprise some 80 percent of Ethiopia’s population are both the primary producers and consumers of maize in Ethiopia. In support of the growing popularity of maize, a number of research centers and institutions have emerged in Ethiopia over the last several years (Dawit and Spielman, 2006). number of research centers and institutions have emerged in Ethiopia over the last several years (Dawit and Spielman, 2006).

Grain yield is the combined outcome of genetic potential and environment interaction. Variability in genetic potential among varieties is a major component of variable yield. Average maize yield in Ethiopia as well as in Southern region is low on account of insect pest damage, lack of high yielding cultivars and poor crop management practices. Another problem expressed by the farmers is lack of appropriate seed varieties at planting time. Available seed varieties are usually not well adapted to the local conditions and this leads to very low yields.

Olakajo and Iken (2001) reported that maize varieties produce significantly different yields at different locations. Olaoye (2009) emphasized the need to evaluate maize varieties in various agro-ecological zones for their adaptation, yield potential and disease reactions so as to identify suitable varieties for cultivation on farmers' fields. There is a need to maintain and evaluate the improved maize varieties in different agro-ecological zones of the country for rapid popularization to farmers in the, Ethiopia. It is, therefore, imperative to understand the relationship among yield testing locations for better adaptation of released varieties in production environments (Trethowan *et al.*, 2001). Keeping this in view, the present study was conducted to evaluate adaptability of some nationally released maize varieties under Somali regional state Hadegal woreda of status.

Material Method

Description of Study Area

The experiment was conducted main in cropping season of 2021 at Hadegala woreda of Siti zone of Somali regional state of Ethiopia. The climatic features are dominantly a rainfall pattern characterized by main rains in summer (i.e. from June to September) preceded by small rainfall peak in spring or by prolonged period of moderate rainfall. The mean annual rainfall varies from less than 300 to 500 mm. Much of the areas in the sub basin exhibit the highest mean temperature during the growing period. The area is within the mean temperature during the growing period exceeding 27.5 ^{O}C. Generally, the areas constitute elevation range between 740 and 817 meters above sea level. The livelihood of the area is composed of both pastoralist and agro-pastoralism.

Treatments and experimental design

Treatments used in this study were four maize varieties (Melkassa 2, MH 138 Q, Melkassa 6Q and MH 140) at Hadegala research center at Somali regional state Siti zone. Treatments were laid out in a Randomized Complete Block Design (RCBD) with three replications. The plot size was 4 x 3.75 m with 1.5 m between replications and 1.0 m between plots. Planting was carried out during 30/12/2020l. Maize was hand planted by placing two seeds per hill and thinned after emergence to maintain the proposed plant density per plot. Each plot comprised five rows of 4 m length with plant spacing between rows and within row 0.75 m and 0.25 m, respectively Weed control was carried out by hand or hand hoeing, while diseases and insect damage were visually monitored during crop growing season other crop management practices carried out as desired.

Data collection

Data were collected on major phonological, growth, yield and yield related traits as described below.

Phonological and growth data:

Days to Anthesis (AD): The number of days from planting to when 50% of the plants in a plot will started to shed pollen.

Days to Silking (SD): This was recorded as the number of days from planting to when 50% of the plants in a plot produced 2-3 cm long silk.

Ears Per Plant (EPP): This was recorded as total number of ears harvested from a plot divided by the total number of plants in a plot at harvest.

Plant Height (PH): The height of from five randomly taken plants from harvestable row was measured from base of the plant to the point where the tassel starts branching and the average value was recorded.

Days to Maturity (DM): This was recorded as number of days from planting to 50% of the plants in the plot reached physiological maturity.

Yield and Yield Related Traits: Number of ears/plant (NEP): This was recorded as the ration of the total number ears from five randomly taken plants from harvestable row and harvested to the total number of plants harvested.

100 Kernel Weight (HKW) (g): One thousand kernels per entry was counted using electronic counter and then weighed using sensitive balance.

Grain Yield (GY): Grain yield per plot was converted to grain was manually harvested from net plot and converted to yield in kg/ha after adjusting to 12.5% moisture kg/ha after

Biomass yield was estimated as the sum of stover weighed and grain yield.

Data Analysis

Subjected to analysis of variance using the general linear model SAS version 9.1 (SAS Inst., 2003). Treatments means were compared using the least significant difference (LSD) at 5% probability level.

Result and Discussion

Crop phenology

Analysis of variance showed significant difference among varieties in days to physiological maturity, plant height, biomass, grain yield, and harvest index. The significant difference observed among varieties showed the genetic difference of the varieties. In days to maturity, analysis of variance showed significant repetition difference among varieties ($p<0.05$). The highest days to maturity was recorded for MH140 (149 days) while the lowest days to maturity was recorded for MH130 which took 127.33 days to mature. Analysis of variance showed significant difference among varieties ($p<0.05$). The data for plant and ear heights as affected by location and varieties are depicted in Table 1. Analysis of variance indicated that maize varieties significant effect on plant height at ($P< 0.05$). The shortest plant height (156 cm) was seen for variety Melkasa 6Q. The data for plant and ear heights as affected by varieties are indicted in (Table 1). Analysis of variance indicated that there was significant difference among maize varieties on plant height at ($P< 0.05$).

Plant height

The tallest plant height (202.67 cm) was recorded for variety MH 138 Q followed by variety Melkassa 6Q (182.67 cm) the shortest plant height was recorded form MH 140 which resulted in mean plant height of 151.67 cm. current finding is agreement with that of Natol *et al*., (2018) who reported the highest plant height was registered for MH140 (196.67 cm) followed by MHQ138 (187.23 cm), while the lowest plant height was registered for MH130 (166.67 cm) (Table 1). Different researchers reported significant difference in plant height for maize genotypes (Tadesse *et al*., 2014; Taye *et al*., 2016; Bakala *et al*., 2017).

Yield and yield components

Number of eras per plant and 1000 seed weight

As indicated in (Tables 2) showed number of ears per plant with values of 1.6 and 1.7, respectively. Prolificacy has been associated to drought stress tolerance (Bakala *et al*., 2017) and to stability of maize hybrids across environments (Demelash and Yasin, 2017). Since in tropical maize growing areas short periods of lack of precipitation during the flowering time are frequent, prolificacy should be considered as an important trait in breeding programs for these regions (Hussain *et al*., 2011; Tekle *et al*., 2014).

Table 1. Some Phonological and growth data of maize varieties

Varieties	Days 50% Emergence	Days 50% tussling	Days to 50% Sillking	Days to maturity	Sand count %	Plant height
Melkassa 2	9.0000	75.00	75.00	108.33	40.00	180.00
MH 138 Q	8.3333	74.33	74.33	106.00	43.33	202.67
Melkassa 6Q	8.6667	76.67	76.67	107.00	41.0	182.67
MH 140	9.0000	74.67	74.67	106.00	36.67	151.67
LSD	1.4219	3.08	2.933	2.203	3.22	88.6
CV%	11.2	2.7		1.4	5.5	11.2

Grain weight is an important yield parameter and is varying from genotype to genotype (Hussain et al., 2011). According to the result in Table 2 there was significance difference among treatment on 100 seed weight of the varieties at ($p< 0.05$). The result pertaining 100-grain weight (g) of the five varieties indicted in (Table 2). According to the result highest 1000 seed weight was recorded form MH 138 Q it was 190.7 g and followed by Melkassa 6Q which resulted in 170 2g. However, variety melkasa 2 resulted the lowest values of 1000 g seed weight which was 144 gm. These results are in line with the finding of (Campos et al., 2006) which used as good criteria in the selection process for high yielding maize genotypes. Similarly, Devi *et al*., (Kinfe et al., 2017) reported that ears plant/plant and 1000-seed weight directly influence the grain yield and indirectly affect several other parameters.

Grain and Biomass yield

The result on grain yield of maize varieties shown in (Table 2). According to the result there was significant differences were revealed for grain yield among different varieties of maze in this study at $P<0.05$. Maize variety MH 138 Q showed higher grain yield (1022 kg/ha), followed by Melkassa 6Q which resulted 933 kg/ha while the variety MH 140 produced lower grain yield (667 kg/ha). Similar results were reported by Kinfe *et al*., (2017) who evaluated and identified high yielding maize varieties among different genotypes tested, since the final goal of maize breeders are selection of high yielding genotypes.

Table 2. Yield and Yield components as effected by maize varieties

Varieties	No of ear per plant	1000 seed weight	Grain yield kg/ha	Biomass kg/ha
Melkassa 2	15.33	144.3	711.	467
MH 138 Q	15.67	190.7	1022	444
Melkassa 6Q	15.33	172.0	933	422
MH 140	15.47	158.3	667	333
LSD	1.225	8.57	88.6	117.2
CV%	2.729	3.5	7.3	19.3

Biomass yield is one of the most important traits animal feeding especially genotypes which have stay green traits. According to the result in (Table 2) there was significant difference at P< 0.05 between varieties on biomass yield. As indicted in Tables 2 variety Melkassa 2 produced highest biomass 467 kg/ha followed by MH 138 Q which produced 444 kg/ha the lowest biomass was recorded from variety MH 140. In current study tested maize varieties showed significantly low biomass yield. However, biomass yield for maize varieties ranges from 7083 to 14792 kg/ha (Kinfe *et al*., 2017). Current finding contradicts with Kinfe *et al*., (2017) who reported that even though varieties exhibited significant differences on biomass yield the lowest biomass yield (7083 kg/ha) was obtained from variety Melkasa 6Q.

Conclusion and recommendation

Maize (*Z. mays* L.) is one of the most important cereal grains grown worldwide in a wider range of environments because of its greater adaptability. Analysis of variance showed significant difference among varieties in days to physiological maturity, plant height, biomass, and grain yield. The significant difference observed among varieties showed the genetic difference of the varieties. The highest plant height of 202 cm was recorded from MH 138 Q. The variety MH 138 Q gave the highest grain yield (1022 kg ha^{-1}). Thus, variety Melkassa 2 was superior in terms of bio mass yield yielded 464 kg/ha. It is, therefore suggested that since the study is a single season experiment for the area to have reliable data on maize varieties the experiment must be repeated by including other promising varieties.

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4. Grain yield evaluation of quality protein maize in Gode and Babile districts of Somali region

Yohannes Seyoum, Khalid Ibrahim, Abdi Hussen

Somali region pastoral and agro-pastoral research institute (SoRPARI), jigjiga, ethiopia

Corresponding Author: E-mail: yohanes1195@gmail.com

Abstract

A field experiment was conducted at the research centers representing the lowland districts of somali region, eastern Ethiopia using six quality protein maize varieties during 2018 and 2019 main cropping season. The study was envisaged to assess the adaptability of six quality protein maize varieties at Godey and babile district. The field experiment was laid out in a Randomized Complete Block Design (RCBD) with two replications for 2019 on The gross plot size was 25m^2 (5m x 4.5m) and net plot size 15m^2 (5m x 3m). The combined analysis of variance revealed that, there was highly significant difference among the test varieties for mean grain yield. Results revealed that Melkassa-2, Melkassa 1Q and Melkasa 6Q showed to be best performing variety across locations Therefore, based on nutrition aspect and due to variety and location interaction, varieties were recommended on location base. Thus, variety Melkassa 1Q for Jigjiga and Dolo-ado; Melkassa 6Q for Gode and Dolo-ado were recommended.

Keywords: quality protein maize, grain yield, evaluation

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops used in the human diet in large parts of the world and it is an important feed source for livestock. Maize is Ethiopia’s leading cereal in terms of production, with 6.2 million tons produced in 2013/2014 by 9.3 million farmers across 2 million hectares of land. Over half of all Ethiopian farmers grow maize, mostly for subsistence, with 75 % of all maize produced being consumed by the farming household (CSA, 2014).

Almost all maize varieties cultivated in the country are normal maize varieties which are devoid of essential amino acids such as lysine and tryptophan. Normal maize varieties grown in Ethiopia cannot sustain normal growth and adequate health of target groups depending on maize as staple food. Because the nutritional profile of maize is poor as it is deficient in essential amino acids such as lysine, tryptophan and methionine due to a relatively higher proportion of prolamines in maize storage proteins which are essentially devoid of lysine and tryptophan.

Therefore, substituting the normal maize grown in Ethiopia with Quality protein maize (QPM) would substantially improve the protein status and greatly reduce the malnutrition problems of resource poor people. Because QPM is a maize variety that possesses significantly higher levels of two essential amino acids, lysine and tryptophan as compared to Normal Maize varieties. The higher levels of lysine and tryptophan are due to the presence of the opaque-2 gene in a homozygous recessive state which contributes to doubling the biological value of maize (Bressani, 1992). Therefore, Quality protein maize variety adaptation trails were conducted under rain-fed and irrigation condition with the aim of selecting best performed and high yielding QPM for recommendation in the study area.

Material and methods

Trial was conducted in Gode and Jigjiga (Fafen site) research center during 2019 cropping season. Three QPM varieties: ***Melkasa-1Q, Melkasa-6Q, MHQ138, and two check varieties: Melkassa-2 and local variety*** were tested under irrigation and rain-fed condition to evaluate their performance. The trial was laid out by Randomized Completely Block Design (RCBD) and three replications The gross plot size was $25m^2$ (5m x 4.5m) and net plot size $15m^2$ (5m x 3m). Besides, agronomic practices were applied based on location recommendation. Plant height, ear height, grain yield, biomass, thousand seed weight, number of rows per ear, number of kernel per ear and pest reaction data were collected and subjected for individual and combing analysis of variance using appropriate statistical analysis system (SAS). Significant differences among mean values were compared using list significant test (LSD) at $P \leq 0.05$.

Results and Discussion

The combined analysis of Variance result indicates that variety, location and their interaction had highly significant ($P \leq 0.01$) effect on maize grain yield (Table 2). There is significance grain yield difference among tested genotypes in both separate and combined analysis over location. The highest grain yield was 3377.33kg h-1 recorded on Melkassa 2 variety which was at par with Melkassa 1Q varieties in Jigjiga. Similarly, the highest grain yield (4166.67and 4110.00kg h^{-1}) was obtained from Melkassa 2 in both Gode and Dolo respectively.

Table 1. Mean grain yield of quality protein maize varieties per location

Entry no	Variety name	Grain yield (kg ha^{-1})			
		Jigjiga	**Gode**	**Dolo ado**	**Combined**
1	Melkassa 1Q	2620.00	2723.33	3684.00	3009.11
2	Melkassa 6Q	1719.56	3670.00	3466.67	2952.07
3	Melkassa 2	3377.33	4166.67	4110.00	3884.67
4	Melkassa 4	2363.11	3006.67	3003.33	2791.04
5	Local variety	1256.44	2266.67	2200.67	1907.93
	Mean	2267.29	3166.67	3292.93	2908.96
	LSD	1195.10	1104.70	1204.70	604.09
	CV (%)	28.00	18.52	19.43	21.34

Melkassa 1Q and Melkassa 6Q had no statistical grain yield reduction compare to Melkassa-2. Moreover, both varieties had significant and high grain yield advantage compare to local variety in all location. Similar results were also reported by Legesse *et al*. (2009), Tamirat *et al*. (2014), Mousa *et al*, (2014) and Hossein *et al*. (2014)

Table 2. Combined Analysis of Variance for grain yield of maize varieties across various locations

Source variation	DF	Mean square
Replication	2	667480.72^{ns}
Location	2	4691925.46**
Rep(loc)	4	179402.19^{ns}
Variety	4	4454702.12***
Variety*location	8	435419.63**
Error	24	385508.28

Conclusion and recommendation

Generally, the present study entails the presence of significant variations among quality protein maize varieties for grain yield. Results revealed that Melkassa-2, Melkassa 1Q and Melkasa 6Q showed to be best performing variety across locations Therefore, based on nutrition aspect and due to variety and location interaction, varieties were recommended on location base. Thus, variety Melkassa 1Q for Jigjiga and Dolo-ado; Melkassa 6Q for Gode and Dolo-ado were recommended.

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5. Adaptation Trial of Improved Sorghum Varieties Under Irrigation in Kallafo Woreda, Shabelle Zone, Somali Regional State (ESRS), Ethiopia

Hassen iskeen, Abdikadir Shekh Abdurahman

Somali region pastoral and agro-pastoral research institute (SoRPARI), Jigjiga, Ethiopia

Corresponding Author: E-mail: hassennour99@gmail.com

Abstract

Five sorghum *genotypes were planted in RCBD with three replications with plot size of 11.25m^2 (3m length x 3.75m width) with inter-row and intra-row spacing's of 0.75 m and 0.25 m, respectively, by furrow irrigation to evaluate adaptation performance of* sorghum *genotypes and identify high yielding and heat tolerant genotypes adapted to Kallafo in order to enhance the net national crop production in general and product diversification in Kallafo in particular in the near future. The analysis of variance showed that genotypes included in the test differed highly and significantly at (p=0.05) probability level for days to 50% emergence, days to 90% maturity, plant height, head weight, thousand kernel weight, grain yield. Sorghum grain yield mean value comparison or mean separation result indicated that the genotype ESH-1 is superior compared to others with 32.00 quintals grain yield per hectare followed by melkam genotype with 31.11 quintals grain yield per hectare value. Based on the productivity standard the superior genotype ESH-*1 *scored 52.38% yield advantage over the national (21 qt/ha) sorghum average productivity.*

Keywords: Sorghum, Grain Yield, Varieties

Introduction

Sorghum (Sorghum bicolor (L.) Moench) grows in a wide range of agro ecologies most importantly in the drought-prone parts where other crops can least survive (Adugna, 2007). This makes sorghum preferable by farmers in drought-prone areas due to its tolerance to drought and harsh environments. It is one of the important indigenous food crops and is only second to tef as injera (leavened local flatbread) making cereal. Sorghum is the fifth most important cereal crop in the world (FAO (Food and Agricultural Organization), 2005).

In Ethiopia, sorghum is the third most important cereal crop after tef and maize in terms of area coverage and total production (CSA, 2018). It accounts for 18.53% of the total area allocated to cereals and it also accounts for 19.3% of the area covered by cereals (CSA, 2018). In spite of the importance of the crop to the farmers in the target area, lack of improved varieties, non-adoption of improved technologies, diseases and pests are major series production constraints in the study area. Some varieties of sorghum were released by different national and regional research centers. However, most of them were not evaluated in Somali Region specially irrigated areas of SoRPARI centers and sub-centers. Therefore, this study was initiated with the objective to evaluate adaptation performance of sorghum genotypes thereby to identify high yielding and heat tolerant genotypes adapted to Kallafo, Somali regional state in order to enhance the net national crop production in general and product diversification in Kallafo in particular in the near future.

Materials and Methods

The trail was conducted at the experimental station of kalafo Research Sub-center of SoRPARI in Somali region. The experimental materials were included five improved sorghums (Adokare, ASSO-1, Dekak, ESH-1 and Melkam**)** varieties. The trail was carried out in Randomized Complete Block Design (RCBD) with three replications. The plot size was 11.25m^2 (3 length x 3.75 width) with inter-row and intra-row spacing's of 0.75 m and 0.25 m, respectively. Agronomic practices were applied based on location recommendation. Days to 50% emergence, days to 50% heading, days to 90% maturity, plant height, head weight, thousand seed weight, grain yield, dry biomass yield, harvest index data were collected and Analysis of variance was performed as per the methods described by Gomez and Gomez (1984) using GenStat 15th software for randomized complete block design and treatment mean comparison is done by Fisher's list significance difference (LSD) at 5%.

Result and Discussion

Days to 50% Emergence

Days to 50% emergence was highly significant (P<0.01) affected due to various maize varieties (Appendix Table 1 at the end this manuscript). Significantly the longest period (5.66) days to 50% emergence were recorded at Adokore, followed by Melkam (5.33). The shortest (5) days to emergence were recorded at ASSO-1, Dekak and ESH-1, However, they were statistically at par with melkam (Table 1). This could be due to genetic difference of the varieties in adapting the environment may vary days to emergence. This result agrees with that of Zinaw *et al*. (2018) who reported that the existence of variation among genotypes for days to emergence.

Days to 50% Heading

The analysis of variance (ANOVA) showed that varieties had no significant effect on days to 50% heading (Appendix Table 1).

Days to 90% Physiological Maturity

The present result revealed that days to 90% physiological maturity was highly significantly affected due to various maize varieties (Appendix Table 1 at the end this manuscript).

Significantly the longest duration (130.67) days to 90% physiological maturity were recorded at ASSO-1, while melkam variety was recorded as the shortest (84.3) days to 90% physiological maturity (Table 1). This may be due to fact that varieties varied in their genetic make-up which affected days to physiological maturity. Similar results were also reported by Zinaw *et al*. (2018) who reported that the existence of variation among genotypes for days to physiological maturity.

Table 1: Main effect of varieties on days of 50% emergence (DE), days of 50% heading (DF), and days of 90% physiological maturity (DPM)

Treatments	**Parameters**		
	DE	**DF**	**DPM**
Adokare	5.66^{b}	50.33^{a}	120.0^{d}
ASSO-1	5.00^{a}	51.33^{a}	130.7^{e}
Dekak	5.00^{a}	50.67^{a}	93.7^{c}
ESH-1	5.00^{a}	51.00^{a}	89.0^{b}
Melkam	5.33^{ab}	51.33^{a}	84.3^{a}
LSD (0.05)	0.64	Ns	2.81
CV (%)	10.7	3.1	1.4

NS = Non-significant, LSD = Least Significant Difference at 5% level of significance, CV (%) = Coefficient of variation in %; Means in column and followed by the same letters are not significantly different from each other

Plant Height

The present result revealed that height of plant was highly significantly (P<0.01) affected due to various maize varieties (Appendix Table 2 at the end this manuscript). The tallest plants were observed was recorded at ASSO-1 (141.1), However, it was statistically at par with Adokore (140) and the shortest was observed in melkam (123.6) (Table 2). This may be due to fact that varieties varied in their genetic make-up which affected plant height. This is in agreement with Selamawit *et al* (2020), who evaluated different improved sorghum varieties and reported that plant height varied from 142.6 to 230.1

Table 2: Main effect of varieties on plant height (PH) and head weight (HW)

Treatments	Parameters	
	PH	**HW**
Adokare	140.0^{c}	93.7^{a}
ASSO-1	141.1^{c}	132.0^{b}
Dekak	128.5^{ab}	103.3^{a}
ESH-1	132.5^{bc}	102.3^{a}
Melkam	123.6^{a}	172.3^{c}
LSD (0.05)	8.67	17.28
CV (%)	3.5	7.6

NS = Non-significant, LSD = Least Significant Difference at 5% level of significance, CV (%) = Coefficient of variation in %; Means in column and followed by the same letters are not significantly different from each other

Head Weight

Analysis of the data revealed that head weight of plant was highly significantly (P<0.01) varied among the tested varieties of maize (Appendix Table 2 at the end this manuscript). The highest head weight was recorded at melkam (172.3). The lowest was observed in Adokore (93.7) (Table 2). This could be that genetic-make difference of the varieties which caused the weight difference.

Thousand Kernel Weight (g)

Analysis of the data revealed that thousand kernel weight of plant was highly significantly (P<0.01) varied among the tested varieties of maize (Appendix Table 2). The highest thousand kernel weight was recorded at variety Melkam (35), However, it was statistically at par with ESH-1 variety with weight of 33.33 grams and the lowest was observed in Dekake (25.67) (Table 3). This could be that genetic-make difference of the varieties which caused the weight difference. Zinaw *et al*. (2019) who reported that mean thousand kernel weight varied from 26.2 to 33.1 g

Grain Yield

Analysis of the data revealed significantly (P<0.05) variations among the tested varieties of maize for grain yield (Appendix Table 2). The highest grain was noticed at variety ESH-1 (3200) followed by melkam (3111) which remained superior among all others genotypes under study, while the lowest recorded in Adokore (2578) (Table 3). The possible reason for the observed differences could be variation in their genetic makeup. The current result is in line with Fuad *et al*. (2018) and Yoseph and Zemach (2014) who reported significant difference for grain yield in sorghum varieties.

Dry Biomass Yield

The analysis of variance (ANOVA) showed that varieties had no significant effect on dry biomass yield (Appendix Table 2).

Table 3: Main effect of varieties on thousand kernel weight (TKW), grain yield (GY), dry biomass yield (DBM) and harvest index (HI)

Treatments	Parameters			
	TKW	**GY**	**DBM**	**HI**
Adokare	26.37^{ab}	2578^{a}	7052	36.58
ASSO-1	28.33^{abc}	2637^{a}	7170	37.06
Dekak	25.67^{a}	2863^{ab}	6993	41.42
ESH-1	33.3^{bc}	3200^{b}	8237	38.81
Melkam	35.0^{c}	3111^{b}	8000	38.96
LSD (0.05)	5.78	413.4	Ns	Ns
CV (%)	10.3	7.6	9.4	8.8

NS = Non-significant, LSD = Least Significant Difference at 5% level of significance, CV (%) = Coefficient of variation in %; Means in column and followed by the same letters are not significantly different from each other

Harvest Index

The analysis of variance (ANOVA) showed that varieties had no significant effect on harvest index (Appendix Table 2).

Conclusion and Recommendation

The analysis of variance showed that genotypes included in the test differed highly and significantly at (p=0.05) probability level for days to 50% emergence, days to 90% maturity, plant height, head weight, thousand kernel weight, grain yield. Sorghum grain yield mean value comparison or mean separation result indicated that the genotype ESH-1 is superior compared to others with 32.00 quintals grain yield per hectare followed by melkam genotype with 31.11 quintals grain yield per hectare value. Based on the productivity standard the superior genotype ESH-1 scored 52.38% yield advantage over the national (21 qt/ha) sorghum average productivity. Therefore, from this study it can be concluded that genotypes ESH-1 which scored the first superior grain yield per hectare mean value and excellent yield advantage over the national maize productivity shall be recommended for commercial production at Kelafo and similar environments and soil types.

Acknowledgment

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Appendix

Appendix Table1: Mean square values of ANOVA of Sorghum varieties for phenological parameters

Source	DF	Days to emergence	Days to heading	Days to maturity
Block	2	0.20	0.46	0.067
Varieties	4	0.26*	0.57^{ns}	263.433 **
Error	8	0.11	2.47	2.233

** Highly significance at P<0.01, * significant of 0.05 at p<0.05, ns: non-significant at p> 0.05 level of significance.

Appendix Table2: Mean square values of ANOVA of Sorghum varieties for plant height (PH) and head weight (HW)

Source	Df	Plant height	Head weight
Block	2	18.06	32.27
Varieties	4	167.30**	3122.57**
Error	8	21.19	84.27

** Highly significance at P<0.01, * significant of 0.05 at p<0.05, ns: non-significant at p> 0.05 level of significance.

Appendix Table1: Mean square values of ANOVA of Sorghum varieties for thousand kernel weight (TKW), grain yield (GY), dry biomass yield (DBM) and harvest index (HI)

Source	Df	Thousand kernel weight	Grain yield	Dry biomass	Harvest Index
Block	2	4.586	7210	539391	10.94
Varieties	4	52.897 *	229836*	$1019786.^{ns}$	10.95^{ns}
Error	8	9.444	48218	491984.	11.43

** Highly significance at P<0.01, * significant of 0.05 at p<0.05, ns: non-significant at p> 0.05 level of significance

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6. Adaptability Evaluation of Recent Released Bread Wheat Varieties in Somali region State, Eastern Ethiopia.

Yohannes Seyoum, Khalid Ibrahim, Abdikadir shekh Abdurahman

Somali region pastoral and agro-pastoral research institute (SoRPARI), Jigjiga, Ethiopia

Corresponding Author: E-mail: yohanes1195@gmail.com

Abstract

*Wheat is one of the major staple crop in Ethiopia in terms of both production and consumption. Even though it is such an important cereal crop in Ethiopia, it gives low yield due to many production constraints such as lack of improved varieties, poor agronomic practice (inappropriate seeding rate and row spacing), diseases, weeds and low soil fertility in Ethiopia in general and in Somali region in particular. Therefore, field experiment was conducted during the 2019 main cropping season at Godey to select high yielding bread wheat varieties for irrigated areas of Somali region. The experiment was laid out RCBD in a factorial arrangement with three replications using four wheat varieties Fentale-1, Fentale-2, Amibare-1 and Amibare-2 as a test crop. Analysis of the results revealed that all considered parameters were significantly (P<0.05) affected by varieties. The highest maturity date was recorded from Fentale-1 (*83.0) while the lowest maturity date (78.00 days) was obtained from *Fentale-2. variety Fentale-2) had highest TSW (26.67gm), while Variety Amibara-1 had the lowest TSW (21.67gm). The highest grain yield (*34.99 *and* 29.17 *qt/ha), was obtained from Amibara-2 and Fentale-2. Therefore, Variety 'Fentale-2' and 'Amibara-2" were selected by their high grain yield and other agronomic performance from tested varieties under irrigated condition in lowland area*

Keywords: bread wheat, grain yield, adaptation

Introduction

Bread Wheat is an important crop commodity in Ethiopia, which could contribute a major part in achieving the millennium goal of the country, food grain self-sufficiency. In sub-Saharan Africa, Ethiopia ranks second next to South Africa in terms of total production and area coverage of bread wheat. The total annual production in Ethiopia` was estimated at about 3,850 metric tons from an area of about 1.6 million hectares. and ranks fourth after teff, maize and sorghum both in area and production among cereal crops in Ethiopia (CSA, 2015).

Wheat is used to make important staple foods like bread, porridge (*genfo*), local beer (*tela*), roasted grain (*Kolo*) boiled grain (*nifro*), pasta, and different confectionary products. It is the third highest source of grain-based calories (20 percent of the total calorie supply) behind corn and sorghum. According to the Central Statistical Agency's (CSA 2015) crop utilization survey, 60 percent of production is used for household consumption, 20 percent is sold to the market, while the balance is used for seed, in-kind wages, animal feed and other uses. Wheat bran from commercial wheat millers is used as one of the ingredients in commercially-produced, compound animal feed. The potential use of bread wheat will be that it will enter the export market if production is expanded and productivity is increased. This will save the foreign currency used to import bread wheat.

In Shabelle Zone, at lowland areas of Somali region, neither genetic variability studies in wheat genotypes nor introduction of improved wheat varieties were attempted. This is due to acidity problem that farmers are not willing to produce bread wheat. To this end, in crop improvement and others technology development and dissemination process with the involvement of the end-users may hasten the process and increase the adaptation and dissemination of the new technology. Therefore, it is necessary to undertake research to develop wheat varieties for the study area in which genetic variability study is the first step. Thus, the study was undertaken with objective of evaluating and select better adapted bread wheat varieties for yield and yield components for the study areas and other similar agro-ecologies.

Material and Method

The trial was conducted in Gode (irrigation) and Lefeisa (rainfed) districts in Somali region during 2010 and 2011 E.C. Four irrigated bread wheat varieties namely: Amibara-1, Amibara-2, Fentale-1, Fentale-2, were tested under irrigation condition to evaluate their performance. Randomized Completely Block Design (RCBD) with three replications was used to laid out the trial. The gross plot size was $25m^2$ (5m x 5m). In addition, all necessary agricultural input and cultural practices were used as per recommendation.

Days to 50% emergence, days to 50% flowering, days to 50% maturity, plant height, number tiller per plant, grain yield, thousand kernel weight were collected. Analysis of Variance (ANOVA) using *Proc GLM* syntax of SAS (SAS version 9.0, 2001) was subjected to analysis yield and yield related data and significant differences among mean values were compared using List Significant Difference (LSD) at P≤0.05. (Rain fed location data were not included)

Result and Discussion

The Analysis of variance result indicated that a significant difference among tested varieties for day to maturity, TSW and grain yield traits, while there had not significant difference for traits like day to heading, plant height and number of tiller (Table 1). According to table 2, the mean performance of tested variety result indicated that early maturity (78.00 and 78.33 days) was revealed by variety Fentale-2 and Amibara-2 respectively whereas late maturity (83.00 and 82.67 days) was shown by variety Fentale-1 and Amibara-1 respectively (Table 2). Thousand Seed Weight (TSW) had similar trained with grain yield trait, i.e. variety Fentale-2) had highest TSW (26.67gm), while Variety Amibara-1 had the lowest TSW (21.67gm).

Regarding grain yield, the highest grain yield was obtained from variety Fentale-2 (34.99 qt/ha) and followed by Amibara-2 and Fentale-1. While the lowest grain yield was recorded from variety Amibara-1(15.29qt/ha) (Table 2).

The significant difference of the traits showed the existence of genetic variability among the varieties tested in study area. These traits could be important for future variety evaluation work. This result is in agreement with the finding of Friedrich *et al*., Fano and Tadeos (2017) and Desta *et al.* (2017) in bread wheat variety selection work in lowland area. Earliness is the phenological traits, it was observed in the variety Fentale-2 and Amibara-2 which had high grain yield and TSW. This variety revealed the possibility developing early matured variety without affecting the yield and yield related traits. Similar result was reported by Desta *et al.* (2017) and Saulescu *et al* (1998).

Table 1. Mean square result of Analysis of Variance for yield and other traits

Source of variation	DH	PH	DM	NT	TSW	GY
Variety	0.43^{ns}	10.67^{ns}	21.88*	0.94^{ns}	14.41*	204.83*
Error	0.78	8.66	2.30	0.20	2.47	26.32
Coefficient of variation (100%)	1.70	6.00	1.88	8.97	6.64	19.38

*ns = non-significant, *=Significant at 5%, DH = Days to heading, PH = Plant height (cm), DM = Days to maturity, NT= Number of tillers, TKW = Thousand Seed Weight (gm) and GY = Grain Yield per hectare (qt)*

Table 2. Mean performance of tested varieties for grain yield and other traits

Ent.no	Variety	DM	TSW	GY
1	Amibara 1	82.67^{a}	21.67^{b}	15.29^{b}
2	Amibara 2	78.33^{b}	23.90^{ab}	**34.99^{a}**
3	Fentale 1	83.00^{a}	22.50^{b}	26.44^{a}
4	Fentale 2	78.00^{b}	26.67^{a}	29.17^{a}
Mean		**80.50**	**23.68**	**26.47**
Least sign. Difference (LSD)		**3.03**	**3.14**	**10.25**

DM= Days to maturity, TKW= Thousand Seed Weight (gm) and GY= Grain Yield per hectare (qt) Means with the same letter within the same column are not significantly different.

Conclusion and Recommendation

As indicated in the result there was significant differences among the varieties for all parameters. Among the varieties, Variety 'Fentale-2' and 'Amibara-2" performed best. Therefore, Variety 'Fentale-2' and 'Amibara-2" were selected by their high grain yield and other agronomic performance from tested varieties under irrigated condition in lowland area. Its selected for demonstration and popularization activities for small as well as large scale wheat producers, for researchers and other stakeholder Thus 'Fentale-2' and 'Amibara-2' are recommended bread wheat varieties for Gode and other similar irrigated agro-ecology areas. For future, evaluating more number of irritated bread wheat verities (including the tested varieties) in many locations and seasons would be improved the variety selection for wide area recommendation.

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7. Performance evaluation of released bread wheat varieties at Hadegala District of Siti zone, Somali Regional State, Ethiopia

Tadeos shiferaw

Somali region pastoral and agro-pastoral research institute (SoRPARI), Jigjiga, Ethiopia

Corresponding Author: E-mail: tadu1352@gmail.com

Abstract

Study was conducted at Hadegala woreda woreda sitizone of Somali regional state Gabi research center to evaluate the performance and yield of six released bread wheat varieties. Study was conducted by involving six varieties including Amibara, Fantale 1, Fantale 2 Werer1, Pavon and Dunada and Kingbird were used as testing materials were tasted in RCBD. The analysis of variance (ANOVA) indicated presence of highly significant differences at (P≤0.01) among the evaluated bread wheat varieties on crop penology, grain and biomass yield of bread wheat. Grain yield was highly significantly (P<0.05) due to varieties. The maximum grain yield (6667 kg/ha) was recorded for variety Amibara2, followed by variety Dunda (6111 kg/ha). Similarly variety Fentale 1 and Fental 2 had similar grain yield 5833b kg/ha. The lowest grain yield was recorded from Kingbird which was 723 kg/ha. The result in Table 2 also indicted intermediate grain yield obtained from 4722 kg/ha warer2 and 5000 kg/ha and pavone 76. There was also significant difference on biomass yield of the varieties at P< 0.05. The value of biomass of varieties ranges from 3333.3 to 10666.7 kg/ha. The highest biomass recorded in the present study was 10666.7 kg/ha from variety Dunda, and the lowest biomass recorded was 3333.3 kg/ha from Amibara 2 variety. Related biomass yield range was reported by Adhiena (2015). However Amibara 2 and Kingbirsd produced the lowest yield with 3333.3 and 5555.3 kg/ha respectively. Current finding corroborates with Kifle et al, (2017) reported maximum above ground biomass of 10491.7 kg/ha with current finding 10666.7 kg/ha. Current study finding indicated promising varieties for grain yield and biomass has been identified. However since this is single season single location trail to find reliable data on bread wheat varieties the trail must be repeated.

Keywords: bread wheat, grain yield, adaptation

Introduction

In Ethiopia, wheat is one of the major cereal crops and largely grown in the southeast, central and northwest parts with moderate rainfall, humidity and temperatures. The most common species grown are *Triticumaestivum L*. (Bread wheat) and *Triticumturgidum* var. durum L. (Durum wheat). Bread wheat is one of the major crops predominantly grown by small-scale farmers under rain fed condition in the highlands of Ethiopia (Obsa 2019).

The ideal cultivar for high grain yield or for any other desirable traits needs to express genetic potential with low value of variance in different environmental factors of growing (Bayisa et al., 2019). The main objectives of wheat breeding in Ethiopia are to develop varieties with high and stable grain yield and quality, and resistant to biotic and abiotic stresses. With these objectives, the Ethiopian institute of agricultural research has developed different improved bread wheat varieties with key characteristics such as high grain yield and quality, resistance to rusts, tolerance to drought and consumer preferences such as taste, baking and nutritional quality. Farmers however have subjective preferences for different varietal attributes and their varietal demand is significantly affected by their perceptions (Afework and Admikew, 2021).

Although there are recently released and better performing irrigated bread wheat varieties in Ethiopia, no variety adaptation or introducing activities performed in potential areas of Somali region specifically siti zone areas. In the study area called Hadegal districts there is no improved or local variety of bread wheat suitable for irrigation production. However neighboring region with similar agro ecology in afar region experiencing better bread wheat production the fore introducing adaptable varieties of wheat to Hadegala woreda is important. The objective of the study was to evaluate adaptability of bread wheat varieties under Hadegala woreda Siti zone Somali regional state conditions.

Material and Method

Seven wheat varieties were used in the experiment namely Fantale 1 Fentale 2 kingbird Amibara2 dunda, pavone 76 and warer2. The seeds of six wheat varieties were obtained from Werer Agricultural Research Center. The experiment was arranged in a Randomized Complete Block Design (RCBD) with three replicates. Each experimental plot had 8 rows at a spacing of 30 cm, having plot length of 3 m and width of 2.4 m. Spacing between plots was 1 m and the distance between replications was 1.5 m. The experimental plots were prepared by tractor ploughing and harrowing. Rows were made by hand-pulled row-marker. Fertilizer was applied at the rate of 125 kg DAP ha-1 diammonium phosphate (DAP) ha-1 during planting and 100 kg

Urea ha-1 was applied at the seedling stage after two weeks for the black soil type. Sowing was done by hand drilling at the seed rate of 125 kg ha-1 (90 g plot-1). All appropriate agronomic practices such as weeding, watering and others were conducted uniformly at the experimental field. Irrigation was provided using a groundwater resource to provide the essential moisture for normal growth.

Data collection

The major agronomic data: - Plant height, number of tillers, biomass, grain yield and other yield related traits were collected. Plant height, tillers per plants were collected from ten plants from the central four rows.

Plant height (PHT): The average height in cm from ground level to the tip of the spike were measured.

Spike length (SL): The average spike length in cm from its base to the tip were measured.

Tillers/plant (TPP): The average number of productive tillers per plants were measured.

Biomass (BM): The plants within the four central rows were harvested and weighed in kilo grams. **Grain yield (GY):** Grain yield in grams obtained from the central four rows of each plot and converted to kilograms per hectare.

Harvest index (HI): The ratio of grain yield were measured to the biomass weight.

Statistical analysis

A significance test was adopted by analysis of variance (ANOVA) for Randomized Complete Block Design. The ANOVA was carried out using the General Linear Model of the SAS Version 9.4 procedure. For factors showing significant effects, mean comparisons were made using Least Significance Difference (LSD) at 5% level of significance.

Results and Discussion

Crop Phenology and Growth Characters

The tested bread wheat genotypes showed no significance difference ($P< 0.05$) on days to 50% emergence, heading and maturity. The variation with respect to days to heading and days to maturity ranged from 64.3-66.0 and 88 to 91 respectively; indicating that there was very narrow range of variation among the varieties for heading and maturity. This result contradicts with Alemu (2016) that range for days to heading at Tongo was 46 to 70 days, with minimum values in the genotypes ETBW 8518 and maximum in ETBW 6940 with an average value of 55 days.

However, days to maturity at Tongo varied from 97 (ETBW 7101) to 117 (ETBW 6940) days respectively, with an average value of 105 indicating that the tested genotypes were early to medium maturing category. However the days to heading and maturity reported for the varieties Amibera and Fentalle nearly equal with previous reports (Girma and Esuyawkal, 2020).

There was significance difference on plant height the average plant height of variety ranged from 53.0 to 60.4 cm. On similar studies Kifle Zerga et al,(2017) reported plant height range of 54.7 to 82.57 cm on wheat varieties (Alemu et al., 2022). In the present study the tallest plants were measured from kingbird 60.46 cm and the shortest plant height were recorded 51.6 cm from Dunda varieties. Longov *et al*. (2014) reported the presence of significant ($P<0.05$) difference among five promising wheat varieties in the case of plant height. The number of productive tillers per plant indicated a significance difference ($P< 0.01$) among tested varieties. The average number of productive tiller ranges from 4.3 to 10.3 for pavone 76 4.23 and kingbird 10.6 respectively. King bird and Fentale 2 varieties ranked first on the number of productive tillers with 3 while the least number of tillers (4.33 and 4.32) were recorded from dunda and pavone 76 varieties. The number of tillers per plant recorded in this study is far greater than reported elsewhere. Related range and mean was reported from the finding of (Obsa 2014; Girma and Demis, 2020). The number of productive tillers has strong positive correlation with grain yield with correlation. There was significant variation in the value of above ground biomass among varieties.

Table 1. Crop Phenology and Growth Characters

Varieties	**50% emergence**	**50% heading**	**50% Mat**	**Plant height (cm)**
Fantale 1	8.00	66.00	91.66	53.0
Fentale 2	7.00	64.33	88.33	58.33
Kingbird	7.66	64.33	88.66	60.46
Amibara2	6.33	64.00	89.66	53.20
Dunda,	8.00	64.33	90.00	51.86
Pavone 76	6.00	63.00	87.00	59.40
Warer2	7.66	65.33	89.333	53.33
LSD	1.46	2.929	6.982	10.77
CV%	7.9	2.3	5.52	9.9

Yield and yield components

Thousand kernel weight was highly significantly (*P<0.01*) difference due to varieties. The mean value of thousand kernel weight ranged from 43.33 g (Fentalle 1) to 38.5 (pavone 76) with an average value of 39.21g. The varieties Werer-1, kingbird and Fantale had weights higher than the mean weight of 39.21g. According to data reported by Obsa (2014) thousand seed weight ranged from 25g to 46.67g; with the average weight of 39.67g showing high genetic variability among the genotypes. However, in contrast to this non-significant difference between genotypes for seed weight has also been reported (Khan et al., 2011). Similarly 1000 seed weight recorded from different varieties is in line with previous reports of the same varieties (Girma and Demis, 2020).

Grain and Biomass Yield

Grain yield was highly significantly (*P<0.01*) due to varieties (Table 2). The maximum grain yield (6667 kg/ha) was recorded for variety Amibara2, followed by variety Dunda (6111 kg/ha). Similarly, variety Fentale 1 and Fental 2 had similar grain yield 5833b kg/ha. The lowest grain yield was recorded from Kingbird which was 723 kg/ha. The result in Table 2 also indicted intermediate grain yield obtained from 4722 kg/ha warer2 and 5000 kg/ha and pavone 76. According to Girma and Demis, (2020) the lowest grain yield was recorded in variety Werer-1 (3.48 t ha-1). However, the yield obtained from variety Werer 1 in current study far greater than that previously reported (Mihratu et al., 2018; Getinet et al., 2020). This higher grain yield might be associated with adaptability and the genetic make-up of the parental material of these varieties since under similar soil, climatic, input and crop management conditions the grain yield differed significantly. The result is in line with Falaki *et al.* (2009) reported different responses of wheat varieties in respect to the yield and yield components examined and suggested that it could be due to their varied genetic composition and adaptation to the soil and climatic conditions under which the study was conducted.

There was also significant difference on biomass yield of the varieties at $P< 0.05$. The value of biomass of varieties ranges from 3333.3 to 10666.7 kg/ha. The highest biomass recorded in the present study was 10666.7 kg/ha from variety Dunda, and the lowest biomass recorded was 3333.3 kg/ha from Amibara 2 variety.

Table 2. Yield and yield components traits of bread varieties at Gabi research sub-center

Varieties	**No. tiller**	**1000 sdwt**	**Yield kg/ha**	**Biomass kg/ha**
Fantale 1	5.66	43.333	5833	8833.3
Fentale 2	9.66	40.667	5833	6694.3
Kingbird	10.6	41.667	723	5555.3
Amibara2	5.0	40.333	6667	3333.3
Dunda,	4.33	40.667	6111	10666.7
Pavone 76	4.23	38.5	5000	8833.3
Warer2	6.33	41.667	4722	6694.3
LSD	3.26	3.463	2499	1326.6
CV%	36.5	7.481	22.1	20.4

Related biomass yield range was reported by Adhiena (2015). However Amibara 2 and Kingbirsd produced the lowest yield with 3333.3 and 5555.3 kg/ha respectively. Current finding corroborates with Kifle et al, (2017) reported maximum above ground biomass of 10491.7 kg/ha with current finding 10666.7 kg/ha.

Conclusion and Recommendations

With current government effort introducing bread wheat to lowland areas of the country different varieties of bread wheat tested and released as part of the activity bread wheat variety evaluation was conducted under Siti zone hade gala woreda. This study generally indicated that there is promising and opportunity to scale up bread wheat varieties. Current study finding indicated promising varieties for grain yield and biomass has been identified. However, since this is single season single location trail to find reliable data on bread wheat varieties the trail must be repeated.

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8. Quality Protein Maize Adaptation Trial in Kelafo Research Station of Somali Region

Yohannes Seyoum, Abdi Hussen, Abdirahman Osman

Somali region pastoral and agro-pastoral research institute (SoRPARI), Jigjiga, Ethiopia

Corresponding Author: E-mail: yohanes1195@gmail.com

Abstract

Lack of improved maize variety is the most important limiting factor in different parts of Ethiopia for maize production and productivity. The experiment was conducted on two quality protein maize varieties against two checks Melkassa-2 and local check at Kelafo research sub-sites of Godey Research Center (HSARC) for 2020 cropping season to identify and recommend high yielding varieties for Kelafo and similar agro-ecologies of Somali region. The seeds were planted in Randomized Completed Block Design (RCBD) with three replications in which gross plot size was 25m^2 (5m x 4.5m) and net plot size 15m^2 (5m x 3m). Agronomic traits viz. days to Maturity, biomass yield and grain yield were collected and analyzed. Analysis of variance revealed significant difference among varieties for most observed traits. Local variety recorded highest number of days to maturity while the lowest number of days to maturity was recorded from Melkassa 2. The highest biomass yield (kg/ha) were from Melkassa 2 which was at par with MHQ138 and Melkassa 6Q. the highest yield was obtained from Melkassa 2 followed by MHQ138 and Melkassa 6Q. Therefore, based on nutrition aspect, varieties Melkassa-6Q and MHQ138 were recommended in the study area and similar area.

Keywords: varieties, quality protein maize, grain yield, adaptation

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops used in the human diet in large parts of the world and it is an important feed source for livestock. Maize is Ethiopia's leading cereal in terms of production, while, almost all maize varieties cultivated in the country are normal maize varieties which are devoid of essential amino acids such as lysine and tryptophan. Normal maize varieties grown in Ethiopia cannot sustain normal growth and adequate health of target groups depending on maize as staple food. Because the nutritional profile of maize is poor as it is deficient in essential amino acids such as lysine, tryptophan and methionine due to a relatively higher proportion of prolamines in maize storage proteins which are essentially devoid of lysine and tryptophan.

Therefore, substituting the normal maize grown in Ethiopia with Quality protein maize (QPM) would substantially improve the protein status and greatly reduce the malnutrition problems of resource poor people. Because QPM is a maize variety that possesses significantly higher levels of two essential amino acids, lysine and tryptophan as compared to Normal Maize varieties. The higher levels of lysine and tryptophan are due to the presence of the opaque-2 gene in a homozygous recessive state which contributes to doubling the biological value of maize (Bressani, 1992). Therefore, Quality protein maize variety adaptation trails were conducted under irrigation condition with the aim of selecting best performed and high yielding QPM variety having comparable grain yield with non QPM varieties for recommendation.

Material and Methods

Trial was conducted in Kelafo sub-center. Two QPM varieties: MHQ138 and Melkasa-6Q, and two check varieties: Melkassa-2 and local variety were tested under irrigation condition to evaluate their performance. The trial was laid out in Randomized Completely Block Design (RCBD) and three replications. The gross plot size was 25m^2 (5m x 4.5m) and net plot size 15m^2 (5m x 3m). Besides, agronomic practices were applied based on location recommendations. Yield and yield related data were collected and subject to analysis of variance with PROC GLM model via SAS version 9.4. Significant differences among mean values were compared using list significant test (LSD) at $P \leq 0.05$.

Result and discussion

There were significant differences among the tested genotypes with respect to days to maturity, grain yield and dry biomass yield. The longest maturity duration (110.67 days) was recorded from MHQ138 which was significantly at par with Melkassa 6Q and Melkassa 2 while the lowest maturity duration (101.33 days) was from local variety. The highest grain and biomass yield were 46.67 and 84.45qt h^{-1} respectively, recorded for the variety Melkassa-2 while the lowest (34.44 and 54.44 qt h^{-1}) ws obtained from the local variety respectively. Besides, Melkassa-6Q and MHQ138 were significantly at par with Melkassa-2 (Table 1**.**). Moreover, both varieties had significant and high grain yield advantage compared to the local variety. Similar result was reported by Taye et al. (2016) and Abduselam et al. (2017) who evaluated and identified high yielding maize varieties.

Table 1. mean of yield traits of QPM and normal maize varieties in kelafo

Entry	Variety name	Days to Maturity (days)	Grain yield (qt/ha)	Biomass yield (qt/ha)
1	MHQ138	110.67[a]	38.67[a]	64.44[b]
2	Melkassa 6Q	109.67[a]	39.33[a]	67.78[b]
3	Melkassa 2	108.67[a]	46.67[a]	84.45[a]
4	Local variety	101.33[b]	24.44[b]	54.44[b]
	Mean	107.58	37.28	67.78
	CV (%)	2.85	14.03	10.72
	LSD	6.13	10.45	14.52

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9. Performance evaluation of Improved Hybrid Maize varieties for grain yield in Kelafo, Somali region, Ethiopia

Yohannes Seyoum, Abdi Hussen, Abdikadir Shekh Abdurahman

Somali region pastoral and agro-pastoral research institute (SoRPARI), Jigjiga, Ethiopia

Corresponding Author: E-mail: yohanes1195@gmail.com

Abstract

Lack of improved maize variety is highly affecting its production in different parts of Ethiopia due to inaccessibility. Lowlands of Somali region is one of such areas where the technologies are not widely addressed and adopted so far. This study was conducted by Kelafo agricultural research sub-center with the objective of selecting and recommending adaptable high yielding quality protien maize varieties for low land agro-ecologies of Somali region. The experiment was done at Kelafo research sub-center during 2020 cropping season. Four released hybrid maize varieties with two checks were evaluated in RCBD design with three replications with net plot size was 15m^2 (5m length x 3 width). All phonological and yield data were collected subjected to analysis using GenStat software. Data analysis was used to test the performance of the varieties across the testing locations. The result of the study shows that, all varieties revealed significant difference for the selected characters. Based on the obtained result, two hybrid Maize varieties (BH549 and BH661) were early maturing. The highest biomass yield was recorded from BH549, BH661 and BH547 *and gave higher yield. Therefore, BH549 and BH547 varieties were selected and recommended in the study area and similar agro-ecology zone in the region.*

Keywords: varieties, hybrid maize, grain yield, adaptation

Introduction

Maize (Zea mays L) is one of the most important cereals broadly adapted worldwide (Christian et al., 2012). It is a major food crop and source of animal feed in Africa, Americas and Asia (Bergvinson, 2000). Maize is largely produced in Western, Central, Southern and Eastern parts of Ethiopia. It is the third most important cereal after wheat and rice globally and the most widely distributed (Siwale et al., 2009). Maize is one of the most important crops grown in Ethiopia (Mosisa et al., 2007). It ranks second after tef in area coverage 18.60% (2,367,797.39 ha) and first in total production 30.08% (94,927,708.34 quintals) (CSA, 2019). In

Ethiopia, it is grown in the lowlands, the mid-altitudes and the highland regions and most important field crop in terms of area coverage, production and utilization for food and feed purposes. In Ethiopia maize is produced for food, especially, in major maize producing regions mainly for low-income groups, it is also used as staple food. Maize is consumed as "Injera," Porridge, Bread and "Nefro." It is also consumed roasted or boiled as vegetables at green stage. The leaf and stalk are used for animal feed and dried stalk & cob are used for fuel. It is also used as industrial raw material for oil & glucose production (MARD, 2014).

Maize is a major crop in Ethiopia and worldwide, its production and yield stability are greatly affected by environmental factors. Improving abiotic stresses in maize has become one of the top priorities for maize breeding programs. Most of the peoples of the Somali Regional State mainly earn their livelihood from livestock; they practice crop production as well. Maize is the major crop cultivated and predominant in the region.

The low productivity of maize is attributed to many factors like frequent occurrence of quality of seed varieties, drought, declining of soil fertility, poor agronomic practice, limited use of input, insufficient technology generation, lack of credit facilities, poor seed quality, disease, Insect, pests and weeds particularly, Striga. Some improved hybrid maize varieties has been released by the different regional and federal research centers in the nation but farmers are still stress on few local maize varieties. Therefore, the objective of this study was to Select adaptable and high yielding varieties as well as good biomass yield hybrid maize varieties.

Materials and Methods

The trial was conducted at the experimental station of Kelafo sub-center. The experimental materials included for hybrid maize varieties (BH549, BH547, BH661, MHQ138) and two check varieties (Melkassa-2 and Local). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The net plot size was $15m^2$ (5m length x 3 width) with inter-row and intra-row spacing's of 0.75 m and 0.25 m, respectively. Agronomic practices were applied based on general and location-specific recommendations. Yield and yield related data were collected and subjected for analysis of variance using PROC GLM procedure of SAS version 9.4, (SAS Institute Inc., 2020). Mean separation among varieties were done by least significant difference (LSD) at $P \leq 0.05$.

Result and discussion

The Analysis of variance result indicated that a significant difference among tested varieties for day to maturity, grain and dry biomass yield traits, while there was no significant difference for traits plant height and thousand seed weight. The mean performance of tested variety result indicated that variety BH549 and BH661 were matured early while BH547 matured late among test varieties (Table 1). The varieties have different genetic background, which might be the reason for the variation in maturity duration among the tested varieties. These results are in line with the findings of Hassan (2005) and Ayelene (2011).

The highest mean grain (46 and 44.89 qt ha^{-1}) and biomass yield (132.22 and 120 qt ha^{-1}) were obtained from BH549 and BH547 varieties, respectively while the lowest (32.67 and 74.44 qt ha^{-1}) biomass yield and grain yield was recorded from local variety and Melkassa 2 (Table 1).

Table 1. Mean grain yield of Hybrid maize varieties in Kelafo research sub-center

Entry	Variety name	Days to Maturity (days)	Grain yield (qt/ha)	Biomass yield (qt/ha)
1	BH549	105.33^{c}	46.00^{a}	132.22^{a}
2	BH547	116.33^{a}	44.89^{a}	120.00^{a}
3	BH661	102.67^{c}	43.33^{ab}	133.34^{a}
4	MHQ138	109.67^{b}	35.56^{bc}	102.22^{ab}
5	Melkasa2	108.67^{bc}	42.22^{ab}	74.44^{b}
6	Local	110.33^{ab}	32.67^{c}	84.44^{b}
	Mean	108.83	40.78	107.78
	CV (%)	3.14	11.04	17.03
	LSD	6.22	8.19	33.40

Conclusions and Recommendations

Using improved varieties of hybrid maize could make an important contribution to increase agricultural production and productivity in areas like Somali region where there is low practice of using improved technologies such as improved crop varieties. The result of the study shows that, all varieties revealed significant difference for the selected characters.

Based on the obtained result, two hybrid Maize varieties (BH549 and BH661) were early maturing. The highest biomass yield was recorded from BH549, BH661 and BH547 and gave higher yield. Therefore, BH549 and BH547 varieties were selected and recommended in the study area and similar agro-ecology zone in the region.

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Part II. Horticultural crops

10. Adaptability of Food-Feed Root Crop, Sweet Potato (*Ipomoea batatas* L) In Fafen, Kelafo, Jerati and Dolo Ado District of Somali Regional State, Ethiopian

Takele Dejene

Somali region pastoral and agro-pastoral research institute (SoRPARI), Jigjiga, Ethiopia

Corresponding Author: E-mail: tekeyafet@gmail.com

Abstract

Sweet Potato (Ipomoea batatas L) is the seventh most important food crop in the world. In Ethiopia, sweet potato is among important root crops cultivated in different parts of the country. The adaptability of four nationally released sweet potato viz., Awassa 83, Awassa 09, Kulfo and NASpot-12 varieties were studied at Gode, Kelafo, Jerati and Dolo Ado districts at on stations, Somali region. In both areas the experiment carried out in Randomized Complete Block Design (RCBD) in three replications. The vine length of 30 cm planted on plots 3.75 width x 3 length (11.25 m^2) with 1 m and 1.5 m space between plots and replication, respectively. The distance between rows and plants maintained at 75 and 30 cm, respectively. The cutting were planted nearly horizontal with two third (20 cm) of the length placed in the soil, while one-third (10 cm) remaining above the soil surface. All agronomic management recommended for sweet potato applied. The highest tuber yield obtained from NASpot-12 (45.15 t/ha) followed by Awassa09 (44.09 t/ha) and Awassa 83(37.79 t/ha). The Kulfo, orange flesh tuber variety gave the lowest tuber yield tone per ha 24.83, 25.31, 26.94 and 31.43 in Grusum, Kelafo, Jerati and Dolo ado, respectively. In recommendation, all tested variety including Kulfo will be promoted to end users of respective location.

Keywords: Sweet potato, white flesh, orange flesh

Introduction

Sweet potato, *Ipomoea batatas* L. is the 7th most important food crop in the world, while ranked the 3rd among root and tuber crops with an annual production of 124 million tonnes (FAO, 1998). With areas of 6.6 million ha China is the biggest sweet potato producer in the world (Feng *et al*., 2000). In Africa, sweet potato is the second most important root crop after cassava which its production mainly concentrated in the East African countries. Currently, root crops like sweet potato are becomes preferable crops in most of developing country particularly in drought-prone areas due to its low input and drought tolerant character.

In Ethiopia sweet potato is among important root crops cultivated in different parts of the country, with bulk of production concentrated mostly in the south, southwest and east. The area of sweet potato cultivation and production is increasing from time to time in Ethiopia. In 2014/15 cropping season, the production area of sweet potato reached 59,397.64 ha and with the estimated production of 27 million quintals, sharing 49.47% of total root crop production (CSA, 2015). Production improvement of root and tuber crops has got due attention in the Growth and transformation plan of Ethiopia. As a results it is planned to increase the average productivity of roots and tubers from 147.6 qt/ha in 2015 to 225.05 qt/ha by the end of 2020. The total volume of produce will increase from 2,446.3 thousands ton at the base year to 5695.28 thousands tones at the end year. In regard to sweet potato it is planned to increase productivity from 179.6 qt/ha to 263.83 qt/ha with an average annual growth rate of 8%. Total production will increase from 1023.57 thousand tons in the base year to 1503.96 thousand tons in the end line (ASGT II, 2015). In dry land where rainfall is low in amount and seasonal distribution crop like sweet potato is valuable importance which serves both as food and livestock feed.

Sweet potato identified as strategic crop for food security, nutrition fulfillment, high productivity, short maturity, low input and suitability to grow in drought prone area. The potential to yielding 4–6 MT/ha within short growing period 4 to 5 month in drought prone areas under no inputs and labor make the crop an ideal to attain bottle neck seasonal food shortage faced by subsistence farmers in developing countries (Sanginga and Mbabu, 2015). These more pronounced under the current condition where climate variability hampered the production and productivity of the usual crop cultivation. Apart from its high yielding and provide food, sweet potato identified as remedial crop that can solve a nutritional deficiency (hidden hunger) which otherwise unaffordable by other means especially in developing country. It is a good source of antioxidants, fiber, zinc, potassium, sodium, manganese, calcium, magnesium, iron, and vitamin C and high in carbohydrates and low in fat and protein. More importantly, some sweet potato variety constitutes Vitamin A which is very serious in developing country. In Africa about 42 percent of children fewer than five age which represents approximately 78 million affected by Vitamin A Deficiency (VAD) in 2014(www.afsafrica.org). The deficiency increases children's vulnerability to common illnesses and impairs growth, development, vision, and immune systems. Orange-fleshed sweet potatoes have received a great deal of attention for their potential to fight vitamin A deficiency (Woolfe, 1992; Jones *et al*., 2012). In this regard currently the production and consumption of the orange-fleshed sweet potatoes widely promoted in African country including Ethiopia. In addition to above mentioned vital role as human nutritious food source, starchy roots and vines can be used as animal feed or feed supplement which make sweet potato a dual-purpose crop (DoAFF, 2011).

With the aforementioned valuable importance of sweet potato both as nutritious human food, livestock feed source that capable to produce prominent yield under low input in drought prone areas, this project initiated to introduced and evaluate the nationally released sweet potato variety with the aim to diversifying livelihoods of agro pastorals thereby contribute to agro pastorals food security improvement. Therefore, the research was conducted with the objective of evaluating the adaptability of nationally released different sweet potatoes in the study areas.

Material and Methods

Nationally released four sweet potato viz., Awassa 83, Awassa 09, Kulfo and NASpot-12 varieties were introduced from Awassa Agricultural Research Center. The adaptability study was conducted in Gode, Kelafo, Jerati and Dolo Ado districts at on stations. In both areas the experiment carried out in Randomized Complete Block Design (RCBD) in three replications. The vine length of 30 cm planted on plots 3.75 width x 3 length (11.25 m^2) with 1 m and 1.5 m space between plots and replication, respectively. The cutting were planted nearly horizontal with two third (20 cm) of the length placed in the soil, while one-third (10 cm) remaining above the soil surface. The distance between rows and plants maintained at 75 and 30 cm, respectively. All agronomic management recommended for sweet potato applied.

Data Collection

Phonological parameters

- Days to 50% emergence (sprouting)
- Days to physiological maturity (DPM), when the vines of 90% of the plant population in each plot turned yellow

Shoot Growth

- Vine length (cm): The vine length will be measured from the base of the plant to the terminal tip on 10 randomly sampled plants per plot.
- Number of branches/plant: The average number of branches emerging from the main stem on 10 randomly sampled plants per plot.

Yield and Yield components

- Length of tuberous roots (cm): The average tuberous length of 10 randomly sampled plants per plot.
- Tuberous diameter (cm): The average tuberous diameter of 10 randomly sampled plants per plot.
- Tuber fresh weight (Kg): tuber will be harvested from four central rows per plot. The mean root fresh weight of a plant will be considered for statistical analysis.
- Average number of tuber per plant(No): as record by counting actual storage roots harvested from net plot and divided by the total number of plants counted at harvest

Data Analysis

Data were subjected to analysis of variance (ANOVA) using Statistix 10 Software 10 procedures as described by Gomez and Gomez (1984). Significant differences between treatment means were separated using fisher's protected least significant difference test at 5% level of significance.

Results and Discussions

Plant Morphological Characters

Vine length

Sweet potato morphological characters such as vine length and numbers of branches were found differences across the location and between the varieties Table 1 and 2. There were significant differences at ($p<0.05$) between tested sweet potato in vine length**.** The highest vine length (157.67 cm) recorded on Awassa83 in Kelafo, while the lowest vine length (104.47 cm) recorded on Kulfo in Jerati. Across the locations Awassa83 variety consistently gave highest vine length of 156.47, 157.67, 154.23 and 156.67 cm in Grusum, Kelafo, Jerati and Dolo ado, respectively.

with different vine height size. Similarly, the Kelafo variety gave the lowest vine length of 119.60, 123.33, 104.47 and 119.43 cm in Gursum, Kelafo, Jerati and Dolo ado, respectively. The current study is in conformity with the previous reports. Shamil (1990) recorded the vine length of 170.07 cm on Awassa83 sweet potato variety. Martha (2004) recorded the highest vine length (151.7 cm) on Awassa-83 variety at the lowest planting density (70 cm x 30 cm), while the lowest vine length (55.3 cm) at the highest planting density (50 cm x 25 cm). Vine length varies with cultivar, and may range from about 1 m to 6 m (Somda and kays, 1990). Internodes length is also highly variable, ranging from a few centimeters up to in length (Somda and kays, 1990). The types of vine cutting used for planting also affect the vine height in sweet potato. Study made on three vine cutting: soft wood, semi hard wood cutting planting materials of sweet potato indicated differences in vine height. The highest plant height (71.108) was obtained at the by soft wood cutting and highly significant from semi hard wood and hard wood cuttings (Birhanu et al., 2016).

Table 1. Mean vine length of sweet potato at four locations in 2021

	Vine length (cm)			
Varieties	**Gursum**	**Kelafo**	**Jerati**	**Dolo ado**
Awassa83	156.47a	157.67a	154.23a	156.67a
Awassa09	153.87a	141.33b	134.00ab	145.67ab
NASpot-12	134.90ab	135.33b	134.97ab	141.60ab
Kulfo	119.60b	123.33c	104.47c	119.43b
LSD5%	23.391	9.7706	34.944	27.688
CV	8.29	14.66	13.18	9.84

LSD (0.05) = Least Significant Difference; CV= coefficient of variation; Ns= non-significant, means in the columns followed by the same letter(s) are not significantly different at 5% level of significance

Numbers of Branches

There were significant differences in mean numbers of braches between the tested sweet potato varieties Table 2. Across the locations Kulfo variety gave highest mean numbers of braches: 11.43, 10.57, 13.17 and 11.87 in Grusum, Kelafo, Jerati and Dolo ado, respectively. The highest mean numbers of braches (13.17) recorded on Kulfo variety, in Jerati, while the lowest branches (5.17) recorded on Awassa09 in Kelafo. Except in Kulfo, the mean numbers of braches between NASpot-12, Awassa83 and Awassa90 were not statistical significant differences. Previous research indicated that Kulfo sweet potato variety has the highest number of branches (11.60) compared to Awassa-83 and Guntute varieties (Martha, 2004). Miheret (2011) also reported that Kulfo variety had maximum average number of branches than Awassa-83. Sweet potato produces three types of branches which are primary, secondary and tertiary at different growth period. The total number of branch varies between cultivars. Spacing, soil moisture and nutrient supply influence the branching intensity in sweet potato plant (Kays, 1985). The types of vine cutting used for planting also affect the branching in sweet potato. Study made on three vine cutting: soft wood, semi hard wood cutting planting materials of sweet potato indicated differences in branching. The highest number of secondary branches (38.35) was found that by using soft wood cutting as plant materials than that of semi hard wood cutting and hard wood cutting (38.35 and 11.12) (Birhanu et al., 2016).

Table 2. Mean numbers of branches of Sweet potato at four locations in 2021

	Numbers of branches(no)			
Varieties	**Gursum**	**Kelafo**	**Jerati**	**Dolo ado**
Awassa83	9.77ab	8.43ab	10.00b	9.13ab
Awassa09	6.77b	5.17c	9.00b	9.00ab
NASpot-12	8.83ab	7.83b	8.63b	8.00ab
Kulfo	11.43a	10.57a	13.17a	11.87a
LSD5%	4.1091	2.4157	2.5084	3.8649
CV	15.62	13.96	25.59	20.36

Yield and Yield Related Variables

Root Length

There were significant differences in mean root length (cm) between four sweet potato Table 3. The highest mean root length (15.57 cm) and the lowest (10.10 cm) recorded on Awassa09 and Kulfo varieties, respectively. Next to Awassa09, the higher mean root length (15.24 cm) and (15.14 cm) recorded on Awassa-83 and NASpot-12, respectively.

Pervious study on the root length of different sweet potato indicated almost similar results of the current study. The root length of (16-20 cm) reported for sweet potato Awassa 09 variety (Gurmu and Mekonen, 2017). The root length of (24.77 cm) (Shamil, 1990) and root length of

(12.16 cm) (Mohammed, 2018) reported for Awassa83 sweet potato variety. Likewise, Martha (2004) reported the root length (14.19 cm) and (10.67 cm) for Awassa-83 and Kulfo varieties, respectively. Shamil (1990) reported root length of (6.66 cm) for Kulfo (Mohammed, 2018).

Numbers of Tubers

There was significant difference between tested four sweet potatoes in numbers of tuber per plant Table 4. The highest number of tuber (7.73) obtained from Kulfo, while the lowest (2.20) obtained from Awassa09. Awassa83 and NASpot-12 gave higher mean number tuber per plant next to Awassa09. The mean number tuber per plant varied across the location. Almost all variety gave higher mean number tuber per plant in Kelafo than the rest location. It may be due to environmental differences between the locations. The mean number tuber per plant obtained in this study agreed with some previous report while disagree with others. The result of this study agreed with the finding of Martha (2004) who reported that, the kulfo variety gave significantly higher numbers of tuber (9.14) than Awassa-83. Mekonnen and Gurmu (2021) reported mean numbers of tuber per plant of 6.6, 3.2, 2.1, 2.1 for NASPOT-12, Awassa- 09, Kulfo and Hawassa- 83, respectively.

Number of root per plant is a direct contributor for root yield in sweet potato and it is considered as one of the primary traits of interest in sweet potato improvement program (Kapinga et al., 2009). However, the size of the roots is very important since under (less than 100 g) and oversized (more than 500 g) roots are not preferred by the consumer and considered as unmarketable (Mekonnen and Gurmu, 2021

Table 3. Mean Root length of sweet potato at four locations in 2021

	Root Length(cm)			
Varieties	**Gursum**	**Kelafo**	**Jerati**	**Dolo ado**
Awassa83	15.24a	14.03a	14.00ab	13.53ab
Awassa09	15.52a	14.60a	15.13 a	15.57a
NASpot-12	15.14a	13.03ab	13.43ab	13.44ab
Kulfo	10.10b	10.63b	11.20 b	10.10b
LSD5%	3.6605	2.8113	3.3123	4.1252
CV	13.09	10.76	27.70	7.48

LSD (0.05) = Least Significant Difference; CV= coefficient of variation; Ns= non-significant, means in the columns followed by the same letter(s) are not significantly different at 5% level of significance

Root Diameters

There was significant difference in in mean tuber diameters between tested sweet potatos Table 5. The highest mean tuber diameters recorded on Awassa83 (12.87) followed by Awassa09 (12.60) and NASpot-12(11.91), while the lowest recorded on Kulfo (6.47) variety. Shamil (1990) reported root diameters of 10.35 cm for Awassa83 variety. Martha (2004) recorded root diameters 6.48 and 4.80 cm on Awassa 83 and Kulfo, respectively. Gurmu and Mekonen (2017) recorded root diameters 7-10 cm on Awassa09 sweet potato variety.

Table 4. Mean numbers of sweet potato Tuber at four locations in 2021

	Mean numbers of tubers			
Varieties	**Gursum**	**Kelafo**	**Jerati**	**Dolo ado**
Awassa83	3.50ab	5.20b	3.90ab	3.83ab
Awassa09	2.20b	4.80b	3.33b	3.53a
NASpot-12	3.80a	5.07b	5.23a	3.80ab
Kulfo	3.50ab	7.73a	4.7ab	3.97a
LSD5%	1.4068	1.7708	1.8150	0.4225
CV	12.33	15.55	21.17	5.59

LSD (0.05) = Least Significant Difference; CV= coefficient of variation; Ns= non-significant, means in the columns followed by the same letter(s) are not significantly different at 5% level of significance

Table 5. Mean Root Diameters of Sweet Potato at four locations in 2021

	Root Diameters(cm)			
Varieties	Grusum	Kelafo	Jerati	Dolo ado
Awassa83	12.47a	12.50a	10.77a	12.87a
Awassa09	12.19a	8.50b	10.47a	12.6a
NASpot-12	11.91a	10.20ab	9.81ab	10.03b
Kulfo	6.43b	7.77b	7.23b	8.70c
LSD5%	5.2961	3.0773	3.0998	4.60
CV	24.66	15.81	16.22	12.51

LSD (0.05) = Least Significant Difference; CV= coefficient of variation; Ns= non-significant, means in the columns followed by the same letter(s) are not significantly different at 5% level of significance

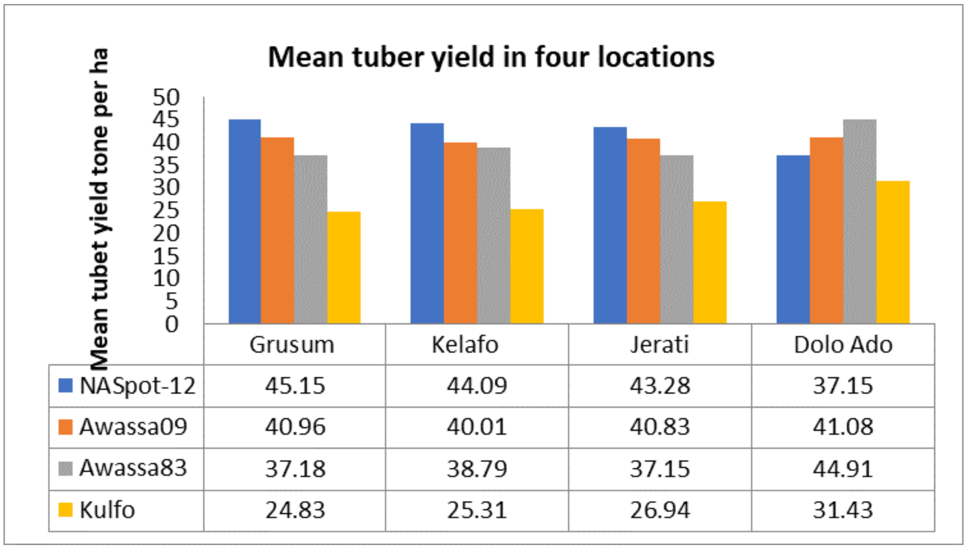
Mean Tuber Fresh Yield

The tuber yield performances of tested sweet potato in four locations shown in Table 6. All sweet potatoes better tuber yield performance almost in the four locations. The highest tuber yield obtained from NASpot-12 (45.15 t/ha) followed by Awassa09 (44.09 t/ha) ton and Awassa 83(37.79t/ha). The Kulfo variety gave the lowest tuber yield tone per ha 24.83, 25.31, 26.94 and 31.43 in Grusum, Kelafo, Jerati and Dolo ado, respectively. The previous study reported the tuber yield of 36.6 t/ha, 49.0t/ha, 60.0t/ha and 27.0 t/ha for, Awassa 83, Awassa 09 and NASpot-12 and Kulfo (Shamil,1990; Gurmu and Mekonen, 2017). All tested sweet potato gave higher tuber yield across the location with difference in quantity. The varieties are adaptable in agro-ecologies of all four locations and will be promoted.

Table 6. Mean Tuber fresh yield of Sweet Potato at four locations in 2021

	Tuber fresh yield t/ha			
Varieties	**Gursum**	**Kelafo**	**Jerati**	**Dolo ado**
Awassa83	37.18a	38.79a	37.15b	37.15ab
Awassa09	40.96a	44.09a	40.83ab	41.08ab
NASpot-12	45.15a	40.01a	43.28a	44.91a
Kulfo	24.83b	25.31b	26.94c	31.43b
LSD5%	8.5307	9.7630	5.4676	8.76540
CV	11.53	13.19	7.39	11.30

LSD (0.05) = Least Significant Difference; CV= coefficient of variation; Ns= non-significant, means in the columns followed by the same letter(s) are not significantly different at 5% level of significance



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Part III. Pulse and Fiber crops

11. Evaluation of Cotton varieties for seed and tint yield in Godey of Somali Regional state, Eastern Ethiopia

Yohannes Seyoum, Abdikadir shekh Abdurahman, Abdirahman Osman

Somali region pastoral and agro-pastoral research institute (SoRPARI), Jigjiga, Ethiopia

Corresponding Author: E-mail: yohanes1195@gmail.com

Abstract

The experiment was conducted at Godey Research Center during 2020 main cropping seasons with the objective to identify adaptable and high yielding cotton varieties for Somali region. Six released cotton varieties were used as a planting material. The experiment was laid down in Randomized Complete Block Design (RCBD) with three replications and 5m x 4.5m gross plot size and 5m x 2.7m net plot size were used. The distance between rows and plants was 90cm and 20cm, respectively. Planting depth was maintained between 3-5 cm. Data on seed cotton yield (kg ha -1) and lint yield (kg ha $^{-1}$), were collected and analyzed. The anaylsis of result revalead that There was significant difference among varieties in terms of seed and lint yield traits. The highest seed cotton yield and lint yield were obtained from Werer-50 and Weyto-07. Therefore, variety Werer-50 and Weyto-07 are recommend by their high performance of cotton seed and lint yield in the study areas as well as similar agro-ecological zone.

Keywords: seed yield, lint yield, varieties, cotton

Introduction

Cotton is the leading natural fibre crop and second most important oilseed crop in the world (Fryxell, 1992). The green revolution was mainly attributed the development and adoption of high yielding varieties in grain crops. However, a similar revolution in cotton was ushered by the introduction of inter- and intra-specific hybrids. Improvements in textile processing, particularly advances in spinning technology, have led to increased emphasis on breeding cotton for both improved yield and improved fiber properties in the world (Patil and Singh, 1994). Cotton production and weaving has a very long history in Ethiopia. It has played an important role as a means of livelihood for craftsmen involved in the weaving cottage industry. It has also been contributing a lot for the development of textile industries and offering considerable employment opportunities in the textile mills and in the farms (Alehegn *et al*., 2019). Currently, the country's textile industry parks are booming in an alarming rate to use cotton fiber as a major source of raw material. The production and productivity of cotton has been constrained by lack of high yielding and widely adaptable varieties with higher fiber quality traits, insect pest and disease management techniques, crop management practices and biotic and abiotic stresses.

Cotton lint is an important input for the textile factories, garment manufacturing and cottage industries; the cotton seed for oil milling industries and the cotton seedcake for animal fattening sub-sector. Cotton as a sub-sector creates huge job opportunities at different value chains (production, processing and marketing) of the crop. It is a source of hard currency for the country through export of the lint and various products as well as by products of the sub-sector.

There is an enormous potential for the production of cotton following its suitable agro-ecological zones and the availability of water. According to Ethiopian investment authority, the total potential area for farming cotton is estimated to be 3,000,810 hectares (EIA, 2012). These areas are found in Amhara, Oromiya, SNNP, Gambella, Afar, Somali, Benshangule Gumuz and Tigrai regions. Ethiopia Somali region account 225,000 ha of land available for cotton production (TIDI, 2017). The packaging industries are other driving forces for expansion of cotton production. Thus the farming of cotton would increase in the coming years. While there is a limitation of getting improved and well adapted variety in Somali region. Moreover, the experiment was conducted with aim of addressing this major technology gap through variety test for seed and lint yield traits. Therefore, the study was conducted with objective of selecting best adapted, high yielder cotton varieties in irrigated area of Somali Regional State.

Material and Methods

Six release varieties: Sisikuk-02, Weyto-07, Werer-50, Ionia, Stam-59A, Deltapine-90 were collected from Werer Agricultural Research Center (WARC) and used to tested in the experiment. The experimental design was Randomized Complete Block Design (RCBD) with three replications and 5m x 4.5m gross plot size and 5m x 2.7m net plot size were used. The distance between rows and plants was 90cm and 20cm, respectively. Planting depth was maintained between 3-5 cm, but fertilizer was not applied. Furrow-irrigation system was used and the schedule depended on soil moisture. Other cultural practices were used as per need like pesticide, weeding and cultivation. Morphological, Seed and lint yield data were collected and analyzed subjected to Analysis of variance via PROC GLM model of Statistical Software (SAS, 9.4 version). Mean separation test were performed for all variables with Least Significant Difference (LSD) at $P \leq 0.05$.

Result and Discussion

There was significant difference among varieties in terms of seed and lint yield traits. The highest seed yield (4876.54 and 4691.36 kg/ha^{-1}) were obtained from Werer-50 and Weyto-07, respectively. While the lowest seed yield was recorded from Ionia. Similarly, the highest lint yield (2187.35 kg/ha^{-1}) was harvested from Werer-50 and followed by Weyto-07 and Sisikuk-02. While the lowest lint yield was recorded from Ionia. This is in line with Amanu AW, et al.2021.

Table 1. Mean of yield of cotton in irrigated condition at Godey research center

ENTRY	Variety name	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})
1	Sisikuk-02	4413.58^{abc}	1987.83^{ab}
2	Weyto-07	4691.36^{ab}	2031.00^{ab}
3	Werer-50	4876.54^{a}	2187.35^{a}
4	Ionia	3549.38^{c}	1579.42^{c}
5	Stam-59A	3827.16^{bc}	1659.83^{bc}
6	Deltapine-90	4444.44^{ab}	1969.93^{abc}
	Mean	4300.41	1902.56
	CV (%)	11.12	11.50
	LSD	869.69	397.93

Conclusion and recommendation

Generally, the present study entails the presence of significant variations among cotton varieties. Based on the analysis result, the varieties Werer-50 and Weyto-07 offered better performance over the other varieties regarding seed cotton yield and lint yield. Accordingly, these two varieties are recommended for production in the study area and similar agro ecologies. Hence if the above mentioned varieties are demonstrated and popularized to the small scale holder farmers and commercial farms they can boost the income of poor farmers and commercial farms.

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Part IV. Agronomy

12. Response of Sesame (Sesame Indicum L.) Varieties to Different Sowing Dates in Lowland Irrigated Areas of Somali Region, Ethiopia.

Omar Hassan, Abdikadir Shekh Abdurrahman

Somali region pastoral and agro-pastoral research institute (SoRPARI), Jigjiga, Ethiopia

Corresponding Author: E-mail: omerhassen780@gmail.com

Abstract

A field experiment was conducted to investigate the yield performance of four sesame varieties in different sowing dates to determine optimum sowing date on performance of improved sesame varieties for lowland irrigated areas of Somali region. The experiment was laid out in randomized completely block design (RCBD) with three replications. In each location Iidan, Barsan, Kelafo and Serkamo sesame varieties and four sowing date (in mid-April, late April, mid-May, and late May) were used as treatments. These research findings showed that the sesame varieties and sowing dates were significantly differed in yield related traits. The variety Idan (ACCOO44) recorded maximum number of capsules per plant (37.75) and Biomass yield (2489kg/ha) and kelafo variety recorded the maximum number of seeds per capsule (53.0), thousand seed weight (2.23g) and grain yield (2216kg/ha). On the other hand, the plots sown on mid April scored highest number of capsule per plant, number of seeds per capsule, thousand seed weight(g), biomass yield(kg/ha) and grain yield(kg/ha) comparing to the other sowing dates. So the present research work recommends that the two varieties, Kelafo and Idan (ACCOO44) should be sown on mid April to earn higher grain and biomass yield in the study areas.

Key words: Biomass yield, Grain yield, Sesame, Sowing dates.

Introduction

Sesame (Sesamum indicum L.) otherwise known as sesamum, member of the family Pedaliaceae, is one of the ancient oilseeds domesticated and cultivated in tropical and sub-tropical parts of the world by man for the edible oil and medicinal purposes for more than 5000 years (Umar et al., 2012). Though it is a controversy for the origin of sesame, it is believed to be originated in Ethiopia due to existence of both cultivated and wild types in the country (Wijnands et al., 2009). Sesame locally called “Selit” or “Sisin,” is one of the major economically important oil crops in Ethiopia. Sesame is used one of the main cash crops and the second export commodity, next to coffee in Ethiopia and plays significant role as source of rural employment and ensuring food-security of millions of people (Abebe, 2016).

The sesame sector is millions of dollars industry that supports the livelihoods of thousands of small farmers and hundreds of medium-to-large-scale private farms along with thousands of other actors involved in the chain of production-to-consumption/export continuum. Ethiopia is one of the famous and major producers of sesame in sub-Saharan Africa, and Ethiopian sesame is among the highest quality in the world (Taghouti,*et al*,2017). From nutrition point of view, sesame is also rich in phosphorous, iron, magnesium, manganese, zinc, and vitamin B1 (Anilakumar et al,2010).

The crop is grown under different environments which may affect its growth performance. Environmental and biotic factors (weed, disease and insect pest) as well as management practices are the main sesame production constraints. The environmental factors include temperature, rain fall and soil types. Areas with annual rainfall of 625-1100 mm, deep, well-drained, fertile sandy loams and temperature of $>27^0$ c is the most conducive for sesame production (Geremew *et al*., 2012). The management practice on the other hand includes plant population, time of sowing, type and rate of fertilizers. The sowing dates plays a vital role in determining the final seed yield of crops (Malik et al., 2013) and types of sesame varieties that adapt for that particular area may also be critical to boost sesame production.

The productivity of sesame in Somali region is lower than the national average yield of 686 kg/ha (CSA, 2019). However, sesame productivity can go up to 1000-1200 kg/ha under optimum agronomic cultivation (Ali et al., 2017). The low productivity of sesame in the study area might be due to cultivation of low yielding varieties and poor management practices like inappropriate sowing dates. Sowing date is one of the agronomic management practices and manipulation of that could increase yield performances of sesame varieties. The effect of sowing dates on yield and yield components of sesame have been reported by several researchers. Therefore, this study was conducted to investigate the yield performance of four sesame varieties in different sowing dates to determine optimum sowing date on performance of improved sesame varieties for lowland irrigated areas of Somali region.

Material and Method

The experiment was conducted at Gode experimental field under irrigation condition during 2019 cropping season. The experiment was laid out in randomized completely block design (RCBD) with three replications. The treatment consisted of Four sesame (Iidan, Barsan, Kelafo-74 and Serkamo sesame) varieties and four sowing date (in mid-April, late April, mid-May, and late May) were used as treatments. Gross plot size of 5 m x 3.2 m (16 m^2) and the net plot size of 5m x 2.4 m (12m^2) were used. Distance of 40cm and 10cm was used between rows and plants, respectively.1 m and 0.5 m distance was used between blocks and plots within a block, respectively. Phonological, growth and yield as well as yield related (Data) parameters was collected and analyzed using Genstat software version 15.

Result and Discussion

Phenological parameters

Date of 50% crop emergence, 50% flowering and 75% crop maturity were not significantly affected by date of sowing and sesame varieties as well as their interaction (Table1).

Plant height

Plant height was highly significantly ($P<0.01$) affected by sowing date (Table 2). Mid-April sowing had highly significantly ($P<0.01$) produced the tallest plants than mid and late May sowings. Late April sowing and mid-May sowing were statistically at par. Mid-April sowing had enough time to grow vegetative than other planting dates which might likely be the reason for producing tallest plants. Similar results were reported by Van-Rheenan (2019), on the effect of planting date on sesame plant height. On the other hand, plant height was not significantly affected by the sesame varieties and the interaction varieties and planting dates.

Number of branches per plant

The mid-April, late April and mid-May plantings had significantly produced the same number of branches but mid-April produced significantly more number of branches than late May sowing (Table 2). Number of branches decreased from mid April to late May. Delay in planting decreases the number of branches per plant (Alam at al., 2015). They maintained that the fewer number of branches in delayed planting may be as a result of environmental factors more, importantly the rainfall. Regarding the varieties, though there were no significance difference among the varieties but kelafo variety produced the highest number of branches (3.50) where serkamo variety produced the lowest number (2.66) of branches per plant. The interaction between planting date and sesame varieties revealed no significance.

Table 24. Date of 50% crop emergence, 50% flowering and 75% crop maturity as affected by sowing dates and sesame varieties

Treatments	Parameters		
Planting dates	DE 50%	DF 50%	DM 75%
Mid April	4.25[a]	39.5[a]	79.42[a]
Late April	4.00[a]	39.0[a]	76.67[a]
Mid May	4.00[a]	40.0[a]	84.50[a]
Late May	3.88[a]	39.58[a]	80.25[a]
LSD(P<0.05)	NS	NS	NS
Sesame varieties			
ACC0016(barsan)	3.92[a]	39.5[a]	84.3[a]
ACCOO44(Idan)	4.0[a]	39.8[a]	81.25[a]
Serkamo	4.08[a]	40.0[a]	78.33[a]
Kelafo	4.1[a]	40.5a	75.92[a]
LSD(P<0.05)	NS	NS	NS
CV (%)	10.1	6.1	12

NS = non-significant, CV (%) = coefficient of variation in %, LSD = least significant difference at 5% level of significance, means in column and followed by the same letters are not significantly different at 5% level of significance according to LSD test.DE50: 50%Date of Emergence ,DF50%:Date of 50% flowering and DM75%:Date of 75% maturity.

Number of capsules per plant

Number of capsule per plant was not significantly affected by sowing dates but varieties (p<0.05). The highest number of capsule (37.75) per plant was obtained from idan(ACCOO44) variety which was statically at bar with the number of capsules from kelafo and barsan (ACC0016) varieties whereas the lowest number of capsule(25.25) per plant was obtained from serkamo variety(Table 2). The maximum number of capsules per plant obtained might be attributed to the genetic difference of the varieties. As described by Valiki et al. (2015), significant differences were found among sesame varieties in the number of capsules per plant due to the genetic difference of the varieties. The interaction between planting date and sesame varieties revealed no significance.

Number of seeds per capsule

The data on seeds per capsule (Table 2) indicated that crop sown on mid-April produced significantly highest (51.83) number of seeds per capsule. Significantly lowest (44.6) number of seeds per capsule were recorded when crop was sown on late May but this value was not significantly different than the one on late April and mid-May (Table 2). The reason for higher seeds in early planting could be the effect of prolonged photoperiod which might have resulted in more assimilates in capsules resulting in larger number of seeds per capsule. Similar results were reported by Alamsarkar et al. (2017) who recorded higher (57) number of seeds per capsule in early sowing as compared to late sowing. From among the varieties, the highest number of seed per capsule (53) was obtained from the variety kelafo and the lowest from variety Barsan (ACC0016) (44.75) (Table 2). This could be due to the inherent genetic variation existing in the varieties. A research done by Gabisa et al. (2015) also found that groundnut varieties varies in number of seeds per pod and the authors explained that number of seed per pod is mainly influenced by genetic factors found in the different varieties than agronomic practices. The interaction between sowing date and sesame varieties revealed no significance.

Thousand Seed weight (g)

Mean values of sowing dates indicated that crop sown on mid-April produced heavier (2.37 g) seed weight while minimum (1.72 g) seed weight was obtained when crop sown on late May(Table 2). Earlier sown crop gained prolonged growth period with ideal growth condition as result heavier grains were produced as compared to late sown. Similar notations were reported by Rahman et al. (2017), Alamsarkar et al. (2015) who reported that early sowing significantly improved seed weight as compared to late sowing. On the other hand, thousand seed weight was not significantly affected by sesame varieties and the interaction of varieties and sowing date.

Biomass yield (kg/ha)

Biomass yield was significantly affected by sowing dates and sesame varieties but not their interaction. The highest biomass yield (2705 kg ha-1) was scored from plots sown on mid April while lowest biomass yield (2022 kg ha-1) was recorded from plots sown on late May and it was statically at par with the rest of sowing dates (Table 2). This might be the higher vegetative growth of the varieties sown early than late sowing. These results are in line with those Alamsarkar et al. (2007) who reported that early June sowing had significant effect on biomass yield when we compared to late sowing. Regarding sesame varieties, ACCOO44 (Idan) variety scored the highest biomass yield (2489 kg ha-1) which was statically similar with kelafo variety where as the lowest biomass yield (2029kg ha-1) was obtained from serkamo variety which was statically similar with barsan (ACC0016) variety. This might be attributed to the genetic difference of the varieties.

Table 25. phenological, yield and yield components parameters as affected by sowing dates and sesame varieties.

Treatments	PH (cm)	NBP	NCPP	NSPC	TSW(g)	BM(kg/ha)	GY(kg/ha)	HI%
Planting dates								
Mid April	111.08^{C}	3.75^{b}	32.58^{a}	51.83^{b}	2.367^{b}	2705^{b}	2181^{b}	13^{a}
Late April	99.75^{bc}	3.08^{ab}	30.50^{a}	48.58^{ab}	2.183^{ab}	2198^{a}	1999^{ab}	11^{a}
Mid May	92.17^{ab}	3.08^{ab}	33.33^{a}	47.08^{ab}	2.117^{ab}	2206 ^{a}	1933^{ab}	12.5^{a}
Late May	81.75^{a}	2.750^{a}	31.25^{a}	44.67^{a}	1.717^{a}	2022^{a}	1536^{a}	12^{a}
LSD(P<0.05)	10.72	0.6	NS	1.63	0.38	334.5	432.2	NS
Sesame varieties								
ACC0016(barsan)	93.42^{a}	3.33^{a}	32.08^{ab}	44.75^{a}	2.175^{a}	2197^{ab}	1824^{a}	12^{a}
ACCOO44(Idan)	93.67^{a}	3.17^{a}	37.75^{b}	46.83^{ab}	1.900^{a}	2489^{b}	1885^{bc}	11.5^{a}
Serkamo	103.67^{a}	2.66^{a}	25.25^{a}	47.58^{ab}	2.075^{a}	2029^{a}	1725^{a}	12^{a}
Kelafo	94.00^{a}	3.50^{a}	32.58^{ab}	53.00^{b}	2.233^{a}	2416^{b}	2216^{c}	13^{a}
LSD(P<0.05)	NS	NS	8.18	1.63	NS	334.5	432.2	NS
CV(%)	13.4	16.8	9.0	11.8	17	17.6	16	12

NS = non-significant, CV (%) = coefficient of variation in %, LSD = least significant difference at 5% level of significance, means in column and followed by the same letters are not significantly different at 5% level of significance according to LSD test.

Grain yield (kg/ha)

Grain yield was significantly ($P<0.05$) affected by sowing date and varsities but not their interaction. The highest grain yield(2181kg/ha) was recorded from plots sown on mid-April and it was statically similar with late April and mid-May where as the lowest yield(1536kg/ha) was recorded from plots sown on late May though it was statically similar with late April and mid-May (Table 2). Grain yield decreased as the planting date was delayed from mid-April to late May Alam et al.(2007) also reported that highest seed yields were obtained from the early sown Sesame compared to the late sown ones. The higher seed yield obtained from the early sown Sesame was mainly due to the production of higher number of branches and number of seeds per capsules. On the other hand highest grain yield (2216kg/ha) was scored from Kelafo variety which was statically similar with Idan variety where as the lowest grain yield (1725kg/ha) was scored from Serkam variety which was statically similar with Barsan variety. This might be due to the variations of adoptability of the varieties to the soil and climatic conditions of the experimental area.

Conclusion and Recommendation

Production of Sesame by introducing the improved and high yielding varieties and planting appropriate date could make an important contribution to increase agricultural production and productivity in lowland irrigated areas of Somali region. The present research findings showed that the sesame varieties and sowing dates were significantly differed in yield related traits. The variety Idan (ACCOO44) recorded maximum number of capsules per plant (37.75) and Biomass yield (2489kg/ha) and Kelafo variety recorded the maximum number of seeds per capsule (53.0), thousand seed weight (2.23g) and grain yield (2216kg/ha). On the other hand, the plots sown on mid-April scored highest number of capsule per plant, number of seeds per capsule, thousand seed weight(g), biomass yield(kg/ha) and grain yield(kg/ha) comparing to the other sowing dates. So the present research work recommends that the two varieties, Kelafo and Idan (ACCOO44) should be sown on mid-April.

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13. Study on the Effect of Inter-Row Spacing and Seed Rate on Yield and Yield Components of Rice in Irrigated Ecosystems in Somali Region.

Omar Hassan, Abdikadir shekh Abdurrahman

Somali region pastoral and agro-pastoral research institute (SoRPARI), Jigjiga, Ethiopia

Corresponding Author: E-mail: omerhassen780@gmail.com

Abstract

A field experiment was conducted in Godey research center, eastern Ethiopia in 2019 years to study to investigate the effect of seeding rate and interrow spacing and their interactions effects on yield and yield components of rice under irrigation in Somali region. The treatments were four levels row spacing (10, 20, 25, and 30 cm) and four seed rates (60, 80, 100 and 120 kgha^{-1}) was tested. The experiment was laid out in RCBD in factorial arrangement with three replications using a rice variety known as 'Nerica-1' as a test crop. The analysis showed that almost all parameters studied were significantly ($P<0.05$ and $P<0.01$) affected by the main effect of spacing and seed rate. The highest number of effective tillers (12 and 12.37) was observed at seed rate of 60 kgha^{-1} and 30cm respectively. The maximum plant height was recorded (78.47 and 82.32cm) at seed rate and spacing of 120 kg ha^{-1} and 30cm respectively. The longest panicle length(22.73cm) was recorded from 10 cm inter-row spacing whereas the shortest panicle length(20.26cm) was recorded from inter-row spacing of 30cm. The highest number of filled grains per panicle (38.59 and 45.28) was found at seed rate and inter-row spacing of 60 kg ha^{-1} and 30cm. Highest thousand seed weight (30.73 g) was obtained from the interaction effect of seed rate of 80 kg ha-1 at 30cm of row spacing. Maximum straw yield (6172 kgha^{-1}) was produced at seeding rate of 120kg ha^{-1} while minimum straw yield (3694kg ha^{-1}) was produced at seeding rate of 60kg ha^{-1}. The highest grain yield (3624 kgha^{-1}) was obtained from seeding rate of 100 kg ha^{-1} at 30cm inter-row spacing and the lowest grain yield was 2630kgha^{-1} obtained from seeding rate of 120 kg ha^{-1} at 10cm inter-row spacing. Therefore, using a seeding rate of 100 kg/ha combine with inter-row spacing of 30 cm can be recommended to obtain maximum rate of return for rice in the above-mentioned study area.

Keywords: Rice, inter-row spacing, seed rate, grain yield

Introduction

Rice (Oryza sativa L.) is an annual cereal grain and it is the most important food crops for the world's population (Zhao *et al*, 2011). Ethiopia is located in the tropical zone, having wide range of altitude gifted with a broad diversity of climate that suitable for successful growth of most types of crops (Hagose and Zemedu, 2015). In Ethiopia, rice production was started three decades ago and the country has reasonable potential to grow various rice types (Mulugeta and Heluf, 2005). The productivity of rice increased from 498,332 t in 2009 to 3,958,323 t in 2019(CSA, 2019). The area under rice production for the same period grew from 155,886 ha in 2009 to 773,504 ha in 2019. There is an increasing trend of expansion both in area and production. Rice could suitably grow in many parts of the country. Amhara, Benshangul-Gumz, Tigray, Gambela, Oromia and Southern Nations Nationalities Peoples Region are the major rice producing areas in Ethiopia (Dawit, 2015).

In Somali region, rice mainly grown under irrigation rather than rain-fed production. During 2019, 31,807 hectares of land was cultivated by rice and 202,649 tons were produced (MOARD, 2019). The region characterizes a fertile land which is highly suitable for rice production. However, rice remains a minor crop both in area coverage and production compared to a large area and favorable agroclimatic conditions the country as well the region has immense potential for expanding rice production. An appropriate agronomic practice plays a key role in maximizing and sustaining crop yields of upland rice (Jana, 2013). These practices for a crop response vary with plant population used with the main environmental conditions (moisture, nutrient, temperature). Then special attention should be given for increasing the yield per unit area by applying improved agronomic management practices like seeding rate and spacing (Mankotia and Shekar, 2005) .Hence, it is necessary to investigate the effect of seeding rate and interrow spacing and their interactions effects on yield and yield components of rice under irrigation in Somali region. Therefore, the study was conducted with the objective of evaluating the effect of different inter-row spacing on the yield and yield component of rice in the study area.

Material and Method

The experiment was conducted at Gode, Kelafo, Jareti and Dola-ado experimental field under irrigation condition during 2012/13 E.C. A factorial combination of four row spacing (10, 20, 25, and 30 cm) and four seed rates (60, 80, 100 and 120 kgha^{-1}) was tested. The plot size was 3m width by 5m length. The number of rows for each inter row spacing was variable i.e 30, 15, 12 & 10 rows for 20, 25 and 30cm inter row spacing, respectively. The central 18, 13,10, and 8 rows of the respective inter row spacing with 4m row length was considered as net plot size. Spacing between plots and replications was 0.5m and 1m, respectively. The best performing and recommended variety for the location under irrigated condition was used. All relevant data was collected from the net plot size and subjected to analysis of variance using Gensat version 15.

Table 1. Combination of treatments

No.	**Row spacing**	**Seed rate(kg/ha)**	**Combination treatments**
1	10cm (30 rows)	60 kg	10cm (30 rows) x 60kg
2		80 kg	10cm (30 rows) x 80kg
3		100 kg	10cm (30 rows) x 100kg
4		120 kg	10cm (30 rows) x 120kg
5	20cm (15 row)	60 kg	20cm (15 row) x 60kg
6		80 kg	20cm (15 row) x 80kg
7		100 kg	20cm (15 row) x 100kg
8		120 kg	20cm (15 row) x 120kg
9	25cm (12 row)	60 kg	25cm (12 row) x 60kg
10		80 kg	25cm (12 row) x 80kg
11		100 kg	25cm (12 row) x 100kg
12		120 kg	25cm (12 row) x 120kg
13	30cm (10 rows)	60 kg	30cm (10 rows) x 60kg
14		80 kg	30cm (10 rows) x 80kg
15		100 kg	30cm (10 rows) x 100kg
16		120 kg	30cm (10 rows) x 120kg

Data collected and Analysis

Data's such as plant height (cm), Panicle length (cm), number of effective tillers, number of filled grain per panicle, number of unfilled grains per particle, thousand seeds weight, grain yield, Straw yield and harvest index were recorded from the net plot.

Result and Discussion

Number of effective tillers

The number of tillers per plant was highly significantly affected by seed rate and inter-row spacing but not their interaction (Table 4). The highest number of effective tillers (12) was observed at seed rate of 60 kgha^{-1}while the lowest number of effective tillers (10.25) observed at seeding rate of 120 kgha^{-1} which was statistically similar with the rest seed rates. This might be due to more number of tillers at higher seeding rate leads to higher competition among upland rice leads to lower number of effective tiller production.

In addition to this the highest number of effective tillers (12.37) was recorded at row spacing of 30 cm while, the minimum number of effective tillers (10.11) was recorded at row spacing of 10cm (Table 4). Wider spacing produced higher effective tillers per than closer spacing. The production of more tillers in widely spaced plants was probably due to absorption of more nutrients and moisture and also to the availability of more sunlight in comparison to densely plants. Similar results were reported by (Haque, 2002). This result was also in agreement with (Sewunet,2005) reported the highest effective tillers were recorded at medium spacing performed better as compared to lower spacing.

Plant height (cm)

The results revealed that the height of the rice plant was highly significantly ($P<0.01$) affected by seed rate and inter-row spacing but not their interaction. The maximum plant height was recorded (78.47cm) at seed rate of 120 kg ha-1 which had highly significant difference with other treatments while the minimum plant height (69.98cm) was recorded at 60 kg ha-1 (Table 4). Overcrowding due to increment of seeding rate per unit area might have resulted in aerial intra-specific competition between rice plants for light and space and promoted elongation of stem or tillers of rice. In conformity with this result (Ghansham and Surjit,2016) observed increasing trend in rice plant height as the level of seeding rate increased from 40 to 80 kg ha-1.

Row spacing of 30 cm scored the highest plant height (82.32 cm) where as the lowest plant height(66.63cm) was obtained from 20 row spacing which was statically at bar with 10 cm row spacing. This increment in plant height at wider row spacing might be due to less competition of plants for nutrients, moisture, space and light providing better environment for growth and development of crop. In line to this result of (Rahel and Fekadu, 2016) found plant heights (79.85 cm) in wider row spacing of 30 cm and the lower plant heights (75.62 cm) in 20 cm a part rows on wheat.

Panicle length (cm)

The analysis of variance revealed that panicle length was highly significantly ($p<0.01$) affected by inter-row spacing. However, seeding rate and their interaction effect did not showed significance difference ($p>0.05$) on panicle length (Table 4). This result is in line with the report of (Yoseph and Wedajo, 2014). Who reported that seeding rate did not affect panicle length of upland rice.

Inter-row spacing was significantly affected on panicle length. As increasing inter-row spacing from 10 to 30 cm the panicle length was decreased. The longest panicle length(22.73cm) was recorded from 10 cm inter-row spacing whereas the shortest panicle length(20.26cm) was recorded from inter-row spacing of 30cm.The reason for shorter panicle length with wider inter-row spacing might be due to more number of tillers which provides inefficient available of growth resources to contribute less physiological process resulted to shorter panicle length. In line with this, it was obtained that more panicle length was recorded from appropriate inter-row spacing with less competition for better physiological process under which could be enhanced growth and development of upland rice (Singh and Tripath, 2008).

Number of filled grain per panicle

The analysis of variance revealed that the effect of seed rate was highly significant ($P<0.01$) and inter-row spacing was significance ($P<0.05$) difference on number of filled grain per panicle while their interaction was not significant (Table 4). The highest number of filled grain per panicle (38.59) was found at seed rate 60 kg ha-1while the lowest number of filled grain (25.23) was recorded at seed rate of 120 kg ha-1 due to high competition of water, nutrients and light (Table 4). The highest number of filled seed per panicle (45.28) was recorded on row spacing of 30 cm where the lowest (22.08) was recorded from row spacing of 10cm and it was statistically similar to row spacing 25 and 30 cm (Table 4). Harris and Vijayaragavan (2015). Reported that the increased plant spacing considerably resulted in vigorous plant growth and caused a significant increase in number of filled kernels per panicle in rice.

Number of Unfilled Grain per Panicle

Number of unfilled grains per panicle was not significantly ($p>0.05$) affected by seed rate and inter-row spacing (Table 4). This result was in contrast with the finding of Melkie (2017) who reported that number of unfilled grains was significantly ($p<0.05$) affected by seed rate and row spacing on rice.

Thousand seed weight (g)

Results from the analysis of variance indicated that seed rate and row spacing as well as their interaction were highly significant ($P< 0.01$) on thousand seed weight. Highest thousand seed weight (30.73 g) was obtained from seed rate of 80 kg ha-1 at 30cm of row spacing while the lowest thousand seed weight (17.53g) was found seed rate of 120 kg ha-1 at 10 cm row spacing, respectively (Table 4). The highest thousand grain weight at widest spacing might be due to efficient utilization of water, nutrients and light with minimal inter rows competition. On the other hand, at highest density competition would increase and little photosynthesis would be available to grain filling and finally thousand seed weight would reduce as result of insufficient photosynthesis during grain filling stage in densely populated crops. This result in line with the findings of Dereje (2016), who reported that increased row spacing, thousand seed weight also increase where the highest thousand seed weight (23.97 g) was recorded at row spacing of 30 cm while the lowest (21.97 g) was recorded at row spacing of 20 cm.

Table 2. The combine interaction effect of seed rate and row spacing on thousand seed weight of rice.

	Row spacing (cm)			
Seed rate (kg/ha)	**10**	**20**	**25**	**30**
60	27.67[cd]	30.27[d]	19.90[ab]	30.73[d]
80	19.10[ab]	28.73[cd]	22.73[abc]	27.37[cd]
100	25.37[bcd]	22.73[abc]	22.10[abc]	27.67[cd]
120	17.53[a]	29.80[d]	18.00[a]	28.33[cd]
LSD(P<0.05)	5.9			
CV%	4.2			

NS = non-significant, CV (%) = coefficient of variation in %, LSD = least significant difference at 5% level of significance, means in column and followed by the same letters are not significantly different at 5% level of significance according to LSD test.

Straw yield (kg/ha)

Straw yield was highly significantly ($p<0.01$) affected by the seeding rate. On the other hand, inter-row spacing and its interaction with seeding rate did not showed significance ($p>0.05$) effects on straw yield (Table 4).

Maximum straw yield (6172 kgha^{-1}) was produced at seeding rate of 120kg ha^{-1} while minimum straw yield (3694kg ha^{-1}) was produced at seeding rate of 60 kg ha^{-1}. The highest straw yield was obtained plants which are grown from seeding rate of 120 kg ha^{-1}. The reason for higher straw yield with higher seeding rate which ensures more number of total tillers and produce high biomass product resulted in maximum straw yield over lower seeding rates. This result was in harmony with Sultana *et al*. 2012, who revealed that as seeding rate increased straw yield was also increased due to higher number of total tillers.

Grain yield (kg/ha)

The statistical analysis of variance indicated that the seeding rate, inter-row spacing and their interaction had highly significantly ($p<0.01$) different on grain yield (Table 3).

The highest grain yield (3624 kgha^{-1}) was obtained from seeding rate of 100 kg ha^{-1} at 30cm inter-row spacing and the lowest grain yield was 2630 kgha^{-1} obtained from seeding rate of 120 kg ha^{-1} at 10cm inter-row spacing. The result of the current study indicated, as increasing seeding rate up to optimum level results increasing grain yield. The highest grain yield recorded from use of optimum seeding rate due to higher plant population in plots and higher number of filled grain per pod. In line with the present finding of Shunsuke *et al*.2017, showed that grain yield increases as plant density increases throughout the density range tested.

Higher grain yield in a wider space is due to higher number of effective tillers per unit area. In line with this result, Kandil *et al*.2010, who reported to a wider inter-row spacing provide higher number of effective tillers per unit area which results higher grain yield.

Harvest Index (%)

Harvest index was not significantly ($p>0.05$) affected by seed rate and inter row spacing as well as their interaction (Table 4). The result was in harmony with the result of Hardev, 2014, who reported that harvest index was not affected by inter-row spacing and seed rate.

Table 3. The combine interaction effect of seed rate and row spacing on grain yield(kg/ha) of rice.

	Row spacing (cm)			
Seed rate (kg/ha)	**10**	**20**	**25**	**30**
60	$2917^{b\text{-}g}$	2697^{ab}	3079^{fg}	$2830^{a\text{-}e}$
80	2718^{ab}	2714^{ab}	2767^{abc}	3103^{g}
100	$3000^{c\text{-}g}$	2695^{ab}	$2860^{a\text{-}f}$	3624^{h}
120	2630^{a}	$2790^{a\text{-}d}$	3029^{efg}	$3013^{d\text{-}g}$
LSD(P<0.05)	208.1			
CV%	8.4			

NS = non-significant, CV (%) = coefficient of variation in %, LSD = least significant difference at 5% level of significance, means in column and followed by the same letters are not significantly different at 5% level of significance according to LSD test.

Table 4. yield and yield components as affected by seed rate and inter-row spacing on rice.

Treatments	NET	PH(cm)	PL(cm)	NFGPP	NUGPP	SY(kg/ha)	HI%
Seed rate(kg/ha)							
60	12.55[b]	69.98[a]	20.43[a]	38.59[b]	6.467[a]	3694[a]	78.71[a]
80	10.83[a]	73.47[ab]	20.98[a]	26.82[ab]	5.192[a]	4019[ab]	70.61[a]
100	10.55[a]	75.17[ab]	19.89[a]	26.28[ab]	5.233[a]	4396[b]	70.93[a]
120	10.25[a]	78.47[b]	20.63[a]	25.23[a]	5.300[a]	6172[c]	67.55[a]
LSD(P<0.05)	1.14	6.3	NS	21.5	NS	470.9	NS
Inter-row spacing(cm)							
10	10.11[a]	71.38[ab]	22.73[c]	22.08[a]	5.133[a]	4653[a]	64.63[a]
20	10.5[a]	66.63[a]	21.50[b]	24.65[ab]	5.942[a]	4710[a]	59.70[a]
25	10.76[a]	76.75[bc]	20.44[ab]	24.92[ab]	5.267[a]	4405[a]	71.75[a]
30	12.37[b]	82.32[c]	20.26[a]	45.28[b]	5.850[a]	4512[a]	71.71[a]
LSD(P<0.05)	1.13	6.3	4.19	22.3	NS	NS	NS
Cv(%)	12.4	10.4	5.2	15.5	16	12.4	6.3

NS = non-significant, CV (%) = coefficient of variation in %, LSD = least significant difference at 5% level of significance, means in column and followed by the same letters are not significantly different at 5% level of significance according to LSD test.

Conclusion and Recommendation

The results indicated grain yield was increased at optimum inter-row spacing. Among inter-row spacing's 30 cm inter-row spacing produced higher grain yield as compared to 10, 20 and 25 cm spacing. In addition, the interaction effect of seeding rate and inter-row spacing indicated different responses on yield and yield components of rice. Therefore, the highest grain yield (3624kg/ha) was obtained at a seeding rate of 100 kg/ha combine with 30 cm inter-row spacing while, the lowest grain yield (2630kg/ha) was obtained at seeding rate of 60 kg/ha combine with 10 cm inter-row spacing. Therefore, using a seeding rate of 100 kg/ha combine with inter-row spacing of 30 cm can be recommended to obtain maximum rate of return for rice in the above-mentioned study area.

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Part V. Protection

14. Survey of Major Arthropod and Disease Pests of Cereals and Horticultural crops in four Districts of Somali Regional State

Takele Dejene

Somali region pastoral and agro-pastoral research institute (SoRPARI), Jigjiga, Ethiopia

Corresponding Author: E-mail: tekeyafet@gmail.com

Abstract

Pest survey was conducted to assess and identify major crop pests (insects and disease) of cereal and horticultural crops during 2020 and 2021 in four districts viz., Gursum, Gode, Berano and Kelafo. The four districts situated in different agro-ecologies with altitudes ranging from 350 to 1568 meters above sea level (m.a.s.l.). Pests were assessed both on plants at research on station and farmers field. Tomato, onion, pepper, okra, water melon and oranges, lemon, papaya, mango were grown in surveyed districts. Sorghum and maize are the dominant cereals in all districts. The survey revealed the occurrences of different economically important arthropods (insects and mites), and diseases on plant at on station and farmers field. Arthropods includes red spider mites, tomato leaf miner (Liriomyza spp.), white flies (Bemisia spp.), Aphids, mealy bugs, thrips, stem borers, fall armyworm, termites, and diseases such as Leaf curl, powdery mildew, purple blotch were recorded on plants in survey locations. The incidences and severity of pests varies across the districts.

Keywords: Cereal, vegetable, fruit, insect, mite and diseases

Introduction

The greatest challenge for humanity in the coming century is to double the present levels of food production to meet the needs of ever-increasing population by sustainable use of shrinking natural resource base (Deka *et al*., 2008). The aggravating pest problems under changing climate regimes are expected to intensify the yield losses; threatening the food security of the countries with high dependency on agriculture (Patterson *et al*., 1999; IPCC, 2007). Crop productivity may be increased in many regions by high-yielding varieties, improved water and soil management, fertilization and other cultivation techniques. An increased site-specific yield potential of crops, however, is often associated with higher vulnerability to pest attack, especially fungal pathogens favored by high plant density and nutrient-rich plant tissue (Oerke *et al*., 2006).

High economic losses in vegetables, due to several insect pests, diseases, nematodes and mites have been the major bottleneck in realizing the full potential of horticultural crops. It is estimated that 25-30 per cent yield is lost due to pest attack in vegetable crops which may be worth several crones a year. With a view to prevent the losses and to manage these pests, farmers usually tend to spray chemical pesticides indiscriminately leading to pesticide residues, greater environmental and health hazards (Sardana et al., 2017).

The crop production and productivity is very low in Ethiopia, one of the main reason are severe damage caused by various types of plant pests such as insects, mites, diseases, weeds and vertebrate pests like rodents and birds. Average crop loss due to these pests during the pre-harvest period is estimated at 30% or even higher, depending upon pest severity and extent and success of plant protection measures applied. Post-harvest crop loss is also estimated to be 15% (PASDEP, 2006). Pest challenges are more aggravated with introduced crops pests. Given poor pest regulatory control in Ethiopia, number of injuries pests, insects, disease and weeds have been introduced and cause significant loss in the agricultural sector. For instance, Tomato leaf miner,*Tuta absoluta*, White mango scale *Aulacaspis tubercularis*, Fall armyworm *Spodoptera frugiperda*, red spider mites, Larger grain borer, *Prostephanus truncatus (*Stored grain) are among major insect and mite pests introduced and widely distributed throughout the country and threating plant production(Tsedeke, 1992; Getu *et al*., 2003;Gashawbeza, 2014).

In Somali Region, the pest problem are more pronounced due to warm climatic condition which conducive for rapid pest population build up and damage. At the same time the region share large boundaries with Somali and Kenya, where exchange of agricultural product extensively move legally through trade and illegally through smuggling the problem of plant pest will one of a great threat crop production. More importantly, regulatory pest control or quarantine spot are permanently absent and the possibility of harmful plant pest introduction is very high. In this regard Orapa, (2006) stated that increased globalization and international trade, and the subsequent movement of biological material across international and bio geographical borders, poses an ever-increasing threat of invasive species problems. Globalization and an ever-increasing dependence on trade by all countries is providing enormous benefits, but these also present enormous new challenges, the movement (intentionally or accidentally) of invasive alien species such as weeds being among the most notable (Orapa, 2006). When these coupled with climate change the risk of devastation plant production will very high.

In Ethiopian in general and in Somali region in particular, scarce compressive information on what kind of pest species, incidences, prevalence, damage and economic importance associated with major crops. This information is perquisites to develop sound pest management option as well as for preventive intervention basis on adequate knowledge of pest occurrence and seasonal abundances on specific crop growth stages. Hence, the project initiated with the following objectives. General objectives of the project were to improve rain fed and irrigated agricultural and horticultural crop production and productivity through intervening with effective major pest management practices options through assessing and identifying major pests and losses associated with these pests on priority crops.

Materials and Methods

Study areas

Pest survey was conducted to assess and identify major crop pests (insects and disease) of cereal and horticultural crops during 2020 and 2021 in four districts viz., Gursum, Gode, Berano and Kelafo. The four districts situated in different agro-ecologies with altitudes ranging from 350 to 1568 meters above sea level (m.a.s.l.) (Hailu, 2009). The Gode, Berano and Kelafo are situated in Shebelle River basin, while Gursum is in upper Fafen valley. The district characterize by arid climatic condition. The major crops are maize and sorghum the two major cereals, vegetables (onion, tomato, pepper, watermelon) and fruits (mango, papaya, citrus) (Ayele, 2005; SoRPARI, 2007).

Survey and Pest Sampling

Field surveys conducted in aforementioned four districts during 2020 and 2021 cropping season to assess and identify major crop pests (insects and disease). The pests were assessed both on plants at on station and farmers field in each location. Different crops vegetables such as onion, tomato, pepper, potato, water melon, fruits such as papaya, mango, citrus, and cereals includes maize, sorghum were sampled and pests were identified under irrigation and rain fed production system. The plants were sampled by walking in (X) manner in the field, 1 plant at 10 paces interval, leaving border 3 row on each side. All sampled plants parts leaves, stems, fruits, flower were examined for pests and pest damages. Arthropod pests (insects and mites) were counted visually with help of magnifying hand lens 10 X in case of small pests like mites. The incidence was determined by summing of insect counts and dividing for total sampled plants in each location following methods of Meck, (2010) and Ogecha et al., (2019) with some adjustment. Severity score scale of 1–5; 1 (no symptoms) and 5; very high infestation levels were used for insect and mites (Ogecha et al., 2019). Disease severity and incidence were determined by examining the sampled plants symptom. The incidence and severity of disease measured following method of Agrios, (2005). Most of insect, mites and disease were identified on spot using colored field guide identification tools and keys (Overholt et al., 2001; Agrios, 2005; Gibb and Oseto, 2006; Alford, 2007, ACES, 2008; NICRA, 2012). In situation unable to identify in field diseased plant and immature insects specimen were collected and identified in laboratory.

3.2.1. Data analyses and interpretation of results

The collected data of insects, mite and diseases of different locations were analyzed using computer software, Statistix 10. The pest incidence and severity were presented in table and graph to all location.

Results and Discussions

Major Agricultural and Horticultural Pests

Different arthropods (insects and mites), and diseases have been recorded on plant at on station and farmers field during survey. Arthropods includes red spider mites, tomato leaf miner, white flies, mealy bugs, thrips, stem borers, fall army warm, termite and diseases such as Leaf curl, powdery mildew, purple blotch, anthracnose, are recorded on plants in survey locations.

Arthropods Pest of Horticultural Crops

Vegetables such as tomato, onion, pepper, potato, okra water melon and fruits like oranges, lemon, papaya and mango are among major horticultural crops assessed for pests both at on station and farmers field.

Arthropods Pest of Vegetables

I. Arthropods Pest of Tomato

Tomato by far the most vegetable damaged by cocktail of insects and mites in all survey locations Figure 1. Two spotted spider mites, tomato leaf miner (Liriomyza spp.), fruit worm, white flies (Bemisia spp) and mealy bugs were recorded on tomato. Except mealy bug which was observed in Gode, the rest were widely distributed in all surveyed locations. The density and infestation level of the pests were varies on tomato across the locations Figure 1. .

a. Two Spotted Spider Mite

Two spotted spider mite, Tetranychus urticae found on almost all sampled tomato of surveyed locations (Figure 1). The incidences and the percent of infestation was found highest with high level of severity in Berano 65.76 percent, Gode 56.98 percent (Figure 1). However, 100% infestation was observed on matured sampled tomato plants in Berano, where tomato totally destroyed by mite. Adults and larvae are two stages that cause feeding damage on plants. The mite inhibit and feed on the undersides of lower leaves that produces yellow spotting or stippling on the upper surfaces ((Frannie et al., 2011). Intensive chemical pest control in Berano and Gode may the underline cause for high incidences and severity of mite infestation in two locations. The pest status of mites is overwhelmingly increasing in line with intensive use of broad spectrum pesticide spray against other insect pests (Alston and Reding, 2011). It is projected that several nations face a potential increase in two-spotted spider mite outbreaks, while biological control by its key predator Phytoseiulus persimilis will not improve by 2050(Litkas et al., 2019). It is one of the emerging serious none insects pests of tomato in many region and countries (Srinivasan *et al.*, 2010). The mites also recorded on potato at on station in Gode.

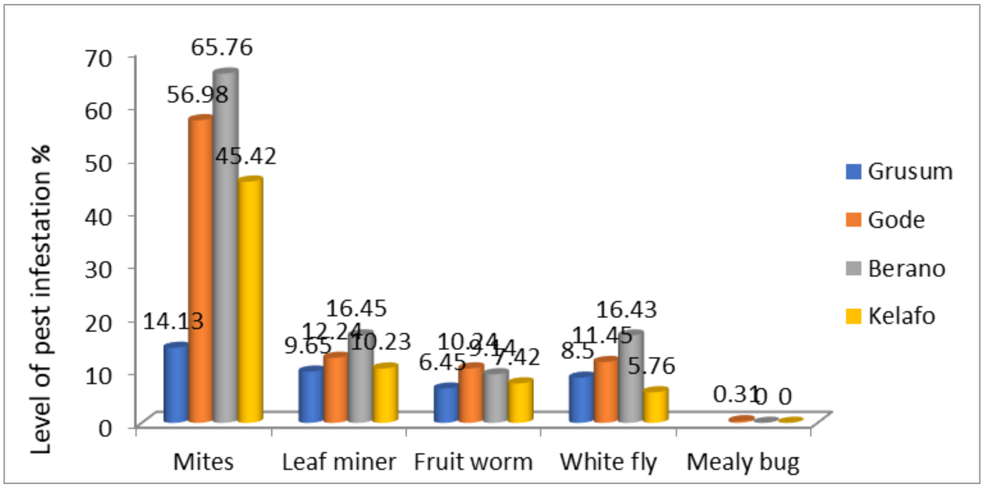

Figure 1. Arthropods pests found on tomato in the four locations

b. Leaf miner, Liriomyza spps.

Leaf miner was important insects pests of tomato recorded in surveyed location with high infestation level of 16.45 percent in Berano (Figure 1). This insect mines the leaf between upper and lower epidermis of the leaf and damage the leaf. It is larval stages that cause different types of mines infesting between epidermal layers. While feeding punctures (also called stippling) can be unsightly, economic damage is inflicted through leaf mining. Heavy leaf mining can reduce photosynthesis and cause leaf desiccation and leaf drop, which can result in sun scalding of fruit (Keularts, 1980). It is considered as secondary insect pests which their population normally checks by natural enemies. However, their population becomes spark when natural enemy population eliminated (Capinera, 2020) and /or reduced due to intensive application of insecticides to control other pests.

c. Whitefly - Bemisia tabaci

Whitefly is small sucking insect identified on tomato in all locations with high infestation level 16.43 percent in Berano (Figure 1)**.** It is found often on the underside of the foliage where it sucks the plant sap. This insect causes damage directly by sucking juices from the plant. With high populations plants may wilt, turn yellow and die. It also excretes honeydew, a sweet sticky fluid which covers the leaves completely. This reduces the capability of the leaves to produce energy from (sun) light (photosynthesis) and may lower harvest quality (Srinivasan *et al.*, 2010). The most important aspect of whitefly in plant damage is the plant disease they vectoring. White fly is the known plant viruses' transmitters, such as leaf curl in tomatoes. Any management that reduces or controls this insect also reduces the impact of the virus disease (Rodríguez et al., 2019).

d. Fruit worm and Mealy bugs

The tomato fruit worm, *Helicoverpa armigera* and Mealy bugs were insect pests found on tomato in different infestation level across the four locations (Figure 1). The highest incidence of tomato fruit worm recorded in Gode with infestation level of 16.45 percent. It is a highly voracious insect and is considered one of the major pests of the world's food and fiber plants (Srinivasan *et al.*, 2010). Leaves are damaged by feeding larvae and flower-trusses can be cut off. The most serious damage of the tomato fruit worm is that caused by penetration of the fruits by caterpillars (Srinivasan *et al.*, 2010). However, during this survey the fruit worm found at lower infestation level. This is because most of tomato sampled for the pest assessment found at vegetative stages except few fields.

A mealy bug was identified on tomato in Gode at farmer field and on tomato at on station (Figure 1). The insects not observed on tomato in other surveyed location. It is small, flat, soft bodied insects covered with a distinctive segmentation. Damage by mealy bugs is characterized by a reduction in plant photosynthesis and growth due to sap feeding and also, as a result of honeydew excretion, from sooty mould development and virus transmission (Canario et al., 2017).

II. Arthropods Pest of Onion

Onion thrips are the major insect pests of onion which found in all four surveyed locations (Figure 2). Mean incidence and infestation level were varies on onion across the locations (Figure 2). The highest incidence and infestation severity recorded in Berano 87.25 percent and 3.4, respectively (Figure 2). Locally called "*engir*" literally mean lice, due small size and hide in onion leaf like head lice in the hair. Thrips is the only insect pest found on sample onion plants in all surveyed locations. In irrigated onion production thrips considered the only economically important insect pest of onion in Ethiopia (Nikus, and Fikre, 2010). Thrips causes economic damage to onion by feeding and by vectoring disease causing microorganism. Thrips are an important vector of plant pathogens, such as fungi, bacteria, and viruses, which are carried around from plant to plant on the outside of the thrips body or in the thrips gut (de Vries, 2010) The owner of the vegetable farms in Berano told that he has no other constraints in onion other than thrips. *He state that "this onion is at two months growing stage, but so far 5 times insecticides spray against onion thrips, he will expect to spray 5 times in the next growth stage, totally least 10 spray thought out onion growing period.*

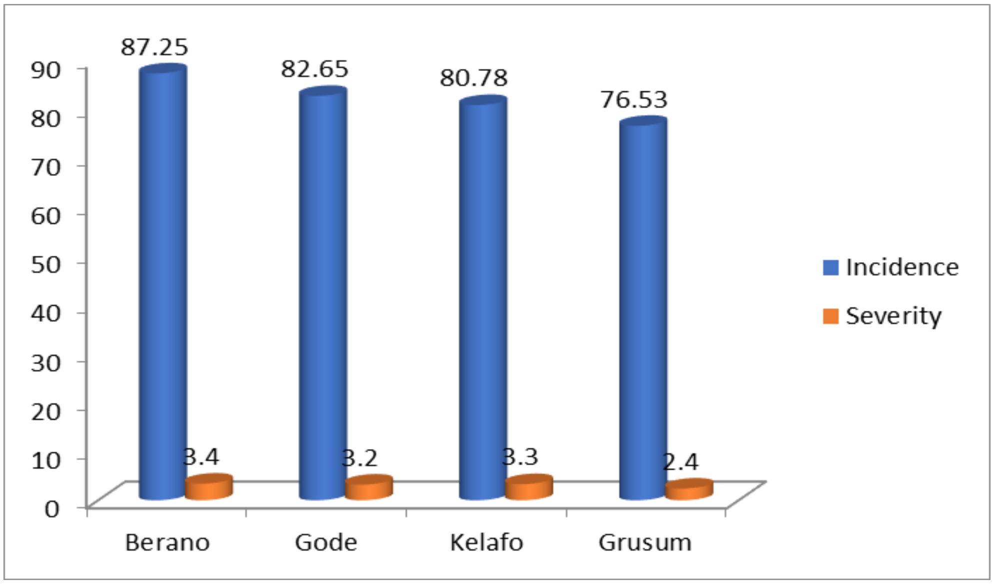

Figure 2: Thrips incidence and infestation severity in four districts

Arthropods Pest of Fruit crops

Different fruits crops such as oranges, lemon and papaya, mango are major fruit crops assessed for pests both at on station and farmers field.

a. Citrus Leaf Miner and Termites

Citrus leaf miner, *Phyllocnistis* spp. and termites were insect pests that observed on sampled orange and lemon fruit trees. The percent of infestation of citrus leaf miner was found higher 32.22 percent in Berano cooperative farms Figure 3. There was limited lemon and orange production in Gursum and Kelafo, and pest was assessed on few fruit field. The larvae of citrus miner feed on the young leaves and shoots and results in leaf curl. Heavily attacked plants can be spotted from a distance and the photosynthesis was adversely affected, vitality is reduced and thus lead to reduction in yield (Minyahil, 2015).

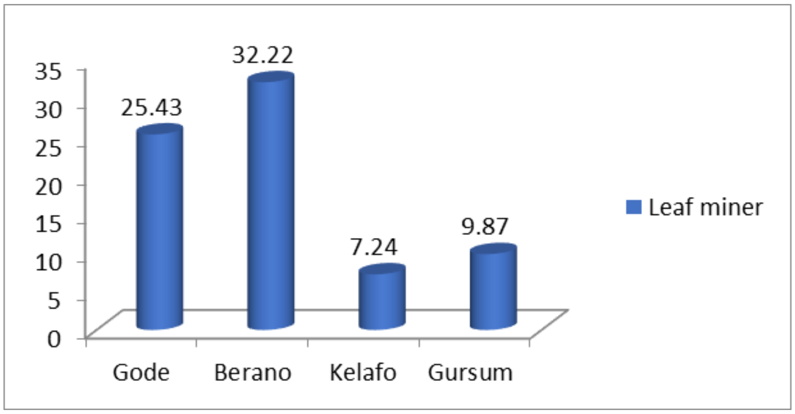

Figure 3. Citrus infestation by leaf miner infestation in three districts

Agricultural insect pest of cereals crops

Cereal includes maize, sorghum and wheat planted at on station and farmers field were assessed for pests. Pest assessed on wheat and rice planted at on station since no these crops found on farmers field. Numbers of insect and disease have been recorded with different in incidences as well as level of infestation. Stem borers, maize stem borer, spotted stem borer, fall armyworm and aphids were insects pests associated with cereals particularly maize and sorghum Figure 3. The incidence of insects pests were different in surveyed location. Highest infestation of maize and sorghum were caused by fall army worm 19.95 percent in Grusum and Gode district. Fall army worm is recently introduced insect pest of cultivated crops but distributed in all surveyed locations.

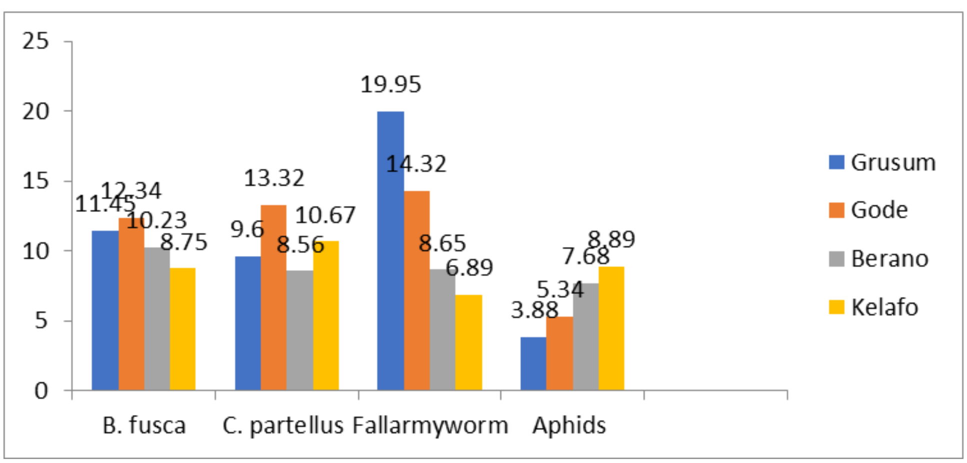

Figure 4: Incidence of insect pests on maize sorghum in four districts

Major Disease of vegetables and Fruit crops

Disease of vegetables

a. Leaf curl of Tomato and Pepper

Leaf curl of tomato and pepper observed in Gode, Berano and Grusum visited farmer field Figure 5.. The incidence and severity of the disease were higher in Gode 26.42 percent and 2.7 and Berano with 23.94 percent and 2.5, respectivelly. It is characterized by severe stunting of the plants with downwards rolling and crinkling of leaves. The old, curled leaves become leathery and brittle. Plants become pale and bushy in appearance. The disease commonly aggravated when there is sucking insects like white fly, thrips etc.

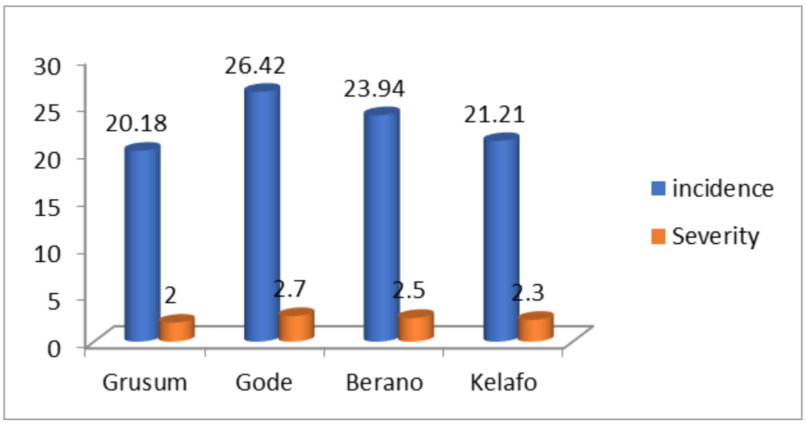

Figure 5. incidence and severity of leaf curl disease

b. Powdery mildew

Powdery mildew is a fungal disease observed in surveyed tomato plants in four locations Figure 6. The incidence and severity found higher in Gode with 21.42 percent and 2.24. The disease covers the upper leaf surface with whitish dusty powder (CABI, 2005). The disease is most commonly observed on the upper sides of the leaves. It also affects the lower sides of leaves, young stems, buds, flowers and young fruit. Infected leaves may become distorted, turn yellow with small patches of green, and fall prematurely. Infected buds may fail to open (CABI, 2005).

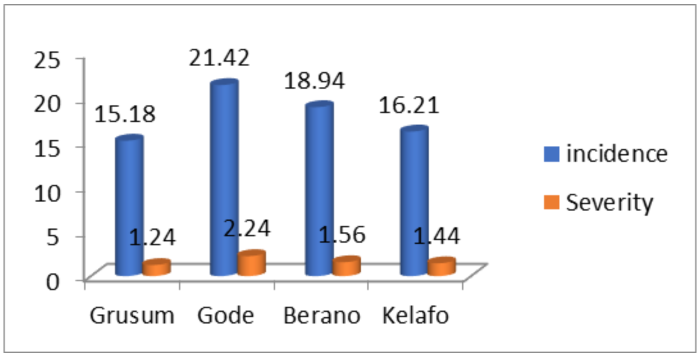

Figure 6. Incidence and severity of Powdery mildew disease

c. Purple blotch on onion

Purple blotch, Alternaria porri, is a regular fungal disease of onion in onion growing areas. During the survey the disease found all surveyed onion fields figure 7. The incidence 28.36 percent and severity of 2.8 was recorded on onion in Gode figure 7. It is one of major disease of onion in survey locations. It is probably one of the most common diseases of onion and is distributed worldwide (UGA, 2020). Thrip presence in onion aggravates incidences of purple blotch as thrips distribute the fungal through the plants. Its feeding also creates openings that allow for the introduction purple blotch (Dutta et al. 2014).

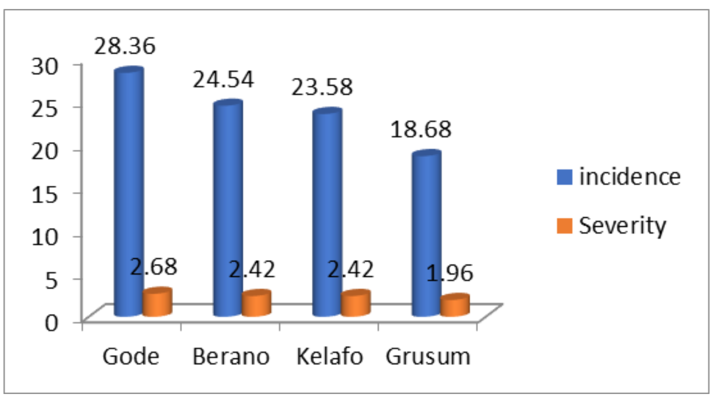

Figure 7. Incidence and severity of purple bloctch disease

Conclustions

Field survey conducted in four districts revealed that vegetables, fruits and cereals damaged by numbers of insect, mites and diseases. Among vegetables tomoto affected by coctial of insects, mites and diseases. Two spotted spider mites found none insect seriouse emerging tomato pests with higher incidences and severity on tomato in all location. Onion thrips the single major insect pest of onion with higher incidences and infestation severity. Citrus leaf miner found imoprtant insect pests of oranges and lemon in surveyed locations. On maize and sorghum stem borer, fall army worm and aphids were major insects pests. The recently introduced fall army worm were found in all locations with higher incidences and infestation severity. Among plant disease leafcrule, powdery mildew, purpl blocth were found important pests of vegetables in survey location.

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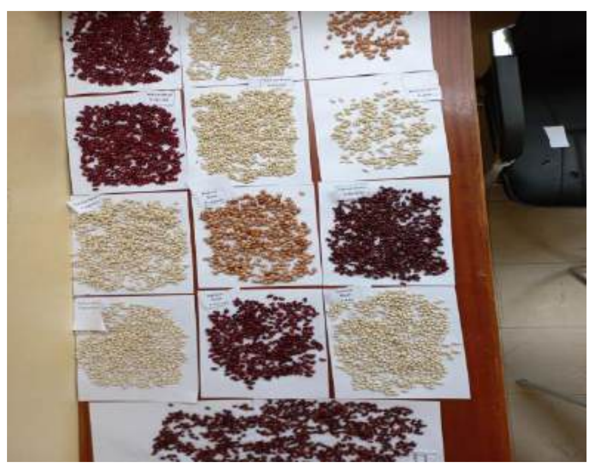
SOMALI REGION PASTORAL & AGRO-PASTORAL RESEARCH INSTITUTE (SoRPARI)

FOOD SCIENCE & NUTRITION RESEARCH DIRECTORATE



1. PHYSICOCHEMICAL PROPERTIES, PROXIMATE AND FUNCTIONAL PROPERTIES OF DIFFERENT RICE VARIETIES PRODUCED/ADAPTED UNDER SOMALI REGION AND IMPORTED RICE

ABDULKARIM MOHAMMED[1], MOHAMMED DOL[2], HODO MOHAMED JAMA[2] , HODO MOHAMED2

1. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition Research Directorate.
2. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition Research Directorate.

Abstract

Rice is one the staple food or crop that widely consumed in Somali community. The study was conducted in Somali Regional state with objective to analyze proximate, functional, physical and cooking qualities of different rice varieties produced in Somali reginal state. Six different types of samples such as Nerica 14, Nerica4, Nerica 2, Gode 1, Shabele 1 and Sukeyna as control sample were collected. Only whole rice grains without any physical damage or insect infestation were selected for analysis. The collected rice samples were individually grounded to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis. Proximate composition such as crude Protein, crude Fat, crude fiber, moisture content, carbohydrate, total energy, different minerals like Calcium, Iron, Magnesium and Total phosphorous were determined by AOAC. The functional and physical as well as cooking quality of the rice were determined different standard procedures. Based on the result all locally adapted rice varieties were better in both macro and micro nutrients especially Nerica 14, Nerica 2, and Gode 1 as compared to the control sample with brand name SUKEYNA which imported from abroad. The protein content ranges from 10.41% to 14.54%, while the ash content ranges from 0.51% to 1.25%. The same is true with other parameters such carbohydrate, crude fat, total energy too. There is significant different in different components of rice between different varieties at $p<0.05$. Significance difference were also observed at $p<0.05$ in minerals content such as Calcium, Magnesium, iron and Total Phosphorous where Nerica 14 had highest in almost all minerals content. The functional and physical properties of different rice varieties under study also significantly different at $p<0.05$. Overall, from the finding we conclude that, all locally adapted rice varieties have better in nutritional content both macro and micro -nutrient and also better in functional as well as physical properties. Therefore, all actors of rice should contribute the promotion as well large-scale production of these adapted rice varieties in order to substitute the imported rice from abroad.

Key words: Rice, Proximate composition, Functional Properties, Physical properties, Cooking time.

Introduction

Rice (*Oryza sativa* L.) is the most important cereal grain grown in the world. It is the staple food of nearly half of the world population. It is a regular Asian diet, usually taken as a whole grain after cooking, contributing about 40–80% of total calorie intake (Sarowar Hossain, Kumar

Singh, & uz-Zaman, 2009). It is mostly consumed at household level as boiled or fried rice. The preference for taste, color, and stickiness of rice varieties varies among different cultures. The two most important cultivated species of rice are *Oryza sativa* and *Oryza glaberriumn*. *Oryza sativa* is grown in most parts of the Asian and American continents, whereas *Oryza glaberriumn* is grown only in Africa. Rice consists mainly of carbohydrates in the form of starch, 72–75% of which contributes to the total grain composition. About 7% of protein mainly glutelin is present in rice. The glutelin present in rice is also called as oryzenin Sarowar (Hossain, Kumar Singh, & uz-Zaman, 2009).

Africa's rice production has not been able to match the growth in demand. With a high dependence on imports, Africa, as a whole, is highly exposed to international market shocks. This may have grave consequences for its food security and political stability. In many countries, African rice fails to compete with imports because large-scale commercial rice processing is poorly developed or limited, and urban consumers have become used to the look and feel of imported rice. The potential for growth in the overall African rice sector is enormous, but a rapid increase in the area under rice, irrigated as well as rainfed, is necessary (Alleoni, A.C.C., 2006).

In East Africa, a strong upward trend in production grew at a rate of 7.21% during the 2001-2005 period. Between 2001 and 2005, East Africa became nearly self-sufficient in rice, with rice imports representing only 7% of the total quantity consumed. However, with increasing rice demand in almost every country, reliance on the world market to supply rice to African consumers, even in relatively small amounts, is becoming a *very risky, expensive, and unsustainable strategy* and may lead to severe food insecurity and civil unrest. In terms of statistics, the total area brought under rice cultivation in East Africa increased at an annual rate of 0.45%. East Africa recorded a remarkably high rate of increase in yield between 2001 and 2005, at 6.73% per year (Childs N., 2015).

Rice is considered as the "Millennium Crop" to ensure food security in Ethiopia. In Ethiopia with about 17 million hectares of land suitable for rice production. Ethiopia has tremendous potential to increase the area under rice and is looking for partnerships to make use of this land. Constraints for sustainable increased production and productivity abound, however: poor access to improved rice varieties, especially for irrigated rice, and limited participation of seed growers in the production and marketing of rice seed; poor access and use of modern postharvest techniques and equipment; grassy weeds and insect pests; limited access to credit; shortage of labor, specifically during periods of intensive weeding; poor knowledge of producers and other market actors about rice product quality; excessive numbers of intermediaries, and price seasonality; and finally, inadequate storage (MoA, 2010).

Rice is a strategic food security commodity in Ethiopia, and its production has effected significant change in the livelihoods of farmers and has created job opportunities for a large number of people across different areas of the country (Minilik T. et.al., 2013). In the Somali region, the production of rice will play an important role in abating the problem of food insecurity in the farming community. Enriching Livelihoods and increasing the quality control of rice production in the Somali region is mandatory, therefore it is important to implant with Rice Research in the Somali region. To the best of our knowledge, there is no literature available regarding the characterization of rice varieties grown in Somali region and despite the good progress with its possible challenges and other source indicate there is no research done on these rice varieties produced under SoRPARI and other part of the region so far. Therefore, this study is aimed to analyze proximate, functional, physical and cooking qualities of different rice varieties produced in Somali reginal state.

Materials and Method

Materials and Equipment Used

Six different rice varieties produced/adapted under SoRPARI were collected and with one popular widely marketed/imported variety as a control was purchased from the local market. The five varieties produced or adapted under SoRPARI that were used for this study includes Shabele 1, Godey 1, Narica 14, Narica 2, Narica 4, and Sukeyna (as control sample) whereas the control rice type might be the one with most likely used by local community and imported one. Only whole rice grains without any physical damage or insect infestation were selected for analysis. Some equipment used in sample preparation were obtained from SoRPARI laboratories and missed equipment can be used from local institutes such as Jigjiga University. Further, after bringing to the laboratory, rice samples were individually grounded to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis.

Equipment and reagent such as size reduction machine, sieve, centrifuge, measuring cylinder, test tube, digital beam balance, distilled water, oil, tap water were used.

Proximate Composition

The proximate composition of rice flours was determined using the standard AOAC methods (AOAC, 2000). Moisture content was done by the gravimetric method in a hot air oven at 105 ºC until constant weight, and the quantity of ash was analyzed using a muffle furnace at 550 ºC. Crude protein content was measured by a standard Kjeldahl method using 5.95 as the conversion factor. Flour lipids were analyzed by the solvent extraction procedure. The content of total carbohydrates was determined by difference from the analysis of moisture, ash, protein and lipids.

Whereas, gross energy was determined by calculation from fat, carbohydrate and protein contents using the Atwater's conversion factors: 16.7 KJ/g (4 kcal/g) for protein, 37.4 KJ/g (9 kcal/g) for fat and 16.7 KJ/g (4 kcal/g) for carbohydrates and expressed in calories (AOAC, 2000).

Mineral analysis

The mineral contents were determined by the procedure of AOAC (1984). Calcium, iron, and zinc were determined according to AOAC 2000 official methods of 985.35 using an Atomic Absorption Spectrophotometer while phosphorous was determined by official method of 986.24 using calorimetric method using ammonium molybdate.

Statistical analysis

All the analysis were performed in duplicate and presented as mean ± standard deviation. Statistical significance of the data obtained were analyzed by One-way analysis of variance (ANOVA) followed by Duncan test by using GenStat version 17.0. The level of significance was considered at $P < 0.05$.

RESULT

Proximate

composition of different Rice

As shown in table 1, Nerica 14 has lowest while Sukeyna has highest moisture content. There is significant difference in moisture content between varieties but no significant difference between Shabele 1 and Nerica 4 varieties at $p<0.05$. When it comes to ash content, Nerica 4, Nerica 2 and Nerica 14 have high ash content than any other varieties. Sukeyna the control sample has least in ash content. Except Nerica 2 and Nerica 4 for which there is no significant difference in ash content all the other four varieties have significant difference in ash content at $p<0.05$.

Table 1: Proximate composition of different Rice Varieties

Varieties	**Results in (%) (100g)**						
	Moisture	**Ash**	**C.Fiber**	**C.Protein**	**C.Fat**	**CHO**	**Energy**
Shabele 1	9.235±0.04[c]	0.86±0.02[b]	0.70±0.01[bc]	11.14±0.12[b]	1.745±0.015[a]	76.32±0.02[d]	365.5±0.27[b]
Gode 1	9.415±0.015[d]	0.94±0.02[c]	1.05±0.05[cd]	12.21±0.08[d]	2.115±0.095[a]	74.27±0.22[bc]	365.0±0.30[b]
Nerica 2	8.915±0.015[b]	1.24±0.00[e]	0.65±0.15[b]	11.56±0.115[c]	2.485± 0.475[a]	75.14±0.46[c]	369.2±2.92[bc]
Nerica 4	9.265±0.035[c]	1.25±0.00[e]	1.00±0.00[bcd]	12.04±0.075[d]	2.200±0.330[a]	74.25±0.29[bc]	364.9±1.51[b]
Nerica 14	8.320± 0.05[a]	1.18±0.02[d]	0.25±0.05[a]	14.54±0.105[e]	2.650± 0.180[a]	73.06±0.27[a]	374.2±0.98[c]
Sukayna	11.565±0.04[e]	0.51±0.02[a]	1.25±0.15[d]	10.41±0.12[a]	2.355± 0.287[a]	73.91±0.31[ab]	358.5±1.81[a]

Key: Same letter in the same column is not significantly different from each other at $p<0.05$
Sukeyna: The control rice sample
CHO: Carbohydrate,
Energy: Energy in Calory unit obtained from consuming 100g of these rice varieties

Sukeyna has lowest protein content while Nerica 14 has the highest in protein content as compared to the other five samples. There is no significance difference in protein content between Gode1 and Nerica 4 varieties at $p<0.05$. but there is significant difference in protein content in between Shabele 1, Nerica 2, Nerica 14 and Sukeyna the control sample at $p<0.05$. According to table 1, there is no significance different in crude fat content between all samples at $P<0.05$.

As shown in table 1, Shabele 1 has the highest carbohydrate content while Nerica 14 has the lowest carbohydrate content. There is no significance difference between Nerica 14 and Sukeyna the control sample and also no significance difference between Gode 1 and Nerica 4 as well at $P<0.05$. There is no significance difference in energy obtained from consuming Shabele 1, Gode1, Nerica 2, and Nerica 4 at $p<0.05$. There is significant difference in energy Nerica 14, Sukeyna the control sample at $p<0.05$.

Minerals content of different rice varieties

The minerals content of the different rice varieties under study also depicted in table 2. Regarding the calcium content, Sukeyna the control sample has the lowest while Nerica 14 has the highest in calcium content. There is significance difference in calcium content between Nerica 14 and Sukeyna the control sample as well Nerica 14 with the others four varieties such as Shabele1, Gode1, Nerica 2, and Nerica 4 at $P<0.05$. With respect to magnesium content, Significance difference were observed at $P<0.05$ between Nerica 14 and Sukeyna the control sample and between Nerica 14 and other four varieties such as Nerica2, Nerica 4, Shabele 1 and Gode 1.

Table 2. Minerals content of different rice varieties

Varieties	**Results in mg (%)**			
	Calcium	**Magnesium**	**Iron**	**Total phosphorous**
Shabele 1	385.5 ± 0.00^{b}	749.3 ± 0.00^{bc}	29.11 ± 1.85^{d}	1685 ± 1.15^{c}
Gode 1	320.1 ± 11.04^{b}	563.2 ± 93.88^{ab}	19.46 ± 0.03^{b}	1383 ± 0.92^{b}
Nerica 2	411.6 ± 27.45^{b}	933.6 ± 0.00^{cd}	27.86 ± 0.355^{cd}	2280 ± 0.23^{e}
Nerica 4	462.7 ± 0.00^{b}	682.7 ± 120.48^{abc}	19.59 ± 0.02^{b}	1756 ± 0.46^{d}
Nerica 14	746.7 ± 92.66^{c}	1059.6 ± 132.45^{d}	25.16 ± 0.135^{c}	2434 ± 0.00^{f}
Sukayna	158.2 ± 0.00^{a}	432.6 ± 0.00^{a}	1.15 ± 0.00^{a}	1250 ± 0.00^{a}

Same letter in the same column is not significantly different from each other at $p<0.05$
Sukeyna: The control rice sample

When it comes to Iron content, Sukeyna the control sample has the lowest of all in Iron content while Shabele 1 has the highest. Significance difference were observed Shabele 1 and Sukeyna the control sample as well between Shabele 1 and Gode1, Nerica 4 and Nerica 14 at $P<0.05$. In total phosphorous content, Sukeyna the control sample has lowest while Nerica 14 has highest in total phosphorous content. There is 100% significance difference between every single varieties of the rice under this study at $P<0.05$.

DISCUSSION

Proximate composition (Macro-nutrient)

The macro-nutrient composition of the different rice varieties has been depicted in table 1; the five rice varieties adapted under SoRPARI potentials areas have lower moisture content than the control sample with SUKEYNA brand name. The lower in moisture content indicate advantage longer shelf life as compared to others varieties with higher moisture content. Basically, the lower moisture content is associated with dry condition storage environment during study time which means lower relative humidity. The difference in moisture content between varieties as compared to the control sample is come from agro-ecology and processing methods difference. Comparable result has been obtained from similar research on rice that has been done in Malaysia (Rachel T, et, al, 2013). Significant difference was obtained in ash content between the different rice varieties. In similar way, the ash content of those rice varieties adapted under SoRPARI potential areas were by far higher than the control sample called Sukeyna. There is also difference in ash content between each variety of SoRPARI rice. This might be the agro-ecology difference especially soil and water, genetic difference, and processing methods difference. The result is in line with the research done in Nigeria Eboniyi State and Malaysia (Oko A, et, al, 2010 and Rachel T, et, al, 2013).

When it comes to protein content, those rice varieties under SoRPARI potential area which is Gode in this case have higher than the control sample called Sukeyna as shown in table 1 above. Specially Nerica 14, Nerica 4 and Gode 1 have highest protein content as compared to others varieties. The highest in protein content might be at the cost of others lower component especially the moisture content. The highest in moisture content is highly advantageous in fighting against malnutrition the so-called protein energy malnutrition (PEM) for the community like Somali who use rice as their staple food. The difference in protein content might be associated with agro-ecology difference, processing method difference and genetic difference between rice varieties. Similar difference in protein content among difference rice varieties were obtained in the research done in India, Manipur province and in Nigeria Eboniyi State and Malaysia (Chagam K., et, al., 2020., Oko A, et, al, 2010 and Rachel T, et, al, 2013).

There also difference in other main composition such as fat, crude fiber, carbohydrate. This difference came as result of difference in processing methods, genetic difference among rice and some other reasons. The cumulative impact of difference in macro nutrient composition come with the difference in energy obtained from consuming these rice varieties as shown in table 1. The result is in line with other research done on difference rice varieties mentioned above.

Proximate composition (Minerals Content)

The minerals content of different rice varieties is also depicted in table 2 above. The mineral content is more or less linked to the ash content of the rice as in other food type. Overall, the control sample called Sukeyna has lowest in almost all minerals content than any others varieties in study area. This indicates, the local varieties are still preferable than the control sample when it come minerals content. With respect to calcium, magnesium and total phosphorous content, Nerica 14 has highest, followed by Nerica 4 and by other varieties as shown in table 2. The variances in the mineral content of selected rice varieties may happen due to various factors such as rice genotypes, agronomic, cultivation conditions and the different processing methods followed. Similar difference in minerals among difference rice varieties were obtained in the research done in India, Manipur province and in Nigeria Eboniyi State and Malaysia (Chagam K., et, al., 2020., and Oko A, et, al, 2010).

CONCLUSION

The study shows that, there is significance difference between different rice varieties in terms of proximate composition both macro and micro nutrient content, difference in functional properties and physical & cooking quality difference. Significance difference were observed in moisture, crude protein, ash, energy in calory unit and other contents among different rice varieties under study. The difference in macro nutrient more prominent when comparison made between the control sample with brand name SUKEYNA and others locally adapted varieties by Somali Pastoral and Agro-Pastoral Research Institute (SoRPARI) specifically with those NERICA varieties. Significance difference also observed when it comes to different minerals analyzed for these rice varieties such as calcium, magnesium, iron and total phosphorous. In general, the locally adapted rice varieties have better in terms of nutritional composition especially Nerica 14, Gode1 and Nerica 4 as compared to the widely used rice available in local market with brand SUKEYNA and others.

RECOMMENDATION

Based on the gaps and problem identified the research team recommend the following points;

- Government and other concerned bodies should set policy and strategy that give more emphasis to rice production at national or if possible regional level to substitute imported rice with mechanized agriculture system. Investors should be encouraged to engage in rice production and also further research with full package should be done.

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2. PROXIMATE COMPOSITION ANALYSIS OF DIFFERENT MAIZE VARIETIES ADAPTED UNDER SOMALI REGION PASTORAL AND AGRO-PASTORAL RESEARCH INSTITUTE (SoRPARI) ETHIOPIA.

ABDULKARIM MOHAMMED[1], MOHAMMED DOL[2], HOODO MOHAMMED[2], HOODO MOHAMED MOHAMUD[2]

1. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research Directorate.
2. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research Directorate.

Abstract

The study was conducted in Somali Regional state with objective to analyze macronutrient and mineral content of different maize varieties adapted under Somali Region pastoral and Agro-pastoral research institute (SoRPARI). Four different types of samples such as Melkasa-6Q, MH-138, BH661 and BH-549 sample were collected. The collected maize samples were individually grounded to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis. Proximate composition such as crude Protein, crude Fat, crude fiber, moisture content, carbohydrate, different minerals like Calcium, Iron, zinc and total phosphorous were determined by AOAC. Based on the result obtained, the ash content of the four maize varieties is in the range 4.06(Bh-549)-5.88% (Melksa-6Q), while the protein content from 12.82 (BH-549)-15.24% (Melkasa-6Q). The fat content is in the range 11.89 (BH661)-31.61%(Melkasa-6Q) while the carbohydrate content is in the range of 34% (Melkasa-6Q)-59.07% (BH-549). Significant difference was observed in most of these macronutrient content at $p<0.05$. Significant difference was also observed at $p<0.05$ in minerals content such as Calcium, Zinc, iron and Total Phosphorous where Melkasa-6Q had highest in almost all minerals content. Overall, from the finding we conclude that, all adapted maize varieties have good in both macronutrient and minerals especially Melkasa-6Q. Therefore, all actors of maize should contribute to the promotion of nutrient dense varieties of maize to the local community which in turn important for the fight against malnutrition.

Key words: *Maize, maize varieties, macronutrient, mineral content*.

1. Introduction

Maize belongs to Family Poaceae and Genus *Zea*. By origin, it is a tropical crop and has adapted magnificently to temperate environments with much higher productivity. It is grown from latitude 580 N to 400 S, from sea level to higher than 3000 m altitude and in areas receiving yearly rainfall of 250 to 5000 mm (Dowswell *et al.,* 1996; Premlatha and Kalamani, 2010). Major maize producers are the USA (30%), China (15%), European Union (14%), Brazil (4%) and India (3%). These five countries have around 60% of the world’s corn harvested area (Annonymous, 2007; Tao Ye *et al.,* 2015).

In sub-Saharan Africa, maize is a staple food for an estimated 50% of the population and it remains the most important agricultural crop for over 70 million farm families worldwide. Of the 22 countries in the world where maize forms the highest percentage of energy in the national diet, 16 are in Africa (Nuss and Tanumihardjo, 2011). Ethiopia is among the major maize producers in Africa and ranked third next to South Africa and Nigeria (FAO,2012).

Maize production takes significant share of cereals and grain in any production year. Among cereals, maize ranked second to tef in area coverage (21.7% for maize and 27.4% for tef), and first in total production (28.5% for maize and 19.9% for tef) and productivity (Mosisa et,al, 2011).

Maize is used as a basic food ingredient, either in its original or modified form. Maize grains are a rich source of starch (72%), ash (17%), protein (10.4%), fiber (2.5%), oil (4.8%), vitamins and minerals (Farhad *et al.*, 2009; Zhiqiang *et al.*, 2018). The oil and protein contents have commercial value and are used in food products manufacturing (Paliwal, 2000). Maize is used primarily as a food for humans in most areas of the world, in contrast to the United States where about 85 percent of the crop is used as cattle feed. Byproducts of processing are gluten feed, gluten meal, oil cake meal, germ meal, distiller's and brewer's grains.

Maize is used as human food in the form of tortillas, porridge, popcorn and barbecues and as forage and silage for animals. It is also a good source of industrial products such as starch (Zhang *et al*., 2012), vitamin (Warman and Havard, 1998), fiber, oil, weaning porridges (Mburu et al., 2012) and ethanol (Lamsal et al., 2011). Yellow maize, in addition to being dietary source of energy, lipids, protein, minerals and vitamins, it is a source of carotenoids (Adam & Liu. 2012, Menkir et.al, 2008). Food composition data is important in nutritional planning and provides data for epidemiological studies (Ali et.al, 2008). However, there is no or limited study about the nutritional content of the different maize varieties growing in Ethiopia particularly in Somali region. This study is designed to provide information on macronutrient and mineral composition of different maize varieties adapted under Somali region pastoral and agro-pastoral research institute (SoRPARI) Somali Region in Ethiopia.

Materials and Method

Materials and Equipment Used

Four different maize varieties produced/adapted under SoRPARI were collected from Kelafo agricultural research sub center. The four varieties collected were BH661, BH-549, Melkasa 6 Q and MH 138. Maize samples were individually ground to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis.

Proximate Composition

The proximate composition of maize flours was determined using the standard AOAC methods
(AOAC, 2000). Moisture content was done by the gravimetric method in a hot air oven at 105 ºC until constant weight, and the quantity of ash was analyzed using a muffle furnace at 550 ºC. Crude protein content was measured by a standard Kjeldahl method using 5.95 as the conversion factor. Flour lipids were analyzed by the solvent extraction procedure. The content of total carbohydrates was determined by difference from the analysis of moisture, ash, protein and lipids.

Whereas, gross energy was determined by calculation from fat, carbohydrate and protein contents using the Atwater's conversion factors: 16.7 KJ/g (4 kcal/g) for protein, 37.4 KJ/g (9 kcal/g) for fat and 16.7 KJ/g (4 kcal/g) for carbohydrates and expressed in calories (AOAC, 2000).

Mineral analysis

The mineral contents were determined by the procedure of AOAC (1984). Calcium, iron, and zinc were determined according to AOAC 2000 official methods of 985.35 using an Atomic Absorption Spectrophotometer while phosphorous was determined by official method of 986.24 using calorimetric method using ammonium molybdate.

Statistical analysis

All the analysis was performed in duplicate (unless stated otherwise) and presented as mean ± standard deviation. Statistical significance of the data obtained was analyzed by One-way analysis of variance (ANOVA) followed by Duncan test by using Genstat version 18.0. The level of significance was considered at $P < 0.05$.

Result and Discussion

3.1. Macronutrient content

Table 1: Proximate composition of different Maize Varieties

Varieties	Results in (%)/(100g)						
	Moisture	Ash	C.Fiber	C.Protein	C.Fat	CHO	Energy
BH661	10.68±0.00^{c}	4.07±0.00^{a}	3.11±0.11^{c}	13.49±0.80^{a}	11.89±0.38^{a}	56.77±1.26^{b}	400.5±1.96^{a}
BH-549	10.00±0.02^{a}	4.06±0.02^{a}	1.85±0.04^{b}	12.82±0.23^{ab}	12.20±0.29^{a}	59.07±0.01^{b}	404.7±1.51^{a}
MH-138	10.36±0.015^{b}	4.74±0.22^{a}	1.77±0.11^{b}	14.57±0.23^{ab}	11.96± 0.11^{a}	56.60±0.21^{b}	399.5±1.45^{a}
Melkasa-6Q	10.94±0.035^{d}	5.88±0.37^{b}	1.44±0.015^{a}	15.24±0.21^{b}	31.61±1.04^{b}	34.89±2.20^{a}	490.8±3.86^{b}

Key: Same letter in the same column is not significantly different from each other at p<0.05
CHO: Carbohydrate,
Energy: Energy in Calory unit obtained from consuming 100g of these maize varieties

The macronutrient content of different maize varieties has been indicated in table 1. As indicated, the moisture content significantly different among different maize varieties at p<0.05. The variation of moisture contents in maize flours may be attributed by different factors such as agronomic, environmental factors and the maize variety. The result in moisture content is in agreement with research done on seven different maize varieties by Kidist (2018) with is in between 9.42-11.45%. It is inconsistent with research done by (Kumar U. and Kweera B., 2014) which is in between 4.3 to 6.7%. On the other hand, the result of moisture content indicates all maize are in very good range for their shelf stability.

As shown in table 1, all maize varieties have high amount ash. The ash content beyond normal values of most common maize varieties of anywhere. This indicates all maize varieties have good source of different minerals. The ash content is a little bit different in amount among the four varieties and some are significantly different at P<0.05. This might be the fact that, there are different in variety, there response against different harsh condition might be different, the way they are managed during their farming time and some other reasons. Ash content of BH661, BH-549 and MH-138 maize flour was also in relatively good agreement with the literature 1.4–3.3% (Shaista Qamar et al.2016), whereas it is higher in melkasa -6Q maize. All maize ash content is inconsistent with result obtained by Kidist (2018) which is in between 1.37 to 1.74%. The difference might be due being in different agro ecology, different farming system and environmental factors.

Fiber has beneficial effects on diabetes, atherosclerosis, cancer, and appendicitis and prevention of duodenal ulcer formation and varicose veins (Yeung D. L. and Laquatra I. 2003). The fiber of different maize varieties under this study shows some significantly different at $P<0.05$ as shown in table 4.1. This might be due being different in variety, the resistance against different environmental factors. The result crude fiber content is in agreement with the research done by Kidist (2018) which are in the range of 1.62 to 3.46%.

Protein is the building block of all cells. All maize varieties have highest in protein content especially Melkasa-6Q which 15.24% as shown in table 1. But there is Significant difference among maize varieties under study at $P<0.05$. This might be the fact that, because of being different in their variety, their difference in their resistance and utility of naturally occurring nutrient, soil difference. The result of protein content is in agreement with the research done by Kidist (2018) on seven different varieties which are in the range of 9.69 to 15.30%. In a similar fashion, the present study range of crude protein contents were within the range reported by (Fageer et.al., 2004) for twelve genotype 11.3 to 16.9% and (Ullah I., Ali M. and Farooqi A. (2010)) for 10 varieties 7.7 to 14.6%. Fat is one the macronutrient which provide more than twice of energy than carbohydrate and protein. Exceptionally, melkasa-6Q has the highest crude fat content than any other maize varieties under study as shown in table 4.1. This might be the fact that, melkasa-6Q is one the new varieties released for its high in protein and some other useful nutrient content in fighting malnutrition. The result obtained is inconsistent with the research done on seven different maize varieties by Kidist (2018) which are in the range of 5.13 to 7.22%.

Carbohydrate is one the macronutrient which provide energy. The carbohydrate content of three maize varieties (BH661, BH-549, MH-138) are under normal range. But there is Significant difference at $p<0.05$ in carbohydrate content when it comes to Melkasa-6Q as shown in table 1. This difference mainly come as result of melkasa -6Q has high amount fat content. And it is also the fact that being different variety, their response against different environmental factors. The result obtained is inconsistent with the research done on seven different maize varieties by Kidist (2018) which are in the range of 67.10 to 69.99%.

Energy is obtained from the main macronutrients such as carbohydrate, protein and fat. There is no significant difference at $P<0.05$ in energy between all maize varieties except melkasa-6Q as shown in table 1 above. But there is a little difference in energy content among the three maize varieties under study except Melkasa-6Q. This is because of their difference in protein, carbohydrate and fat content. The result obtained is a little bit different from the research done by (Ullah I., Ali M. and Farooqi A. (2010)) on ten different maize varieties which are in the range of 365.95 to 385.83Kcal/100g.

3.2: Mineral content of maize

Table 2. Mineral's content of different Maize varieties

Maize varieties	Result in (mg/Kg)			
	Calcium (Ca)	**Zink (Zn)**	**Iron (Fe)**	**Total phosphorous (TP)**
BH661	670.7±41.54[a]	59.62±1.59[a]	135.1±7.85[a]	669.9±21.38[a]
BH-549	852.6±53.32[b]	61.84±1.22[a]	129.4±6.6[a]	759.7±11.98[a]
MH-138	1068.3±2.31[c]	66.84±3.43[a]	150.6±6.49[ab]	976.5±19.82[b]
Melkasa-6Q	1001.0±31.84[c]	85.42±0.31[b]	186.9±12.7[b]	901.4±26.59[b]

Key: Same letter in the same column is not significantly different from each other at p<0.05

Minerals are essential for body functions. The calcium content is in the range of 670.7 to 1068.3mg/Kg as shown in table 2 above. Except MH-138 and Melkasa-6Q there is significant difference in calcium content at P<0.05 among the maize varieties under study at p<0.05. This might be due to difference in variety, environmental factors, their utilities toward minerals in the soil. The result obtained is in contradict with the research done in Ethiopia by Kidist (2018) on seven maize varieties which are in the range of 219.8 to 481.0mg/Kg and it also inconsistent with result of (Shaista Qamar et al.2016) done in Pakistan which are in the range of 1290.27 to 1327.56mg/Kg. This difference may be due to being in different agro-ecology, different farm management system, virginity of soil and some other reasons.

When it comes Zinc, the values are in the range of 59.62 to 85.42mg/Kg. There is no significant difference in zinc content except Melkasa-6Q at P<0.05 as shown in table 2. This little difference come as result of being difference in variety, their response against different harsh condition, soil types. The result obtained is in contradict with the research done in Ethiopia by Kidist (2018) on seven maize varieties which are in the range of 23.1 to 29.3mg/Kg and it also inconsistent with result of (Shaista Qamar et al.2016) done in Pakistan which are in the range of 6.1 to 33.89mg/Kg. This difference may be due to being in different agro-ecology, different farm management system, virginity of soil and some other reasons.

The iron (Fe) content of different maize varieties under study is in the range of 129.4-186.9mg/Kg. There is some significance difference among maize varieties under study as shown in table 2 above. This is because of being different in their variety type, utility of minerals with in a soil, difference in soil minerals continent. The result obtained is in contradict with the research done in Ethiopia by Kidist (2018) on seven maize varieties which are in the range of 23.4 to 37.3mg/Kg and it also inconsistent with result of (Shaista Qamar et al.2016) done in Pakistan which are in the range of 80.73 to 115.13mg/Kg. This difference may be due to being in different agro-ecology, different farm management system, virginity of soil and some other reasons. Finally, the total phosphorous content of the four maize under study is in the range of 669.9 to 976.5mg/Kg. There is some significant difference among maize varieties under study as shown in table 4.2 above. This difference come as a result of being different in variety, soil mineral content, their utility toward this mineral.

Conclusion and Recommendation

From the result we conclude that, all maize verities have high macronutrients and minerals content especially melkassa-6Q. The high in protein and ash content is most important in fighting malnutrition especially the hidden hunger if these maize varieties are mixed with nutrient dense legumes and nuts or fortified with different supplements. The high in minerals content is an indication that our region soil is rich of minerals and virgin. Therefore, we recommend all stakeholders to work in collaboration to provide stress resistant, nutrient dense maize varieties to the community in ensuring food security.

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CONFLICT OF INTEREST

This is to confirm that, there is no conflict of interest between authors for this study.

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SOMALI REGION PASTORAL & AGRO-PASTORAL RESEARCH INSTITUTE (SoRPARI)

AGRICULTURAL MECHANIZATION RESEARCH DIRECTORATE

1. Development and evaluation of engine driven Multi-crop Grain Cleaner in Somali Region State, Ethiopia

Firew Kassahun[1], Kalid Hussein[2]
Email: firew2719@gmail.com and kalidxusen2015@gmail.com
Somali Region Pastoral and Agro-pastoral Research Institute, Agricultural Mechanization Research Directorate, Jigjiga, Ethiopia

ABSTRACT:

It is impossible to grow and harvest cereal grains without getting undesirable intermixtures despite proper care and tending of the crops. The cleanliness of small sized grains such as sorghum and millet, is usually challenging after threshing operations. A grain cleaning machine was developed using locally available materials and based on detailed engineering design. The machine was used to clean sorghum and millet. It was evaluated using output capacity, cleaning efficiency, and percentage grain scatter loss as the performance parameters, while feed rate, air speed and crank amplitudes were used as the experimental factors. Results from the machine evaluation, indicates that the output capacity ranged between 620.83 to 1088.5 kg/hr. and 620.50to 1097.83 kg/hr. for sorghum and millet, respectively while the cleaning efficiency ranged between 98.04 to98.66 % and 97.30 to 98.05 % for sorghum and millet, respectively. The scatter loss was obtained within ranges of 0.83 - 1.27 % and 1.31 - 2.12 % for millet and sorghum, respectively. The best performance of the machine

was obtained at air speed and crank amplitude of 4.5 m/s and 25 mm, respectively for both crops, and feed rates of 1400 kg/hr. for sorghum and 1200 kg/hr. for millet. The research however, achieved the best cleaning efficiencies of 98.64 and 98.05 %, for sorghum and millet, respectively.

KEYWORDS: *Grain cleaning, fabrication, cleaning efficiency, output capacity, grain scatter loss*

I. INTRODUCTION

Grain cleaning is a postharvest operation undertaken to remove foreign and undesirable materials from

Threshed seeds/grains thereby leaving the produce clean for storage, planting or further processing. It is material separation process. Cereal and leguminous crops need to be threshed and detached from their cops, panicles or pods before the process of cleaning. Grain cleaning is done to: reduce requirement for drying and cost; remove materials that could cause deterioration during storage; remove materials that could damage the conveying and milling machinery; remove materials that cause a reduction in the grade (thus reducing the value of the grain); and reduce storage requirements. There are a number of factors that affects the cleanliness and loss of grains during cleaning operations. According to Simony an (2006), the physical parameters that affect grain cleaning processes are broadly grouped into; crop characteristics and machine parameters. The crop factors are; crop variety, maturity stage, grain moisture content, straw moisture content, bulk density of grain, bulk density of straw, stalk length, and equivalent grain diameter, while the machine factors are; velocity of air, air stream pressure, air density, angle of air direction and terminal velocity of particles (both grain and other materials).Other scholars and researchers have also reported on factors such as feed rate, amount of wind or air velocity, shaker frequency, sieve tilt angle, dimension of sieve opening, crop variety and moisture content (Awady et al.,2003; Ebaid, 2005; Sahay and Singh, 2008; Salwa et al., 2010, Muhammad et al., 2013).

The constantly expanding Somali region population will continue to demand an ever-increasing agricultural production of food and fibber. In order to address the problem of our persistently increasing population there is the need to introduce modern farming. Modern farming involves the use of different agricultural technology.In modern agriculture, there are two major inputs especially for cereal crops which are machinery and labor. The main objective from this input is maximizing the profit, productivity must increase and the cost must reduce. From that, the conclusion is machinery can be maximizing the profit, increase productivity and reduce cost. One of the important activities in most cereal crops cultivation is post-harvest processing operations.

Almost all the food, feed, fiber and fuel commodities go through a number of postharvest processing operations such as cleaning, grading, separation, drying, storage, milling, food processing, packaging, transport and marketing before it reaches to the consumers. Agricultural processing is directed towards conservation of produce and value adding to make the material more readily usable, consumable and economically more remunerative. This research aims to develop a prototype cleaning machine for major cereal crops that can clean at-least one ton of the grains in an hour, thereby reducing the drudgery in post-harvest processing. The development of the prototype machine would be of importance to cereal and seed producers, as it will improve the cleanliness of their products and increase the market value.

II. MATERIALS AND METHODS

Construction of Grain Cleaning Machine

A prototype grain cleaning machine was designed and constructed in the metal and fabricating Workshop of the Department of Agricultural Engineering Technology,jigjigs Somali Region State. The major components of the prototype machine are shown in the drawing(Fig. 1) and Table 1 gives a description of the machine. Figure 2(a and b) present the pictorial views of the machine. The main parts of the cleaner consist of the frame which serves as the skeletal support and means of coupling and holding other component parts together.

The hopper is trapezoidal shape with the base inclined at an angle of 300 for discharge and even distribution of grains over the first screen. The shaft diameter was determined using

Equation expressed by Khurmi and Gupta (2007), while the size of the driven pulley was determined using Equation given by Hannah and Stephen (1984). The blower has three blades enclosed in the casing to deliver air current over the reciprocating screens. The sieve compartment consists of the casing, two outlets, and three round screens (6.0, 4.5 and 2.0 mm) made with mild steel, selected based on determined physical properties of the grains. All screens are replaceable and adjustable between 0 and 120. The screen compartment oscillates with the aid of a connecting rod attached to the main shaft and an adjustable crank which helps to achieve various levels reciprocating amplitude.

Fig 1: Machine prototype

Table 1. Description of Construction Materials

S/No	Material Description	Quantity	Material
1	Frame (25 × 25 × 5mm - Angle iron)	1	M.S - Angle iron
2	Hopper (1.5mm)	1	M.S – Sheet (Gauge 18)
3	Shaft (Ø 25mm)	1	M.S - Rod
4	Connecting rod (Ø 16 mm)	1	M.S - Rod
5	Pulley (150 diameter)		M.S
6	V-Belt	1	Leather
7	Sieve compartment (3mm)	1	M.S – Sheet (Gauge 18)
8	Sieves (2.0, 4.5 & 6.0 mm hole diameter)	3	M.S – Sheet (Gauge 18)
9	Flexible support for sieve compartment (5mm)	4	M.S – Flat bar
10	Fan housing (1.5mm)	1	M.S – Sheet (Gauge 18)
11	Fan blades (5 mm)	3	M.S – Sheet (Gauge 18)
12	Outlets	2	M.S – Sheet (Gauge 18)
13	Pillow Bearing	2	
14	Prime mover (Petrol Engine - 3.5hp)	1	

Scale - 1:5
All dimensions in mm

III. RESULTS AND DISCUSSIONS

Effect Feed Rate on Machine Performance

The regression analysis shows a polynomial relationship of feed rate with cleaning efficiency for millet and a high negative linear correlation of feed rate with cleaning efficiency for sorghum. The coefficient of determination for the effect feed rate on the cleaning efficiency for sorghum and millet is 0.9182 and 0.7174, respectively. Simonyan et al. (2006), Salwa et al. (2010), Muhammed Et al. (2013) and Afolabi (2015) have reported similar trends of decreasing cleaning efficiency with increasing feed rates. The effect of decreasing cleaning efficiency with increasing feed rates may be on the sieve and multiple particles acting as obstructions to the air flow. As the feed rate is increased the materialAttributed to the increasing load intensity flowing across the air current forms a thicker blanket making it increasingly more difficult for air current to penetrate and flush out the unwanted materials.

The regression analysis showed a positive linear correlation between feed rate and scatter loss for sorghum and a polynomial relationship forMillet. Grain scatter loss increased with corresponding increase in feed rate. Muhammad et al. (2013) reported polynomial relationship between scatter loss and feed rate for sorghum and millet grains. The coefficients of determination for the relationship is 0.9996 and 0.9566 for sorghum and millet, respectively. The increase in grain scattering with feed rate could be explained due to the fact that as the feed rate increase gradually, the material that flow across the air current allows air to flush out some of the grains alongside the unwanted material. The output capacity for both grains increased with increase in the feed rate.

Fig 2: (a & b): pictorial veiw of th machine

IV. CONCLUSION

A multi-crop cleaning machine was developed based detailed design and it was found to be very effi SAMSORG 43) and millet (Ex BORNO) at moisture levels suitable for storage were sourced locally and used as the test crops. The machine was tested and the output capacity ranged between 620.83 to 1088.5 kg/hr and 620.50 to 1097.83 kg/hr for sorghum and millet, respectively, while 98.04 to 98.66 % and 97.30 to 98.05 % are the respective ranges for cleaning efficiency of sorghum and millet. The scatter loss was obtained within ranges of 0.83 - 1.27 % and 1.31 - 2.12 % for millet and sorghum, respectively. Cleaning efficiency of 98.05% at 0.89%grain loss was obtained as the best in cleaning millet, while the corresponding value for sorghum is 98.64% at 1.59%.The optimum cleaning efficiencies were obtained at air speed of 4.5m/s, crank amplitude of 25mm, and feed rates of 1400kg/hr. and 1200kg/hr. for sorghum and millet, respectively.

Client in the separation process of grains from the associated foreign matter. Samples of sorghum.

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2. Development of Rice Para-Boiler and Socking Machine in Somali region

Firew Kassahun[1], Kalid Hussein[2]
Email: firew2719@gmail.com and kalidxusen2015@gmail.com
Somali Region Pastoral and Agro-pastoral Research Institute, Agricultural Mechanization Research Directorate, Jigjiga, Ethiopia

Abstract:

The rice parboiling machine is used for parboiling of paddy rice before milling. The machine is made to have five main units which includes the water supply tank, boiler, energy unit, steamer and the soaking unit. The existing parboiling machine has a production capacity of 5kg per batch in every five hours and has no provision for soaking the paddy. In the traditional parboiling process, paddy is soaked in water for 3 days, steamed and dried before milling, and the rice usually give off bad odor due to fermentation as a result of prolonged soaking. The modified rice par boiling machine is designed to par boil about 400kg per day which will take not less than 5 days to parboil traditionally

Keywords: Rice, parboil, milling, boiler steamer, soaking

1. Introduction

Rice is a cereal crop which is cultivated in swampy fields of human/animal consumption. It comes third to wheat and maize in terms of world cereal production, but nevertheless being rated second to wheat in the carbohydrate content and stands as a principal feed crop for over half of the world population. The principal growing areas are in India, Bangladesh, China, Japan, South Africa, but smaller quantities are grown in Africa, Italy, Spain, Brazil, United State and Chile (John.1981)

More than 8,000 botanically different rice varieties are known, but by and large they fall into two main type of group. The India varieties mostly long-grained and are harder while the Japonica varieties are shorted grained and are less hard - a variety commonly found in African countries (John, 1981)

When harvested from field, it is threshed and after which the grain is known as paddy rice (sometimes referred to as rough rice) which consist of about 20% hull sand 80% grains. The hull consists of two half leaf like structure i.e. lamina and paleainter locked by enclosing the bran layers which are removed by abrasion and finally, the naked grain known as white rice has been processed (John,1981).

Parboiling of rice paddy involves soaking the paddy in water or hot water to hasten the soaking rate. Thereafter, steamed and later dried to a moisture content of about15% by mass before milling operation.

The poor quality of a locally produced rice is causing a serious draw back in the Nigerian economy

Foreign rice is one of the food items which the Federal Government as expressed serious concern for the rate at which it is imported for consumption at the expense of locally produced one. The Government considered that as a threat for our economy and therefore solicit for patriotic citizen or even foreign bodies to come and establish factories to improve the quality of our locally produced rice.

Generally, the two major factors influenced a quality outturn from milling are the degree of ripeness and the parboiling process. A thorough investigation and analysis was carried out and it was discovered that the traditional parboiling process practiced contributed a lot to the poor physical qualities of our indigenous rice. The process involves soaking rough rice or rice paddy over right in water for three (3) days at ambient temperature followed by boiling or steaming the steeped rice at 100°C to gelatinize the starch and then sun dried before milling operation. This result in soul odour due to fermentation for its longer time of soaking period, and greater percentage of broken grain on milling operation for not drying to optimal moisture content before milling operation.

The development is aimed at elimination of unwanted odour and reduction in soaking period by the use of hot water to soak at 60°C below the starch gelatinization temperature, steamed at optimum temperature and pressure; thereafter to be dried under shade to a moisture content of 15% by mass. The existing traditional parboiling machine has a problem with the control of pressure and temperature generated in the system. This result in subsequent failure of the system while in operation. The rate of the above problem, we have incorporated an automatic pressure relief valve to operate base on (10sN/m2 and100°C) at which the hull of the paddy begins to split. Not only that, but also to safeguard the cylinder from failure through explosion. Another problem encountered with the existing machine is its low capacity and subsequent less production (5kg every 5 hours) compared to the traditional method in place. These we have tackled by using bigger size cylinder tank, boil energy unit, and also by incorporating a soaking cylinder (40kg per batch) which is four time bigger in size than steamer so as to ensure continuous production of about l0kg/hr of steamed paddy.

The project is aimed at developing an improved rice parboiling machine, the objectives is to produce a rice parboiling machine that is simple in construction and easy to operate using locally available materials so that it will be affordable to an average farmer.

There are many advantages in rice parboiling. It reduces grain breakage during milling, greatly improve the vitamins and nutritional value of the grain, enhance the cooking and eating quality of the rice and reduces insect infection during storage. In the traditional parboiling process, due to some problems such as fermentation as a result of prolonged soaking produce soul odor, poor physical quality of milled rice etc. The development is aimed at eliminating of unwanted odor, reduce soaking period, reduction of heat loss and greatly improvement in terms of percentage of breakage during milling operation. This project is done to parboil our local rice varieties (short grain rice) the construction of the machine was made using locally available materials.

2. Methodology

2.1 Design of the Component

The following show the size, type, shape and material used for each component in this project

2.2.1 Water Tanker

A tank with a capacity almost twice that of boiler is constructed with the pipe outlet at the base and positioned on its stand above the boiler so as to feed the boiler by gravity. Between the boiler and the tank is a non-return valve and a gate valve. When the gate valve is fully opened, the velocity of the flow is proportional to the square roof of the heard producing (Torricelli Cheorem),

2.2.3 The Boiler Design

In engineering field, we usually come across vessels or cylinders of hemispherical ends containing fluids such as boilers. Generally, the walls of such vessels are very chin compared to their diameter. They are considered thin wall thickness to diameter doles not exceed approximately ratio 1:20 (Zhigalla, 2004).

The vessels are subjected to internal pressure due to the steam generated inside it and its walls are subjected to tensile stress. The choice of cylindrical shape with hemispheric end is made for its ability to withstand such high pressure that is liable to cause subsequent failure of the unit. Since the boiler is a cylinder with hemispheric ends and with the fact that the unit experience high stress at the ends than the cylindrical part, the hemispheric ends are made to have thicker materials than the cylindrical part. Let t 1 be the thickness of the cylindrical portion and t2 be the thickness of the hemispheric end with the internal diameter assumed to be same for both: p be the internal pressure.

2.2.4 Steamer

A cylindrical air tight whose top cover in incorporated with a pressure relief valve is constructed. The pressure relief valve is employed to control the optimum pressure and temperature with which the hull of the paddy begins to split. This optimum condition are 105N/m2 and 1000 c analysed by food technologist (Magnus Pyke, 1981) using 0.03 m diameter of unknown weight as in figure above.

2.2.5 Soaking Cylinder

Since the production for soaking a paddy at 60°c is four hours per batch, while that of steamer is one hour to ensure a continues production, the capacity of the soaking cylinder is made at least twice bigger in capacity than the targeted steamer production per batch. A cylinder whose diameter is 0.57m and length of 0.78m will conveniently be used for soaking. The total capacity of the soaking cylinder is 1.99 x 10-1m 3 out of which 1.1024 x 10-m 3 will be occupied by the targeted production per batch of soaking which is 100kg of paddy while the remaining 4.87 x 102m 3 will be occupied by the water used for soaking.

2.2.6 Drying Process

The steamed is to be dried to an optimum moisture content of between 13% - 15% by mass under shade on a clear concrete floor or mat let the initial weight of 10 No. of paddy = W, Then weight of equal number of the soaked paddy=WS Let the final weight of some number while drying = Wf Moisture content

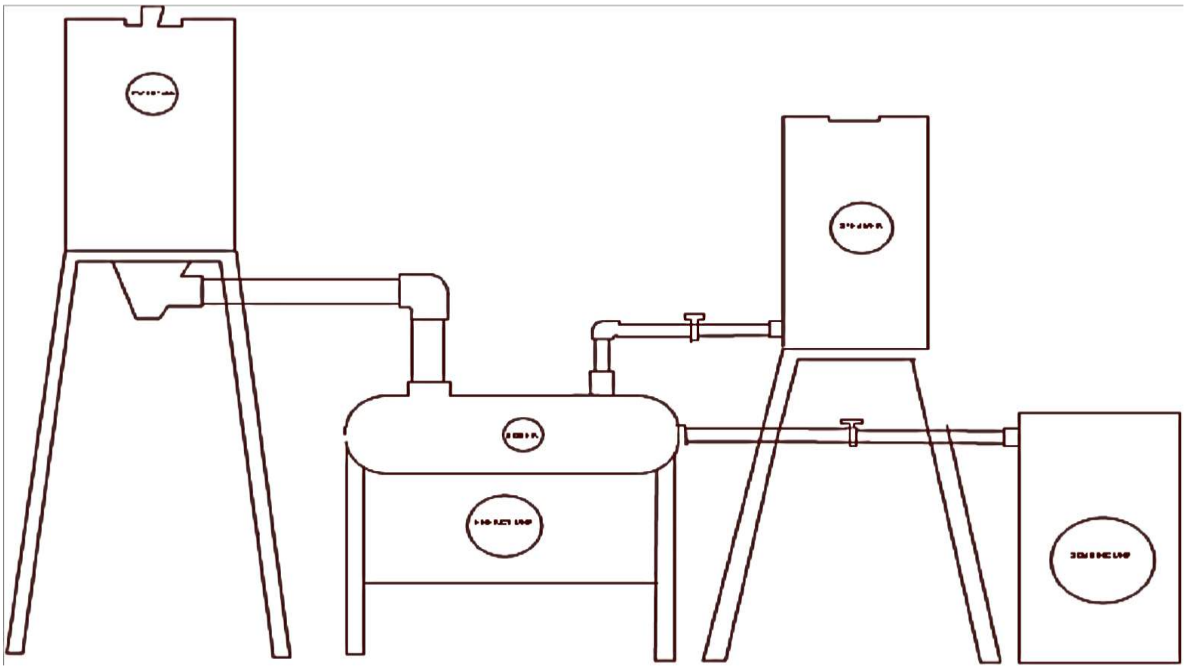

Figure: Rice par-boiling machine

1. **Material Selection**

S/No	Description	Material	Size
1	Boiler	Galvanized Steel	$0.01995M^3$
2	Water Tanker	Galvanized Steel	$0.0321M^3$
3	Soaking Cylinder	Galvanized Steel	$0.087978M^3$
4	Steamer	Galvanized Steel	$0.0321M^3$
5	Distribution Pipe	Mild Steel Coated with Zinc	160mm and 140mm
8	Elbow Joint	Galvanized Steel	¾ Inch and 1½
9	Socket	Galvanized Steel	¾ Inch

1) **Result & Discussion**

Table 1: Parboiling Time of the Rice

Weight of Rice (Kg)	Time To Parboil (Hr.)
5	1
10	2
25	4
50	8

Figure 4: Variation of Time to the Quantity of Rice Parboiled

The rice parboiling machine after construction was tested with 5kg (20measure of paddy rice and the following are processes and facts obtained.

1) **Soaking Process:** Paddy was soaked at 60°C temperature inside a soaking cylinder for the period of four hours to reduce the incidence of aflatoxin contamination during the soaking. Separation of chaff and offer foreign material from the good paddy was made by floatation.

2) Steaming Process: during steaming, Slitters of water was sup pliedintotheboiler.7.5kg of charcoal was supplied into the energy unit. They were burned for the period of about 80 minutes from which it took about 20minutes before the water attained its saturation temperature (boiling point).

At the end of steaming process about 1 liter of water was left unevaporated, unbound; thus 5.5kg of charcoal was expanded to convert 71itresof water into steam under atmosphere pressure.

3) Drying Process: After 60minutes of steaming, the steamed paddy was discharged for tempering under shade and it took about 24hours to attain 15% moisture content by mass.

Figure: 6 Rice-Para-boiler Components

Conclusion

Design processes are sometimes very heavy work. At times they are measure and the results obtained are not good enough, redesign are made over and over until the task is accomplished. The difficulties encountered along the run, however. Are always well rewarded with clear success attained.

It is important to note that the change design to facilitate ease of manufacture, low cost and good output in both quantity and quality and not easy to go by. Some of the problems encountered was that of the construction of a boiler with a capacity of about 371itre that will be able to steam about 200kg (80 measure) of soaked paddy i.e. steaming about 50kg per batch. The rice parboiling machine has been tested and found to be more effective with over 60% of material constituting the construction are locally contained. The machine being designed and constructed is able to increase the capacity output of parboiling about 400kg (3bags) per day which would make not less than 3days to parboil it traditionally. Not only in the area of capacity but also use had less energy cost i.e. charcoal in place of firewood.

Other areas of improvement include

- Elimination of bad odor due to fermentation
- Less breakage of rice during milling operation
- Improvement of nutritional value as it retains more protein and vitamin

Recommendation

The parboiling machine construction was incomplete because the following parts could not be found in the market:

- Temperature gauge (metal type)
- Pressure gauge
- Water gauge

These gauges give accurate pressure and temperature dairy parboiling process for accurate result. Since they are absent in our construction, the result of the parboiling will be accurate when the machine is tested. We therefore recommend that those who wish to carry on from where we stop can get these items and fit them for efficient performance of the machine. Also to hasten the rate of water heating, a blower should be incorporated because the average atmospheric air velocity of 2.5 m/s is not enough to provide 111 5kg of air which is the stoichiometric value of the air per kg of charcoal, otherwise firewood may be used. While installing the machine of soaking cylinder with a capacity of about 0.2m be incorporated to guarantee continues production without storage.

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3. Introduction and Evaluation of Walking Type Two Wheel Wheat Harvester (Reaper and Binder) in Lefyssa Kebele, Awubere Woreda, Somali Region, Ethiopia

Kalid Hussein[1], Firew Kassahun[2]

Email: kalidxusen2015@gmail.com and firew2719@gmail.com

Somali Region Pastoral and Agro-pastoral Research Institute, Agricultural Mechanization Research Directorate, Jigjiga, Ethiopia

Abstract

The walking type harvester machine was introduced and evaluated its performance by harvesting wheat. The field experiments were carried out at Jigjiga Research Center research field. The main Parameters considered during this study were crop mositure content, operating of the harvesting machine, harvesting losses and cost of harvesting. The average effective field capacity and field efficiency of the harvester was found to be 0.182 ha/h and 81% respectively whereas the effective field capacity in manual harvesting was 0.008 ha/h. Fuel consumption of the reaper was 0.92 lit/h, 5.08 lit/ha. Average value of harvest losses in mechanical harvesting was 1.42 percent only whereas average value of harvesting losses in manual harvesting was 1.73% which is more than that of mechanical harvesting. The cost of harvesting for harvester and for manual harvesting were 479Birr/ha and 1600Birr/ha respectively. The percent saving in the cost of harvesting is reduced by 30% harvesting of wheat with harvester over manual harvesting. Hence, the machine harvesting would be feasible and economical compared to manual harvesting method in terms of time, money and labor requirement.

Keywords: *walking behind harvester, field capacity, field efficiency, harvesting lose.*

INTRODUCTION

Ethiopia is an agrarian economy with a mainly rain fed agricultural system; wheat (Triticumvulgare) and barley are among the main cereal crops which contribute about 68.3% of the national food grain production (CSA, 2008). Ethiopia is the second largest wheat producing country in Africa followed to South Africa. Wheat is mainly grown in the central and southeastern highlands during the main (Meher) rainy season (June to September) and harvested in October-November. Arsi, Bale, and parts of Shoa are considered the wheat-growing belt.

Harvesting is one of the most important operations of farming. Most of the parts of the country have been harvesting manually. This is a labour intensive seasonal operation consuming about 18-20% of the labour required for growing cereal crops (Singh et al., 2008). The traditional method of harvesting with sickle is both labour as well as time consuming, where both are scarce during the peak harvesting season. Labour scarcity during peak period of harvesting leads to delay in harvesting and field grain losses. Also high labour cost during peak period adds extra cost in total cost of harvesting. Mechanized harvesting is an alternative solution to tackle this problem. As a step towards mechanization of the harvesting operation for cereal crops, the alternatives available were considered such as selfpropelled combine harvesters and tractor mounted combine harvesters. The uses of combine harvesters have their limitations. The farmers want to recover both grains as well as the straw from wheat crops, because the straw is main source feeds of the cattle. Moreover, Ethiopian farmers' fragmented and small farm size holdings, over 69 percent of smallholder farmers in the cereal growing own farmlands less than or equal to one hectare (CSA, 2013). However, high level harvesting combine harvester is not affordable for them. Most of the cereal crops are harvested by sickle, which is quite tedious and labor-intensive job. During the peak season of harvesting, farmers face the difficulty of getting their crop timely reaped due to shortage of agricultural laborers. Non-availability of labor due to increased rural-urban migration. Hence, keeping these facts in view, this study was conducted to evaluate the performance of the walking behind harvester machine and introduce technology options, to minimize the cost of harvesting through farm mechanization.

OBJECTIVES

General Objectives

- To contribute in the enhancement of agro-pastoralist wheat production through the application of Walking Type Two wheel wheat harvester (Reaper and Binder).

Specific Objectives

- To introduce and evaluate walking-type harvester that could enhance production and productivity of agro-pastoral community of the region.
- To increase harvesting technologies options by availing best performing self-propelled walking- type harvester.

MATERIALS AND METHODS

Description of the study area

This activity was implemented in Awbare Woreda Lefe isa kebele. This Woreda is one of the woredas in the Fafan Zone of Somali regional state (SRS). The woreda is bordered on the southwest by Jijiga, on the west by the Sitti Zone, on the east by Somaliland, and on the southeast by Kebri Beyah. Cities and towns in the Awbare district include Awbare, Awbube, Sheder, Lefe Isa, Derwernache, Gogti, Jaare and Heregel. The experiment was conducted at Jigjiga Research Center Lefe Isa kebele. The majority of the land under cultivation is covered with wheat, and barley ,most of the small scale agro-pastralist/farmers harvesting wheat was performed manually with sickle.

Technology Introduction and Evaluation Methods/Technique

The introduction and evaluation of the technology was conducted first by selecting best walking type two wheel small scale harvester. The detailed manufacturers technical Specifications of walking type harvester used for field performance evaluation used are Presented below in table 1:-

Table 1: Technical Specification of Reaper binder Harvester

S.No	**Performance Indicators**	**Unit**	**Value**
1.	Overall Dimension (LxWxH)	**mm^3**	1830 x 610 x420
2.	Handle Type	---	Both Hands
3.	Power Transmission Method	---	Automatic Centrifugal Clutch, Spiral Gear
4.	Applied Blade	---	4-teeth blade, 8-teeth blade, bamboo blade, round saw blade, round saw blade, chip saw, more unit nylon cutter
5.	Blade Rotation Direction		Counter Clockwise (From Operator`s View)

6.	Harvesting row		**-**	Two row
7.	Weight		**Kg**	74
8.	Engine	Manufacturer	---	China or Japan
		Type	---	Single cylinder air cooling 2 cycle gasoline engine
		Displacement Volume	**Cc**	41.5
		Carburetor	---	Float, Piston Valve
		Starting Method	---	Recoil starter
		Stopping Method	---	Sparking Circuit Primary Short
		Fuel Used	---	Gasolin
		Lubricating oil used	---	2-cycle engine oil
		Fuel thank capacity	**Lit**	3

Field Experment

The evaluation of the walking type mini harvester machine was conducted on experimental plot size of 30mx10m (300m^2). Then the wheat harvested by mechanical harvester and manual with sickle and replicated three times. The area of the plot was measured with tape. Also randomly three small areas were selected in the plot for determining shattering loss. To calculate the operational speed of harvester, time was recorded that was taken to travel a certain distance. The distance was measured with a measuring tape and time was counted with a stop watch. Such operations were done in several times to calculate the average speed of operation. The actual field capacity was calculated by dividing the total area harvested by total time taken to harvest a certain plot.

RESULTS AND DISCUSSION

The walking behind harvester was evaluated for its performance by harvesting of wheat durig 2011 harvesting season. The experiments were carried out in the extent of 0.18 ha at Jigjiga research Center of research farm. Parameters and Measurements considered during this study were crop parameters, machine performance parametr, harvesting losses and cost of operations. The results of field performance based on test conducted are summarized in Table 2 and 3.

Table 2: Wheat crop parameter considered on the test results

Parameters	Growth stage				
Height of plant , cm	97.2	89.6	87.9	91.6	90.2
Number of tillers per sq. m	252	243	287	261	261
Height of cut, cm	20	13	15	16	32
Condition of crop	erect	erect	erect		erect
Grain moisture content, %	8.9	8.6	8.7	8.73	8.73
Straw moisture content, %	8.32	8.47	8.47	8.42	8.42

Table 3: Test results of mechanical harvester compared with manual harvesting by sickle

Parameter	**Harvesting Methods**				
	Mechanical Harvesting				**Manual Harvesting**
Replication	1	2	3	Average	
Actual area covered (ha	0.03	0.03	0.03	0.03	0.03
No. of Labours	1	1	1	1	5
Total time of operation (min)	10.25	9.45	10	9.73	44.40
Effective working width (cm)	120	120	120	-	-
Forward speed (km/h)	1.95	1.78	1.88	1.87	-
Theoretical field capacity (ha/hr)	0.234	0.214	0.226	0.225	-

Actual Field capacity (ha/hr)	0.175	0.190	0.180	0.182	0.008
Field efficiency %	74.78	88.78	79.64	81	-
Labour requirement, manhr/ha	5.69	5.25	5.56	5.5	123.33
Fuel consumption (lit/hr)	1.06	0.79	0.92	0.92	-
Fuel consumption (lit/ha)	5.83	4.33	5.08	5.08	-
Potential grain Yield (gm/m2)	533.95	482.87	606.18.	541	541
Harvesting losses (g/m2)	5.85	7.50	6.60	6.65	7.99
Harvest losses (shattering + Uncut) %	1.10	1.55	1.08	1.22	1.48
Conveying loss (g/m2)	1.10	1.19	1.04	1.11	1.37
Conveying loss, %	0.20	0.24	0.17	0.20	0.25
Total harvesting loss, %	1.30	1.79	1.25	1.42	1.73

Machine performance

Measurements of harvester performance for wheat crop were the rate and quality of the machine at which the operations are accomplished. The mean value of the performance parameter that include time losses; total working time, test plot area, cutting width, cutting height, operating speed, theoretical field capacity, actual field capacity and field efficiency are shown in Table 3. The cutting width was 1.2 meter and the operating forward speed of the machine was found 1.87 km/h. The actual field capacity of the reaper for wheat crop was 0.182 ha/h. The theoretical field capacity of the machine is a function of speed of travel and cutting width and computed result is 0.225ha/h. Field efficiency of reaper harvesting machine was 81%. In manual harvesting with sickle, a laborer on average can harvest 80 m2 /hr, but this amount can differ with respect to crop condition, laborer ability and weather condition. The required time for harvesting one hectare of wheat in manual harvesting was 123.33 man-h/ha compared to 5.5 man-h/ha for the harvesting (Table 3). The harvester was 22.42 times faster compared to manual harvesting.

Harvesting losses

The measured values of harvesting, conveying losses and total harvesting (conveying and harvesting) losses for wheat in reaper and manual harvesting methods are presented in Table 2. The mean percentage of conveying losses in reaper and manual harvesting for wheat crop were 0.20% and 0.25% respectively and that of harvesting losses were 1.22% and 1.48% respectively. The total losses in reaper and manual harvesting were 1.42% and 1.73%. In earlier study, S.S. Karahle (2015) reported that 0.93% harvesting loss during harvesting of wheat by self-propelled reaper binder against 1.83% loss of manual harvesting. **Economic analysis**

The local purchase price of the reaper was 52,000birr. The annual fixed cost (7410 Birr) and variable cost (68.34Birr/h) were found from the calculation. The working hour of the reaper was considered 416 hours per year. The fixed cost and variable costs for both reaper and manual harvesting are presented in Table 4. In this study, manual harvesting required 16 man/days to harvest one hectare of wheat field.

Considering the labor cost as 100Birr per day, 1600.

Table 4: Harvesting cost of reaper and manual harvesting

Machine harvesting cost				Manual harvesting cost	
Cost items	Birr/Year	Birr/ha	Birr/hr	Birr/ha	Birr/hr
Fixed cost				1600	12.50
Depreciation	4,680	62.55	11.25		
Interest	1,430	19.13	3.44		
Taxes, insurances and shelter	1,300	17.40	3.13		
Total fixed cost	7,410	99.08	17.82		
Variable cost					
Fuel		14,094.08	188.35		
33.88 lubrication		2,114.11	28.25		
5.08					
labor	10,400	139	25		
Repair and maintenance	1,820	24.33	4.38		
Total variable cost	28,428.19	379.93	68.34		
Total cost of harvesting	35,838.19	479.01	86.16	1600	12.5

Figure: 1 a) Walking Type Reaper Binder Mini Harvester b) Evaluation of the harvester machine at
Jigjiga center

SUMMERY AND CONCLUSIONS

Based on the field performance evaluation harvester conducted during harvesting season of 2011, it can be summarized as follows:-

The average effective field capacity and field efficiency of the reaper was found to be 0.182 ha/h and 81% respectively whereas the effective field capacity in manual harvesting was 0.008 ha/h. Fuel consumption of the reaper was 0.92 lit/h, 5.08 lit/ha. Average value of harvest loosens mechanical harvesting was 1.42 percent only whereas average value of harvesting losses in manual harvesting was 1.73% which is more than that of mechanical harvesting.

The cost of harvesting for reaper harvester and for manual harvesting were 479Birr/ha and 1600Birr/ha respectively. The percent saving in the cost of harvesting is reduced by 30% harvesting of wheat with reaper harvester over manual harvesting. For economic justification of machine application, the yearly capacity of machine must not be less than 6ha/year. It can be conclude that, the use of harvesting is much more economic and efficient for harvesting of wheat compared to manual harvesting method. Therefore in fields where the use of walking behind harvester is possible, it will play an important role in reducing production costs.

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4. Adaptation and Evaluation of Hammer mill (Livestock and poultry Miler) in Somali Region Fafen Zone

Kalid Hussein[1], Firew Kassahun[2]

Email: kalidxusen2015@gmail.com and firew2719@gmail.com

Somali Region Pastoral and Agro-pastoral Research Institute, Agricultural Mechanization Research Directorate, Jigjiga, Ethiopia

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Abstract

Crop residues are considered among the most important materials in Ethiopia especially maize Stalk, beanstalk, sorghum stalk, and wheat and barley straw. There are many types and models of imported top hammer miller in Ethiopia to assist in milling the grain. Those machines, which are imported, have many problems such as size of mill and rusting of hammers which not advisable to human food. Therefore, the machines adapted and evaluated for livestock feed process purpose in terms of crop residues like maize stalk, beanstalk and wheat straw with predetermined feed rate and hammers' shaft speed (RPM). The research was conducted at Somali Region Pastoral & Agro-pastoral Research Institute (SoRPARI) to evaluate the machine performance in crushing maize stalk, beanstalk, and wheat straw for animal feed. In this paper, two top feed hammer mills were used. They are collected from market in Jigjiga town. The performance of the machine is evaluated in terms of crushing capacity, crushing efficiency and crushing loss. The output of the market top hammer miller was satisfactory. The market top hammer miller produced a highest crushing efficiency and capacity about 99.33 % and 152.54 kg/hr. while the BAERC's was produced 94% and 78.68 kg/hr, respectively. The crushing losses of the market top hammer miller were 2.67, 0.67 and 5 % on maize stalk, bean stalk and wheat straw respectively.

Key words: crushing capacity, crushing loss, crushing efficiency.

INTRODUCTION

Ethiopia has the largest livestock population in Africa (wiki, 2017, CSA, 2015/16). The livestock subsector comprised 11 percent of national GDP and 24 percent of agricultural GDP and is a source of revenue for 60–70 percent of the population. Between 2005 and 2008, livestock population (in terms of cattle, sheep, and goats) in Ethiopia grew at 22 percent. Oromia region produced the largest share, 38 percent of livestock within Ethiopia, while Amhara and Southern Nations, Nationalities, and Peoples (SNNP) regions produced 26 and 16 percent of livestock shares, respectively according (CSA, 2013). Livestock play a central role in the natural resource-based livelihood of the vast majority of the population living in developing countries. However, most of these regions face the problem of acute shortage of feed resources. The pastures are degraded and poorly managed and the area under green forage crops is shrinking due to increase in human population and urbanization (FAO, 2012).

In other hand, Agricultural farming is characteristics of huge scrap and waste material. On completion of harvesting activities, the biomass is invariable left in the fields to decay naturally or disposed of by burning away. However, a small part of the biomass is used as domestic fuel and cattle feed. Normally, farmers pay a great attention to collection of the widely scattered and strewn stem fragments in the field owing to high cost of labor as also that of transporting the stalk to the place where it store or consumption. In general, there is no alternative processing technology for farmers, that the agricultural crop residue can be put to productive use and products of significance.

On the national scene prospect, the quantity of biomass so generated is certainly very large. This underlines the undisputed need for effective end use this form of agricultural waste. Huge quantity of biomass in the form of stalk, if systematically collected and processed, can be gainfully deployed for produce animal feed.

Problems Statement

Livestock feed preparation is a great problem nowadays. Earlier time there is grazing area. Now the quest to increase the agricultural production in all surfaces, have intensified crop production by increasing cultivated areas causes reducing the grazing areas. Livestock farmers especially in the sector of goats, sheep and cattle are constantly faced with problem of feed shortage during the dry season. During this period, grazing livestock lose weight and in extreme cases, some deaths do occur. As a result, bulky of feeds available for ruminants in these regions are the crop residues. The crop residues have low nutritional value and are bulky and fibrous.

In addition, these feed resources are also not well managed, especially where these are available in plenty. Availability of crop residues varies with season and region. In some regions, there is deficiency of crop residues only in certain seasons, in others a perennial deficiency may prevail, while in some other regions and in particular seasons them are available in abundance but are largely wasted. Thus, straws worth millions of dollars are burnt in the fields in these places after the grain harvest. Apart from the wastage of a potential feed, the burning of straws causes environmental pollution and degradation of soil fertility. Improvement in the management of crop residues enables efficient utilization of this potentially useful feed resource. Therefore, in order to help and address the problem of small-scale farmers and develop it into a modern production sector strengthening the intermediate technology were essential.

Objective

To adapt and evaluate the top hammer miller machine to crush crop residue for livestock feed purpose.

MATERIALS AND METHODOLOGY

Description of the Machine

The Top feed hammer miller machine was constructed in Somali Region Pastoral Research Institute (SoRPARI). The major components of the top feed hammer miller's machine are the frame, pulleys, hopper, sieve, and hammer, hammer house and 5Hp electric motor. Figure:1 show the hummer miller used in the experiment.

Figure 1: Evaluation of Top Feed Hammer Miller Machine

Sieve size Determination

Determination of the sieve whole size was done depends on the recommended particle size for different animals. According to the Egyptian standard specification for prepared animal feeds and feedstuffs, compressed feeds are sized into four categories a) sizes < 2mm in diameter ranked: powder or mash, which was used for all types of poultry and birds. b) Sizes 2-6mm in diameter, which was used for rabbits, goats and fishes. c) Sizes 5-10mm in diameter for small animals (<6months). d) Sizes 10-22mm in diameter for large animals (>6months) (Basiouny and Yamani, 2016).

Working Principle

A 5Hp electric motor was used as source of power to operate the machine during the entire work of the experimental investigation. The machine was adopted to employ a combination of hammering and sieving principles to crush and mill the crop residue. Crop residue was prepared and subjected to the hammer through the hopper with predetermined rate. Then the rotating hammer bit the crop residue in the hammer house until, it abled to pass through the sieve to the outlet. The hammer mill is conventionally a hammer-like projection mounted on a rotating shaft. The hammers are hung in such a way that they can swing either ways depending on centrifugal force or impact on the materials. The hammers revolve at high speed and crush the materials fed into its chamber by beating. Hammer size, number and arrangement are very important. Hammers are usually installed on high-speed shafts. The distant between the screen and hammer should be 12 to 14 mm for size reduction of cereal grains and about 5mm for fibrous material (HOQUE et al., 2007). However, according this experiment the distance is fixed to 2.5 cm.

Measuring Devices and Instruments

Cole-Parmer 8204 tachometer, with measuring range of 62 to 19999 rpm and having a resolution of 1rpm was used to measure the speeds of shafts. Digital balance, made in England capacity of 50kg with 200g difference, was used to measure weights of samples before and after crushing the experiments.

Preparation of Samples

Samples for experimental investigations were prepared from materials obtained after threshing of wheat and bean, and after harvesting of maize. Three kilogram of samples with three replications were taken, crushed and weighed to determine the mass of crushed materials before and after commencing on the experiment. The samples prepared were fed at the rate of 3kg at predetermined hammer shaft speed (1200, 1800 and 2200RPM).

Performance Evaluation

During each test, run materials inserted in the hopper and leaving through the outlet (mass before and after crushing) were weighted using digital balance Performance evaluation of the top hammer mill was made based on crushing efficiency, crushing capacity, crushing loss and fuel consumption. As per Hesham et al., 2015 crushing efficiency and capacity as well as crushing losses were calculated using Eq. (1, 2 and 3).

1. Crushing efficiency (CE)

$$CE = \frac{Mass\ of\ materials\ after\ crushing(kg)}{Mass\ of\ materials\ before\ crushing(kg)} x100\% \qquad (1)$$

2. Crushing capacity (CC)

$$CC = \frac{Total\ Mass\ of\ crushing(kg)}{Total\ time\ taken(hr)} \qquad (2)$$

3.Crushing loses (CL)

$$CL = \frac{Mb - Ma}{Mb} x\ 100\% \qquad (3)$$

Where M_b=mass before crushing (kg)

M_a= mass after crushing (kg)

RESULT AND DISCUSION

Primary testing

The crusher defined as the machine or the tool, which designed and manufactured to reduce the large materials into smaller chunks (Hesham et al., 2015). It could be considered as primary, secondary or fine crushers depending on the size-reducing ratio. Crushers classified depending on the theory of the crushing acting as, Jaw crusher, conical crusher and impact crusher. The impact crusher type is widely used in agricultural applications, these crushers use the impact rather than the pressure to chuck and break the materials.

The crushers have been feeding by different materials, which were available in the test site. Feeding materials were, maize stalks, bean and wheat straws. The primary performance evaluation includes, crusher feed rate, productivity (output materials), and crushing and materials loss. Each sample was weighted (mass before crushed) and passed through the feeding chute (hopper) into the crushing chamber, coming into contact with the pivoted hammers. The crushed materials were collected through the perforated screen below the crushed chamber. The time taken to crush each sample was recorded. The collected materials were weighted as mass after crushed. Each test replicated three times. The specific crushing resistance increases with the increase of the stalks fed through the chute.

Table1. Each top Hammer miller test results on different trial

Parameters	**SoRPARI Top hammer miller**			**Market top hammer miller**		
	Maize stalk	**Bean straw**	**Wheat straw**	**Maize stalk**	**Bean straw**	**Wheat straw**
Crushing efficiency (%)	98±1.9	94±2	97.33±4	97.33±1.5	99.33±1.6	95±2.1
Crushing capacity (kg/hr)	92.78 ± 3	78.68 ± 2.5	109.75±2.6	119.21±1.3	152.54±2.2	109.1±1.7
Ave. Crushing loss (%)	2 ± 0.1	6 ± 0.5	2.67±0.37	2.67±0.6	0.67±.02	5±0.3

Effect of Speed (Rpm) On Crushing Capacity

Nikolov (2004) stated a general scheme of crushing process as the impact breakage takes place in a very few time and results into a dynamic crack propagation that leads to much faster failure of particles at high speed. Increase in hammer shaft rpm, in general, lead to increasing crushing capacities on both SoRPARI and Market machines as shown in Figure 2. The mean values of crushing capacity were increased from 60 to 169 kg/hr for SoRPARI and 74 to 189 kg/hr for market top hammer mill machines respectively as rpm increase from 1200 to 2200 for all stalks on maize stalk. This was because at higher hammers speed the crop residue forced to the crushed because of high inertia force acting on them.

Cost Analysis of the Machine

The cost of the machine includes raw material cost and production (machine and labor) cost only. Materials wastage and overhead costs are estimated from raw material and production cost.

Table 2: The summarized cost of the machine

No.	Variable	Cost(ETB)
1.	Raw Material	58,968.00
2.	5Hp Electric Engine	26,500
3.	Material Wastage =2.5% of 1	1,474.2
4.	Material Inflation rate = 5% of 1+2	4,273.4
5.	Production (Machine +Labor)	24,450
	Total Cost	**115,665.60**

CONCLUSION AND RECOMMENDATION

Performance evaluations of the machines were done to determine crushing capacity, crushing efficiencies and associated losses at different speeds and constant feed rate. Three levels of hammer speed (1200, 1800 and 2200 rpm) were investigated to identify the optimum combination of the variables in question. The top hammer millers/crushers were subjected to test using available material such as

Maize stalk, beanstalks and wheat straw with different hammer shaft speed.

Based on the performance evaluation made and results obtained, the following conclusions can be drawn

- The outputs of the top hammer millers were satisfactory. The market top hammer miller produced a highest crushing efficiency and capacity about 99.33 % and 152.54 kg/hr while it was 94% and 78.68 kg/hr when using the SoRPARI one respectively.
- The crushing losses the market top hammer miller were 2.67, 0.67 and 5 % on maize stalk, beanstalk and wheat straw respectively.
- Where SoRPARI top hammer were 2, 6 2.67 % on maize stalk, beanstalk, wheat and barley straw respectively.
- It is recommended to use the Market one top hammer mill for it is better performance and simplicity, save the cost, easy of transportation and it is less in weight, simplicity in operation.

Based on the findings obtained, the following recommendations are made:

- Since the top hammers millers were originally designed for milling grain, the uniformity of feed materials (crop residue) into the crushing unit was not consistent; hence an automatic feeding or feeding table system and regulator must be developed and used instead of hopper,
- Lack of a variable electric or hydraulic motor made the use of diesel engine a must and control of speeds at different level was through reduction of engine speed, which was felt inappropriate; hence, further test, using power sources with digital variable speeds be made,
- The machine was tested and found satisfactory. However ,a flywheel was attached to the hammer mill shaft to stop the lowering of the diesel engine speed noticed whenever much raw material was added to the chamber and

- Finally, It is decided that future commercialization shall been incorporating with feeding table system regulator and a flywheel at the hammer mill shaft.

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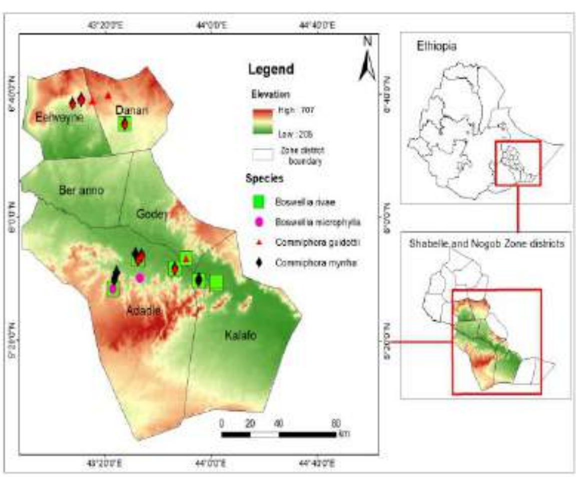
SOMALI REGION PASTORAL AND AGRO-PASTORAL RESEARCH INSTITUTE (SoRPARI)

RANGELAND & FORESTRY RESEARCH DIRECTORATE



1. Effect of Integrated Mechanical and Chemical Management Tactics against *Prosopis Julifloral*

Abdinasir Abdikadir[1] and Tedious Shiferew[2]

Email:-aweisbare22@gmail.com[1]; tadu1352@gmail.com[2]; Telephone: +251915076088[1] +251953185591[2].

1. Somali Region Pastoral and Agro-Pastoral Research Institute (SoRPARI), Rangeland and Forestry Research Directorate
2. Somali Region Pastoral and Agro-Pastoral Research Institute (SoRPARI). Crop Research Directorate,

ABSTRACT

Prosopis julifloral is regarded as one of the worst weed in the world because of its invasiveness, potential for spread, and economic and environmental impacts. The trees continue to invade forests and range lands in many countries across the world. The cost to remove these trees is staggering, the invasions of prosopis have created challenges for livelihood of pastoralist and agro pastoralist communities in invaded areas, similar scenarios happening in Shebelle zone, the weed is making the lives of pastoralist and agro-pastoralist in Kalafo difficult. Therefore, study was conducted at Kelafo woreda under natural prosopis invaded area. Based on the following objectives to study integrated effect of cutting/stumping and herbicide application against the rejuvenation of Prosopis julifloral: Effect of different mechanical, chemical and herbicide treatment against the rejuvenation of Prosopis julifloral stump, the study was used 2, 4-D, Oxyfluorfen and Glyphosate, the study recommends to Introduce and popularizing prosopis based rural livelihood alternatives those which can be implemented using prosopis as a resource income.

Keywords: *Chemical Management, Mechanical, Management Tactics, Prosopis Julifloral*

INTRODICTION

Prosopis julifloral is regarded as one of the worst weed in the world because of its invasiveness, potential for spread, and economic and environmental impacts (Shiferaw, 2004). The 44 species of *Prosopis* (Fabaceae), commonly known as mesquite in the English language, *khejri* in Hindu, or *algarroba* in Spanish, are spread across large regions of the southern United States, South Asia, Africa, the Middle East, South America, and the Caribbean (Ellsworth *et al*., 2018). The trees continue to invade forests and range lands in many countries across the world. The cost to remove these trees is staggering.

Based on the few reports available, prosopis forests and shrub lands today may cover at least ten million hectares across Africa, with about five million hectares (about 50%) in the Greater Horn of Africa alone (Pasiecznik et al., 2012). As for the rate of spread in the region, estimates from Kenya suggest that areas of prosopis expand at a rate of at least 5% per year (Choge *et al.*, 2007). A ten-year study of satellite imagery in Afar, Ethiopia and mathematical modelling (Tilahun and Asfaw, 2012), found that prosopis has been spreading at a rate of more than 50,000 hectares per year in this regional state alone, giving a further indication of the scale of the spread (Pasiecznik *et al*., 2015).

P julifloral is becoming invasive and seriously out-competing the indigenous vegetations which are serving as a feed for livesstock, fuel resource and losses of range land and crop land due to the Prosopis invasion (Mohammed *et al*., 2017). Local studies have shown that invasive plant species can directly or indirectly affect the food security of local residents. In areas where they spread, invasive can destroy natural pasture, displace native trees, and reduce grazing potential of rangelands. They compete for and reduce productivity of croplands.

Several efforts were made in Ethiopia, to eradicate *Prosopis*. However, because of high cost and complexity of the problem, most of the efforts were not successful or sustainable. Different studies have shown that the invasion of *Prosopis* would be not controlled or reduced by engaging a single management approach (Mohammed et al., 2017). Thus, integrated approaches are warranted to restrict the invasion of this weed by combining more than one option (Samuel *et al*., 2013). The experiences from other countries shows that control of *Prosopis* is extremely difficult and costly to eradicate once it takes root (Shanwad et al., 2015). Several methods suggested including physical i.e cutting and chaining, using large powered truck to uproot, and application of chemical herbicides. According to several studies use of different herbicide can result in the control of prosopis but the success is highly dependent on many existing conditions including age of the plant, method of application, type of herbicide used and other issues.

Somali region is a region most suffered due to the invasion of prosopis. This notorious weed invaded vats land stretching south to north rangeland of the region. The invasion of this weed resulted in disruption of the livelihood of the pastoralist and agro pastoralist communities across different zones. It has triggered displacement; shrink in the pasture resource and deteriorations of the food security. Rangeland in Shebelle zone is one of the areas in Somali region which severely invaded and affected by the prosopis.

The invasions of prosopis have created challenges for livelihood of pastoralist and agro pastoralist communities in invaded areas, similar scenarios happening in Shebelle zone, Kalafo woreda that making the lives of pastoralist and agro-pastoralist in Kalafo difficult. Therefore, study was conducted at Kellafo woreda under natural prosopis invaded area. Therefore, this research was goaled to study the integrated effect of cutting/stumping and herbicide application against the rejuvenation of Prosopis julifloral as well as the effect of different mechanical, chemical and herbicide treatment against the rejuvenation of Prosopis julifloral stump

Material and Method

Description of study area

Kalafo is one of the woreda in the Somali Region of Ethiopia. Part of the Shabele Zone, Kalafo is bordered on the south by the neighboring Somalia, on the west by Adadle, on the northwest by Gode, on the northeast by the Korahey Zone, and on the east by Mustahil. The Shebelle River is flowing through this woreda. The major town in Kalafo is Kalafo.

The average elevation in this woreda is 374 meters above sea level. As of 2008, Kalafo has 35 kilometers of all-weather gravel road and 300 kilometers of community roads; about 6.36% of the total population has access to drinking water.

Site selection

The location of experiment was first surveyed so as to select the trees to be treated. Selection was based on the maturity stage so that all the trees under experimentation were all approximately homogenous in age, height, canopy size, vigorous and density per unit area. Site selection has been made, which was highly dense area of extremely invaded by Prosopis julifloral l at about 3km west side of kalafo woreda. The size of the area enclosure was 1,200m^2 and fenced. Site clearing and putting the layout of the experiment were completed to conduct the trail of integrated mechanical and chemical management tactics against *Prosopis julifloral l*.

Material Used

Herbicides used

2, 4-D

2, 4-D is an herbicide and secondarily a plant growth regulator. 2,4-D is used on a wide variety of terrestrial and aquatic broadleaf weeds. It has little effect on grasses. It appears to work by causing uncontrolled cell division in vascular tissue. Abnormal increases in cell wall plasticity, biosynthesis of proteins, and production of ethylene occur in plant tissues following exposure, and these processes are responsible for uncontrolled cell division. The ester forms of 2,4-D penetrate foliage, whereas plant roots absorb the salt forms. 2,4-D appears to be similar in action to other auxin-type herbicides

Oxyfluorfen

Oxyfluorfen is a diphenyl-ether herbicide used for broad spectrum pre- and post-emergent control of annual broadleaf and grassy weeds in a variety of tree fruit, nut, vine, and field crops. The largest agricultural markets in terms of total pounds' active ingredient are wine grapes and almonds. There are also non-agricultural ornamental and forestry uses. Oxyfluorfen is also used for weed control in landscapes, patios, driveways, and similar areas in residential sites

Glyphosate

Glyphosate (Glyphosate (*N*-(phosphonomethyl) glycine; 1071-83-6) is the active ingredient in several commercial herbicides for nonselective weed control. Glyphosate herbicides are among the world's most widely used herbicides. Roundup®, containing the active ingredient glyphosate, was developed and introduced by Monsanto Company in 1974. Other formulations include Weatherwax, Ultra MAX, Buccaneer, Razor Pro, Rodeo, and Aqua Master®. Some crops such as soybeans and cotton have been genetically engineered to be resistant to glyphosate (Roundup Ready), allowing farmers to use glyphosate as a post emergence herbicide. The United States Environmental Protection Agency (EPA) considers glyphosate to be relatively low in toxicity compared to organochlorine and organophosphate pesticides.

Field experiment

Field experiments were conducted during 2011 to 2012 at consecutively. During 2011 matured prosopis trees were stumped to the height of 0 cm, 10 and 20 cm above ground. The stumps were arranged in plots and block manner before the application each plot allowed to have at least 5 prosopis stumps. Similarly blocks were arranged by marking on the ground. There were a total of 9 experimental plots which were arranged on three blocks. Then the experiment was conducted using randomized completely block design (RCBD) which were replicated in three. After stumping process were completed three herbicides were applied on the top of each stumps. The detail of the herbicide application treatments is listed in the Table-1.

Table -1 Treatment (stumping and herbicide treatment) Year-I

Treatments Code	**Treatments**
T1	Glyphosate @ 0 cm stump height
T2	Glyphosate @ 10 cm stump height
T3	Glyphosate @ 20 cm stump height
T4	Oxyfluorfen @ 0 cm stump height
T5	Oxyfluorfen @ 10 cm stump height
T6	Oxyfluorfen @ 20 cm stump height
T7	2,4-D @ 0 cm stump height
T8	2,4-D @ 10 cm stump height
T9	2,4-D @ 20 cm stump height
T10	Control @ 10 cm height
T11	Control @ 0 cm height

Year II

Based on the findings of the Year-I experiment on stumping and herbicide application, year II was conducted. During the 2nd phase of the experiment all three chemicals was used with stumping at 10 cm above the ground. During the 2nd year of experiment all three chemicals were diluted with water in three proportion the detail of treatments has been indicted in the following table

Code	Treatment
T1	2, 4-D without water
T2	Glayphosate without water
T3	Exofloracinewithout without water
T4	2, 4D water 50:50%
T5	Glayphosate water 50:50%
T6	Exofloracine . water 50:50%
T7	2, 4D to water 25:75
T8	Glayphosate to water 25:75
T9	Exofloracine to water 25:75
T10	Control

Each herbicide was diluted as described in the above Table-2 and applied on cut stumps of prosopis

Data collection and Analysis

Data collected

1. Sprouted Sumps %: proportion of sprouted stumps after treatment per each plot
2. Day took to sprout after treatment
3. No. @120 DAF SP
4. New sprout/Stump SP height in cm
5. Branch number per new sprout

Result and discussion

Results Growth and development of *Prosopis julifloral l* varied with different herbicides applications and application concentration (Table 1 & 2).   During the first year chemicals trail all the herbicides (2,4-D, roundup and Oxyfluorfen) Showed effective control of prosopis stub from sprouting when herbicides applied at 0 cm stumping height. However, this controlling effect has been seen decreasing when prosopis plats stumped at 10 cm and 20 cm above the ground. According to the result in the (Table-1) new sprouts rejuvenated on stumped trees at 72, 69, 60 days after stumping and herbicide treatment. Compared to those three applied herbicides roundup (Glyphosate) found to be effective and followed by Oxyfluorfen this group of herbicides has been controlling the rejuvenation time and total rejuvenation of the treated prosopis stumps.

According to the result in the (Table-2) Glyphosate and Oxyfluorfen treated stumps, 100 % of the not germinated till the end of the experiment time and these stumps were completely dried and dead. However nearly 37.19 % of the Oxyfluorfen treated stumps with stumping height of 20 cm found rejuvenated. In terms of effectiveness herbicide 2, 4-D found relatively weaker and it didn’t avoid the stumps from rejuvenating.

Table 2: Mean result of effect of stumping and herbicide application against prosopis

Treatments	Day took to sprout after treatment	Sprouted Sumps %	No. New sprout/Stump	SPr height in cm @120 DAF SP	BN/SP
Glyphosate @ 0 cm stump height	-	0	0	0	0
Glyphosate @ 10 cm stump height	-	0	0	0	0
Glyphosate @ 20 cm stump height	-	0	0	0	0
Oxyfluorfen @ 0 cm stump height	-	0	0	0	0
Oxyfluorfen @ 10 cm stump height	-	0	0	0	0
Oxyfluorfen @ 20 cm stump height	75.5	12.19	2.12	26.61	2.11
2,4-D @ 0 cm stump height	67.71	17.81^{b}	4.66^{b}	44.00^{b}	3.05^{b}
2,4-D @ 10 cm stump height	69.96	22.87^{bc}	7.17^{b}	44.62^{c}	3.59^{b}
2,4-D @ 20 cm stump height	41.41	62.17c	13.11bc	54.17cd	5.12bc
Control @ 0 cm height	33.0	100d	18.38c	83.17 d	7.07c
Control @ 10 cm height	33.3	100d	18.00c	83.14d	9.11c

According to the result in the (Table-2) there were significant difference among treatment on days taken to rejuvenate after the stumping and application of herbicides. Based on the result the study the shortest day to rejuvenate was recorded for those stumps treated with 2,4-D with the

/stump height of 20 cm however, stumps which were not treated with herbicide rejuvenated earlier than the other treatment regardless of their height.

Stumping and herbicide application also affected number of new sprout rejuvenated per each stump according to the result in the (Table-2) the maximum number of rejuvenated sprout was recorded from control treatment regardless of stumping height. However, those stumps treated with herbicides sprouted in different quantity. According to the result the largest quantity of sprouts next to control treatments were recorded from those stumps treated with 2,4-D and with the stump height of 20 cm. In this study 2, 4-D treated stumps with stumping height of 0 cm, and 10 cm showed small variation. Similarly stumps with the height of 20 cm which were treated with Oxyfluorfen herbicide sprouted however Oxyfluorfen treated stumps with the stumping height of 0 and 10 cm had no sprout, this may indicate that stumping height had an influence in rejuvenation of stumped prosopis trees.

According to the result in the Table-2 there were significance differences among treatment on the height of rejuvenated sprout after 120 days of sprouting. According to the result maximum height war recorded from control treatment and there was no difference was observed on the height among different stumping height. The lowest sprout height was also obtained form.

During the 2nd phase of the study herbicides was applied after diluting them with water. According to the result in the (Table-3) all herbicides applied without dilution resulted in complete control of prosopis tree stumps. All treated stumps failed to rejuvenate due to the applied herbicide without dilution. According to the result in the Table -3 effectiveness of herbicides decreased as dilution proportion of water increased.

Off all three herbicides diluted with water in the proportion of 50:50 ratios, Glyphosate (round up) resulted in effective control of prosopis stump rejuvenations followed by 2,4-D. In this study Oxyfluorfen had resulted week performance when it was diluted using 50:50 water to Oxyfluorfen diluting ratio. Similarly controlling efficacy of all three herbicides showed significant reduction in the controlling efficacy of prosopis rejuvenations' (Table-3).

Table: 3 Effect of herbicide application on prosopis stump rejuvenation and general stats of sprouts

Code	**Treatment**	**DTSP**	**NSPST**	**SPH@ FWSP**	**NLPST @ FWS**	**SH@ 3rd WSP**	**NLPST@ 3rd WSP**	**NSPS@4th WSP**
T1	2, 4-D without water	00	00	00	00	00	00	00
T2	Glayphosate without water	00	00	00	00	00	00	00
T3	Exofloracinewithout without water	00	00	00	00	00	00	00
T4	2, 4D water 50:50%	59.67	2.67	20.00	3.67	69.00	19.02	16.67
T5	Glayphosate water 50:50%	77.36	1.33	23.67	2.33	56.67	12.14	16.67
T6	Exofloracine . water 50:50%	46.33	3.33	19.67	6.33	77.33	26.31	16.67
T7	2, 4D to water 25:75	55.00	4.46	20.67	11.00	81.00	28.71	18.67
T8	Glayphosate to water 25:75	69.33	2.33	20.00	7.33	69.19	22.52	20.67
T9	Exofloracine to water 25:75	40.67	6.36	21.00	19.00	84.72	35.17	20.33
T10	Control	19.14	12.12	31.67	23.33	96.33	47.19	20.00

Key: DTSP- days to sprout after herbicide app; NSPST number of sprout per stump; SPH@FWSP, sprout height at first; SPH@FWSP sprout height at first week of sprouting; NLPS@FWSP number of leaf/sprout at the first week of spouting; SPH@TWSP sprout height at third week of sprouting; NLPS@3rd WSP number of leaf/sprout at the third week of spouting; NSPS@4th WSP no. of sprout/stump @ 4th week of stumping

Discussion

Results Growth and development of *Prosopis julifloral* varied with different herbicides applications and application concentration (Table 1 & 2). In this study it was found that all chemicals were effective at more concentrated than dilution. Current finding was supported and agreed with Shanwad *et al.*, (2015) study findings whom reported that prosopis weed can be controlled using herbicides like 2,4-D and glyphosate. In bush or perennial weed like prosopis the efficacy of herbicide is highly relies on the chemical concentration. The higher concentrations of herbicides have more effective than the lower concentrations. But other similar studied also suggesting plant characteristics like early stage plants (stem thickness size < 1 cm and 1-2 cm) are more susceptible to herbicides effect than the later stage plants (>2cm stem thickness) (Geesing *et al*. 2004). *Prosopis julifloral* susceptibility to different herbicides was strongly influenced by individual tree stem number. The basal bark and cut-stump techniques used with an appropriate registered herbicide are effective on mature trees. Among the methods of applications of herbicides, smearing the herbicide to cut portion of Prosopis julifloral found better than the spraying method especially in aged plants. The cut stump technique, where herbicide is immediately applied to a stump that has been cut horizontally very close to the ground, is effective year round. Seedlings can be controlled by spraying foliar herbicide over the entire plant. This is particularly effective for dealing with actively growing, dense stands of mesquite up to 1.5 m tall Geesing *et al*. (2004). But in early stage plants both methods found better. In this scenario controlling the Prosopis julifloral by spraying or smearing with locally available chemicals like Glyphosate and 2, 4- D ester seems to be better options than the other chemicals.

Similarly, within each stem thickness class by herbicides, resistance increased with increasing stem number, illustrating why interactions among herbicides, plant stem thickness and stem number were insignificant Shanwad et al., (2015).

Though herbicide usage along with tree stumping had resulted in very good control of prosopis its applicability may raise technical and economical issues when it comes to the practicality on the real filed conditions (Zimmermann, 1991). By using its potential beneficial effects as opportunity there is a possibility to eradicate this weed through time. This can be achieved by creating job opportunity for job seekers which ensuring the proper removal of the tree for different purpose (Mohammed et al., 2017.)

Experiances from other Similar Affacted Areas

Many experiences of prosopis invaded countries indicted that despite the invasive and hardy nature of the prosopis the tree can be utilized in different forms while controlling its spreader. Among best recommended tactics to manage the impact of prosopis and its spread was to use the prosopis through its biomass exploitations. These biomass exploitations include, use of prosopis tree for lumbering, using the pod and the seed for livestock feed preparation, using prosopis for biomass energy generation, preparation of woodchips of prosopis, for cooking and backing fuel. These systems of biomass exploitations tactics effective in not only reducing the spread but also create alternate and sustainable livelihood for the community of invaded area.

Wood chips are wooden residues from *prosopis julifloral* can be chipped off and used as mulch in gardens and little vegetable gardens (Pasiecznik, 2001). The mulch is effective in reducing evapotranspiration. Consequently, it also reduces the plant water consumption. The chips have also been successfully proceeded into wooden pulp, which is the primary raw material for paper production (Pasiecznik, 2001). 4.4 Fodder Free ranging animals can eat prosopis julifloral pods directly from the tree.

Prosopis wood chips were regarded as efficient fuel for cooking and baking. Prosopis wood chips have also been tested as an organic filter material (OFM). An OFM is an organic material that retains different pollutants that later biodegrades into to CO_2, H_2O, and N2. An OFM can be used as a bio-filter over municipal wastewater treatment (Sosa-Hernandez et al. 2016). Ansley et al. (2010) analyzed mesquite's potential use as a biofuel and found not only would harvesting mesquite be economically feasible and sustainable, it also would yield other ecosystem benefits, including increased grass and foliage production for livestock foraging. The energy values of charcoal made from *P. julifloral was* high 7.854 7 Kcal. The charcoal obtained from this wood is also of very high quality and can be produced as easily from green wood as from dried wood. It burns with a hot and even heat giving high heating value. The wood from this species can be promoted as a source for charcoal as it has high density, which gives high quality charcoal (Nellie and Joseph, 2013).

Conclusion and Recommendation

The usefulness of P julifloral *has* long been recognized. It is considered to be a valuable tree species of the desert ecosystem. So they remain underutilized, while they have the proven potential to provide enormous quantities of ‘free’ resources and new livelihood options, improve food security, and buffer against the risks of ever-increasing droughts. Many experiences of prosopis invaded countries indicted that despite the invasive and hardy nature of the prosopis the tree can be utilized in different forms while controlling its spread. For instance, in Brazil in 2012, the company was reported to have an annual turnover of US$6 million solely from the manufacture and sale of prosopis-based animal feeds, and had also developed equitable benefit-sharing initiatives with local communities involved in collecting, cleaning and delivering pods. In Argentina, Mexico and southwestern United States, *Prosopis* lumber is very highly regarded due to its outstanding 3 dimensional stability and above average hardness and commands good prices of about $800 per cubic meter Pasiecznik et al. (2001).

Recommendation

Introducing and popularizing prosopis based rural livelihood alternatives those which can be implemented using prosopis as a resource

- Livestock feed using prosopis wood, pod and seed
- Wood chip production packaging and marketing using prosopis wood for fuel
- Value addition on prosopis to use as multi role resource
- Introducing pod crushing machines develop appropriate hammer mill, hydraulic blocker, and a pellet mill
- Development of innovative packaging and packing systems
- Introducing wood crushing and packing machines
- Market linkages creation.
- Strengthen prosopis product value chains.

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2. Assessment of market opportunities, challenges and production of gum and resin to local economic pastoralist livelihood in Somali region.

[Idil Amin ,tell +251915731434 email: idilamin90@gmail.com][1], [Ibrahim Jibril, tell: +251915774379 email: abduyeehani@gmail.com][1] [Abdinasir Abdikader, Tell: +251915076088 email:awiesbare22@gmail.com][1] Somali Region Pastoral & Agro-Pastoral research institute, Range and Forestry research Directorate.

Abstract

*A study on evaluation of gum and resins Production, challenge and opportunities was carried out in Qorahay, shabele and Afdher zone of Somali Region. The study was conducted at Dhobo weyn, Adadle and Qohale district at the study sites, which were selected on the bases of the presence of good population of the study species The potential gum and resin yield from the vegetation resources were estimated based on literature data on annual yields of gum and resin per tree. To assess the socio-economic importance of the study species, a multi-stage sampling procedure was used to select sample households. In the first stage three districts with higher abundance and distriuution of the study species were selected purposively Then the number of households who are native to district and know the socio- economic uses of the gum and resin in the area were determined based on probability proportional to the size (number of households of the three districts). For this study, the number of households (N) selected for face to face interview were 130: N ≥ 50 + (8*10)=130. The numbers of households from each district were determined proportional to the total numuer of households in each district. A total of 3 Kebles, from three districts were systematically identified and 39, 42 and 45 households were randomly selected from Dhoboweyne ,Adadle and Qahole district respectively The three major commercial gum and resin in the study areas include frankincense from the three Boswellia species, myrrh from Commiphora myrrha and opoponax from Commiphora guidott. Based on the present study, the total potential annual production for frankincense is about 15,161.54, 17,651.10 and 23,659.83 tonnes (Table 9) from the vegetation of Shebelle, Korahe and Afder zone. The total potential annual production for myrrh is auout 18,222.10, 269.72 and 6,241.55 tonnes (Table 9)from the vegetation of Shebelle, Korahe and Afder zone. The total potential annual production for opoponax is about 12,485.51, 809.17 and 5,795.73 tonnes (Table 9) from the vegetation of Shebelle, Korahe and Afder zone. In addition to animal husbandry significant numbers of households, 54.5% at Adadle, 73.1% at Dobo Weyn and 68.4% at Kohle participate in gum and resin production to generate cash income. The results of this study had also showed that collection and sale of oleo-gum resins from vegetation in Adadle, Dobo weyn and Kohle district supplied on average US$ 1613.22, 94.47 and 47.69 incomes per household per year (1USD = 45 ETB in August 2021).*

***Key words**: gum, resin, yield, socio economic importance, house hold income marketing*

1. Introduction

The vegetation resources of Ethiopia in dry lands are classified as dry forest resources of Ethiopia. The dry land vegetation resources are: (1) dry evergreen Afromontane vegetation, (2) Comuretum–Terminalia (broad-leaved) deciduous woodland, (3) Acacia–Commiphora (small- leaved) deciduous woodland, (4) lowland dry forests, (5) lowland semi-desert and desert vegetation, (6) evergreen scrub, (7) wetland (swamps, lakes, rivers and riparian) vegetation, (8) moist evergreen montane forest, and (9) Afroalpine and sub-Afroalpine vegetation (Lemenih and Tadesse, 2010). Most of the Ethiopian dry forests are located in arid and semi-arid with marginal potential for rain-fed agriculture (Hawando, 1997). They occur in large parts of the lowland of the northern, western, north western, south western, eastern, southern and south-central parts of the country (Friis et al., 2010). The climatic condition in these areas is warm with a mean annual rainfall range of 500 to 1500 mm. In spite of being characterized as lower moisture zone, dry forests are believed to support diverse biological (plant, animal and microbial) resources The Acacia – Commiphora woodland is the first richest vegetation type in species and genetic diversity in Ethiopia with auout 542 species

The common species in this vegetation type include species of the genera *Acacia, Boswellia, Commiphora, Zizyphus, Maerua, Cadaba, Boscia, Euphorbia, Aloe,* and *Sansevieria*. The vegetation has different species composition and form different plant communities that vary mainly with altitude, climate and edaphic factors (Lemenih et al., 2003; Worku, 2006).

These plant communities are home to a relatively high number of endemic species uniquely adapted to the variable and extreme conditions of dry lands. These endemic species have great potential as drought-tolerant high-value species, among other characteristics (Lemenih and Teketay, 2004; Worku, 2011).

The Combretum – Terminalia woodland and Acacia – Commiphora woodland are both dominated by gum and resin producing tree species, and the gums and resins in particular gum Arabic, myrrh and frankincense are economically very important non-timber forest products. Case studies show that, forests in the dry lands of Ethiopia have the potential to significantly contribute to climate change adaptation and poverty reduction, combating desertification and protecting biodiversity. These versatile resources, however, have yet to ue sustainably managed but rather are exposed to large-scale land use conversion (Teketay 2004-5; Lemenih and Kassa 2011; Worku et al. 2011; Worku et al., 2014).

In Somali Region, although most part of the Region is dry land, it is believed to have untapped natural resources, and therefore great future development potential. The vegetation resources in Somali Region are predominantly covered by Acacia-Commiphora woodland.. Gum and resin uearing species are the dominant species in terms of the total stem density in the woodlands (Tadesse et al., 2007). The gum and resin bearing species are much known for their well-recognized actual and potential socio-economic importance to the local people (Lemenih, et al., 2003; Worku, 2006). Limited works have been carried out so far on thearea coverage, abundance and population structure of gum and resin bearing specie and their socio-economic importance in Liban zone of the Somali Regional States of Ethiopia. Lemenih, et al., (2003) have shown the type, number and structure of gum and resin bearing species and their variation between sites depending on the geographic location and edaphic factors

In spite of the growing recognition of and concern of gum and resin bearing species in particular and the woodland in general by different GOs, NGOs and scholars almost no quantitative data on the baseline information like the area coverage, type of gum and resin bearing species, the opportunities and challenges for sustainable production and marketing of gum and resin products to enhance the livelihood the local community are available for most part of Somali Region,

No efforts deployed to improve the current collection method, processing (for domestic or international use), grading, storing and marketing of gum and resin bearing species. Very few efforts have been made to elucidate the socio-economic important of the species and pave ways for enhancing their importance

Therefore, the present study was carried out with the overall objective of Evaluating Gum and Resins Production, Challenges, Opportunities and market aspects in three selected districts of Somali Region, Ethiopia. The specific objectives of the study include ; (1) to determine the potential gum and resin yield in the study areas; (2) to identify and understand critical challenges constraining pastoralist to benefit gum and resins production, The outputs of the study will be used to design overall regional intervention to overcome producer constraints and challenges of gum and resin production and marketing and incense the volume of production and its socio-economic contribution to improve the livelihoodof the local people.

2. Materials and Methods

The study areas

The present study was carried out at three different districts, namely ‘Adadle, Kohle and Dobo weyne located in three zones of the Somali National Regional State (SNRS) (Fig. 1). The three zones are the project areas for Lowlands Livelihood Resilience Project (LLRP). The three districts (one district per each Zone) were selected purposely based on the thorough discussion with different bodies among which were the project leader at the SOPARI, Zonal and District agricultural experts, and local elders who have knowledge on the study species

Study site selection

An intensive field reconnaissance survey was conducted to select study sites with relatively good population of the study species. Accordingly, Dobo-weyn district from Korahey, Adadle district from Shebelle and Kohle from Afdher were selected for the study.

Estimation of gum and resin yield

The actual gum and resin yield from each studied species were not experimented because of limited time allocated for the field study. Thus, the potential gum and resin yield from the vegetation resources were estimated based on literature data on annual yields of gum and resin per tree. According to Lemenih (2011), the average annual yield of 0.5 and 1 kg per tree was estimated to ue for frankincense from Boswellia species and resins from Commiphora species, respectively. The tree/shrub species in this vegetation are multi-stemmed with more than two branches. The average number of branches was calculated for each gum and resin bearing species and found to ue 3.7, 2.3, 2.3, 2, 3.6, and 2.7 for Medafur, Didin, Hadi, Hagar, Chewder and Ged hareg. Since the individual stems were separately counted and measured, the annual yield per tree was then divided by the average number of stems to estimate the annual yield per single stem. The average single stem number per hectare for each gum and resin producing species was multiplied by the average yield per tree and year to obtain the annual harvest for each of the products per hectare. Finally, estimates of per hectare production for each gum and resin weremultiplied uy the area of each vegetation type to obtain estimated total production for each ofthe three studied zones of Somali Regional states

Sampling Procedure and Determination of Sample SizeSelection of household respondents

A multi-stage sampling procedure was used to select sample households. In the first stage three districts with higher abundance and distribution of the study species were selected purposively from the three the three zonal administrations of the Somali Regional State. Then the number of households who are native to district and know the socio- economic uses of the gum and resin in the area were determined based on probability proportional to the size (number of households o the three districts) following the formula developed by Green (1991)

$N \geq 50 + 8m$ ....(1)

N= Sample size required

m= Variables/predictors (in our case, the variables were 10)

For this study, the number of households (N) selected for face to face interview were 130: N ≥

50 + (8*10) =130. The numbers of households from each district were determined proportional to the total number of households in each district. A total of 9 Kebele, from three districts were systematically identified and 39, 42 and 45 households were randomly selected from Adadle, Qohale and Dhoboweyn district.

Data collection

Close and open-ended questionnaires were developed and face to face semi-structured interviews were under taken to assess the socio-economic importance of gum and resin bearing species. The questions were prepared in English and translated to 'Somali language, the official language of the Regional State and the study sites. Enumerators who were researchers, knowledgeable about the area were involved in data collection.

In addition, 4 to 10 key informants and village traders in each study district were invited for group discussion. The discussions were conducted to get general information on the vegetation status, production and marketing of gum and resin products and challenges of the production and marketing of gum and resin products. The information generated here were used to validate the information retrieved from household respondents.

Gums and resins marketing and value addition practices

Data on marketing or value chain at producers and village traders level was mainly collected from primary information through group discussion. Two sets of check lists (one each for local producers and village traders) were designed by focusing on the various key market players. Discussions were held with primary producers who directly collect gum and resin about its source and supply as they are the major harvesters of the resource. Similar discussions were also held with local traders using the developed check lists. The survey included mapping the value chain and capturing factors affecting gums and resins supply at the primary producerlevel, market information, access to market, credit service availability, extension service, the quantity of product sold, cost of production/transaction, the price of the products sold, etc

Methods of data processing and analyzing

Socio-economic importance and market chain of gum and resin

The content of the interviews of individual respondents and group discussions with the key informants were summarized and discussed using descriptive statistics such as percentages and tables. Market chain of gum and resin was analyzed through mapping and description of the commodity chain -graphic presentation of the different actors involved in the chain to show the linkage between chain actors involved in transferring the product from gatherer to consumer and their principal activities as well as their functions. In this regard, the main actors in the value chain and the flow of the commodity through different channels were mapped uy the market value chain structure analysis and the market conduct examined by evaluating the behavior of these actors.

3. Results and Discussion

Gum and resin production potential

The three major commercial gum and resin in the study areas include frankincense from the three Boswellia species, myrrh from Commiphora myrrha and opoponax from Commiphora guidotti. Frankincense from the three Boswellia species is traded mixed while myrrh and opopponax is traded separately. Although not traded currently, a product called Hagar from C. Commiphora coronillifolia has also a high production potential. Based on the present study, the total potential annual production for frankincense is about 15,161.54, 17,651.10 and 23,659.83 tonnes (Table 9) from the vegetation of Shebelle, Korahe and Afder zone. The total potential annual production for myrrh is auout 18,222.10, 269.72 and 6,241.55 tonnes (Table 9) from the vegetation of Sheuelle, Korahe and Afder zone. The total potential annual production for opoponax is about 12,485.51, 809.17 and 5,795.73 tonnes (Table 9) from the vegetation of Sheuelle, Korahe and Afder zone. The total potential annual production for hagar is about 4,390.82 and 5,702.41 tonnes (Table 9) from the vegetation of Korahe and Afder zone. A total of 110,389.48 tonnes of gum and resins is estimated to ue collected annually from the vegetation of Shebelle (45,869.16), Korahe (23,120.80) and Afder zones (41,399.52) (Table 9).

Table 1: Potential production of gums and resins in the three zones of Somali Regional State

No.	Zone	Frankincense	Myrrh	Opoponax	Hagar	Total
1	Shebelle	15,161.54	18,222.10	12,485.51	-	45,869.16
2	Korahe	17,651.10	269.72	809.17	4,390.82	23,120.80
3	Afder	23,659.83	6,241.55	5,795.73	5,702.41	41,399.52
	Total	56,472.47	24,733.37	19,090.41	10,093.23	110,389.48

Economic contribution of gum and resin resources

Pastoralism is the dominant mode of livelihood strategy in the three study sites. Goats, Sheep and camel are the major animal species owned by the pastoralists in the study area. Average herd size per household per species is presented in Table 10.

Table 2. Livestock resources of households in three districts of Somali Region

Livestock types	Adadle			Douo Weyn			Qohle			Total		
	N	Mean	SD.	N	Mean	SD.	N	Mean	SD.	N	Mean	SD.
Camel	18	5.61	4.65	10	6.20	4.94	42	10.33	18.30	70	8.53	14.57
Cow	2	3.00	2.83	6	7.33	4.08	42	0.64	1.79	50	1.54	3.07
Sheep	29	20.24	13.50	16	11.25	11.60	42	16.95	15.53	87	17.00	14.41
Goats	27	23.85	15.83	21	14.95	12.95	43	19.81	19.44	91	19.89	17.22
Donkeys	6	1.00	0.00	13	1.46	0.88	38	0.32	0.74	57	0.65	0.88

In addition to animal husbandry significant numbers of households, 54.5% at Adadle, 73.1% at Dobo Weyn and 68.4% at Kohle participate in gum and resin production to generate cash income. The other income generating activities in the study sites include crop production and fire wood and charcoal production. According to the interview results, 28.6%, 35.7%, 38.1% and 19% of the households interviewed generate cash from the sale of crop, livestock, gum and resin and charcoal and fire wood, respectively at Adadle district; 0%, 23.1%, 28.2% and 48% of households generate cash income from the sale of crop, livestock, gum and resin and charcoal and fire wood, respectively at Dobo weyn district, whereas 0%, 80%, 71.1% and 40% of households generate cash income from the sale of crop, livestock, gum and resin and charcoal and fire wood, respectively at Kohle district.

Table 3. Proportion of households that participate in gum and resin collection

District name	Yes		No		Total	
	N	%	N	%	N	%
Adadle	18	54.5	15	45.5	33	100.0
Dobo Weyn	19	73.1	7	26.9	26	100.0
Qohle	26	68.4	12	31.6	38	100.0
Total	63	64.9	34	35.1	97	100.0

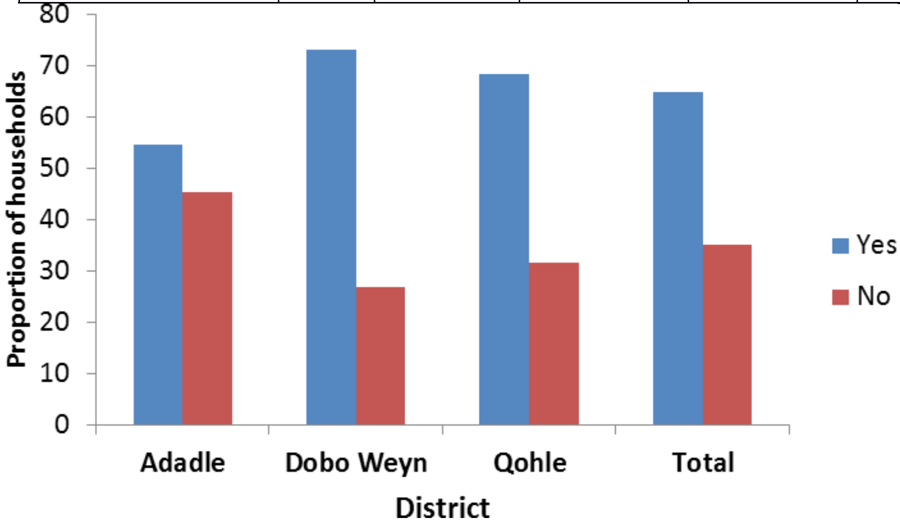


Figure 1: Proportion of households that participate in gum and resin collection

The dominant cash generating activity vary from site to site. Gum and resin production (52.1%) and livestock production (41.6%) are the dominant cash generating activity at Adadle; Charcoal and fuel wood collection (51.6%) and livestock production (40.9%) are the dominant cash generating activity at Dobo Weyn while livestock production (50.8%) and gum and resin production (32.7) are the dominant cash generating activity at Kohle district. These results showed that gum and resin production is either the first (at Adadle) or the second (at Kohle) and the third (at Douo Weyn) most prominent source of family income depending on the site. The results of this study had also showed that collection and sale of oleo-gum resins from vegetation in Adadle, Dobo weyn and Kohle district supplied on average US$ 1613.22, 94.47 and 47.69 incomes per household per year (1USD = 45 ETB in August 2021).

Table 11. Average and per capita income

Income sources	Adadle		Dobo Weyn		Qohle		Total	
	N	**Mean**	**N**	**Mean**	**N**	**Mean**	**N**	**Mean**
Crop income	12	2750.0	0	0.00	0	0	12	804.88
Livestock Income	15	57866.67	9	23288.89	36	3333.33	60	19960.00
Gum andresin income	17	72594.71	11	4251.82	32	2146.88	60	22493.00
Charcoal+ fire wood	8	5925.00	20	29377.50	18	1083.33	46	14227.17

Production, processing and Marketing system of gum and resin products

Production

Gum and resins are collected in the study sites through collection of natural exudates. When myrrh is collected from natural exudation, it is collected as a thick, strongly aromatic yellow liquid from natural cracks or cuts in the tree bark, which then dries into amuer or reddish- brown color lumps. The tears are found in many sizes, the average being that of a walnut. Gum and resins are collected two times in a year, during the two dry seasons. The main collectors are the herdsmen, women and children. During drought periods, and when there is high demand for the products, collection is made without any discrimination of either age or sex. There is no very clear program for the collectors to collect the gum and resins like that of the resin from *B. papyrifera*. Except households are in need of cash income, commonly the collection is done simultaneously with herding. The major production season is from December to February and from June to August. The better rainfall during the major rain season, between Februarys to April, results in higher gum and resin yield in June - August. However, households collect very few quantities of gum and resin per season and/or year compared to the potential production volume of the vegetation resources.

Processing and grading of gum and resin

Collected gums and resins shall pass the process of cleaning and grading before packed for sale. Processing of gum and resins involves drying under shade, sorting into piles of whole tears and smaller pieces, separating any dark gum and resin and removing pieces of bark and other foreign matter. In most cases the processing is done by hand. The resin from *B. papyrifera* in northern Ethiopia is subjected to processing after collection. The raw frankincense is stored in dry caves or small hats constructed for the purpose of drying the resin before being packed for transporting. The dried resins are further processed by women in the main stores uy hand picking to sort the product based on size, and color, and to remove any foreign materials. The processed resin from *B. papyrifera* in Ethiopia is graded in to 7 based on size and color. The grading system involves sieving the resin with different mesh size. The larger and white pieces, usually bagged for export, are more highly valued than the smaller, darker and powdery pieces and siftings. A tear size of 6 mm and above and white in color is first grade. The sorting and grading of the resin mentioned earlier is the only form of primary processing undertaken.

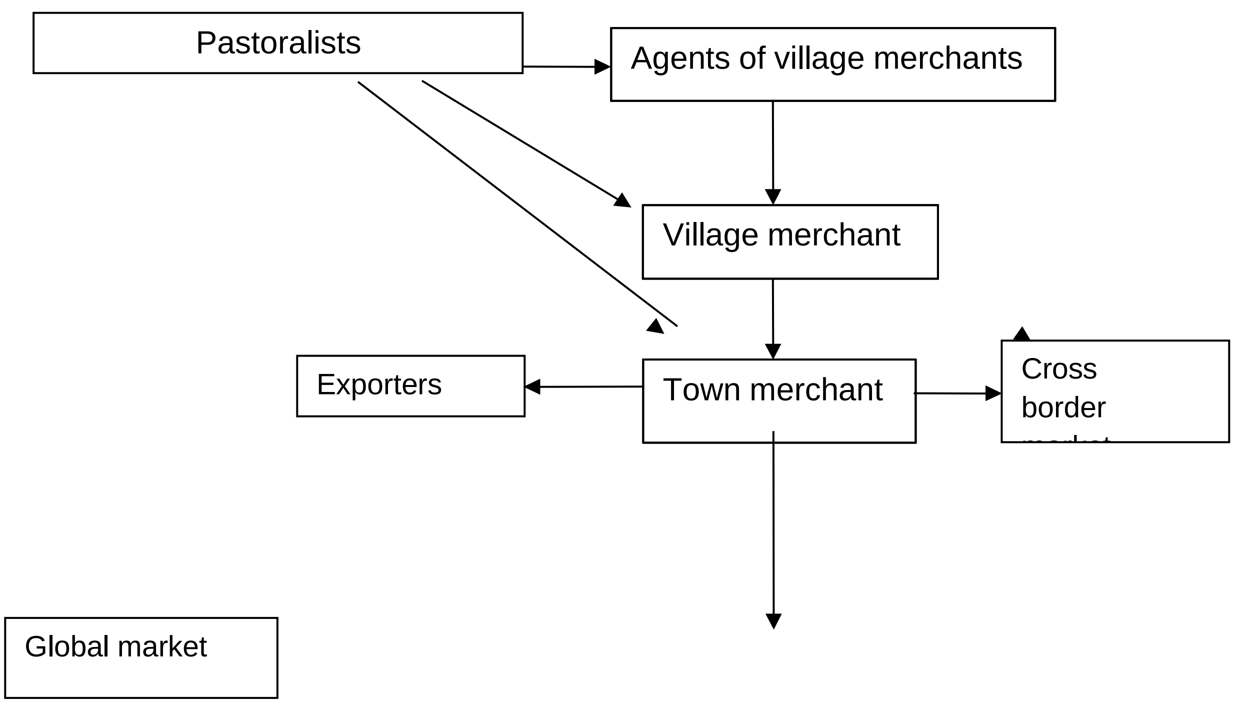
Myrrh is usually classified as cleaned or not cleaned. It is more susceptible to quality variation than resin from *B. papyrifera* because of the mixture of species that often exists in export shipments. Pieces of good quality selected myrrh should be slightly sticky on breaking, rather than crystalline, indicating high oil content. It is important to use high quality material such as this for production of essential oil. Myrrh is also graded based on size and color. Red in color and big in size are considered first grade while big size but brown color gives a second grade.

Resin (from Boswellia rivae, B. microphylla and B. neglecta), Oppoponex from Commiphora guidotti and myrrh (from Commiphora species) are produced in commercial quantities from the study sites. Most of the gum and myrrh products are marketed either to neighboring countries (Somalia) or locally through licensed organizations. Very few volume of resin products are currently marketed to national markets. The gum and resin collected in the study sites are not being processed as indicated above at the production area. The only process done is drying and removing some very conspicuous foreign materials. The normal processing is taking place at town by organizations that have trading license. This resulted in low quality there by lower price for the gum and resin collectors in the study areas. A major problem for buyers at the production area is the lower quality of resins and myrrh due to improper collection methods and processing. Since the products are not processed to sort the product based on size, and color, and to remove any foreign materials. The collected resin and myrrh are not dried very well and get stick together and form large size. Both myrrh and resin from Boswellia species are susceptible to quality variation than gum from Acacia species because of the mixture of species that often exists in the collection and marketing of myrrh and resin at the local and national market. The mixing of different types of myrrh or resin adversely affects the quality.

Marketing chain of gum and resin products

The commodity chain of gum and resin produced and marketed from the study sites has two functional segments until it reaches the local or cross border markets: production and marketing. Various actors are engaged in this commodity chain operating at different levels. Sketching the commodity chain of gum and resin is important to understand the relationship among the segments of the chain, activities involved along the chain from production to end users and to design an intervention or restructure the market chain for improving the efficiency of the market (FIAS, 2007). These also help to improve the benefit share of the actors that fetch the lower benefit under the current marketing structure.

Figure 2 shows a schematic presentation of functions and major chain actors in the gum and resin commodity chain.



Challenges of the production and marketing of gum and resin

The pastoralists and village traders as well as the experts in the study area have identified several challenges that limit their participation and production of more volume of gum and resin products.

The challenges are indicated below

1. Cultural influence:
2. Poor market access, poor market linkage and lack of market information
3. Lower price for gum and resin products
4. Inaccessibility of production area
5. Poor knowledge on production process, storage and quality of gum and resin product
6. Limited financial service
7. Absence of support from GOs and NGOs

4. Conclusion and Recommendation

The dry forest resources of the study areas have important gum and resin producing trees which are popular in the region. Production and marketing of gum and resin in the region have started to develop to support household, local and national economies. The development ofthe resources thus helps to further diversify the communities' income base, and hence improve livelihood. Besides, these products have the potential to expand the country's export potential.The current actual production is far below the potential although there is a high demand for quality gum and resin in this part of the country. The production is not in an organized way like that of the northern parts. In fact the current production system rarely constitutes a threat to the forest resources. However, the benefits from the huge resources are limited uy lack of production skill, variability in quality and inadequate best practices at harvest and post-harvest handling stage. There is also poor institutional structure and strong policies/legal framework to support the development, production and marketing of forest resources in general and gum and resin products in particular. To conserve and utilize the huge forest resources of the region thereby enhance their economic contribution at household, local and national level, designing and implementing any intervention related to the development, production and marketing of dry forest resources is urgently required. The first most important intervention required is to put in place strong policies/legal framework and institutions for successful development, production and marketing of gum and resins. This is strongly recommended as a means to sustainable management of gum and resin resources.

- Setting up specific policies that promote and regulate management of gum and resin resources is very important

- Establishment or strengthening of relevant institutions within the government that will provide supportive roles
- Institutions that provide credit facility or that facilitate loans for producers or groups of producers, create improved and sustained market links, market networks and timely provisions of market information are also equally important
- In order to achieve the aforementioned interventions, multi-institutional collaboration and integration of actions are required to optimize impacts for the sustained production and development of the resources. Activities may be shared among various institutions and stakeholders at federal, regional and local levels, including the private sector.

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3. Plant Survey and Resource Mapping of Gum and Resins Production, Challenge and Opportunities in Somali Region

[Idil Amin ,tell +251915731434 email: idilamin90@gmail.com][1], [Ibrahim Jibril, tell: +251915774379 email: abduyeehani@gmail.com][1] [Abdinasir Abdikader, Tell: +251915076088 email:awiesbare22@gmail.com][1]
Somali Region Pastoral & Agro-Pastoral research institute, Range and Forestry research Directorate.

Abstract

A study on evaluation of gum and resins Production, challenge and opportunities was carried in Qorahay, shabele and Afdher zone of Somali Region. The study was conducted at Dhobo weyn, Adadle and Qohale district at the study sites, which were selected on the bases of the presence of good population of the study species. Remote sensing data collection and classification of land use land covers were used for resource mapping. Transect lines were systematically laid at 500 metersr distance apart for the study sites in two districts (Kohle and Adadle) while at 1000m distance apart for the study site at Dobo weyn district. a total of sample 105 plots (45 at Adadle, 30 at Kohle and 30 at Dobo weyn) were used to collect data on the vegetation of the area. Quadrates were distributed in east west compass directions along established transect lines located at approximately 500 m from each other. In each quadrat, vegetation data such as identity, abundance, DBH, height, and counting of seedlings and saplings were made .The potential gum and resin yield from the vegetation resources were estimated based on literature data on annual yields of gum and resin per tree.

Based on the analyses of remote sensing and geospatial data, The study area is characterized by hot, arid to semiarid, corresponding to the Ethiopian “Bereha” and “Kola” climatic zones altitude range between The altitude ranges between 87 and 1600 meters above sea level, with an average altitude of less than 450 meters above sea levelGypsisols and Calcisols are the two most commonly types of soils in the area. The area is dominated by sandy textures. Usually, the Acacia - Commiphora woodland ecosystem found on red (locally referred as “Soben”) or brown (locally referred as “Deber”) sand soils.. vegetation survey shows A total of 21, 16 in Adadle, 17 in Dobo weyn and 11 in Kohle woodlands, gum and resin bearing tree and shrub species were recorded, respectively. Of these, 8 species occurred at the three sites. Dobo weyn was (648.3 individuals/ha) was higher than in Adadle (319.4) and Kohle (340).Boswellia species are more dominant in Dobo weyn and Kohle than in Adadle while gum commiphora bearing species are more dominant in Adadle.

The three major commercial gum and resin in the study areas include frankincense from the three Boswellia species, myrrh from Commiphora myrrha and opoponax from Commiphora guidotti

Keywords; dry land, Gum and resin, gum and resin bearing species, vegetation survey,

1. Introduction

The vegetation resources of Ethiopia in dry lands are classified as dry forest resources of Ethiopia. The dry land vegetation resources are: (1) dry evergreen Afromontane vegetation, (2) Comuretum–Terminalia (broad-leaved) deciduous woodland, (3) Acacia–Commiphora (small- leaved) deciduous woodland, (4) lowland dry forests, (5) lowland semi-desert and desert vegetation, (6) evergreen scrub, (7) wetland (swamps, lakes, rivers and riparian) vegetation, (8) moist evergreen montane forest, and (9) Afroalpine and sub-Afroalpine vegetation (Lemenih and Tadesse, 2010). Most of the Ethiopian dry forests are located in arid and semi-arid with marginal potential for rain-fed agriculture (Hawando, 1997). They occur in large parts of the lowland of the northern, western, north western, south western, eastern, southern and south-central parts of the country (Friis et al., 2010). The climatic condition in these areas is warm with a mean annual rainfall range of 500 to 1500 mm. In spite of being characterized as lower moisture zone, dry forests are believed to support diverse biological (plant, animal and microbial) resources The Acacia – Commiphora woodland is the first richest vegetation type in species and genetic diversity in Ethiopia with about 542 species

The common species in this vegetation type include species of the genera *Acacia, Boswellia, Commiphora, Zizyphus, Maerua, Cadaba, Boscia, Euphorbia, Aloe,* and *Sansevieria(* Abdela,2019). The vegetation has different species composition and form different plant communities that vary mainly with altitude, climate and edaphic factors (Lemenih et al., 2003; Worku, 2006).

These plant communities are home to a relatively high number of endemic species uniquely adapted to the variable and extreme conditions of dry lands. These endemic species have great potential as drought-tolerant high-value species, among other characteristics (Lemenih and Teketay, 2004; Worku, 2011).

The Combretum – Terminalia woodland and Acacia – Commiphora woodland are both dominated by gum and resin producing tree species, and the gums and resins in particular gum Arabic, myrrh and frankincense are economically very important non-timber forest products. Case studies show that, forests in the dry lands of Ethiopia have the potential to significantly contribute to climate change adaptation and poverty reduction, combating desertification and protecting biodiversity. These versatile resources, however, have yet to ue sustainably managed but rather are exposed to large-scale land use conversion (Teketay 2004-5; Lemenih and Kassa 2011; Worku et al. 2011; Worku et al., 2014).

In Somali Region, although most part of the Region is dry land, it is believed to have untapped natural resources, and therefore great future development potential. The vegetation resources in Somali Region are predominantly covered by Acacia-Commiphora woodland.. Gum and resin uearing species are the dominant species in terms of the total stem density in the woodlands (Tadesse et al., 2007). The gum and resin bearing species are much known for their well-recognized actual and potential socio-economic importance to the local people (Lemenih, et al., 2003; Worku, 2006). Limited works have been carried out so far on the area coverage, abundance and population structure of gum and resin bearing specie and their socio-economic importance in Liban zone of the Somali Regional States of Ethiopia. Lemenih, et al., (2003) have shown the type, number and structure of gum and resin bearing species and their variation between sites depending on the geographic location and edaphic factors

In spite of the growing recognition of and concern of gum and resin bearing species in particular and the woodland in general by different GOs, NGOs and scholars almost no quantitative data on the baseline information like the area coverage, type of gum and resin bearing species, the opportunities and challenges for sustainable production and marketing of gum and resin products to enhance the livelihood the local community are available for most part of Somali Region, No efforts deployed to improve the current collection method, processing (for domestic or international use), grading, storing and marketing of gum and resin bearing species. Very few efforts have been made to elucidate the socio-economic important of the species and pave ways for enhancing their importanceTherefore, the present study was carried out with the overall objective of Evaluating Gum and Resins Production, Challenges, Opportunities and market aspects in three selected districts of Somali Region, Ethiopia, The specific objectives of the study include: (1) generating spatial map of production potential areas and (2) Study diversity distribution of gum and incense tree bearing species of Somali region; The outputs of the study will be used to design overall regional intervention to overcome producer constraints and challenges of gum and resin production and marketing and incense the volume of production and its socio-economic contribution to improve the livelihoodof the local people

2. Materials and Methods

The study areas

The present study was carried out at three different districts, namely 'Adadle, Kohle and Dobo weyne located in three zones of the Somali National Regional State (SNRS) (Fig. 1). The three zones are the project areas for Lowlands Livelihood Resilience Project (LLRP). The three districts(one district per each Zone) were selected purposely based on the thorough discussion with different bodies among which were the project leader at the SoRPARI, Zonal and District agricultural experts, and local elders who have knowledge on the study species

Study site selection

An intensive field reconnaissance survey was conducted to select study sites with relatively good population of the study species. Accordingly, Dobo-weyn district from Korahey, Adadle district from Shebelle and Kohle from Afdher were selected for the study.

Methods of data collection

Remote sensing data collection and classification of land use land covers

For the purpose of mapping, freely available Sentinel 2A satellite images with 10 meter spatial resolution were downloaded. A better of cloud free image was selected from the available list of images. Twenty-one tiles (GRANULE) were required from T37/38 to cover the entire landscape. The images selected were acquired in late dry season (January – February/2022) in order to allow for a clear separation different land cover types. Only the spectral bands of the satellite images (Sentinel L2A) covering the Blue (Band - 2), Green (Band - 3), Red (Band - 4), Near Infra-red (Band - 8) were selected.

Vegetation data collection

Transect lines were systematically laid at 500 meter distance apart for the study sites in two districts (Kohle and Adadle) while at 1000m distance apart for the study site at Dobo weyn district. Along each transect line sample plots that measure 20 m X 20 m (400m^2) were systematically laid at the distance of 200 meters for the study sites in two districts (Kohle and Adadle) while at 300 m distance apart for the study site at Dobo weyn district. Accordingly, a total of sample 105 plots (45 at Adadle, 30 at Kohle and 30 at Dobo weyn) were used to collect data on the vegetation of the area. The differences in the distance between transect lines as well as plots were due to the difference in area coverage of the study sites.

To study the composition and diversity of the gum and resin bearing species, data on identity, diameter at breast height and height were recorded for tree, tree/shrub and shrub species rooted in all sample plots. Tree diameter was measured at 1.3 meter using Diameter Tape, while tree height was measured using height measuring devices (Nikon Forestry Pro II laser rangefinder). For trees and shrubs that forked below 1.3 meters, individual stems were separately measured. Seedling and saplings of gum and resin bearing species within the sample plots were counted and recorded to determine the regeneration pattern of study species. In this particular study, adult trees or tree/shrubs are defined as woody species with height > 1.5 meter in height; saplings are individuals with height between 0.5 and 1.5 meter while seedlings were smaller woody plants with height < 0.5 meter, but have developed permanent above ground shoot. For comparison purpose, all other woody species with > 1.5 m height encountered in the sample plots were counted and recorded

Data processing and analyses

Resource mapping

After the image processing is accomplished, classification was conducted using supervised classification technique. Random forest (Breiman, 2001) and Maximum likelihood algorisms were implemented during classification. The classification of target classes was assisted uy calculating spectral indices such as normalized difference vegetation index (NDVI). Supplementary spatial data were used to improve the accuracy of the classification and to support the interpretation of the classified map. ASTER data (30 m spatial resolution) and its derived variables such as altitude assist the classification processes. In addition, the soil type map of FAO, agro-ecological zone map of MOA and potential vegetation map of Ethiopia were implemented as auxiliary datasets during training samples. The images were geometrically and radio metrically (i.e. Top of Atmosphere) corrected. Image pre-processing techniques such as sub-setting, layer stacking and image enhancement was conducted for the downloaded images. Maximum likelihood algorithm of supervised classification technique was implemented Accuracy assessment was conducted to verify the quality of the classified land cover map. Therefore, 40 verification plots of one pixel (10 x 10m) were selected randomly for each class, within 60 meters from the boundary to another class. The "true" class of these verification plots was identified visually based on the reflectance nature of each class using and Google Earth andthen compared with the classes assigned uy the classification. Then, overall accuracy and Kappa statistics were used to know the level of accuracy of the classified image. The analysis was conducted on QGIS, R and ArcGIS software programs

Table 1: Description of different land cover types from the three zones

No.	**land cover classes**	**Description**
1	Bare land	Areas with no vegetation cover consisting of exposed soil and/or bedrock
2	Farmland	Areas covered with annual crops followed by harvest and uare soil period
3	Grassland	Landscapes that have a ground story in which grasses are the dominant vegetation forms.
4	Settlement	Land covered uy residences, road networks, buildings and small industrial areas in both rural and urban areas.
5	Water uody	Any type of surface water such as lakes including other intermittent ponds
6	*Prosopis* invaded	Land invaded uy exotic species called *Prosopis juliflora*
7	*Acacia* dominated Woodland	Land covered by *Acacia-Commiphora* woodland but *Acacia* is a dominant species than *Commiphora*
8	*Commiphora* dominated woodland	Land covered by *Acacia-Commiphora woodland but Commiphora species are dominant than Acacia species*
9	Scrubland	Land covered uy small trees, shruus and herbs, which may be Succulent, geophytes or annual.

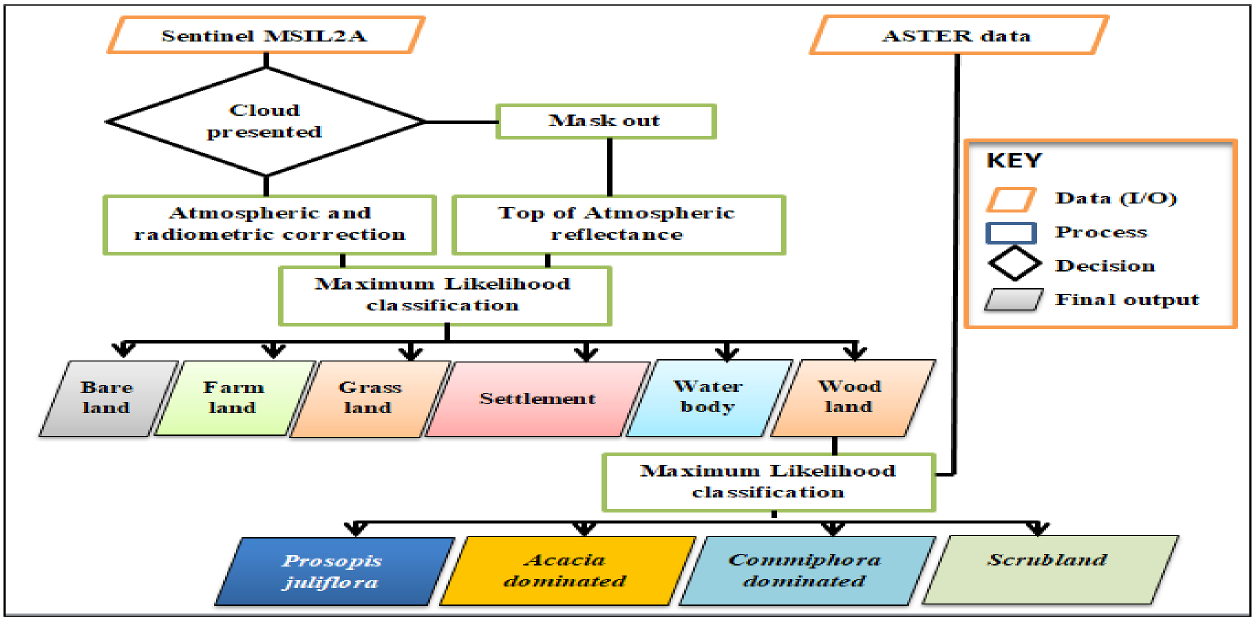


Figure 1: work flow to classify land cover classes

Species composition and vegetation structure

The floristic composition, species richness and species diversity were determined. We calculated individual density per species, basal area, frequency (number of plots in which a species is present) and importance value index (IVI) of each species per plot. IVI of a species is defined as the sum of its relative abundance (number of individuals per hectare of a species divided by total number of individuals per hectare of all species), its relative dominance (total basal area for a species divided uy total basal area for all species), and its relative frequency (frequency of a species divided uy the sum of all frequencies of all species) (Kent and Coker, 1992). To estimate the species richness and diversity of both sites, Shannon diversity indices were calculated using Estimates software version 8.2 (Colwell, 2006). To determine the population structure of tree/shrub species at community level, first all individuals encountered in the plots were grouped into 6 arbitrary diameter classes: 1 = 0-4 cm, 2 = 4-8 cm, 3 = 8-12 cm, 4 = 12 – 16 cm, 5 = 16 – 20 cm and 6 = > 20 cm. Then, uy employing the total numbers of individuals that were grouped in the different arbitrary diameter classes; the population structure was constructed using histograms of diameter class distributions

3. Results and Discussion

Resource mapping and area cover of gum and resin producing trees

General overview of the landscape using Auxiliary spatial datasets

The study area is characterized by hot, arid to semiarid, corresponding to the Ethiopian "Bereha" and "Kola" climatic zones. In the three zones, the southern and central areas have a flat plain and mostly plateaus landform. The altitude ranges Between 87 and 1600 meters above sea level, with an average altitude of less than 450 meters above sea level. According to Iu Friis et al (2010), Acacia - commiphora woodland found between 400 – 1900meter altitudes while most areas below 400 metres have been covered with desert and semi desert scrubland. In the study area, Gypsisols and Calcisols are the two most commonly types of soils in the area. The area is dominated by sandy textures. The black fluvial soils also occur along river bank mainly at Shebele zone which comprises flood plains. Usually, the Acacia - Commiphora woodland ecosystem found on red (locally referred as "Soben") or brown (locally referred as "Deber") sand soil.

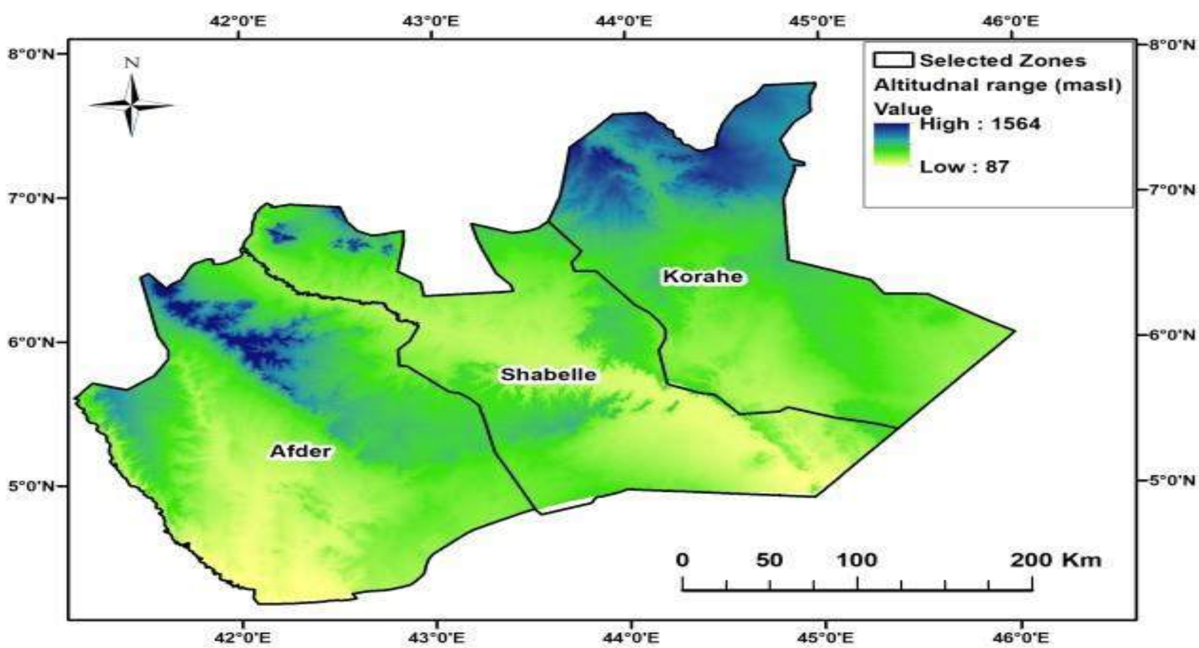


Figure 2: Altitudinal gradient map of the three Zones

Table 2: Area proportion of different soil types (Spatial data source, FAO)

Soil type	Afdeer		Korahe		Shabele	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Arenosols	6712.9	0.2	238891.5	7.0	19650.2	0.8
Calcisols	757031.8	18.0	1573713.9	46.5	627096.1	18.7
Camuisols	684.0	-	-	-	-	-
Fluvisols	99164.6	2.4	-	-	281094.9	8.5
Gypsisols	2309547.0	54.7	715174.7	21.1	1502869.2	44.5
Leptosols	844961.7	20.0	533323.8	15.7	609091.3	18.1
No Data	-	-	-	0.0	10467.3	0.5
Regosols	-	-	38625.1	1.1	-	-
Solonchaks	-	-	-	-	136329.5	4.2
Vertisols	197974.1	4.7	293214.9	8.6	153831.0	4.7
Wateruodies	-	-	-	-	803.6	-
Total	**4216076.1**	**100.0**	**3392943.7**	**100.0**	**3341232.9**	**100.0**

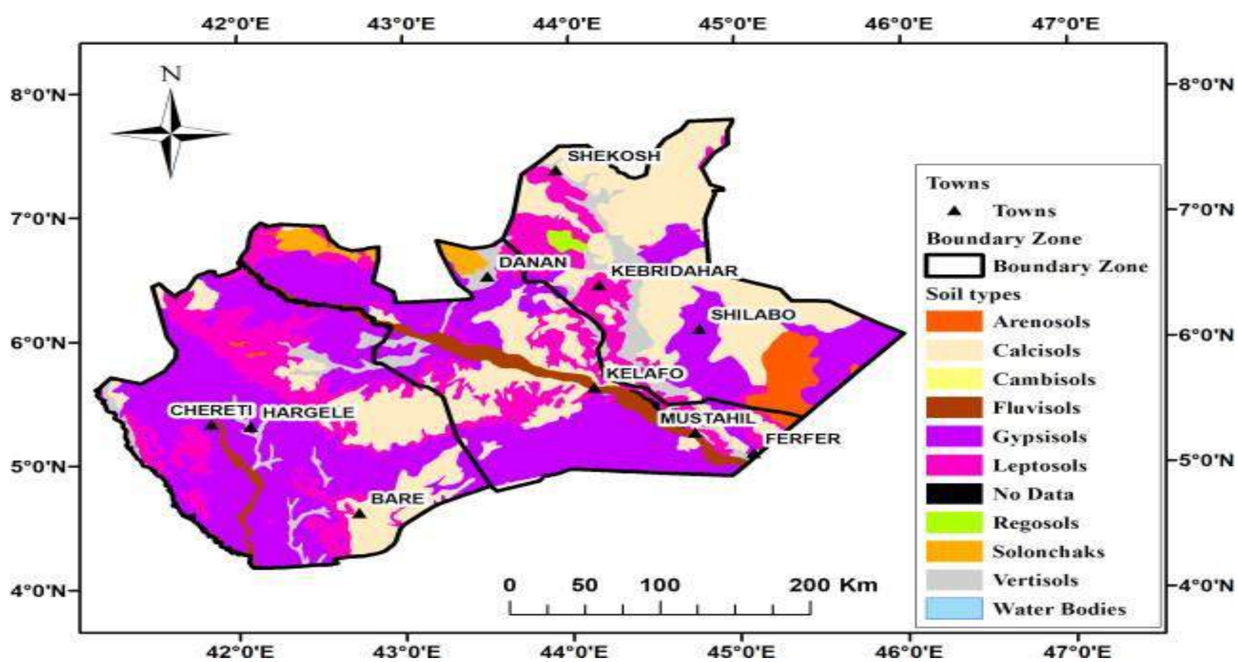


Figure 3: Soil map of the three zones (Spatial data source, FAO)

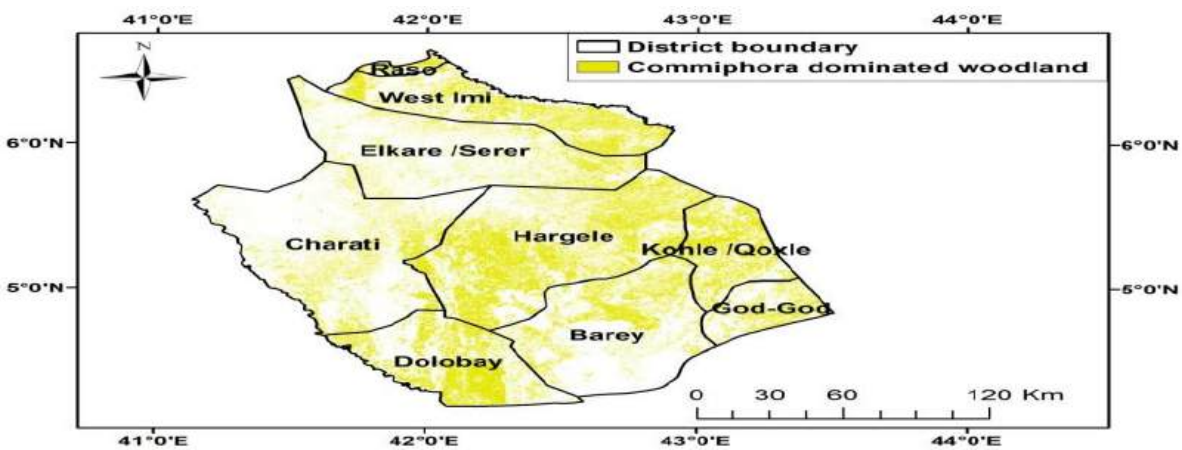
Spatial distribution map of the three zones

In the three zones, we identified six possible land cover classers namely bare land, farmland, grassland, settlement, water body and woodland. For the purpose of distinguishing gum and resin bearing species, we reclassify the woodland into four subclasses namely Prosopis Juliflera invaded, Acacia dominated and Commiphera dominated and scrubland. The result shows that Commiphera dominated woodland hold the greatest proportion in the three zones as compared to other types of land covers (Table 3).

Table 3: Land covers types and its areal proportion of the three zones

Zone	Bareland	Settlementt	Waterr body	Farm Land	Grass land	***Prosopis* invade D**	***Acacia* dominated woodland**	***Commiphora* dominated woodland**	Scrub land
Korahe	358134	16591	0	818	144658 4	3359	626073	**752712**	136961
Sheuelle	578931	15544	1922	2175 7	257308	7473	200915	**1412566**	896528
Afder	668667	10902	845	2006	976280	1373	994734	**1244163**	317105
Total	**160573 2**	**43037**	**2767**	**2458 1**	**268017 2**	**12205**	**1821722**	**3409441**	**135059 4**

Figure 4: Land cover and spatial distribution map of Afder Zone



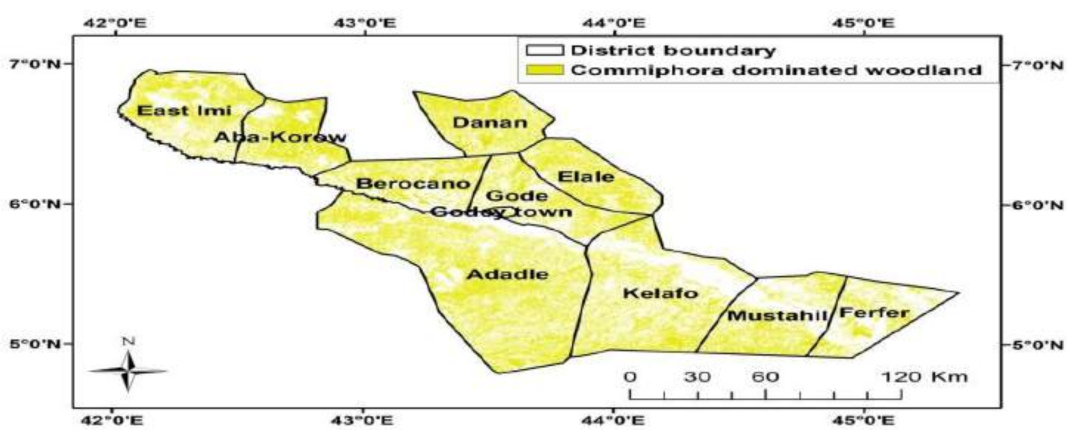


Figure 5: Land cover and spatial distribution map of Shebele Zone

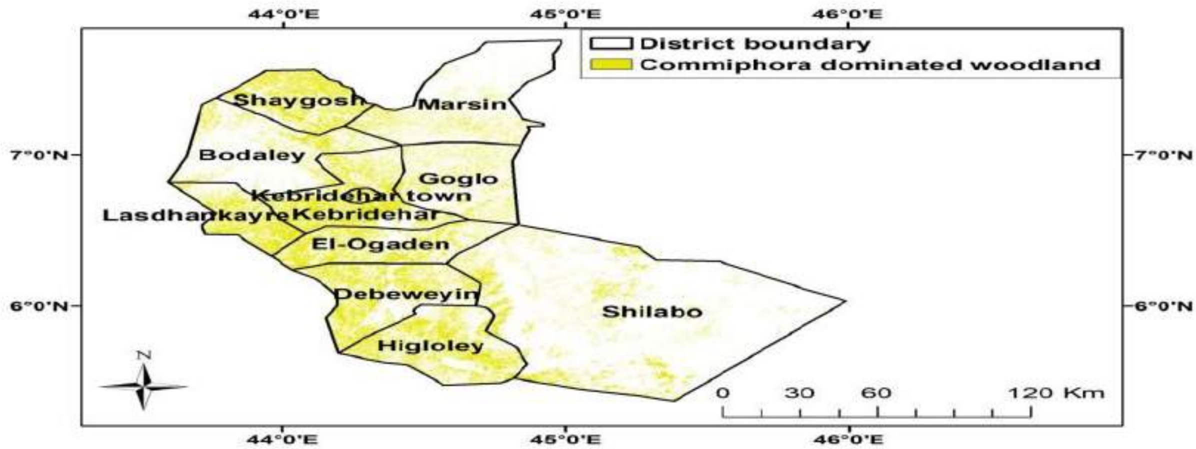


Figure 6: Land cover and spatial distribution map of Korahey Zone

Classification accuracies

The overall accuracy of the classified image is more than 80% which can be considered as a better result as compared with the classified image using Land sat images. Hence, the results of overall accuracy and kappa statistics of the classified images suggest almost perfect agreement

Table 4: Confusion matrix result of the classified image

		Real									
		AD	**BL**	**CD**	**FL**	**GL**	**PJ**	**SL**	**ST**	**WB**	**Total**
Classified	**AD**	**34**	0	3	0	0	0	3	0	0	**40**
	BL	0	**31**	0	1	3	0	2	3	0	**40**
	CD	3	0	**35**	0	0	0	2	0	0	**40**
	FL	0	2	0	**35**	0	3	0	0	0	**40**
	GL	0	4	0	1	**33**	0	0	2	0	**40**
	PJ	2	2	0	0	1	**35**	0	0	0	**40**
	SL	4	3	0	0	2	0	**31**	0	0	**40**
	ST	2	3	0	0	0	0	1	**34**	0	**40**
	WB	0	4	0	0	2	0	0	0	**34**	**40**
Overall accuracy : 83.8 %				**Kappa statistics : 0.81**							

Species composition, vegetation structure and regeneration status

Species composition, richness and diversity

A total of 21, 16 in Adadle, 17 in Dobo weyn and 11 in Kohle woodlands, gum and resin bearing tree and shrub species were recorded, respectively. Of these, 8 species occurred at the three sites. The vegetation at the three sites was dominated by Medafur (*B. rivae*). Among these oleo-gum resin bearing species, 15 species uelong to the genus Commiphora, 3 to the genus Boswellia and 3 to the genus Acacia. The co-dominants vary from site to site. The total number of observed species (species richness) was significantly higher for Dobo weyn than Kohle (Table 1). At Dobo weyn, woodlands were also more diverse and species were more evenly distributedthan at Abergelle (Table 5).

Table 5: Species richness, diversity and Density (in ha) of the different life stages of tree/shrub species inthree districts of Somali Region

No.	Diversity and density of Life stage	Adadle	Dobo weyn	Kohle
1	Species richness (gum and resin bearing)	16	17	11
2	Shannon-Wiener diversity of gum and resin spp	1.66	1.95	1.53
3	Density of Adults (gum and resin bearing spp	319.4	648.3	340
4	Density of other species Adults	22.2	103.3	24.2
5	Density of Saplings (gum and resin bearing spp)	37.2	69.2	50.8
6	Density of Seedlings (gum and resin bearing spp)	23.9	41.7	10.8

Vegetation Structure of gum and resin bearing species

Density, Diameter, Height and Frequency

Density

The total mean density of gum and resin bearing tree/shrub species in Dobo weyn was (648.3 individuals/ha) was higher than in Adadle (319.4) and Kohle (340) (Tables 5). Among the commercially important species, Didin is more abundant (51.7 individuals/ha) in Adadle than Dobo weyn (7.5) and Kohle (25). Hadi is more abundant in Adadle (43.3 individuals/ha) than in Dobo weyn and (2.5) and Kohle (12.5). Medafur (273.3 individuals/ha), Chewder (42.5) and Ged hareg (60) are more abundant in Dobo weyn than in Adadle and Kohle. This suggest that Boswellia species are more dominant in Dobo weyn and Kohle than in Adadle while gum commiphora bearing species are more dominant in Adadle than in Dobo weyn than Kohle. Associated with gum and resin bearing species, a total of densities of other species were 22.2,103.3 and 24.2 individuals/ha at Adadle, Dobo weyn and Kohle, respectively (Table 5).

Table 6: Density, frequency, Basal area and important value index (IVI) of tree/shrub species at Adadle district

No.	Local name	Scientific name	Density/ha	Freque ncy	BA/ ha	R densit y	RF	R dominan ce	IVI
1	Cadad	Acacia Senegal	1.1	1	0.00 4	0.348	1.042	0.130	1.52
2	Jeerin	Acacia Edgeworhii	0.6	1	0.00 1	0.174	1.042	0.031	1.25
3	Dhidin	Commipher a myrrh	51.7	18	0.48 8	16.174	18.75 0	17.100	52.0 2
4	Dhirin-dhir	Commiphera ellenueckii	7.2	3	0.04 1	2.261	3.125	1.423	6.81
5	Gowlele	Commiphera Kua	1.1	1	0.00 3	0.348	1.042	0.097	1.49
6	Gunre	Commipher a Africana	7.2	4	0.13 8	2.261	4.167	4.850	11.2 8
7	Hadi	Commiphor	43.3	16	0.43	13.565	16.66	15.144	45.3
		a guidottii			2		7		8
8	Hagar	Commiphor acoronillifol Ia	4.4	3	0.01 5	1.391	3.125	0.525	5.04
9	Hodey	Commiphor a Hodai	1.1	2	0.04 5	0.348	2.083	1.571	4.00
10	Jeerin	Acacia edgeworhii	2.2	2	0.00 5	0.696	2.083	0.177	2.96
11	Jelefan	Acacia Zizphispina	4.4	5	0.01 5	1.391	5.208	0.538	7.14
12	Qadhon	Commiphera confuse	23.9	9	0.21 4	7.478	9.375	7.498	24.3 5
13	Qurar	Commiphera samharensis	8.3	2	0.08 6	2.609	2.083	2.999	7.69
14	Midhafur	Boswellia rivae	158.3	26	1.34 8	49.565	27.08 3	47.251	123. 90
15	Liuew/su uegle	Commiphora rostrata	2.2	2	0.00 6	0.696	2.083	0.211	2.99
16	Touog	Un known	2.2	1	0.01 3	0.696	1.042	0.454	2.19
	Total		319.4		2.85				

Table 7: Density, frequency, Basal area and important value index (IVI) of tree/shrub species at Doo weyn district

No.	Local Names	Scientific name	Density /ha	Frequency ncy	BA/ ha	Rdensity	RF	dominance	IVI
1	Cadad	Acacia senegal	10.83	2	0.01	1.67	1.79	0.18	3.63
2	Jewder	Boswellia neglecta	42.50	6	0.20	6.56	5.36	3.77	15.68
3	Dhemajo	Commiphera incise	13.33	4	0.03	2.06	3.57	0.52	6.15
4	Dhidin	Commipheramyrrh	7.50	1	0.03	1.16	0.89	0.59	2.64
5	Dhirin-dhir	Commiphera ellenueckii	5.00	2	0.01	0.77	1.79	0.24	2.80
6	Geed-harreg	Boswellia microphylla	60.00	16	0.39	9.25	14.29	7.16	30.70
7	Gunre	CommipheraAfricana	27.50	8	0.18	4.24	7.14	3.33	14.72
8	Gunweyn	Un-known	70.83	11	0.37	10.93	9.8	6.85	27.6
9	Hadi	Commiphoraguidottii	2.50	1	0.03	0.39	0.89	0.53	1.81
10	Hagar	*Commiphoracoro nillifolia*	46.67	17	0.33	7.20	15.18	6.01	28.39
11	Hagar madow	Commiphora hauessinica	0.83	1	0.00	0.13	0.89	0.04	1.06
12	Hodey	CommiphoraspHodai	72.50	14	1.17	11.18	12.50	21.70	45.38
13	Qadhon	Commipheraconfuse	4.17	2	0.02	0.64	1.79	0.39	2.82
14	Qurar	Commiphera samharensis	1.67	1	0.06	0.26	0.89	1.02	2.17
15	Libew/suuegle	Commiphorarostrata	1.67	1	0.00	0.26	0.89	0.05	1.20
16	Midhafur	Boswellia rivae	273.33	22	2.54	42.16	19.64	46.95	108.76
17	Suuegle/Lebew	Commiphorarostrata	7.50	3	0.04	1.16	2.68	0.68	4.51
	Total		648.33		5.41				

Table 8: Density, frequency, Basal area and Important value index (IVI) of tree/shrub species at Kohle district

No.	Local Name	Scientific name	Density /ha	Frequency	BA/ ha	Rdensity	RF	Rdominance	IVI
1	Jewder	Boswellia neglecta	34.2	7	0.21	10.05	9.09	6.32	25.46
2	Dhidin	Commipheramyrrh	25.0	9	0.20	7.35	11.69	6.05	25.09
3	Gowlele	Commiphera Kua	10.0	6	0.05	2.94	7.79	1.52	12.25
4	Hadi	Commiphoraguidottii	12.5	5	0.17	3.68	6.49	5.21	15.38
5	Hagar	*Commiphoracoronillifolia*	19.2	7	0.18	5.64	9.09	5.54	20.27
6	Hodey	CommiphoraspHodai	1.7	1	0.05	0.49	1.30	1.56	3.35
7	Qadhon	Commipheraconfuse	10.8	7	0.07	3.19	9.09	2.21	14.49
8	Qurar	Commiphera samharensis	2.5	2	0.02	0.74	2.60	0.59	3.92
9	Midhafur	Boswellia rivae	199.2	23	2.16	58.58	29.87	66.59	155.04
10	Subegle/Leuew	Commiphorarostrata	10.8	4	0.02	3.19	5.19	0.74	9.12
11	Tobog	Un known	14.2	6	0.12	4.17	7.79	3.68	15.64
	Total		340		3.24				

A few species of trees/shrubs were found to pre dominate the density of the vegetation of the study areas. For instance, three species: Medafur, Didin and Hadi contributed to 79.3% of the total density at Adadle; four species: Medafur, Hode, Gunweyn and Ged hareg contributed to 73.5% of the total density at Dobo Weyn, whereas two species: Medafur and Chewder contributed to 68.6% of the total density at Kohle

Productivity (Diameter and Height)

The DBH ranges for gum and resin bearing tree/shrub species were from 2 - 28, 1.8 - 30 and 2 - 22 cm at Adadle, Dobo weyn and Kohle, respectively (Fig. 7). Moreover, trees with DBH of ≥ 20cm were 1.91%,2.31%and 0.98% at Adadle, Dobo weyn and Kohle respectively. On the other hand, the lowest DBH was < 2 cm for several species at uoth sites while the highest DBH was recorded for Hadi (28 cm) at Adadle, Hode (30 cm) at Dobo Weyn and Hagar (22 cm) at Kohle. Height of gum and resin bearing species ranged between 1.5 and 6.3m at Adadle, 1.5 and 8.1m at Dobo weyn and 1.6 and 6.2m at Kohle

Frequency and Basal area (BA in m^2)

Horizontal distribution of the species along the transect lines showed the existence of variation from site to site. For instance, Medafur, Didin, Hadi and kadon were found to ue the most frequent species at Adadle. These four species were recorded in 26, 18, 16 and 9 out of 45 sample plots. In contrast, Tobok, Gewlele, Cadad and Cheerin were encountered only in one plots at Adadle.

Medafur, Hagar, Ged hareg, Hode and Gunweyn were the top five frequent gum and resin bearing species encountered in 22, 17, 16, 14 and 11 out of 30 plots at Dobo weyn woodland. They were encountered in 25 and 19 out of the 32 sample quadrates, respectively. At Dobo weyn district, Didin, Hadi, Libew, Kurar and hagar ulack were among the least frequent species encountered in only one sample plots. In Kohle district, Medafur and Didin were the top two frequent gum and resin species encountered in 23 and 9 out of 30 plots. While Kurar and Hode are the least frequent species encountered in only two and one sample plots. Medafur, Didin and Hadi were the three top dominant species at Adadle, Medafur and Hode were the top dominant species at Dobo weyn, while Medafur was the only dominant species at Kohle. The total basal area ha^{-1} of gum and resin bearing species at Adadle, Douo weyn and Kohle were found to be 2.85 m^2 ha^{-1}, 5.41 m^2 ha^{-1} and 3.24 m^2 ha^{-1}, respectively.

Important value index

In terms of importance value index (IVI), Medafur, Didin and Hadi were the three most important species at Adadle. Medafur and Hode were the two most important species at Dobo Weyn. At Kohle, only Medafur was the most important species (Table 6, 7 and 8).

Population structure

The diameter class distribution of gum and resin bearing species at the three study sitesshowed a sort of un-modal (bell shaped) distribution of the diameter classes with few individuals at the lowest classes (0-4 cm), progressively increasing numbers of individuals up to the middle class (8-12 cm) followed uy a sharp decline towards the upper classes (Fig. 8)..The size class distribution of gum and resin bearing species at all sites showed a deviation from the reversed J-shape that indicates the regeneration of the study species is severely limited. Moreover, the distribution showed an increase in the frequency of trees with the increase in diameter classes. However, the small proportion or absence of trees in the smaller size classes indicates the poor establishment of seedlings or recruitment. The presence of few or no individuals in the smallest classes and increased numbers in the successive classes can also indicate low recruitment from the seed bank to the seedling bank and from the seedling bankto sapling bank and, relatively, the low mortality at the successive classes.

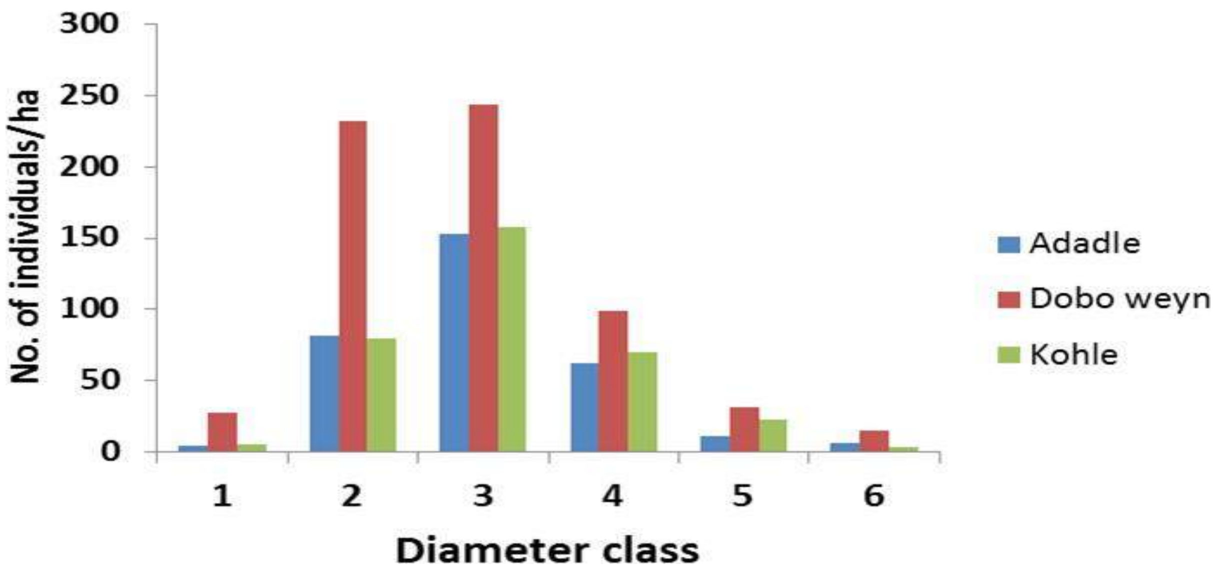


Figure 7. Diameter size class distribution of gum and resin bearing species in three districts of Somali Region, Ethiopia

Regeneration status of gum and resin bearing species

The regeneration status of gum and resin bearing tree/shrub species was determined based onthe population sizes of seedlings, saplings, and adults, according to Khan et al (1987), Shankar (2001), and Khumuongmayum et al (2006). Regeneration was categorized as follows:

Good if seedlings > saplings > adults;

Fair if seedlings > saplings ≤ adults;

Poor if there were saplings but no seedlings (irrespective of the relative numbers of Saplings and adults);

None if only adults were present, with no seedlings or saplings; or new if only saplings and/or seedlings were present, with no adults.

The number of adult trees, saplings and seedlings of gum and resin bearing tree species varied in the three study sites as far as their seedling/sapling stages are concerned (Table ….). The overall seedling density ranged between a maximum of 41.7 Ind/ha in Dobo Weyn of the Korahe zone and a minimum of 10.8 Ind/ha in Kohle of the Afdere zone, whereas sapling density varied between a maximum of 69.2 Ind/ha in Dobo Weyn of of the Korahe zone and aminimum of 37.2 Ind/ha in Adadle of the Shebelle zone.

In Adadle, density of Adult trees (Ind/ha) was highest (319.4 Ind/ha), followed uy saplings (37.2 Ind/ha) and seedlings (23.9 Ind/ha; Table …). In Dobo Weyn Adult trees (Ind/ha) was highest (648.3 Ind/ha), followed by saplings (69.2 Ind/ha) and seedlings (41.7 Ind/ha; Table …).

Whereas in Kohle, Adult trees (Ind/ha) was highest (340 Ind/ha), followed by saplings (50.8 Ind/ha) and seedlings (10.8 Ind/ha; Table …). Based on the above categorization, the three study vegetation showed poor regeneration

4. Conclusion and Recommendation

The dry forest resources of the study areas have important gum and resin producing trees which are popular in the region. Production and marketing of gum and resin in the region have started to develop to support household, local and national economies. The development of the resources thus helps to further diversify the communities' income base, and hence improve livelihood. Besides, these products have the potential to expand the country's export potential. The current actual production is far below the potential although there is a high demand for quality gum and resin in this part of the country. The production is not in an organized way like that of the northern parts. In fact the current production system rarely constitutes a threat to the forest resources. However, the benefits from the huge resources are limited uy lack of production skill, variability in quality and inadequate best practices at harvest and post-harvest handling stage. There is also poor institutional structure and strong policies/legal framework to support the development, production and marketing of forest resources in general and gum and resin products in particular. To conserve and utilize the huge forest resources of the region thereby enhance their economic contribution at household, local and national level, designing and implementing any intervention related to the development, production and marketing of dry forest resources is urgently required. The first most important intervention required is to put in place strong policies/legal framework and institutions for successful development, production and marketing of gum and resins. This is strongly recommended as a means to sustainable management of gum and resin resources.

- Setting up specific policies that promote and regulate management of gum and resin resources is very important
- Establishment or strengthening of relevant institutions within the government that will provide supportive roles
- Institutions that provide credit facility or that facilitate loans for producers or groups of producers, create improved and sustained market links, market networks and timely provisions of market information are also equally important
- In order to achieve the aforementioned interventions, multi-institutional collaboration and integration of actions are required to optimize impacts for the sustained production and development of the resources. Activities may be shared among various institutions and stakeholders at federal, regional and local levels, including the private sector

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4. Characterization And Mapping of Gum And Incense Tree At Selected District of Adadle, Elwayne And Kalafo Somali Region, Ethiopia

Abdinasir Abdikadir [1] Ibrahim Jibril[1] Idil Amin[1] Somali Region Pastoral and Agro-Pastoral Research Institute (SoRPARI) Forestry Resource Program Range and Forestry Research Directorate

ABTRACT

*Ethiopia has large coverage of gum and resin bearing species, widely distributed throughout its arid and semi-arid agro-ecological zones (Wubalem Tadesse et al., 2002). According to Vollesen (1989) there are about six species of Boswellia, 52 species of Commiphora and many Acacia species in Ethiopia. According to Coulter (1987), for instance, a large volume of myrrh produced and exported in Somali is actually originated from Ethiopia, mainly from Borana and Somali regional zones. Hence, collection and trade of gum and resin in Ethiopian economy in general and the local communities, in particular cannot be overlooked, as this sub-sector is still among the few export articles the country have to earn foreign currency. Somali region especially some of the districts (e.g. Elwayne, godey and Adadle etc..) has huge potential of gum and incense resin production that can significantly support the income of the local people and the country. Therefore, this research is designed and conducted to address the research gap exist in the country and the specific objective are to 1) conduct biometry survey and characterize the gum and incense trees and shrubs of selected districts; 2) understand the species composition of gum and incense trees and 3) map the spatial location of gum and incense tress within selected districts, and 4) to estimate above ground biomass and carbon stock potential of gum and incense trees and shrubs at the selected districts. The study was conducted at three districts of Somali region which are named as Elwayne, Adadle and Karinka (midway between Gode and kalafo district). We travelled to the selected district to collect land use and cover (LULC) data as well as to conduct biometry survey and identify species composition of gum and incense tress. We used Garmin GPSMAP64 devices with a reported 2-m accuracy to collect representative ground truth data for each land use and cover in the selected zones. to match the coordinate and projection system of GPS readings. Then, hybrid unsupervised and supervised classification was carried out. About 179 GPS points (20–30 samples for each class) were used for classification accuracy; thereby, our classification achieved overall accuracy of 92 pe cent. Besides the land use and cover investigation, we made a transect walk in the areas where there is a significant coverage of "gum and incense trees covers" and selected study plot where we collected biometry species composition data, The dominant land use and cover in the district includes woodland (58.37%), shrubland (18.27%) and bareland (23.36%), Accordingly, the height of **gum and incense** trees in the district ranges from 2.4 to 4.89 meter while the mean height is 4.11 meter. The DBH ranges from 33 to 11 cm (mean 71.92 cm) while tree density ranges from 475 to 725 (mean 589.58 count/ha). The AGB biomass ranges from 2,310 to 211,203 (54,158 kg/ha) while the carbon stock ranges from 1,086 to 99,265 (mean 25,455 kg/ha).In Adadle district, the largest coverage is bare land (22.31) and sparse shrub land (22.15%) followed by woodland (16 .79%) . Accordingly, the height of **gum and incense** trees in the district ranges from 2.55 to 4.55 meter while the mean height is 4.18 meter. The DBH ranges from 45 to 91 cm (mean 73.50 cm) while tree density ranges from 375 to 650 (mean 575 count/ha). The AGB biomass range from 7,178 to 28,096 (mean 19,362 kg/ha) while the carbon stock ranges from 3373 to 13205.28 (mean 9100* *kg/ha Thus, our result revealed that Elwayne district alone could stock a carbon which amount 3642.12 ton from gum and incense trees followed by Adadle (1115.59 ton) and Godey (723.46 ton). Thus, similar to AGB, Elwayne district ranks first in this aspect as well followed Adadle and Godey distric.*

Keywords: - Characterization, Mapping Gum and Incense.

1. Introduction

Even though there is no full national inventory on wood resources, it is reported that Ethiopia has large coverage of gum and resin bearing species, widely distributed throughout its arid and semi-arid agro-ecological zones (Wubalem Tadesse et al., 2002). According to Vollesen (1989) there are about six species of Boswellia, 52 species of Commiphora and many Acacia species in Ethiopia. The use and trade of Oleo-gum resin is an age-old activity in Ethiopia and Ethiopia is one of the world's major producers and exporters of these products (Mulugeta Lemenih et al., 2003; Abeje Eshete et al., 2005). According to Mulugeta Lemenih (2005) in the period 1996 - 2003, Ethiopia exported 13,299 tons of natural gum and earned 141,064,151Birr (≈18, 000,000 USD). This does not include the informal trans-border trade with Somali, Kenya and Sudan. According to Coulter (1987), for instance, a large volume of myrrh produced and exported in Somali is actually originated from Ethiopia, mainly from Borana and Ethio-Somali zones. Hence, collection and trade of gum and resin in Ethiopian economy in general and the local communities, in particular cannot be overlooked, as these sub-sector is still among the few export articles the country have to earn foreign currency.

The potential areas of gum and incense production in Ethiopia are located at arid and semiarid parts of the country (Hedbergand Edwards, 1989; Azene et al., 1993). In this regard, the Somali region is among the areas that are endowed in gum and incense producing woody species in the country that need to focus their potential and distribution areas to be explored. The region especially some of the districts (e.g. Elwayne, godey and Adadle etc..) has huge potential of gum and incense resin production that can significantly support the income of the local people and the country.

Therefore, this research is designed and conducted to address the above research gap and the specific objective are to 1) conduct biometry survey and characterize the gum and incense trees and shrubs of selected districts; 2) understand the species composition of gum and incense trees and 3) map the spatial location of gum and incense tress within selected districts, and 4) to estimate above ground biomass and carbon stock potential of gum and incense trees and shrubs at the selected districts.

2. Material and methods

2.1 Description of the study area

The study was conducted at three districts of Somali region which are named as Elwayne, Adadle and Karinka (midway between Gode and kalafo district) **(Figure 1).** These districts are well known in their high production capacity and availability of **gum and incense resin** which has regional as well as national production potentials, and hence are selected for this study.

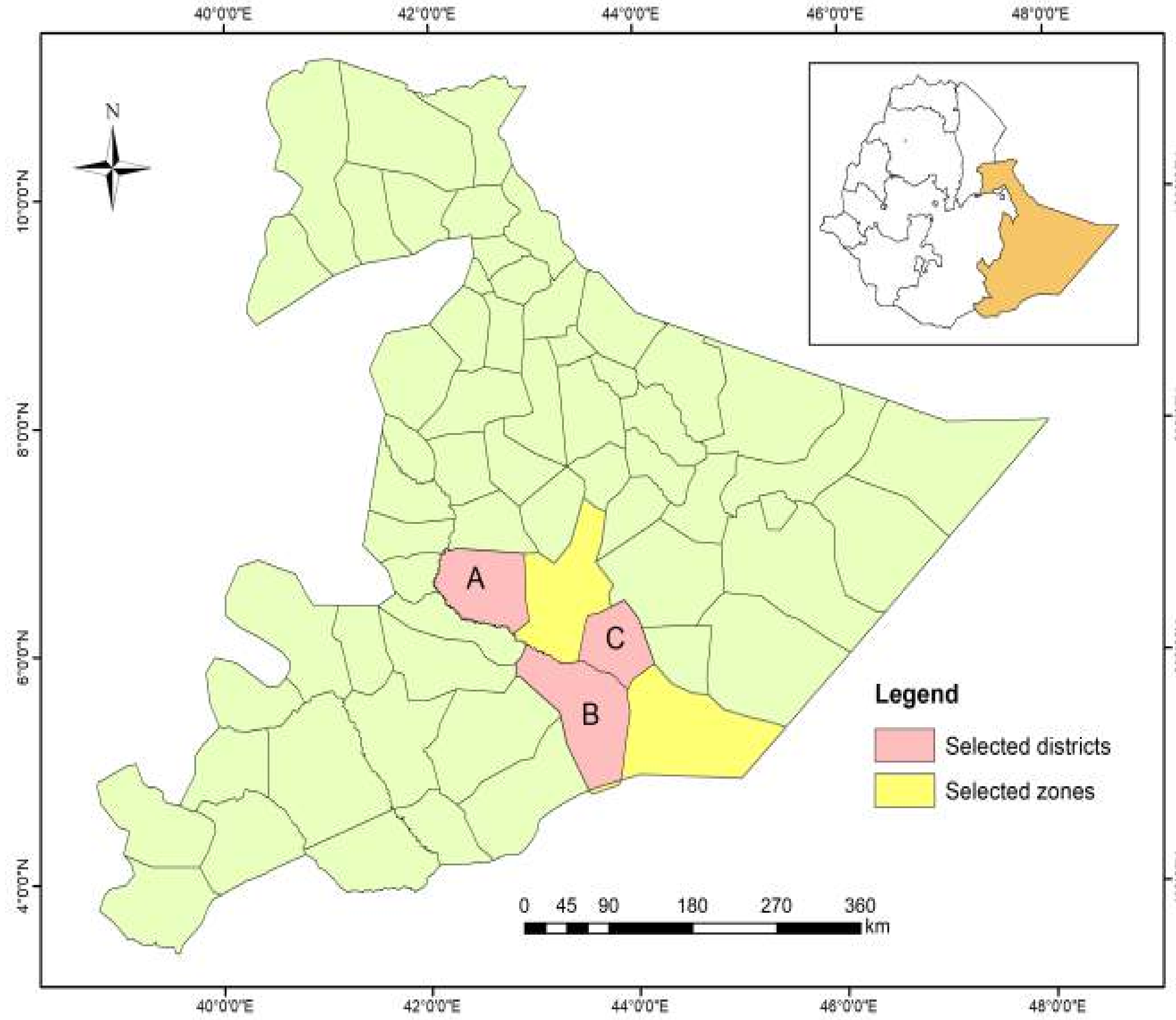

Figure 1: Map of the study area: Elwayne (A); (Adadle (B) and Godey (C)

2.2 Data type and method of collection

2.2.1 Field observed data.

We travelled to the selected district to collect land use and cover (LULC) data as well as to conduct biometry survey and identify species composition of gum and incense tress. We used Garmin GPSMAP64 devices with a reported 2-m accuracy to collect representative ground truth data for each land use and cover in the selected zones. Thereby, a total of 179 Ground Control Points (GCP) were collected from different districts (e.g. Elwayne 43 points; Adadle 54 points; and Godey 71 points), and used as a reference during image interpretation and classification accuracy assessment. We also marked by GPS the plot location where the biometry survey and measurement was conducted.

2.2.2 Remote sensing data

Cloud-free satellite images were downloaded and processed to obtain the land use and cover map of the different zones. Particularly, Sentinel-2 data are acquired on 13 spectral bands in the Visible and Near-Infrared (VNIR) and Shortwave Infrared (SWIR) regions. First, the downloaded images were geometrically corrected (UTM Zone 38N, datum Adindan, Spheroid-Clark1888) to match the coordinate and projection system of GPS readings. Then, hybrid unsupervised and supervised classification was carried out. About 179 GPS points (20–30 samples for each class) were used for classification accuracy; thereby, our classification achieved overall accuracy of 92 per cent **(Figure 2).** Thereby, the proportional area coverage of each LULC in the districts was analyzed from the satellite image and then **gum and incense** tree coverage were separated from the other land use and cover for further analysis.

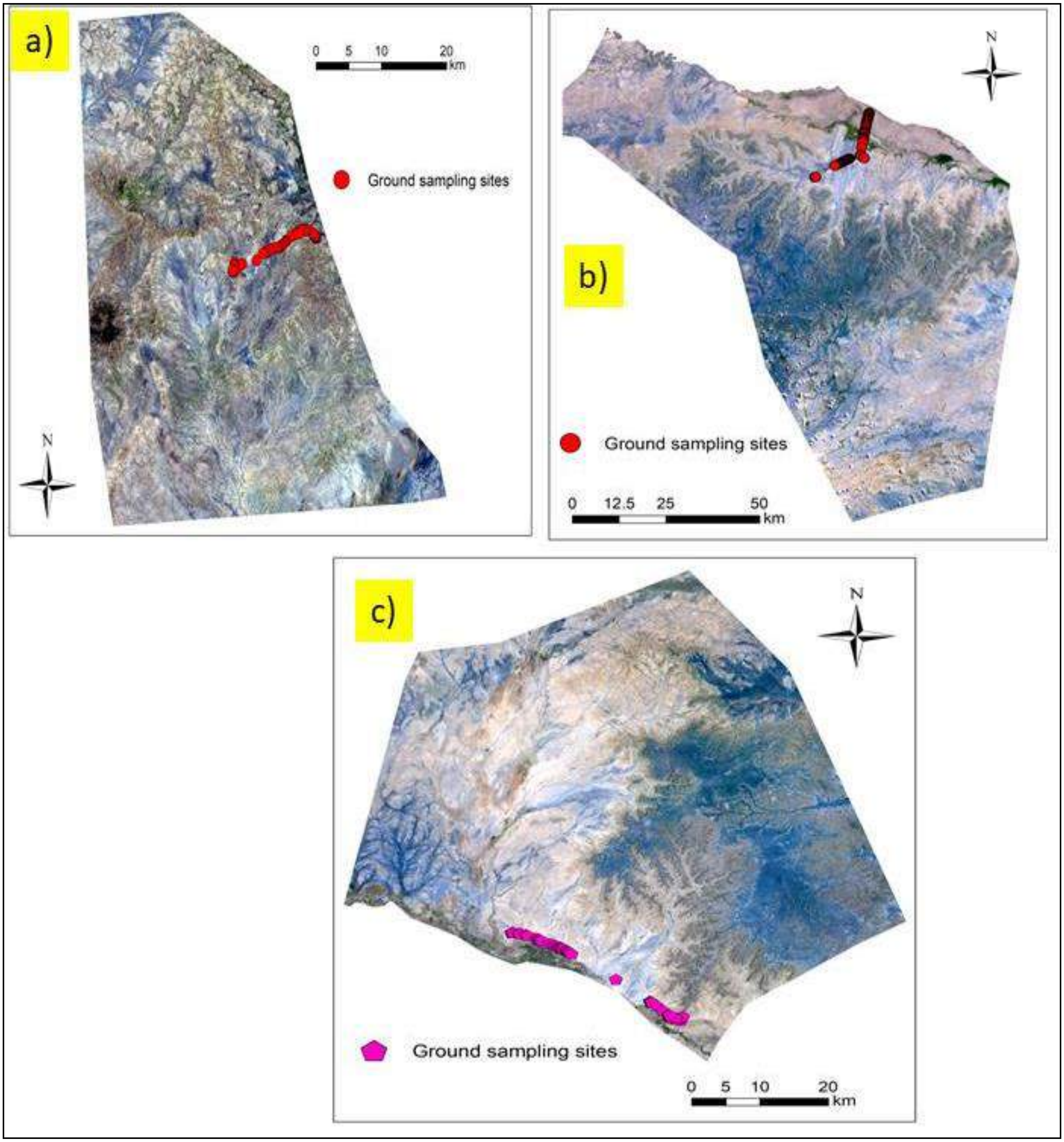

Figure 2: Satellite image (sentinel 2) of the 3 districts (a= Elwayne; b=Adadle; and C =Karinka) for the year 2020 with ground sampling location.

2.2.3 Biometry and species composition data

Besides the land use and cover investigation, we made a transect walk in the areas where there is a significant coverage of **"gum and incense trees covers"** and selected study plot where we collected biometry species composition data. Thus, in each district we selected 6 plots that can be representative for gum and incense tress of the district in terms of biometry (tree height, DBH, and density) and species composition. Thus, each plot had a minimum of 20 by 20 meter (400 m^2 quadrant) size and we established this size using a tape meter and a rope which is used as a base/boundary to make all the measurements.

After the quadrant is established, we made different biometry survey and measurements such as tree diameter at breast height (DBH) and tree height The DBH was measured by normal tape meter while the tree height was measured using a clinometer**.** The DBH was measured for all trees with their DBH $\geq$10cm within the plot. This help to know the min, max and mean of DBH of tress within the plot. As pointed out by Brown (2002) trees with DBH less than 10cm have an insignificant contribution to biomass/carbon stock. DBH was measured using diameter tape at 1.3-meter height from the ground.

2.2.4 Above ground biomass and carbon stoke

The allometric equation was applied to estimate the AGB of the district through integrating the measured biometric data (tree density/ha) and the total area of "gum and incense trees" obtained from image analysis. The allometric equation were developed based on the relationship of the biophysical parameters of trees mainly DBH and tree height (Ketterings et al., 2001). The equation can be either species specific or generic. However, for highly homogenous species of trees like in the "gum and incense tress" allometric equation is very appropriate and widely used (Gibbs, Brown, Niles, & Foley, 2007). Therefore, for this study, the generic allometric equation developed by Chave et al. (2005) was employed (eq. 1) to estimate ABG and carbon stock of gum and incense trees in each district.

$\mathrm{AGB} = 0.0673\ \mathrm{X}(\rho D^2 H)0.976$……………………….(1)

Where,

AGB: Above ground biomass (Kg)

ρ: Specific wood density (g/cm3) (Reyes et al., 1992) of wood density for tropical forest tree species which is 0.57g/cm3

D: Diameter at breast height (cm)

H: Height (m)

Carbon is derived from above ground biomass, and it is assumed that approximately 50% of dry biomass is carbon (Basuki et al., 2009; Drake et al., 2003). Therefore, to calculate the carbon stock, AGB is multiplied by a conversion factor (CF) of 0.47 (Aalde et al., 2006) (Equation 2).

$$C = AGB \text{ X } CF \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where,
C-carbon stock (Mg); AGB-Above-ground biomass (Mg); CF-conversion factor which is 0.47.

3. Results and discussion

3.1 Characterization of gum and incense trees at Elweyne district

3.1.1 Land use and cover map of Elwayne district

The dominant land use and cover in the district includes woodland (58.37%), shrubland (18.27%) and bareland (23.36%) (Figure 7 and table 1). Hence, woodland which is dominated by **gum and incense** trees are the most common LULC found in the district followed by bareland and shrubland (table 1).

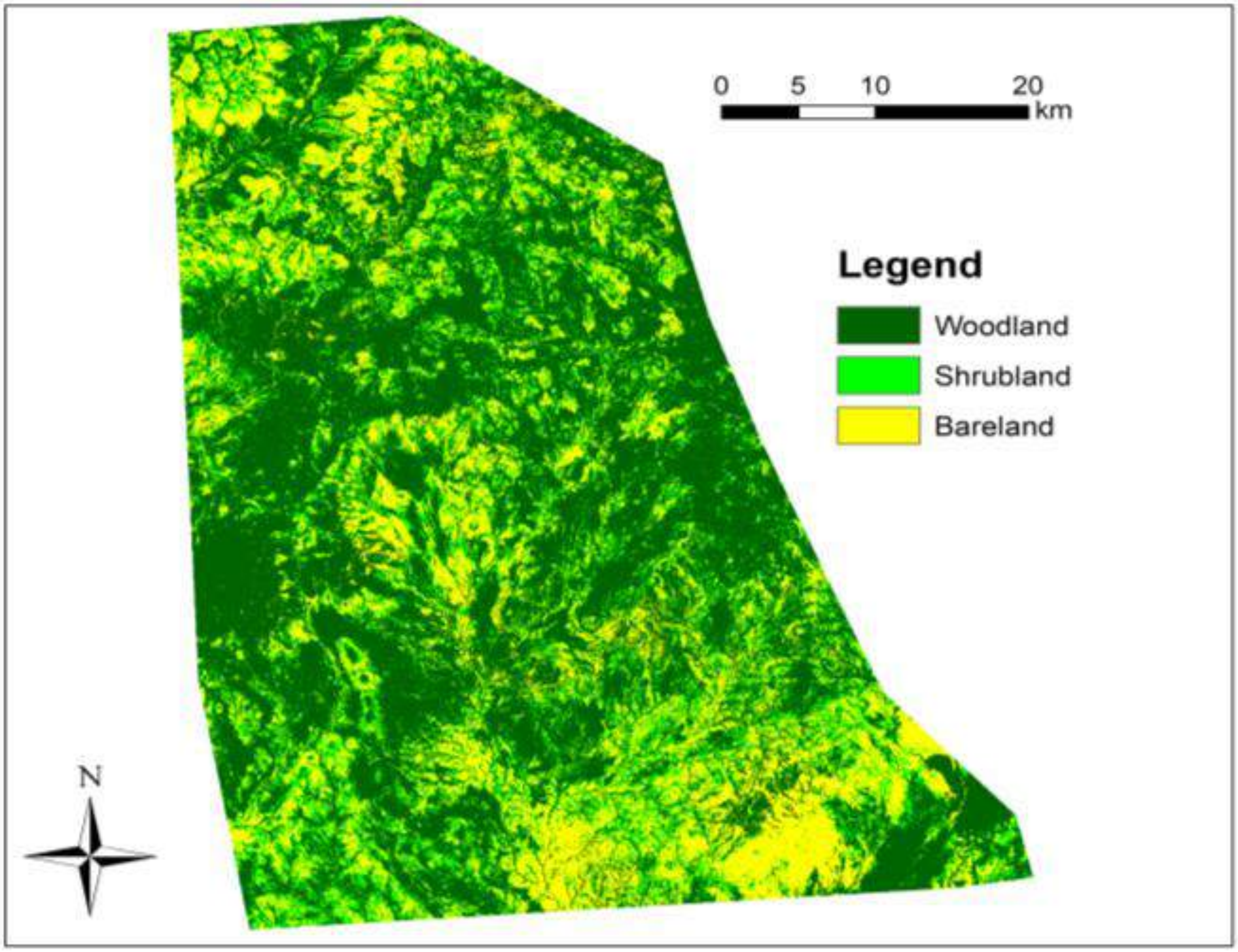

Figure 7: land use and cover map of Elwayne district (2020)

On the basis of our field survey and prior knowledge of land use and cover classification, we gave operation definition and description to each land use and cover (table 1). However, among the different land use and cover our interest is on woodlands which contain gum and incense trees with significant composition.

Table 1: Land use and cover types of Elwayne district (2020) with their operational definitions and area coverage

Land-cover types	Area coverage		Operational Land-use	Brief description of each land cover
	Km^2	Per cent		
Woodland	**1430.80**	**58.37**	**Browsing to animals (mainly camels); source of fuel (charcoal and fire wood)**	**Land with woody species cover >50% (height ranges 2–20m) and mostly dominated by gum and incense, and acacia trees**
Shrubland	447.80	18.27	Browsing to mainly goats and camels	Land covered with sparse acacia plants and other short tree species.

Bareland	572.70	23.36	Barren land with no economic value	Areas mainly with no vegetation cover and to some extent very scattered Acacia tree or non-vegetated areas, or areas, very little vegetation cover and may rock is exposed to surface.
Total	2451.30	100.00		

3.1.2 Biometry and species composition of gum and incense trees (Elwayne)

We conducted biometry survey on the woodlands specifically to understand their characteristics in terms of tree height (minimum, maximum and average), diameter at breast height (DBH), tree density, above ground biomass (AGB) and carbon stock per unit area. Hence, we conducted this survey on fixed plot size (20 meter by 20 meter) and repeated the measurements at several plots to obtain the mean value of the district in each parameter. The result of biometry and species composition survey for Elwayne district is summarized in table 2 below.

Accordingly, the height of **gum and incense** trees in the district ranges from 2.4 to 4.89 meter while the mean height is 4.11 meter. The DBH ranges from 33 to 11 cm (mean 71.92 cm) while tree density ranges from 475 to 725 (mean 589.58 count/ha). The AGB biomass ranges from 2,310 to 211,203 (54,158 kg/ha) while the carbon stock ranges from 1,086 to 99,265 (mean 25,455 kg/ha).

Table 2: Summary of biometry and species composition for **Elwayne district**

Plot ID.	GPS code	Tree height (meter)	DBH (cm)	Tree number (GI-count)	Tree density (n/ha)	AGB (kg/ha)	Carbon stock (kg/ha)	Species composition		
								Commiphera	**Boswelia**	**Others**
1	977	2.40	33.5	19	475	2310.95	1086.15	6-C. samharenses 5- C. Myrrha	7-B. rivae; 1-B.negleta	3-acacia; 5 other trees
2	978	3.90	33	21	525	3604.42	1694.08	6- C. Myrrha, 13-C. samharensis	2 B. microphylla	5-acacia; 6-other trees
3	979	4.70	111	29	725	46158.80	21694.64	9- C. myrrh, 7-C. samharensis 4- C. terebinthine	5-B. microphylla, 4- B. rivae	5-acacia
4	980	4.10	68	18	563	15522.12	7295.40	7 C. samharensis, 3 c. guidottii And 3-C. terebinthine	5-B. rivae	8-acacia; 11 other tree
5	983	4.89	75	29	725	211203.7 4	99265.76	5- C. guidottii, 6-C. Myrrha 4- C. samharensis	11 B. rivae 3-B. Microphylla	4-acacia; 7-other tree
6	984	4.70	111	21	525	46158.80	21694.64	7-C. myrrha, 2-C. samharensis 3-C. guidottii 2- C. Africana	4 B rivea 3 B. microphylla	6 acacia; 4 other
Average		4.11	71.92	22.83	589.58	**54159.80**	**25455.11**			
CV (%)		22.48	48.45	21.53	18.41	146.62	146.62			

GI=gum and incense; C= Commiphera species; B=Boswelia species

Note: For consistency, the horizontal distance of clinometer reader from the tree was taken as 10 meter for all cases. Thus, the reading from clinometer could be directly changed to height (tan theta =opposite/adjacent) and then the height of the person who make the reading will be added to it **(in our case 1.70 meter). Thus, the calculation of tree height become (tree height=tan theta*adjacent (10 meter) + height of the person (1.7 meter).** The quadrant of each biometry measurement plot was 20 by 20 (400m^2).

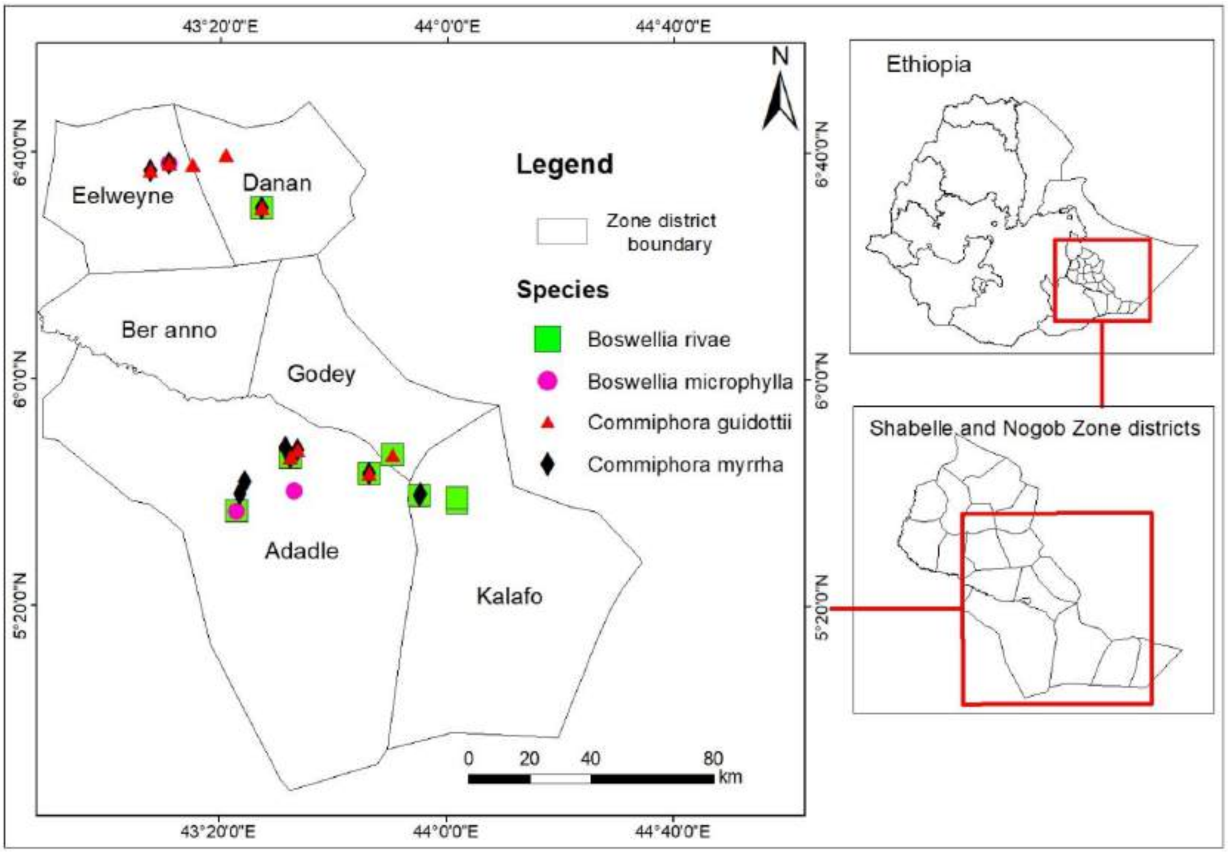

Figure: Map of all species (Boswellia and Commiphora species) encountered

Regarding species diversity, **Commiphera and Boswelia** are the most dominant gum and incense tree species available in the district (table 2). However, their proportional density varies from plot to plot that are considered in our measurements. Besides, these two species, there are other trees and shrub species (mainly acacia) that were found in our selected plots where we conducted the measurement (table 2).

3.2 Characterization of gum and incense trees at Adadle district

3.2.1 Land use and cover map of Adadle district

In Adadle district, the largest coverage is bare land (22.31) and sparse shrub land (22.15%) followed by woodland (16.79%), **sparse bushland (11.18%)** and grassland (8.68%) (Figure 8 and table 3). However, out of these LULC, our interest area is **sparse bushland** because of gum and incense trees are found under this particular land use/cover (table 3). Sparse bushland has the lowest proportional area coverage (11.18%) in the district which is only slightly higher than grassland (8.68%) but lower than all other land use and cover. Similarly, based on our field survey and prior knowledge of land use and cover classification, we gave operation definition and description to each land use and cover found in Adadle district (table 3). In terms of land use and cover, Adadle district has more diversity as compared to Elwayne district.

Table 3: Land use and cover types of Adadle districts (2020).

Land-cover types	**Area coverage**		
	Km^2	Percent	Description of land use and cover
Woodland	1839.92	16.79	Land with woody species cover >50% (height ranges 2–20m) and mostly dominated by acacia trees
Grassland	951.16	8.68	All areas covered mainly by different grass species, which is used as a natural pasture.
Sparse shrubland	2427.5	22.15	Land covered with dry and highly sparse acacia plants
Sparse bushland	**1225.9**	**11.18**	**Scattered woods larger than shrubs mainly gum and incense tree species**
Bareland	2445.33	22.31	Areas mainly with no vegetation cover and/or to some extent scattered Acacia tree and/or rock is exposed to surface.
Total	10961.56	100	

The spatial distribution of each land use and cover is presented under Figure 8. Hence, **sparse bushland** which indicate the presence of gum and incense tress are dominantly found at the north western part of the district (Figure 8).

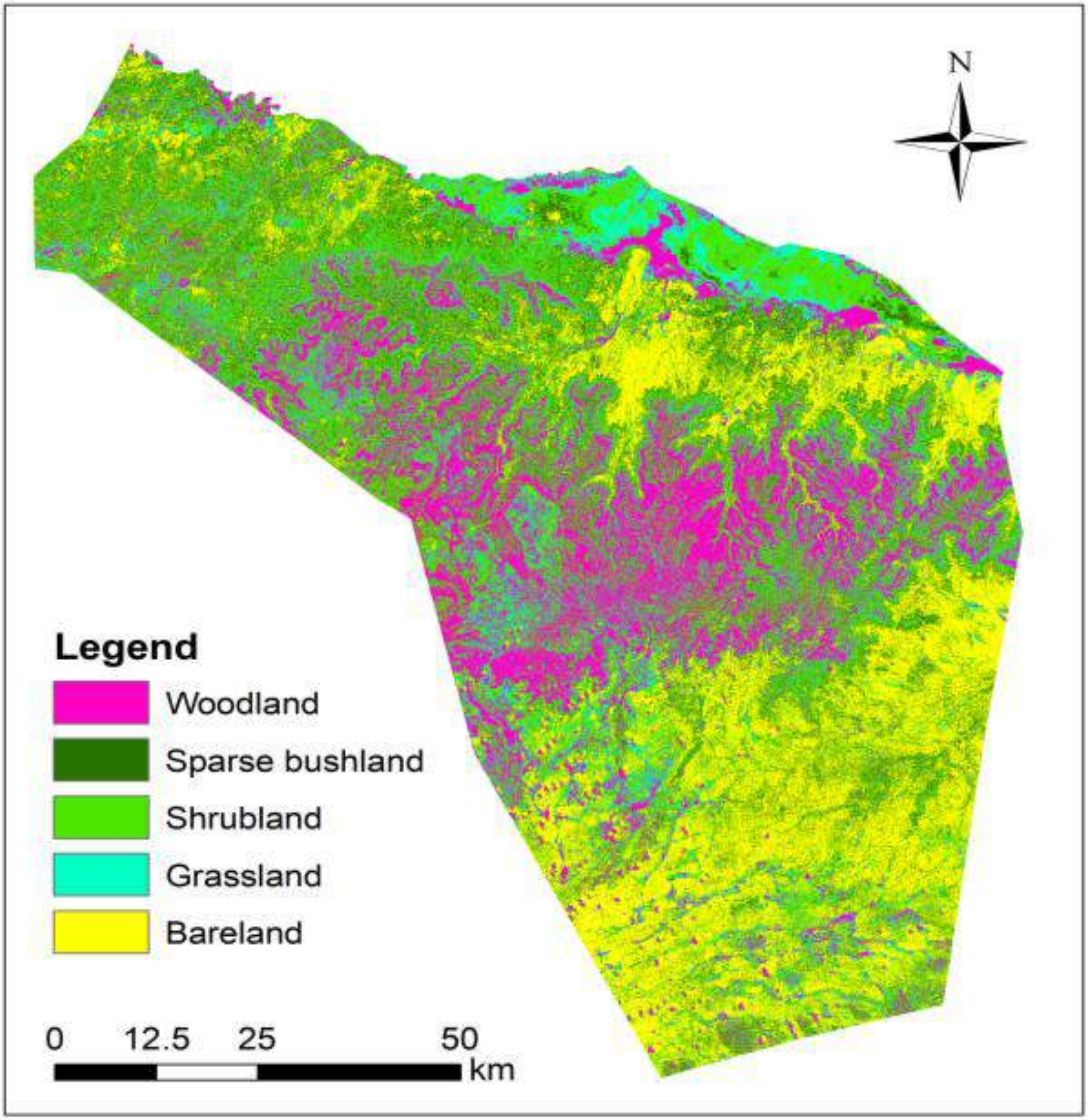

Figure 8: Land use and cover map of Adadle district (2020

In the district, we conducted the survey and measurement on 20 meter by 20-meter quadrant and replicated in 6 different plots to obtain the mean value of the district in each parameter (table 4). Accordingly, the height of **gum and incense** trees in the district ranges from 2.55 to 4.55 meter while the mean height is 4.18 meter. The DBH ranges from 45 to 91 cm (mean 73.50 cm) while tree density ranges from 375 to 650 (mean 575 count/ha). The AGB biomass range from 7,178 to 28,096 (mean 19,362 kg/ha) while the carbon stock ranges from 3373 to 13205.28 (mean 9100 kg/ha) **(table 4).**

Table 4: summary of biometry and species composition for Adadle district

Plot ID.	GPS code	Tree height (meter)	DBH (cm)	Tree number (GI-count)	Tree density (n/ha)	AGB (kg/ha)	Carbon stock (kg/ha)	Species composition		
								Commiphera	**Boswelia**	**Others**
1	1040	4.49	80	26	650	23301.39	10951.66	3- C. samharensis	23-B. rivae	2 other
2	1041	4.19	91	24	600	28017.44	13168.20	-----	24-B. rivae	6-acacia
3	1043	4.05	57.5	15	375	11041.87	5189.68	4-C.habasinica; 2-C. hottziana; 2- C. Africana	3-B. microphylla; 4-B. rivae	1-acacia;19 other
4	1044	4.55	87.5	22	550	28096.35	13205.28	8-C. Africana	10-B. Rivae; 4- B. neglecta	4 others
5	1045	4.25	45	25	625	7178.64	3373.96	9-C. myrrh; 6-C.samharensis; 5- C. guidottii;3-Commiphera ;2-C. aerruleta	…………………….	8-others
6	1046	3.55	80	26	650	18536.73	8712.26	9-C. myrrh;7-C. guidottii;4-C. sp;3- C. Hottziana	3-B. rivae	6-acacia 3-others
Average		**4.18**	**73.50**	**23.00**	**575.00**	**19362.07**	**9100.17**			
CV (%)		8.62	24.75	18.24	18.24	45.32	45.32			

3.3 Characterization of gum and incense trees at kalafo district

3.3.1 Land use and cover map of kalafo district

The survey in this district was conducted specifically at a location called “kerenka egay” where the gum and incense trees and species are widely found. However, since Keren has no its own shape file boundary, we are forced to considered the whole district (Godey) in the remote sensing work and upscale of the field data that was conducted at Keren.

According to our field survey and image analysis result, **in Godey district,** the largest land use and cover is bareland (24.13%) followed in decreasing order by sparse shrubland (17.37%), cropland (16.83%), dense shrubland (10.03%), and woodland (5.67%) (Figure 9 and table 5). The land use and cover category where the gum and incense are found is **sparse shrubland** and hence we gave special attention to this particular LULC. In proportion, **sparse and shrubland** covers 17.37% of the total area in Godey district (table 5).

Table 5: Land use and cover types of Godey districts (2020).

Land-cover types	**Godey**		
	Km^2	Percent	Description of land use and cover
Woodland	324.33	5.67	Land with woody species cover >20% (height ranges 5–20m) and mostly dominated by acacia trees
Sparse shrubland	**993.15**	**17.37**	**Land covered with dry and highly sparse gum and incense plants**
Dense shrubland	573.59	10.03	Land covered with dense and green shrubs/mainly of acacia species.
Cropland	962.36	16.83	Mainly of wheat crops in irrigation farms
Bareland	1380.2	24.13	Areas mainly with no vegetation cover and/or some scattered Acacia tree and/or rock is exposed to surface.
Total	5719.22	100.00	

The spatial distribution of each land use and cover in Godey district is presented under figure 9. Hence, **sparse shrubland** which indicate the presence of gum and incense tress are dominantly found at the south western and south eastern part of the district **(Figure 9).**

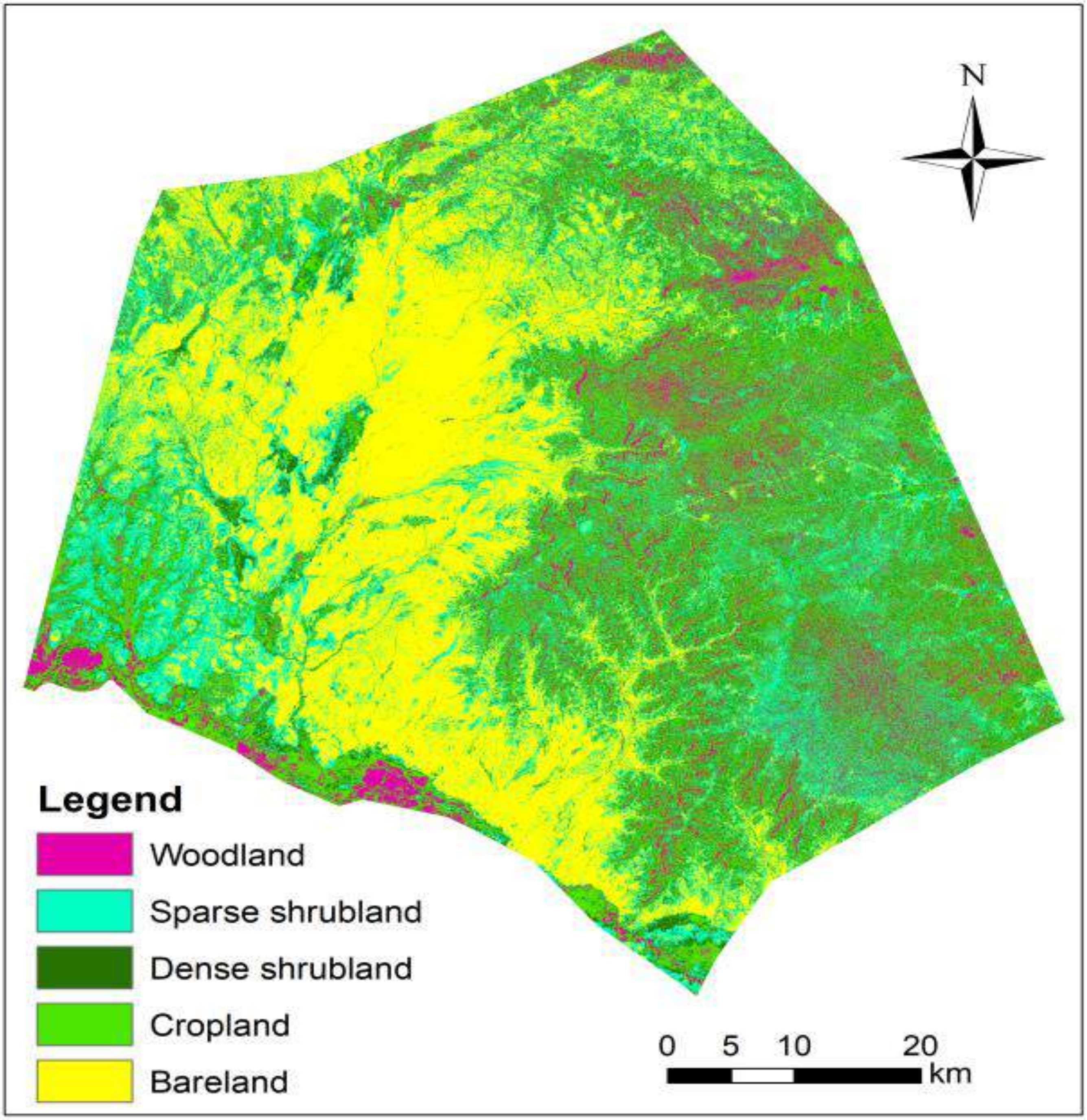

Figure 9: Land use and cover map of Godey district (2020)

3.3.2 Biometry and species composition of gum and incense trees at Godey district

We conducted the biometry and species composition survey on the **sparse shrubland** at Keren area with specific interest of understanding the tree height, diameter at breast height (DBH), tree density, above ground biomass (AGB) and carbon stock per given area (table 5). Thereby, up-scaled the information at district level.

Table 5: Summary of biometry and species composition for Godey (kerin) district

Plot ID.	GPS code	Tree height (meter)	DBH (cm)	Tree number (GI-count)	Tree density (n/ha)	AGB (kg/ha)	Carbon stock (kg/ha)	Species composition		
								Commiphera	Boswelia	Others
1	1107	2.70	57.5	26	650	7436.63	3495.22	3- C. samharensis	23-B. rivae	2 other
2	1108	3.05	90	24	600	20110.55	9451.96	…………………	24-B. rivae	6-acacia
3	1109	3.44	85	15	375	20245.67	9515.46	4-C. habasinica;2-C. hottziana;2- C. Africana	3-B. microphylla; 4-B. rivae	1-acacia;19 other
4	1110	3.05	57.5	22	550	8387.15	3941.96	8-C. Africana	10-B. Rivae; 4- B.neglecta	4 others
5	1111	2.95	87.5	25	625	18386.15	8641.49	9-C. myrrh;6-C. samharensis;5- C. guidottii;3-Commiphera sp; 2-C. aerruleta	……………..	8-others
6	1112	3.44	81	26	650	18427.61	8660.98	9-C. myrrh;7-C. guidottii;4-C. sp;3-C. Hottziana	3-B. rivae	6-acacia 3-others
Average		3.11	76.42	23.00	575.00	**15498.96**	**7284.51**			
CV (%)		9.42	19.57	18.24	18.24	38.31	38.31			

3.4 Comparison of biometry information (gum and incense trees) among district

In terms of spatial coverage of the **gum and incense trees**, Elwayne district ranks first which has area coverage of 1430 km^2 followed by Adadle district (1225km^2) and Godey district (993 km^2). In proportion of gum and incense trees within a district, Elweyne ranks first (58%) followed by Godey (17%) and Adadle (11%). Hence, among the district, relatively most of the **gum and incense** resource is concentrated at Elweyne district both in spatial coverage and proportion. Hence, the government should invest more on this district to make use of and benefit from the resource followed by Adadle and Godey.

With respect to average tree height of gum and incense trees, Adadle ranks first (4.18 meter) followed by Elweyne (4.11 meter) and Godey (3.11 meter) district. Hence, the height of gum and incense trees are longer at Elweyne and Adadle districts , while in Godey district they are relatively shorter. The measured average DBH information at the 3 district indicated that Godey gum and incense trees ranks first (76.4 cm) followed by Adadle (73.5 cm) and Elweyne district (71.9 cm), respectively. On the other hand, the measured average tree density analysis of gum and incense revealed that Elwayne has the highest tree density (589.5 tree count/ha) while Adadle and Godey has equal tree density of 575 tree count/ha.

3.5 Comparison of AGB and carbon stock (gum and incense trees) among district

Using ground measured data together with other allometric equation; we calculated the above ground biomass and carbon stock of gum and incense trees at the different districts (table 6).

Accordingly, the total above ground biomass of gum and incense tree from Elweyne district alone is estimated about 7749.18 ton and it rank first followed by Adadle (2373.6 ton) and Godey (1539.28 ton) districts (Table 6). Thus, Elweyne district has significantly higher biomass as compared to the other two districts to the extent of equivalent of the combined biomass from the 2 districts.

Hence, when we compare the total above ground biomass of gum and incense trees that comes from the three districts; in proportion, Elwayne district has 66.45% of the total sum followed by Adadle 20.35% and Godey 13.2%. This is well in line with the discussion and recommendation given under section 3.4.

Table 6: Above ground biomass and carbon stock information of the 3 districts.

District name	Gum and incense cover		Above ground biomass		Carbon stock	
	km^2	Ha	Ton	Percent	ton	Percent
Elweyne	1430.8	143080	7749.18	66.45	3642.12	66.45
Adadle	1225.9	122590	2373.60	20.35	1115.59	20.35
Godey	993.15	993.15	1539.28	13.20	723.46	13.20
Total	11662.06	11662.06	11662.06	100.00	5481.17	100.00

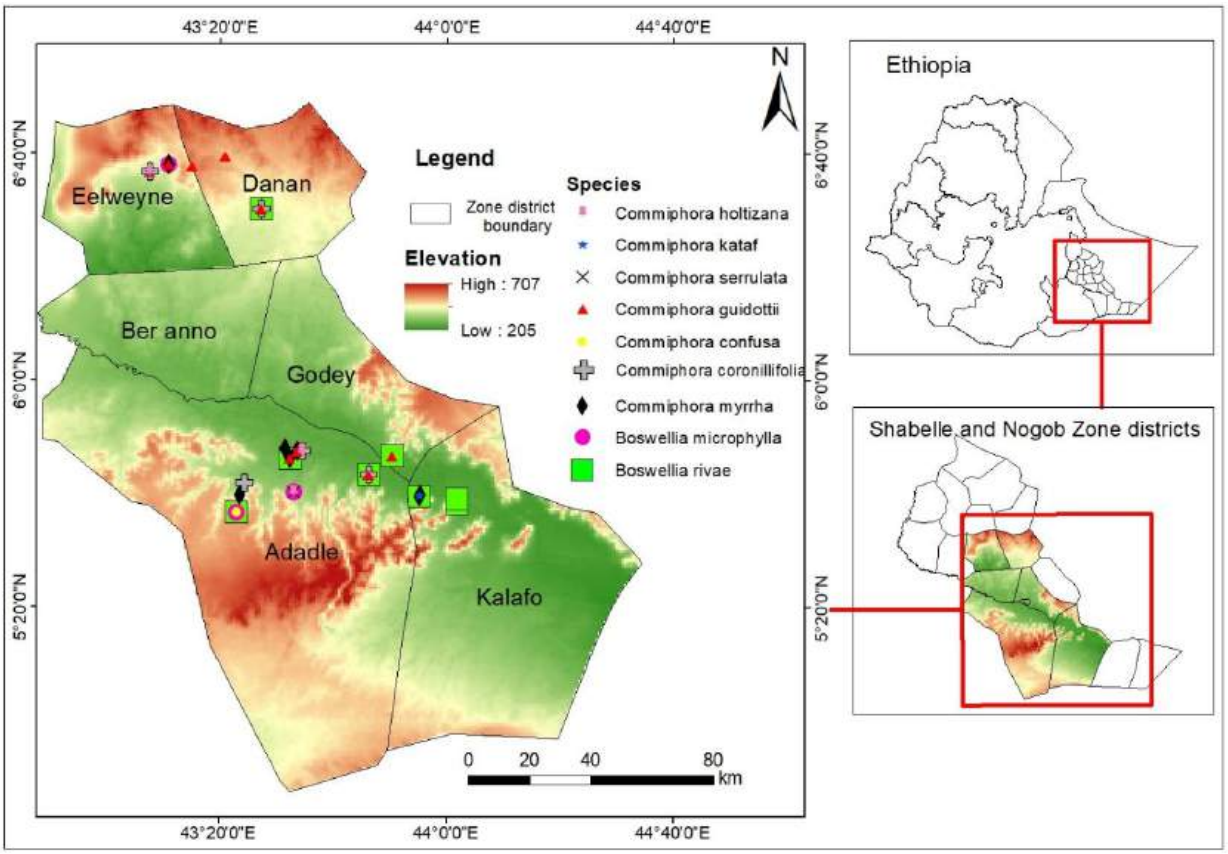

Figure Map of the frankincense economically important species (*Boswellia microphylla* & *B. rivae* and *Commiphora guidottii & C. myrrha*).

The other important information derived from our field data and allometric calculation is the **carbon stock amount of gum and incense** trees at each districts. This is particularly important from the concept of green economy and carbon balance of our planet. Thus, our result revealed that Elwayne district alone could stock a carbon which amount 3642.12 ton from gum and incense trees followed by Adadle (1115.59 ton) and Godey (723.46 ton). Thus, similar to AGB, Elwayne district ranks first in this aspect as well followed Adadle and Godey districts (table 6). Hence, the result further indicates that the gum and incense trees alone can sequester and stock significant amount of carbon from the atmosphere especially at Elweyne district.

4. Conclusion and Recommendation

- Further research is required to estimate the gum and incense resin production of the selected districts.
- Finally, creation of mass awareness focused on the steadfastness of population pressures, associated resource management constraints should be emphasized as part of rural development policies.
- What has been mapped out as an effective area of Boswellia and Commiphoras stands as site of gum and incense production preferments base in general, the progressive or regressive trend analysis of major biophysical factors including soils, climate, and vegetation should be a subject of further research.
- The study, of course, should be combined with estimates of future demand for various goods and services that can be obtained from the forest/woodland and alternative forms of land use.
- Policy Implications: In order to narrow the gaps existing between the immediate needs of the local people and the lack of infrastructure services, and at the same time to ensure socially, economically and ecologically equitable environment,
- identification of problems and possible solutions should be addressed on a partaking basis. Appropriate local inducements including multidisciplinary training in the field of diversification of local peoples' activities such as bee keeping and acceptable approaches of gum and incense production, and locally sound technical involvement to the crop-livestock system with facilitation of infrastructures should be given importance.

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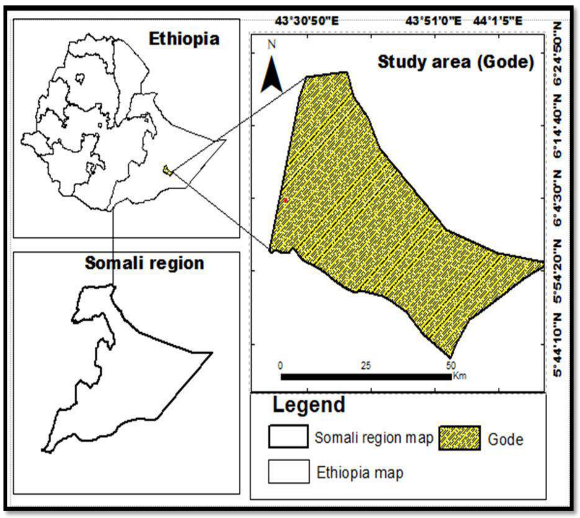

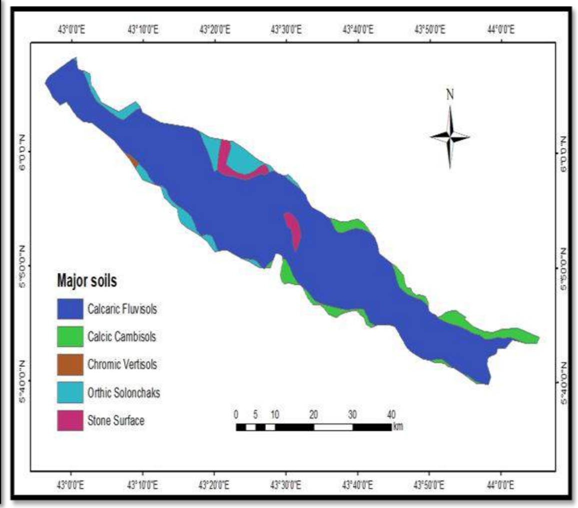

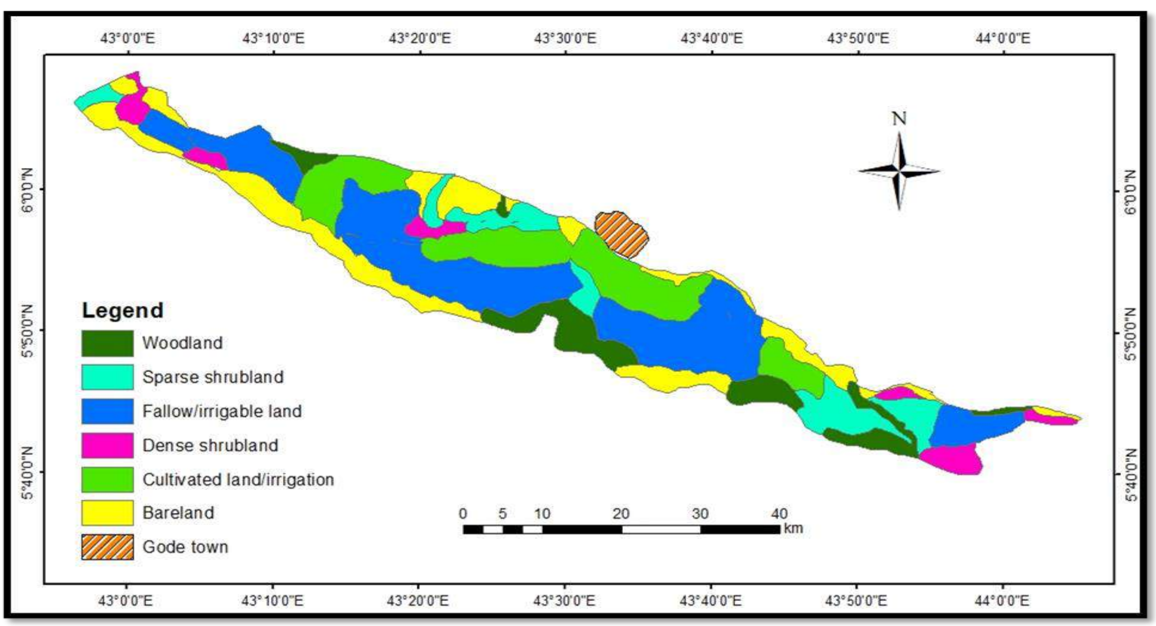

1. Determination of Optimum Water Regime and Scheduling for Sesame in Gode, Somali Region, Ethiopia

Authors; Dahir Yosuf Abdi[1] Abdinasir Esmail[1] Mustafe Ismail Mohamed[2]; **2019**

Somali Regional Pastoral and Agro-pastoral Research Institute (SoRPARI), Soil and Water Research Directorate

Abstract

Water is the most limiting factor for crop production in arid and semiarid areas. Hence, determining the appropriate time of irrigation and the amount of water applied to the crop is of paramount importance to increase yield and water productivity. In view of this, a field study was carried out with an objective to determine the net water requirement and optimum irrigation schedule for sesame in Gode, Somali region, Ethiopia. The experiment was conducted for two consecutive years (2018 and 2019) at Gode Agricultural Research Center. The treatments consisted of three irrigation levels established based on moisture depletion levels (MDL) at 60%, 80% and 100% soil MDL. The experiment was laid out in a randomized complete block design with three replications. Long term metrological data (1990-2018 years) and CROPWAT 8.0 software were used to determine optimum irrigation depth and scheduling for sesame. Partial flume was used to compute the daily soil moisture depletion and thereby to determine crop water requirement of each treatment. Results of the analysis of variance revealed that the grain and biomass yield as well as water use efficiency of sesame responded significantly to the different deficient irrigation levels. The maximum grain yield (1643.7 kg ha^{-1}) was obtained when sesame was irrigated at 100% of SMD followed by 80% SMD (1359.1 ka ha^{-1}), while the lowest yield (1232.5 kg ha^{-1}) was recorded for 60% SMD treatment. However, the highest (1.57kg m^{-3}) and lowest (1.32 kg m^{-3}) water use efficiency (WUE) was recorded for 100% and 60% SMD treatments, respectively. Therefore, it can be concluded that grain and biomass yield of sesame increased with irrigation management at increased SMDL while an in increase WUE was observed when irrigation was managed at reduced SWDL.

Keywords: CROPWAT 8.0, SMDL, Optimum water requirement, Sesame.

Background and justification

Ethiopia is known to be endowed with a huge surface and ground water resources that has given a prestige of being called the water tower of East Africa. Quite a significant number of lakes, dams and reservoirs are also found in various parts of Ethiopia. The national master plan study indicated that Ethiopia has 12 river basins. Most of the rivers are trans-boundary and about 97% of the water flows out of Ethiopia in to the neighbouring countries with only 3% of the total remains within the country. The water resource of the country is estimated at 124.4 billion cubic meter (BCM) river water, 70 BCM lake water and 30 BCM groundwater. The irrigation potential of the country is estimated at 11.1 million hectares (MHa) of which 4.3 MHa is from surface, 4.7 MHa from ground and 4.4 MHa from rain water resources (MoA 2019). However other studies based on topography and soil types has put the total suitable area for irrigation more than 42 MHa (Ethiopian Policy Institute and Addis Abeba Institute of Technology 2019).

The Somali region has four perennial rivers namely Shebele, Genal, Dawa and Weyb rivers which can irrigate an estimated land of 1,313,204.3million hectares. In addition, the region also has small perennial streams such as Erer and Berak; and major seasonal streams like Fafan, Daketo, Borale and Jarer(BoA, 2021). Expansion of the area under cultivation is a finite option, especially in view of the marginal and vulnerable characteristics of large parts of the region`s land and increasing population. Increasing yields in irrigated agriculture and cropping intensity in irrigated areas through various methods and technologies are therefore the most viable options for achieving food security (IWMI, 2005). Agriculture sector is facing increasing challenges in the face of changing climate, rapid population growth, increasing salinity accumulation, land degradation, decreasing availability of land and competition for scarce water resources. One of the most important considerations in increasing and stabilizing agricultural production is through irrigation and drainage development, reclamation of degraded lands and wise use of water resources (Gebremedhin and Asfaw, 2015; Hagos et.al, 2009).

Sesame (*Sesamum indicum* L.) is an important annual oil seed crop grown especially in developing countries as a rich source of oil, protein, calcium and phosphorus. Among oilseed crops, sesame is the most ancient oilseed known and grown by humans according to archaeological records (Nayar, 1984). There are no definite findings on the origin of sesame, though Ethiopia is considered to be the center of cultivated sesame (Weiss, 1983).

Traditional irrigation practices are used in the study area to grow vegetables in various areas. However, there is no known requirement for both crop and irrigation water, including irrigation scheduling. Furthermore, the level of depletion of soil moisture for sesame should be 0.60. as recommended FAO. However, it is necessary to verify the recommendations on the operating environment as the requirement for crop water depends on the crop type (variety) and climatic condition. It is important to determine the actual need for crop water and the right time for water application (irrigation schedule) for effective use of the available water resource. This study was therefore carried out to determine the optimum water requirement and irrigation schedule based on the level of depletion of soil moisture in Gode for sesame (Adi).

Methods and materials

Description of the Study Area

Gode (Godey) is one of the woredas in the Somali Region of Ethiopia, named after its major town, Gode. Gode is bordered on the south by the Shebelle River which separates it from Adadle, on the northwest by Imiberi, on the north by Danan, on the northeast by the Korahe Zone, and on the southeast by Kelafo (https://en.wikipedia.org/wiki/Gode_(woreda)). The Gode town lies between N 05^{o} 57' latitude and E 43^{o} 33' longitude at an altitude of around 300 m above sea level. The mean annual rainfall hardly exceeds 340 mm, whereas mean annual temperature is around 28.7^{o}C (Mahamed and Mishra, 2021).

There are four distinct seasons in the zone. However, their beginning and end varies from place to place and year to year. The four seasons are: *Gu*' (late March to early June, which is the main rainy season), *Hagaa* (late June to early September, which is dry and windy with clouds in the sky but rarely with rain), *Deyr* (the small rainy seasons between late September and early December), and *Jilal* (the hottest and driest season between late December and early March) (https://www.africa.upenn.edu/Hornet/som1299.html)

Although Gode is mainly characterized by arid climate, some crops as cereals (maize & sorghum), vegetables (peppers, tomatoes and carrots) and fruits (mango, papaya, guava, banana and lemon) are observed to be grown along the Shebelle river (https://en.wikipedia.org/wiki/Gode_(woreda))

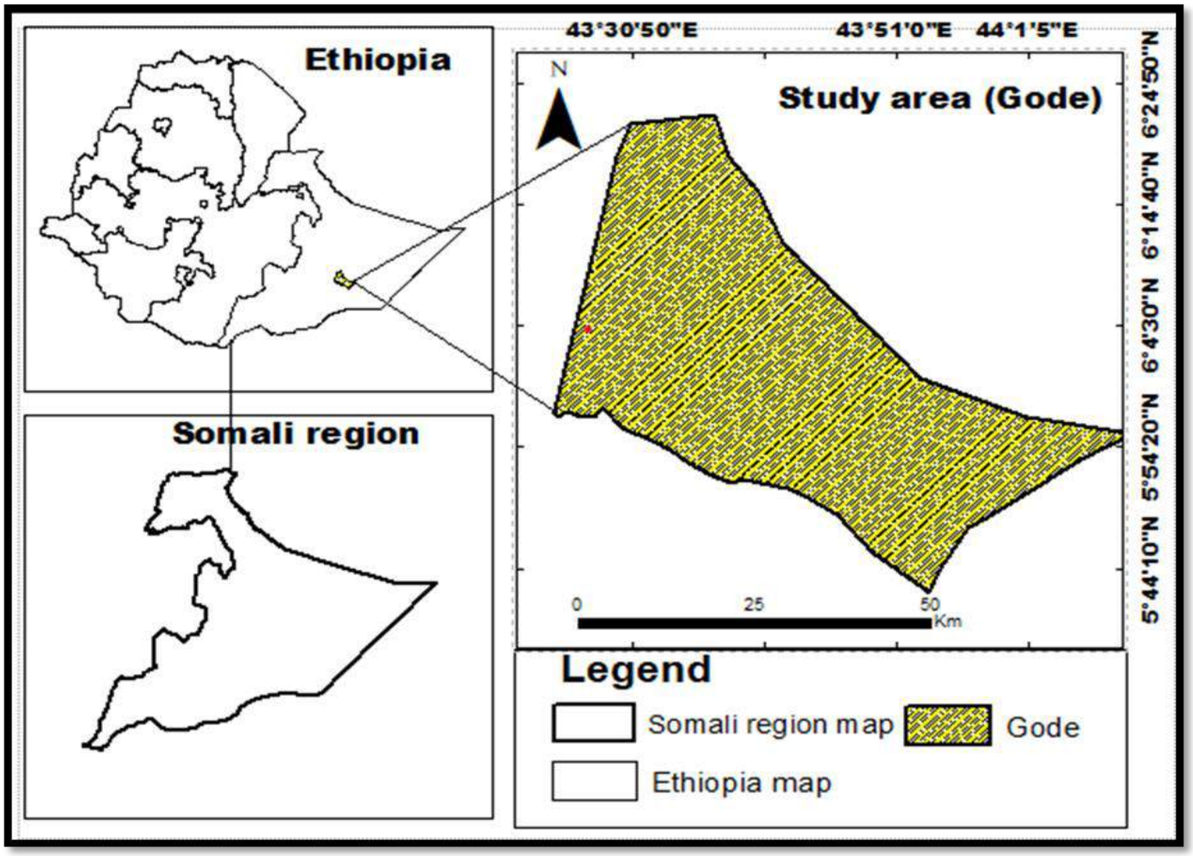

Figure 3 Location of the Study area

1.1. Experimental design

The experiment was conducted for 2 consecutive years (2018 and 2019). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The experiment included three levels of soil moisture depletion. The three level of SMDL were 60% SMDL, 80% SMDL, and 100% SMDL. The recommended allowable depletion of soil moisture for sesame is 60% of the total available soil moisture and this is used as 100% SMD, as described in Allen et al. (1998). Finally predetermined amount of irrigation water were applied to each plot using Partial flume. The total number of plots was 9 and each experimental plot had a gross area of 22.5 m^2 with 5.0 m length and 4.5m width. Planting was done by adopting the recommended spacing of 50 cm between rows and 15 cm between plants. A distance of 1 m and 1.5 m was maintained between plots in each replication and between blocks, respectively. The sesame variety called '*Adi*' was used as a test crop

Table 26 Treatment setting for field experiment

Treatments	Description
SMDL 1	60% Soil moisture depletion level
SMDL 2	80% Soil moisture depletion level
SMDL 3	100% Soil moisture depletion level

Table 27 Spacing of field experiment

Crop Type	Spacing				
	plot	block	Plot size	Plant	Row
Sesame(Adi)	1m	1.5m	5m*4.5m	15cm	50cm

Input parameters and data description

Climatic and soil data of study area

More than 27 years' climatic data of study area (Gode) and its surrounding were collected from National Meteorological Agency (NMA) of Ethiopia. The used parameters were rainfall, maximum and minimum temperature, relative humidity, wind speed and sunshine hours. Then monthly reference Evapo-transpiration (ET_O) of the study area was estimated by CROPWAT-8 software model (Table 3). Similarly, the long term daily rainfall of the study area was collected from National Meteorological Agency (NMA) of Ethiopia. Then effective rainfall of the study area was estimated (Table, 3).

Table 28 Estimated ETo and Climatic data records of Gode (1990-2018)

Longitude-43° 58' E; Latitude-5° 90' N						**Altitude-260 m.a.s.l**			
Month	min temp (° C)	max temp (° C)	Relative humidity (%)	Wind speed (m/s)	Sun shine (Hr/day)	Solar radiation	Total rainfall (mm)	Effective rainfall (mm)	ETo (mm)
January	21.1	35	44	138	9	21.5	0	0	5.49
February	22	36.2	42	147	9.2	22.9	3	0	6.04
March	23.7	36.9	45	130	8.9	23.2	16	0	6.08
April	23.7	35.2	53	86	7.7	21.3	89	47.2	5.12
May	22.7	33.7	63	130	6.7	19.1	63	27.8	4.81
June	22.3	32.7	61	216	6.6	18.4	1	0	5.22
July	22.5	32.7	54	233	5.8	17.4	0	0	5.53
August	23	33.5	51	233	6.6	19.2	0	0	5.98
September	23.2	35	48	190	7.8	21.4	8	0	6.22

October	22.2	33.9	62	112	6.7	19.2	48	18.8	4.71
November	21	33.7	54	86	8.3	20.6	35	11	4.61
December	21.1	35	44	104	8.9	20.9	3	0	4.95
Total							266	104.8	5.4

The soil type of the study area is characterized by clay soil with initial soil moisture depletion of 50% and total available soil moisture level was 200.0 (mm/meter depth) varying with soil depth. The mean infiltration rate was recorded to be 30 mm/day and it has maximum rooting depth of 90cm (Table, 4).

Table 29 The soil characteristics and description of Gode

Soil description	**Clay to clay loam**
Total available soil moisture	200 mm/meter
Maximum rain infiltration	30 mm/day
Maximum root depth	90cm
Percentage of Initial soil moisture depletion	50%
Initial available soil moisture depletion	100 /meter

Crop water requirement and irrigation scheduling

According to Savva and Frenken, 2002, crop water requirement usually refers to the Evapo-transpiration from excellently managed, large, well-watered fields. This field achieves full production under the given climatic conditions and varies substantially during the growing period mainly due to variation in crop canopy and climatic conditions ((Djaman et.al, 2013). For this study, daily crop water requirement was determined by equation-1. Irrigation water requirement (IR) had been calculated by long-term rainfall data (1983-2018) from the study site. Long-term monthly rainfall data was obtained from the study site. The obtained values were used during the computation of CWR.

Generally, IR can be estimated from the expression:

CWR = ETo x Kc …………………………. (1)

IR = CWR – Effective rainfall ...…………. (2)

Where; CWR= crop water requirement (mm/day) and Kc is in fraction which is an empirical ratio of actual crop water use to reference Evapo-transpiration. The Kc- values were obtained from reference texts, in FAO Irrigation and Drainage Paper No. 33 and 56. In this study the CWR was computed using Penman-Monteith method (Allen et al., 1998) from a computer based

CropWat models and IR= irrigation requirement (mm). Effective rainfall which was part of the rainfall that entered into the soil and became available for crop production in mm. Different formulae were available to compute effective rainfall but for this study dependable method equation (3) and (4) were used because it had been developed based on the analysis of different arid and sub-humid climates (FAO/AGLW).

Pe = 0.6 x P-10/3; for P < 70/3 ………….…… (3)

Pe = 0.6 x P-10/3; for P > 70/3………….…….…..... (4)

Where; Pe = Effective precipitation determined in mm and P = Total precipitation occurred in the crop growing season in the area, in mm. The preliminary soil physical data for the study area was determined by using equation (5). Since the figures were on weight basis, it was converted to volume bases. But Permissible depletion levels for sesame crop were determined at different growth stages using equation (6).

TAW = (FC – PWP) x BD x Rd x 10………. (5)

ASMDL = TAW x p ………………………. (6)

Where: TAW = Total available soil moisture, mm/m; FC = Field capacity of the soil in wt. bases (%); PWP = Permanent wilting point of the soil in wt. bases (%); BD = Bulk density (g/cm3) and Rd = Root depth (m), ASMDL = Available soil moisture depletion level or net irrigation requirement (mm) and P = Allowable soil moisture depletion by the crop (0.55). Crop Evapo-transpiration (ETc) of maize was determined using FAO CROPWAT computer model. Besides, effective rainfall was calculated with this model. Using mean sesame Evapo-transpiration at different growth stages.Net irrigation requirement, irrigation water application interval was calculated and gross amount of water to be applied to the field was determined using 60 % irrigation efficiency separately (Yi, et.al, 2010).

$$\text{Interval (Days)} = \frac{\text{Net IR}}{\text{ETc}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(7)}$$

$$\text{GI} = \frac{\text{Net IR}}{\text{Ea}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(8)}$$

Where; Net IR = Net Irrigation Requirement or ASMDL (mm), ETc = Crop Evapo-transpiration (mm/day), GI = gross amount of water (mm) and Ea = irrigation application efficiency (%).

1.1. Data collection and analysis

The selected verity of Sesame was planted in January for two consecutive years in Gode woreda. During the implementation period all agronomic parameters and data of irrigation water was collected following the data sheet including date of 50% crop emergence, days of 95% maturity, stand count at harvesting, biomass yield (BMY), grain yield (GY) and 1000 seed weight. The main yield parameters BMY, GY data and water use efficiency (WUE) were considered as indicators of the performance of sesame and analyzed using appropriate statistical package. The water use efficiency was also calculated using equation (9) and analyzed using Genstat software.

$$WUE = \frac{Y}{I} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Where: WUE=Water use efficiency (kg/m3) is the amount of Sesame grain yield per meter cubic of irrigation water applied, Y = Yield of Sesame (kg/ha) & I = Total irrigation water applied (m3 /ha).

Results and discussion

Crop water requirement and irrigation scheduling

CROPWAT 8 was used for the computation of the reference crop Evapo-transpiration (ETo) and crop water requirement (CWR) of Sesame in the study area (Gode). The reference crop evapo-transpiration (ETo) and crop water requirement (CWR) of Sesame for the selected area has been prepared. ETo was computed on monthly basis and CWR was computed for the growing period of the corresponding crops. Since there was no determined crop coefficient (Kc) so far for this area, the FAO recommended Kc values for the Sesame growth stages are used to calculate CWR. The local planting date of the crop had been used for the computation. The ETc and Irrigation requirement of Sesame in the study area is shown in (Table5).

Table 30 CWR and Irrigation scheduling of Sesame in main season of irrigation

Growing stage	**Days**	**Kc**	**ETc (mm/dec)**	**Irr. Req**	**Net irr.**	**Gross irr.**	**Flow (l/s/ha)**	**RF**	**Eff. RF**	**Irr. Interval (days)**
Initial	20	0.30	27.7	6.4	36.1	51.6	0.6			
Dev.	20	0.75	118.1	111.6	170.6	243.7	0.8			
Mid	40	1.10	193.5	193.5	226.1	323	1.2			
Late	20	1.00	155.3	155.3	28.0	36	1.36			
Total	100		496.6	466.8	460.8	654.3	3.96	105	48.5	**7**

1.2. Biomass (BM) and grain yield (GY)

The results of the two consecutive years of pooled mean values showed that the use of different levels of depletion of soil moisture had significant effect ($p < 0.05$) on biomass and grain yield of sesame.

The maximum grain yield (1643.7 kg/ha) was obtained at 100% SMDL while the minimum yield (1232.55kg/ha) was obtained at 60 % SMDL which was practiced with frequent irrigation or increased number of irrigation events with the most labor payments (Table 6). This result is in line with the findings of Oumer (2019) which indicated the significant response of sesame grain yield to different soil moisture depletion levels Similarly, the biomass yield of sesame was also found to be significantly affected by the different soil moisture depletion levels

The pooled mean of the biomass of Sesame was recorded as 3545.3 kg/ha. Hence, the highest biomass yield (3833.3 kg/ha) was recorded at 100% SMDL, whereas the least biomass 3283.3 kg/ha was observed at 60% SMDL (Table 6). This result is contradicted with the findings of Robel (2019) and Supported by Tefera (2017).

Table 31 Response of Sesame (Adi) for different irrigation regimes and WUE at Gode

TREATMENTS	BM (kg/ha)	GY(kg/ha)	WUE (kg/m^3)
SMDL60%	3283.3a	1232.55a	1.57a
SMDL80%	3519.2b	1359.1a	1.40b
SMDL100%	3833.3c	1643.7b	1.32b
MEAN	**3545.3**	**1411.8**	**1.5**
CV%	**7.8**	**14.9**	**6.9**

BM, GY, WUE & CV; presents; Biomass, Grain Yield, Water use efficiency and Coefficient of Variation

Water use efficiency

The effects of testing different levels of allowable moisture depletion level using Sesame crop were significant at ($p \leq 0.05$). But, the difference in WUE values between SMDL-80% and SMDL-100% were statistically non-significant. The highest (1.57 kg/m^3) WUE value was recorded for 60% SMDL which was statistically at with 80% SMDL. However, the lowest (1.32 kg/ha) water use efficiency was observed for 100% SMDL. The response of crop water use efficiency had decreasing tendency when the soil moisture depletion increased from 60 to 100% of SMDL. The current result is in agreement with the findings of Oumer (2019) but it contradicted the results of Ashebir (2017).

Conclusion and recommendations

The experiment was conducted to study the needed depth of water application &water use efficiency for Sesame. The result showed that there was significant difference among the treatments regarding the grain yield, biomass yield and water use efficiency of sesame in the study area. The obtained result lay within FAO recommendation range. However, the current study has shown that reducing or increasing of the SMDL from 60% to SMDL 100% has significant effect on the biomass and grain yield as well as water use efficiency of Sesame. Therefore, based on this findings water application at 100% SMDL resulted in highest biomass and grain yield compared to 60% and 80% SMDL in the study area. In the contrary water application at 100% SMDL recorded the least water use efficiency compared to the other treatments. Thus the finding of the current study suggests that FAO's recommendation of water depth application for Sesame is also appropriate in the Gode area. Besides; it was also found that he appropriate irrigation interval for Sesame in the study area is every other seven days.

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2. Determination of Optimum Water Regime and Scheduling for Maize in Gode, Somali Region, Ethiopia

Authors; Dahir Yosuf Abdi[1]Abdinasir Esmail[1]Mustafe Ismail Mohamed[2];**2019**

Somali Regional Pastoral and Agro-pastoral Research Institute (SoRPARI), Soil and Water Research Directorate

Abstract

Irrigation means applying adequate water at the right time to crops in the right amount. A significant concern has become the sustainable use of water in agriculture. The adoption of irrigation water saving and the maintenance of acceptable yields could help preserve this ever more restricted resource in most cases. Although irrigation has been practiced for a long time, farmers have limited experience of this. It is therefore very important to monitor soil moisture levels for effective management of irrigation water. For two successive years, a field study was conducted to determine the optimum water requirement and irrigation schedule for Maize crop production at Gode. The study' was aimed to evaluate the effect of different irrigation regime (different levels of depletion of soil moisture) on yield and water use efficiency of Maize(malkassa-2) variety. The treatments were established based on the levels of depletion of soil moisture as SMDL1 (60% Soil moisture depletion level (SMDL), SMDL2 (80% SMDL) and SMDL3 (100% SMDL). These were then used (selected to evaluate the optimum irrigation water regime and schedule, the result showed that even though statistically not significant (P> 0.05), SMD3 has increased the grain and biomass yield of maize by 34 and 54.4% (in 2018) and by 33.3 and 13.9% (in 2019), respectively Likewise, a non-significant response of water use efficiency (WUE) of maize was noted due to the irrigation treatments. However, the WUE values were observed to decrease from 5.22 to 3.39kg/m3 (in 2018) and from 2.51 to 1.67kg/m3 (in 2019) as the SWDL is increased from 60% to 100%. The findings of the present study did not lie within the ranges recommended by FAO. Therefore, the study suggests that more such studies need to be carried out in similar ago-ecologies to validate the findings of the present study

Keywords: Gode, Irrigation scheduling, Maize, Water use Efficiency.

1. Background and justification

Ethiopia is known to be endowed with a huge surface and ground water resources that has given a prestige of being called the water tower of East Africa. Quite a significant number of lakes, dams and reservoirs are also found in various parts of Ethiopia. The national master plan study indicated that Ethiopia has 12 river basins. Most of the rivers are trans-boundary and hence 97% of the water flows to the neighbouring countries with the rest 3% remaining within the country. The water resource of the country is estimated at 124.4 billion cubic meter (BCM) river water, 70 BCM lake water and 30 BCM groundwater. The irrigation potential of the country is estimated at 11.1 million hectares (MHa) of which 4.3 MHa is from surface, 4.7 MHa from ground and 4.4 MHa from rain water resources (MoA 2019). However other studies based on topography and soil types has put the total suitable area for irrigation more than 42 MHa (Ethiopian Policy Institute and Addis Abeba Institute of Technology 2019).

Nonetheless, the Somali region has four perennial rivers such as Shebele, Genal, Dawa and Weyb Rivers which can irrigate an estimated land of 1,313,204.3 million hectares. In addition, the region has small perennial streams such Erer and Berak; and major seasonal streams like Fafan, Daketo, Borale and Jarer(BoA, 2021). Expansion of the area under cultivation is a finite option, especially in view of the marginal and vulnerable characteristics of large parts of the region`s land and increasing population. Increasing yields in irrigated agriculture and cropping intensity in irrigated areas through various methods and technologies are therefore the most viable options for achieving food security (IWMI, 2005). Agriculture sector is facing increasing challenges in the face of changing climate, rapid population growth, increasing salinity accumulation, land degradation, decreasing availability of land and competition for scarce water resources. One of the most important considerations in increasing and stabilizing agricultural production is through irrigation and drainage development, reclamation of degraded lands and wise use of water resources (Gebremedhin and Asfaw, 2015; Hagos et.al, 2009).

Ethiopia is one of the largest maize producing countries in Africa. Maize, in Ethiopia, is the main food securing crop that accounted for 16.7% in terms of calorie intake, surveyed nationally at 2004/05, as in (Berhane *et al.,* 2011) However, the cultivation of maize is mostly dependent on rainfall. In the study area, little concern has been given to the necessity and extension of irrigation technologies due to the presence of sufficient rainfall. However, recently, the occurrence of erratic rainfall or impact of climate change drastically reduced crop production. Consequently, traditional irrigation practices are being used for cultivating vegetables in different areas. However, both crop and irrigation water requirement including irrigation scheduling are not known. For better production of medium matured maize crop, J. Doorenbos and A. H.Kassam (1986) has recommended 500 to 800mm depth of water depending on the climate. In addition, R. G. Allen (1998) has expressed the soil moisture depletion level for maize should be 0.55.

However, the recommendations are needed to be verified on the operational environment since the crop water requirement is dependent on the type of crop (variety) and climatic condition. For effective use of available water resource, it is relevant to determine the actual crop water need and the right time of water application (irrigation scheduling). Hence, this study was conducted to determine the optimum irrigation scheduling based on the soil moisture depletion levels for maize (Malkassa-2) at Gode. The identified information is important for increased crop production & productivity, improved irrigation water management, and conservation of this specific environment.Therefore, the main objective of this current study is to determine the crop water requirements and irrigation scheduling of maize at Gode Weroda of Shebelle zone

Materials and methods

Description of study area

Somali region is the region that exists at eastern part of Ethiopia and highly gifted by surface water sources like wabi Shebelle, Ogaden, genale Dawa Rivers are part this region. There are two main cropping seasons: Gu (wet season) and Jilaal (dry season). Within the Gu there are three sub seasons: dira' (late March - late May), Hagaaaa (late May - late July), and Karan (late July - late September). The Jilaal (late September - late March) can be further divided into two sub seasons: deyr (late September - late November) and kalil (late November - late March). The livelihood of the area is majorly dependent upon the river water and also dira' rains (mid-March – mid June) and the Karan rains (mid July – mid September). These sources of water are important for agriculture (cultivation and livestock). The main crops cultivated in those areas are sorghum and maize varieties. Additionally, onions, tomato, paper and few fruit crops cultivated in the area.

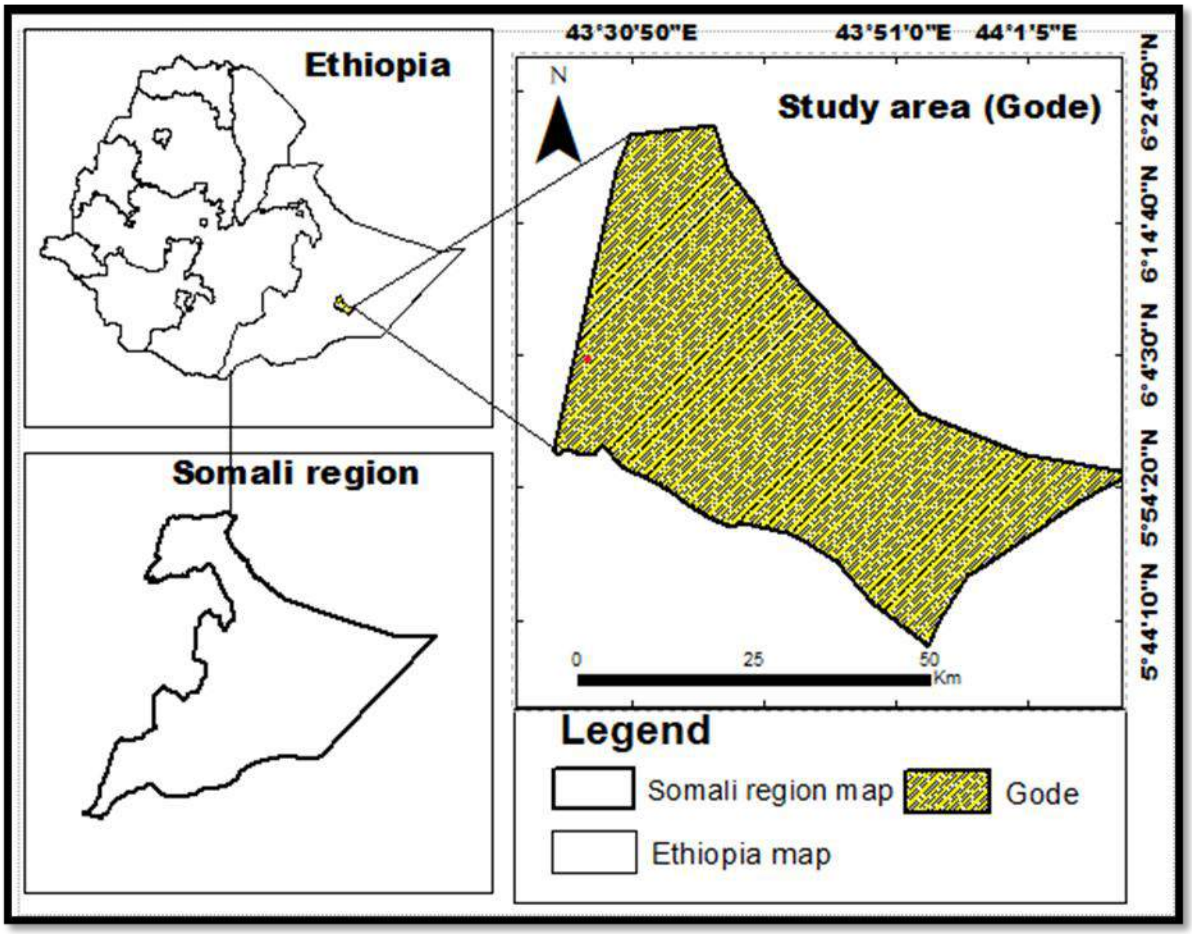

Figure 4 Location of the Study area

Experimental design

The experiment was conducted for 2 consecutive years (2018 and 2019). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The experiment included three levels of soil water depletion. The three level of SMDL were (60% SMDL, 80% SMDL, 100%SMDL (FAO recommended SMDL)). The recommended allowable soil moisture depletion for maize is 55% (Allen et al., 1998) of the total available soil moisture that was used as 100% of SMDL. Finally predetermined amount of irrigation water were applied to each plot using Partial flume. The total number of plots was 9 where the size of each plot was 25m^2 (5m*5m.). The spacing was 70cm by 25cm. The distance between each plot in a block and between blocks were1m and 1.5 m, respectively. The outer two rows at both sides of each plots and one plant at both ends of the rows were considered as border plants.

Table 32Spacingof the field experiment

Crop	Spacing				
	plot	block	Plot size	Plant	Row
Maize (melkassa2)	1m	1.5m	5m*5m	25cm	70cm

Table 33 Treatment setting for field experiment

Treatments	Description
SMDL 1	60% Soil moisture depletion level
SMDL 2	80% Soil moisture depletion level
SMDL 3	100% Soil moisture depletion level

Input parameters and data description

Climatic and soil data of study area

More than 28years' climatic data of study area (Gode) were collected from National Meteorological Agency (NMA) of Ethiopia (Jigjiga Branch). The maximum and minimum temperature, relative humidity, wind speed, and sunshine hours were used for the estimation of ETo. Then monthly reference Evapo-transpiration (ETo) of the study area was estimated by CROPWAT-8 software model (Table-3). Similarly, the long term of daily rainfall of the study area, was collected from National Meteorological Agency (NMA) of Ethiopia. The daily rainfall was used to estimate the effective rainfall of the study area (Table, 3).

Table 34Estimated ETo Climatic data records of from (1990-2018)

Longitude-43.58ELatitude-5.90N				**Altitude-260 m.a.s.l**					
Month	min temp	max temp	Relative humidity	Wind speed	Sun shine	Solar radiation	Total rainfall	Effective rainfall	ETo
January	21.1	35	44	138	9	21.5	0	0	5.49
February	22	36.2	42	147	9.2	22.9	3	0	6.04
March	23.7	36.9	45	130	8.9	23.2	16	0	6.08
April	23.7	35.2	53	86	7.7	21.3	89	47.2	5.12
May	22.7	33.7	63	130	6.7	19.1	63	27.8	4.81
June	22.3	32.7	61	216	6.6	18.4	1	0	5.22
July	22.5	32.7	54	233	5.8	17.4	0	0	5.53
August	23	33.5	51	233	6.6	19.2	0	0	5.98
September	23.2	35	48	190	7.8	21.4	8	0	6.22
October	22.2	33.9	62	112	6.7	19.2	48	18.8	4.71
November	21	33.7	54	86	8.3	20.6	35	11	4.61

December	21.1	35	44	104	8.9	20.9	3	0	4.95
Total							266	104.8	5.4

The soil type of the study area is characterized by clay soil with initial soil moisture depletion 50% and total available soil moisture level was 200.0 (mm/meter depth) varying with soil depth. Hence; the soil is clay to clay loam, a mean infiltration rate was recorded 30 mm/day and it has maximum rooting depth of 900cm (Table, 3).

Table 35the soil characteristics and description of Gode

Soil description	**Clay to clay loam**
Total available soil moisture	200 mm/meter
Maximum rain infiltration	30 mm/day
Maximum root depth	900cm
Percentage of Initial soil moisture depletion	50%
Initial available soil moisture depletion	100 mm/meter

2.1.1. Crop water requirement and irrigation scheduling

According to Savva and Frenken, 2002, crop water requirement usually refers to the Evapo-transpiration from excellently managed, large, well-watered fields. This field achieves full production under the given climatic conditions and varies substantially during the growing period mainly due to variation in crop canopy and climatic conditions ((Djaman et.al, 2013). For this study, daily crop water requirement was determined by equation-1. Irrigation water requirement (IR) had been calculated by long-term rainfall data (1983-2019) from each study sites. Long-term monthly rainfall data was obtained from the study sites. The obtained values were used during the computation of CWR.

Generally, IR can be estimated from the expression:

CWR = ETo x Kc …………………………. (1)

IR = CWR – Effective rainfall …..………. (2)

Where; CWR= crop water requirement (mm/day) and Kc is in fraction which is an empirical ratio of actual crop water use to reference Evapo-transpiration. The Kc- values were obtained from reference texts, in FAO Irrigation and Drainage Paper No. 33 and 56. In this study the CWR was computed using Penman-Monteith method (Allen et al., 1998) from a computer based CropWat models and IR= irrigation requirement (mm). Effective rainfall which was part of the rainfall that entered into the soil and became available for crop production in mm. Different formula were available to compute effective rainfall but for this study dependable method equation (3) and (4) was use because it had been developed based on the analysis of different arid and sub-humid climates (FAO/AGLW).

Pe = 0.6 x P-10/3; for P < 70/3 ……………….… (3)

Pe = 0.6 x P-10/3; for P > 70/3…………………....... (4)

Where; Pe = Effective precipitation determined in mm and P=Total precipitation occurred in the crop growing season in the area, in mm. The preliminary soil physical data for the study area was determined by using equation (5). Since the figures were on weight basis, it was converted to volume bases. But Permissible depletion levels for maize crop were determined at different growth stages using equation (6).

TAW = (FC – PWP) x BD x Rd x 10………. (5)

SMDL = TAW x p ………………………. (6)

Where: TAW = Total available soil moisture, mm/m; FC = Field capacity of the soil in wt. bases (%); PWP = Permanent wilting point of the soil in wt. bases (%); BD = Bulk density (g/cm3) and Rd = Root depth (m), SMDL = Available soil moisture depletion level or net irrigation requirement (mm) and P = Allowable soil moisture depletion by the crop (0.55). Crop Evapo-transpiration (ETc) of maize was determined using FAO CROPWAT computer model. Besides, effective rainfall was calculated with this model. Using mean Maize Evapo-transpiration at different growth stages.Net irrigation requirement, irrigation water application interval were calculated and gross amount of water to be applied to the field was determined using 60 % irrigation efficiency separately (Yi, et.al, 2010).

$$\text{Interval (Days)} = \frac{\text{Net IR}}{\text{ETc}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\text{.....}\ (7)$$

$$\text{GI} = \frac{\text{Net IR}}{\text{Ea}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{..}\ldots\ldots\text{.}\ldots\ (8)$$

Where; Net IR = Net Irrigation Requirement or SMDL (mm), ETc = Crop Evapo-transpiration (mm/day), GI = gross amount of water (mm) and Ea = irrigation application efficiency (%).

Data collection and analysis

The selected verity of maize (Malkas-2) was planted in January for the consecutive two years in Gode woreda. During the implementation period all agronomic parameters and data of irrigation water was collected following the data sheet including date of 50% emergency, days of 95% maturity, stand count at harvesting, biomass yield (BMY), grain yield (GY) and 100 seed weight.

The main yield parameters BMY, GY data and water use efficiency (WUE) were considered as indicators of the performance of maize crop (Melkasa 2) and analyzed using appropriate statistical package. The water use efficiency was also calculated using equation (9) and analyzed using Genstat software.

$$WUE = \frac{Y}{I} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(9)}$$

Where: WUE=Water use efficiency (kg/m3) is the amount of maize grain yield per meter cubic of irrigation water applied, Y = Yield of maize (kg/ha) & I = Total irrigation water applied (m3 /ha).

Result and discussion

Soil chemical and physical characteristics of the experimental site

As can be seen in the table below (Table 5), the soil test results indicated that soils of Gode area have a sandy clay textural class with slightly alkaline reaction (pH=7.62) and moderate salinity (EC=4.5ds/m), whereas total N, available P and organic matter content of the soil are all rated as low as per the rating set by Tekalign (1991).

Table **36:** Soil physical and chemical properties of the experimental sites

Soil property	**Study area Gode**
Particle size distribution	**Values**
Sand (%)	50
Silt (%)	35
Clay (%)	15
Textural class	Sand clay
Bulk Density (gm/cm^{-3})	1.12
Organic matter (%)	1.45
pH	7.62
Electrical conductivity (EC) dS/m	4.5
Nitrogen (%)	0.11
Phosphorus (mg/kg)	6.51
Potassium (cmol/kg)	0.45
Field capacity (FC) %	16.65
Permanent wilting point (PWP) %	7.45

Source: Own survey

Crop water requirement and irrigation scheduling

CROPWAT 8 was used for the computation of the reference crop Evapotranspiration (ETo) and crop water requirement (CWR) of maize in the study area (Gode). The reference crop evapo-transpiration (ETo) and crop water requirement (CWR) of Maize for the selected area has been prepared. ETo was computed on monthly basis and CWR was computed for the growing period of the corresponding crops. Since there was no determined crop coefficient (Kc) so far for this area, the Kc values recommended by FAO for the maize growth stages are used to calculate CWR. The local planting date of the crop had been used for the computation. The ETc and Irrigation requirement of maize in the study area is shown in (Table 6).

Table 37 CWR and Irrigation scheduling of Maize in main season of irrigation

Growing stage	Days	Kc	ETc (mm/dec)	Irr. Req	Net irr.	Gross irr.	Flow (l/s/ha)	RF	Eff. RF	Irr. Interval (days)
Initial	20	0.3	27.7	6.4	36.1	51.6	0.6			
Dev.	30	0.75	118.1	111.6	170.6	243.7	0.8			
Mid	40	1.2	193.5	193.5	226.1	323	1.2			
Late	20	0.85	155.3	155.3	28.0	36	1.36			
Total	110		496.6	466.8	460.8	654.3	3.96	105	48.5	10

Biomass (BM) and grain yield (GY)

Based on the ETc and FAO, the available moisture depletion level had been calculated and field experiment was done for two years to evaluate the effect of deferent moisture depletion level on maize yield and water use efficiency. The biomass yield, grain yield and water use efficiency data in 2018 showed no significant differences ($p \geq 0.05$) among the irrigation treatments. Reducing or increasing the amount of water application was not significantly affecting the grain and biomass yield of maize at Gode. Though statistically not significant, in 2018 the highest grain yield (3333kg/ha) was obtained when water was applied at 100% SMDL. This treatment had a 34% grain yield advantage over the first treatment (i.e. 60% SMDL) (Table 7). The result of the current study is against the findings of previous study by Tefera and Mitku (2017) which reported the significant effects of irrigation treatments on grain yield of maize.

The highest biomass yield was also observed in 2018 and obtained at 100% SMDL; that was 5816kg/ha which is 54.4% greater than the least biomass yield (3767kg/ha) obtained at treatment 1 (60% SMDL) in the same year. Besides; in 2019, it was observed that there was no significant difference ($p \geq 0.05$) among the treatments regarding the biomass and grain yield of maize. Even if statistically not significant, treatment 3 (100%SMDL) recorded the highest grain yield (1600 kg/ha) which is 33.3% greater than the least yield (1067kg/ha) obtained at treatment 1(60% SMDL). The highest biomass yield (3683kg/ha) was also obtained at treatment 3(100% SMDL), which was about 13.9% greater than the least biomass yield (3234kg/ha) obtained at treatment 1 (60% SMDL). Both years analyses showed that the maximum grain as well as biomass yield obtained was at optimal irrigation regime of 100% SMDL. Therefore, 100% of SMDL was identified as best performing water application for the irrigated maize fields in the study area

(Table 7). This result is in line with the findings of Admasu et al.(2019),which revealed that there is no a significant difference in above ground biomass across different water application depths.

Table 38: Response of Maize (Malkasa-2) For different irrigation regimes and WUE at Gode

		BM (Kg/ha)		**GY(Kg/ha)**		**WUE (kg/m^3)**	
Treatments	**Years**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
SMDL60%		3767	3234	2167	1067	5.22	2.51
SMDL80%		5583	3350	3183	1233	4.99	1.93
SMDL100%		5816	3683	3333	1600	3.39	1.67
CV%		**18.9**		**23.7**		**23.7**	
LSD@$_{0.05}$		**971.4**		**903.8**		**1.416**	

2.2. Water use efficiency

The effects of testing different levels of allowable moisture depletion level using maize crop were not significant (p$\geq$0.05) in both years. But there was numerical difference among treatments. Water use efficiency of the crop to convert irrigation water to grain was high in treatment 3 (100% SMDL) which had 5.22 kg/m^3 followed by 4.99 kg/m^3 in treatment 2 (80% SMDL) in 2018. Similarly; in 2019, the highest water use efficiency (2.51kg/m^3) was recorded for treatment 3 (100% SMDL) followed by treatment 2 (80% SMDL) (1.93kg/m^3) while the least WUE (1.67kg/m^3) was noted for treatment 3 (100%SWDL).

The response of crop water use efficiency had g decreasing tendency when the soil moisture depletion increased from 60 to 100% of SMDL (Table 7). This current study is contradicting the findings of Muktar and Yigezu (2016) which indicates that The response of crop water use efficiency had increasing trend when the soil moisture depletion level rose.

Conclusion and recommendations

The experiment was conducted to determine the optimum depth of irrigation water and application interval for profitable maize production. The result showed that there was no significant difference among the treatments regarding the grain yield, biomass yield and water use efficiency in the study area. The obtained result did not lie within FAO recommendation range. However, the current study shown that reducing the SMDL up to 60% from the SMDL 100 has no significant effect on the biomass and grain yield and also water use efficiency of maize which is un expected result. Therefore, based on this findings water application of 100%, 80% and 60% SMDL have the same role to enhance the biomass and grain yield of maize in the study area. Furthermore, in order to validate this result, the study need to be repeated including more SMD levels in different area of similar agro-ecology.

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3. Variability of Soil Chemical Properties in Lower Wabi-Shebelle Sub-Basin in Somali Region Ethiopia, as Influenced by Land Use and Land Cover

By: Dahir Yosuf Abdi; Email: daahirtwo@gmail.com; **2020**

Somali Regional Pastoral and Agro-pastoral Research Institute (SoRPARI), Soil and Water Research Directorate

Abstract

Study was performed at lower Wabishebele sub-basin in Somali region south eastern Ethiopia to analyze the land use and cover and spatial variability of soil chemical properties of the sub-basin and develop soil map. A total of 41 soil samples were collected from 0-30 cm depth and analyzed for; pH Total Nitrogen (TN), Available Phosphorus (AP), and Exchangeable Potassium (EK). The data was analyzed through descriptive statistics and geostatistical methods. The results showed that highest mean value of pH was recorded from bare land (8.05). The highest mean of soil N was seen on potential croplands (0.251) followed by dense shrub land (0.230), woodland (0.230), croplands (0.187), and sparse shrub land (0.159) and bare land (0.151). The highest mean of AP recorded at dense shrub land (7.279) followed by potential croplands (6.607ppm), cropland, woodland, bare land and sparse shrub land. Soil map was developed for lower Wabishebele sub-basin. Therefore, the findings of this study can be used as baseline information to implement appropriate soil management intervention for current study area.

Keywords; Land use, Land cover, Soil properties, Lower Wabishebele, Sub-basin

1. Introduction

Ethiopia has potentially rich land resources but agricultural productivity has been below optimum yield. One of major factor hampering crop productivity in Ethiopia is decline in soil fertility and productivity from time to time (Gebreyesus et al., 2011; Yared et al., 2021). The decline in soil productivity mainly resulted from range of factors including soil erosion, nutrient depletion, lack of appropriate and area specific soil rehabilitation and management schemes (Gebreyesus et al., 2011). This might happen due to unavailability of area specific soil information and the remedy it may require. Appropriate soil management requires an understanding of the spatial and temporal variability of soil properties of specific locations and land use systems (Guan et al., 2017; Yared et al., 2021).

Nowadays, understanding the variability of soil properties has received considerable attention by many scholars (Guan et al., 2017; Rosemary et al., 2017). The knowledge in soil property of specific area will help experts and researchers to develop and implement area specific sustainable soil management schemes (Singh et al., 2010; Yared et al., 2021). Scientific information on the spatial variability and distribution of soil properties is critical for understanding ecosystem processes and designing sustainable soil–crop and environmental management decisions (Gebreyesus et al., 2011).

The lack of site-specific soil management recommendation to replenish declining soil fertility has been the major challenge to boost crop production in Ethiopia (Alemu et al., 2016). Therefore, assessing the spatial variability of soil chemical parameters is crucial to design and implement sustainable soil management and improved cropping systems, (Mersha and Meten 2020; Yared et al., 2021). However, soil properties vary in spatially and temporarily due to the combined effect of biological, physical, and chemical processes over time (Mersha and Meten 2020; Panday *et al.*, 2019**)**. Perhaps, this can vary within farmland or at the landscape scale and land use systems as well (Alemu et al., 2016; Corwin et al., 2003). Therefore, soil fertility management requires extremely site-specific interventions. However, site-specific soil management often requires precise and detail spatial information about soil properties of given area (Huang et al., 2006). This detail soil information can be made available through intensive soil chemicals analysis for each specific area and delineating information obtained using remote sensing tools in the form of maps. Modern remote sensing tools including Geo-statistics, GIS and GPS will allow in generating detail soil information along with their map for specific areas and land use system **(**Alemu et al., 2016; Mohamed et al., 2019)

Despite the importance land used and cover based soil characterization, in Ethiopia few studies have been conducted to examine the spatial variability of soil properties at different land used catchment-scale. Particularly in south eastern part of Ethiopia at lower Wabishebele sub-basin almost no study has been made on soil property and variability and no information is available on general soil status regardless of land use. The unavailability of such vital soil information has created challenges in designing appropriate and area-specific soil fertility management interventions Yared et al., 2021. Therefore, the objective of the study was to assess and analyze the spatial variability of some selected soil chemical properties of different land uses and cover in lower Wabi-Shebelle sub-basin in Somali region of Eastern Ethiopia.

2. Materials and methods

2.1. Description of the study area

This study was carried out in the lower Wabi-Shebelle sub-basin involving four districts namely Gode, Kelafo, Ber'ano and Addadle in Somali regional state of Sheble Zone southeastern Ethiopia. All mentioned districts were under the lower Wabi-Shebelle sub-Basin. Geographically the sub basin is located at 5° 40` 0``N latitude to 43° 0` 0``E longitude with an elevation range of 285–800 meters above sea level (Figure 1). The study area had coverage of 1398.7 km^2.

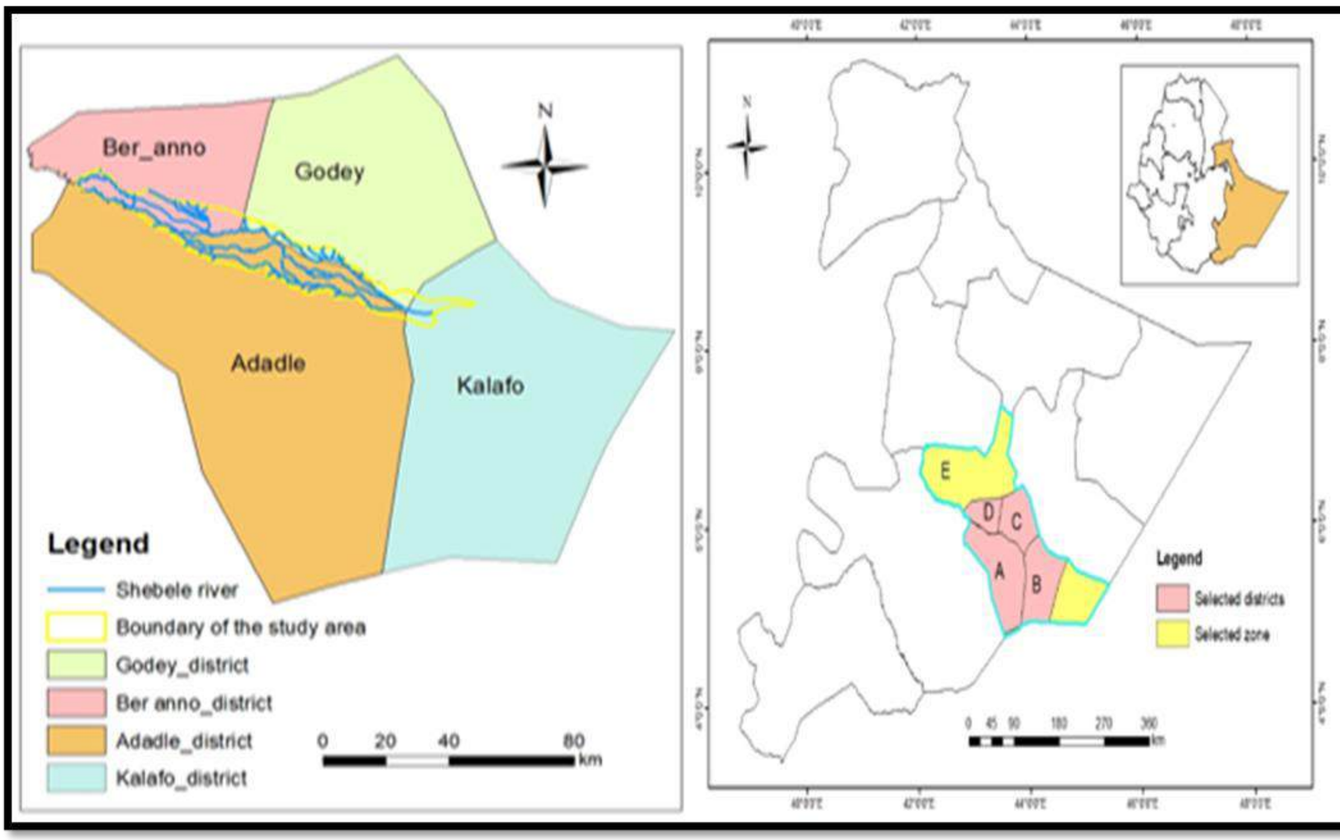

Figure 5 Map of the study area with districts (left) Location map of the study area Right

A=Adadle district; B=Kalafo district; C=Godey district; D=Ber_anno and E=Shebele zone.

The major crops cultivated in the study areas include cereals (Wheat and Maize) fruit crops including mango, papaya, banana and lemon and vegetable onion and tomato. The native vegetation existing in the study areas includes drought-resistant shrubs, salt-resistant shrubs, and perennial sand-loving herbaceous plants. The soil map of the study area indicates that (118096 km^2) 84% is Calcaric Fluvisols followed by Orthic Solonchaks (9334.1km^2) (6.6%), Calcic Cambisols (9145.3km^2)6.5%, Stone Surface (3784.1 km^2) 2.5% and Chromic Vertisols (274.3 km^2) 0.2% **(Figure 2).**

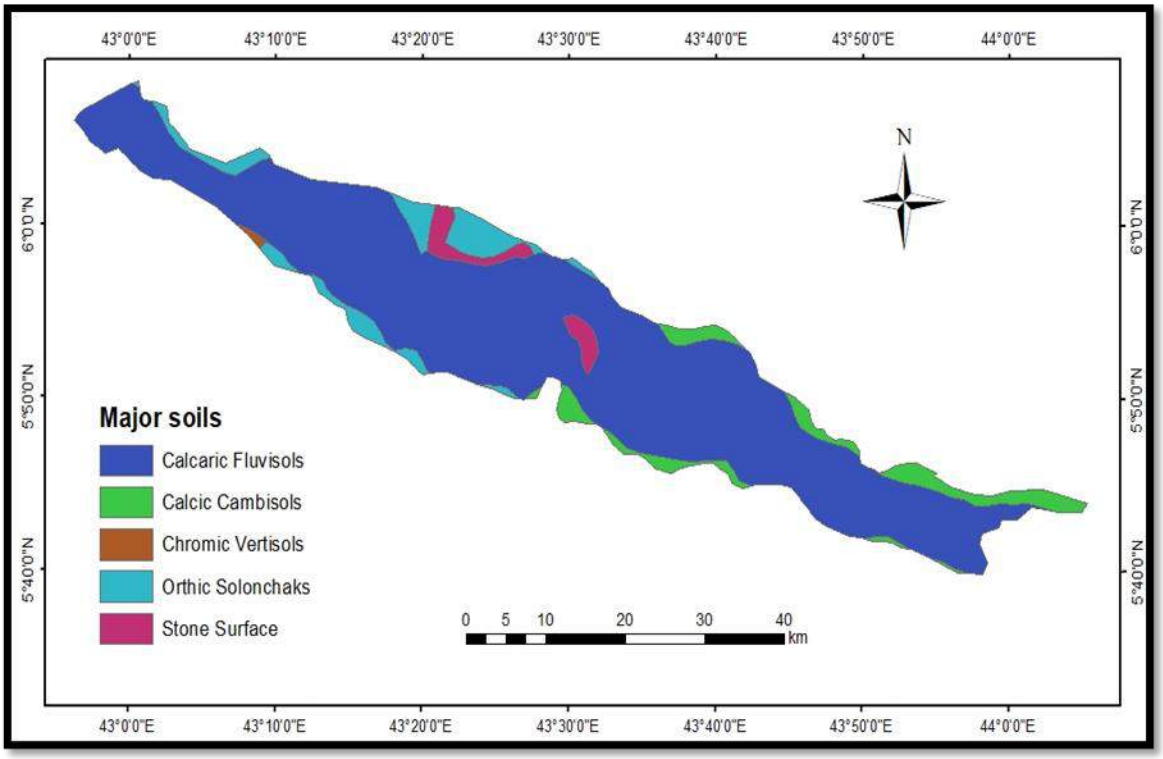

Figure 6 Soil map of the study area

2.2. Soil sampling and geo-statistical analysis

A total of 41 composite samples composed of three sub samples were collected using a soil auger from 0 to 30 cm depth during June 2020. The samples were collected from different land use and land cover namely: agricultural, dense shrub land, sparse shrub land, woodland and bare land. During soil sample collection a global positioning system (Garmin; ETREX 22x) was used to locate the sampling locations. Finally 41 soil samples were sent to Haramaya university soil laboratory analysis.

2.3. Method of soil analysis

The collected soil was sieved through a 2 mm mesh screen to remove plant roots, rocks, and macro fauna the sieved soil samples were analyzed for chemical properties of soil including soil pH, total nitrogen (*TN*) percentage available phosphorus (*AP*) and exchangeable potassium (*EK*). Soil pH was determined using glass electrode pH meter maintaining soil to water ratio 1: 2.5 as suggested by (Barber and Chen, 1990). Total nitrogen of the soils was determined using the Kjeldahl distillation method as described in (Pauwels et al. 1992; Tellen and Yerima, 2018). Available phosphorus was determined by Olsens's bicarbonate method (Olsen et al., 1982). The exchangeable potassium (*EK)* was determined by ammonium acetate method as described by (Simard, 1993).

2.4. Data analysis

Descriptive statistics such as minimum, maximum, mean, standard deviation, and coefficient of variation (CV) values of the entire data set of measured soil properties were calculated using SPSS 19 ver. Geo-statistical analysis has been performed to interpolate the values of un-sampled locations and produce maps of soil properties for the different land uses and covers. ERDAS-2010 and Arc GIS-10 software was operated to prepare the spatial soil chemical variability, land use, and cover map of the study area.

3. Results and discussion

3.1. Land use and cover of the study area

The result of land use and land cover of lower Wabishebele basin expressed in (Figure 3). Accordingly, fallow land (potentially irrigable land) ranks first covering 35.3% of the area followed by cultivated land 19.66%, bare land 18.56%, sparse shrub land 10.61%, woodland 10.56% and dense shrub land 5.31%. The result implies there is a significant land (49, 942.8 ha) which could be used for irrigation but not utilized yet.

Thus, the soil nutrient amount and other parameters should be checked and this land should be irrigated in the near future, which can play a great role to tackle food insecurity of the region and generally the Ethiopia (IEGNWRC, 1973).

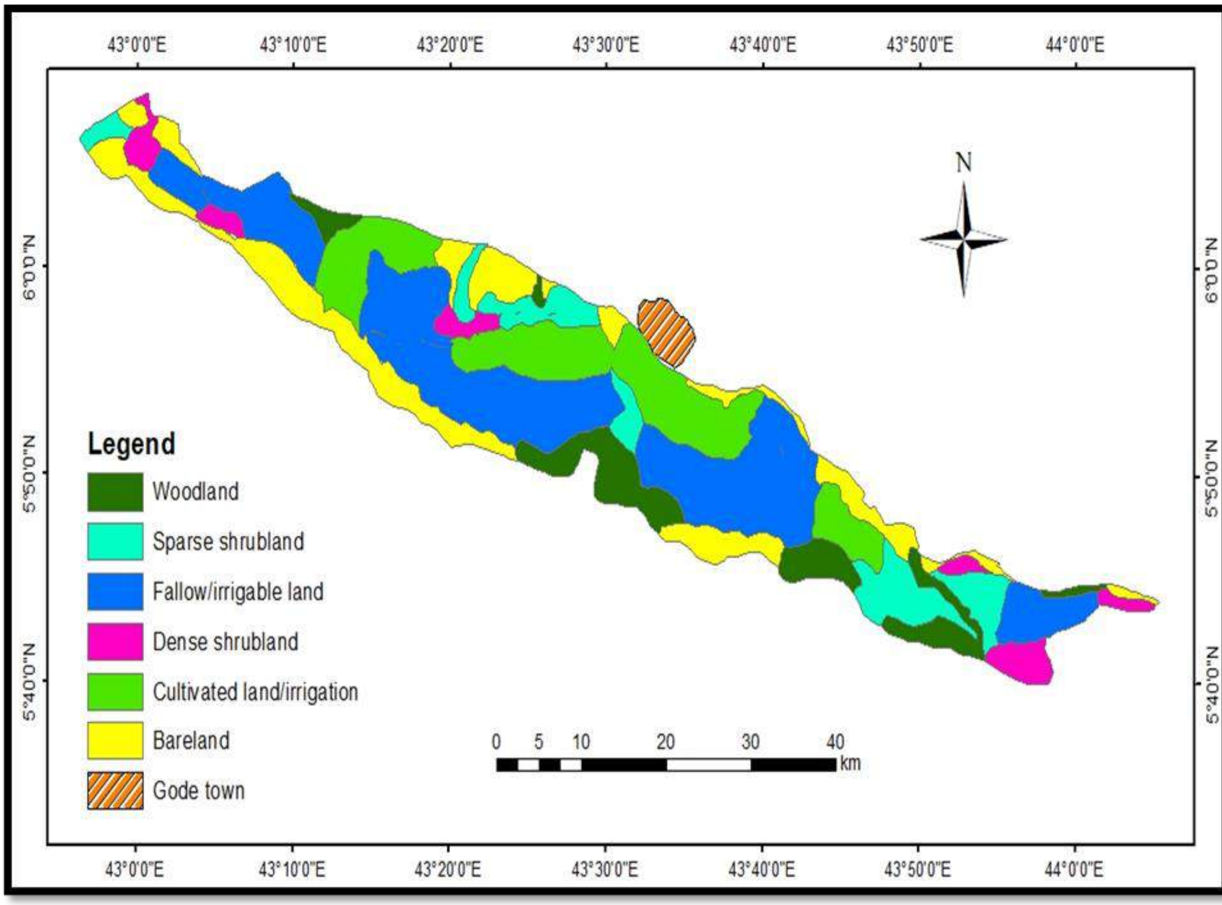

Figure 7 Land use and cover map of the study area (2019)

3.2. Description of chemical properties of soils

Soil pH

According to the result, the soil pH was showed very low variability (CV=1.64% to 4.46%) under different land uses and it was found to be moderately alkaline to alkaline. When the highest pH recorded from bare land and the lowest was recorded from dance shrub land and woodland. Furthermore, the result of the pH revealed that high pH was recorded at northwestern part of the sub-basin whereas low pH values were located at southern periphery of the sub-basin. Crop land and potential crop land remained similar and exhibited slightly alkaline pH range (Table, 1) Despite slight spatial variation, the soil pH of the study area categorized under moderately alkaline pH (Figure, 4 & Table 1).

The result in (Figure, 4 & Table 1) on soil pH of different land use revealed that the soil pH of study area was high and it is in the range of slightly alkaline to alkaline soil pH values. Current finding is in agreement with Debela et al. (2011) who reported that high soil pH value for different land use in semi-arid lowland areas of northeaster Ethiopia. Similarly, the soil pH of lowland semi-arid areas expected to be at the pH value between neutral and alkaline ranges **(**Debela et al., 2011**).** The high pH value in lowland semi-arid soil is due to low precipitation, high value of exchangeable Ca^{+} and high evapotranspiration that resulted in low losses of base from soil profile (Debela et al., 2011; Gebrejewergs et al., 2019).

Table 1: Soil pH descriptive statistics of lower Shebelle basin of the Somali region Ethiopia

Land use & cover	Parameter					Area coverage	
	pH					Area	Percent
	Minimum	Maximum	Mean	SD	CV (%)	Ha	%
Cropland	7.25	7.95	7.73	0.23	3.43	14945.7	10.56
Potential cropland	6.99	8.15	7.62	0.34	4.46	7516.3	5.31
Dense shrub	7.41	7.86	7.54	0.18	2.45	15005.1	10.61
Sparse shrub	7.76	7.90	7.83	0.07	0.89	27806.2	19.66
Woodland	7.01	7.80	7.54	0.23	3.05	49942.8	35.30
Bare land	7.89	8.21	8.05	0.13	1.64	26249.5	18.56
Total						141465.6	100

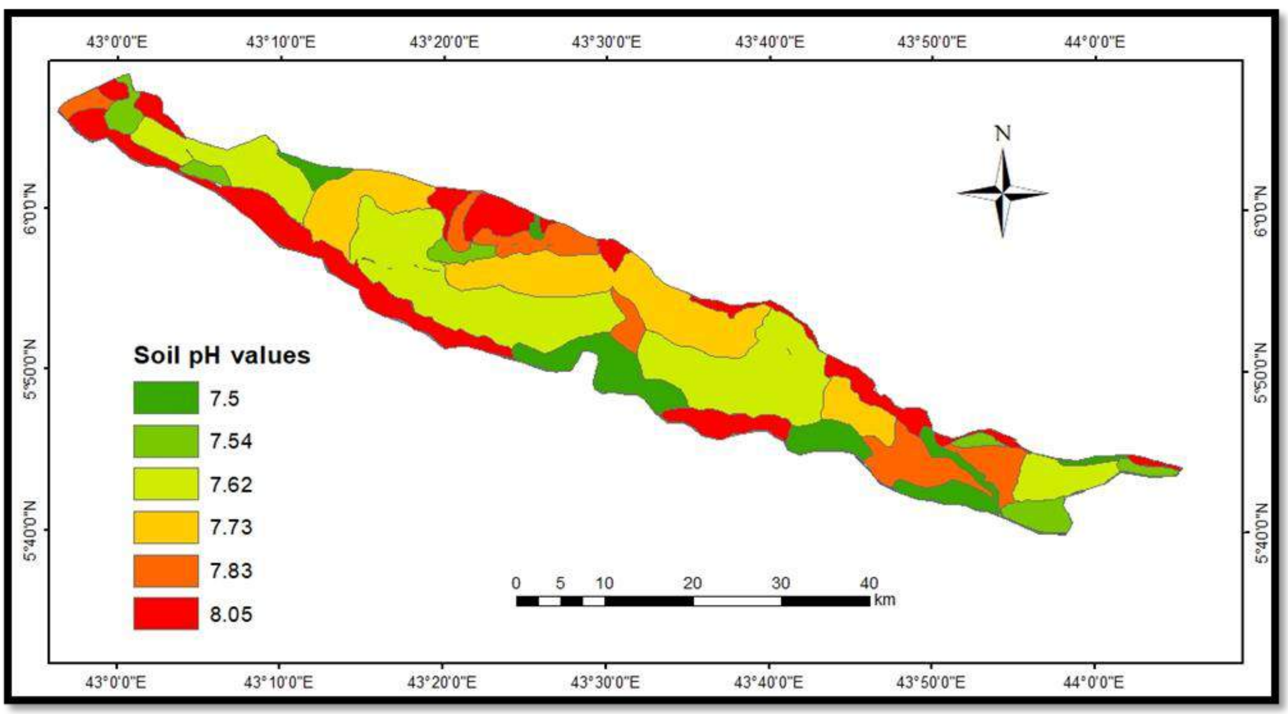

Figure 8: Soil pH spatial variability map in the lower Shebelle sub-basin south eastern Ethiopia

Total Nitrogen *(TN*)

The results on soil *TN* showed that the potential cropland had relatively higher *TN* content followed by wood land and dense shrub land, cropland, sparse shrub and bare lands (Table, 2). However, the soil *TN* content showed certain spatial variability (Figure, 5). Generally most of the study area (82%) had medium soil *TN* content and low soil *TN* was present in only (18%) of the total area. Thus, the northwestern part of the sub basin generally had exhibited medium soil *N* content; while the central part of the area showed lower nitrogen content. The result indicted that variation in soil *TN* content was highly influenced by land use and land cover (Table 2 and Figure 5). The highest *TN* value was recorded from potential cropland followed by dens shrub land while the lowest recorded from bare land and cropland respectively.

Table 2: Soil N descriptive statistics of lower Shebelle basin of the Somali region Ethiopia

Land use & cover	Parameter					Area coverage	
	Nitrogen (*N*) %					Area	Percent
	Minimum	Maximum	Mean	SD	CV (%)	Ha	%
Cropland	0.042	0.364	0.187	0.108	57.61	27806.2	19.66
Potential cropland	0.042	0.448	0.251	0.119	47.61	7516.3	5.31
Dense shrub	0.084	0.308	0.230	0.092	40.12	49942.8	35.30
Sparse shrub	0.140	0.182	0.159	0.021	13.48	15005.1	10.61
Woodland	0.14	0.42	0.23	0.09	39.31	14945.7	10.56
Bare land	0.098	0.196	0.151	0.042	27.78	26249.5	18.56
Total						141465.6	100

The lowest N in bare and cropland could be resulted from reduced organic matter content of the soil due to the absence of vegetation cover and due to low nutrient cycle (Wondimagegne , 2012)**.** Current finding corroborates with the findings of Sebhatleab (2014) who reported that the lower organic matter in farm and bare lands compared to forest and grasslands consequentially resulted in low *N*. similarly Sabiela et al. (2020) indicted that very low value of soil *TN* observed under cultivated lands may be due to continuous cultivation, soil erosion, plant uptake, and volatilization of *Nitrogen*. The result also in line with the findings of Belayneh and Eyasu (2020) who reported higher *TN* values in forest land compared to croplands and grazing land uses.

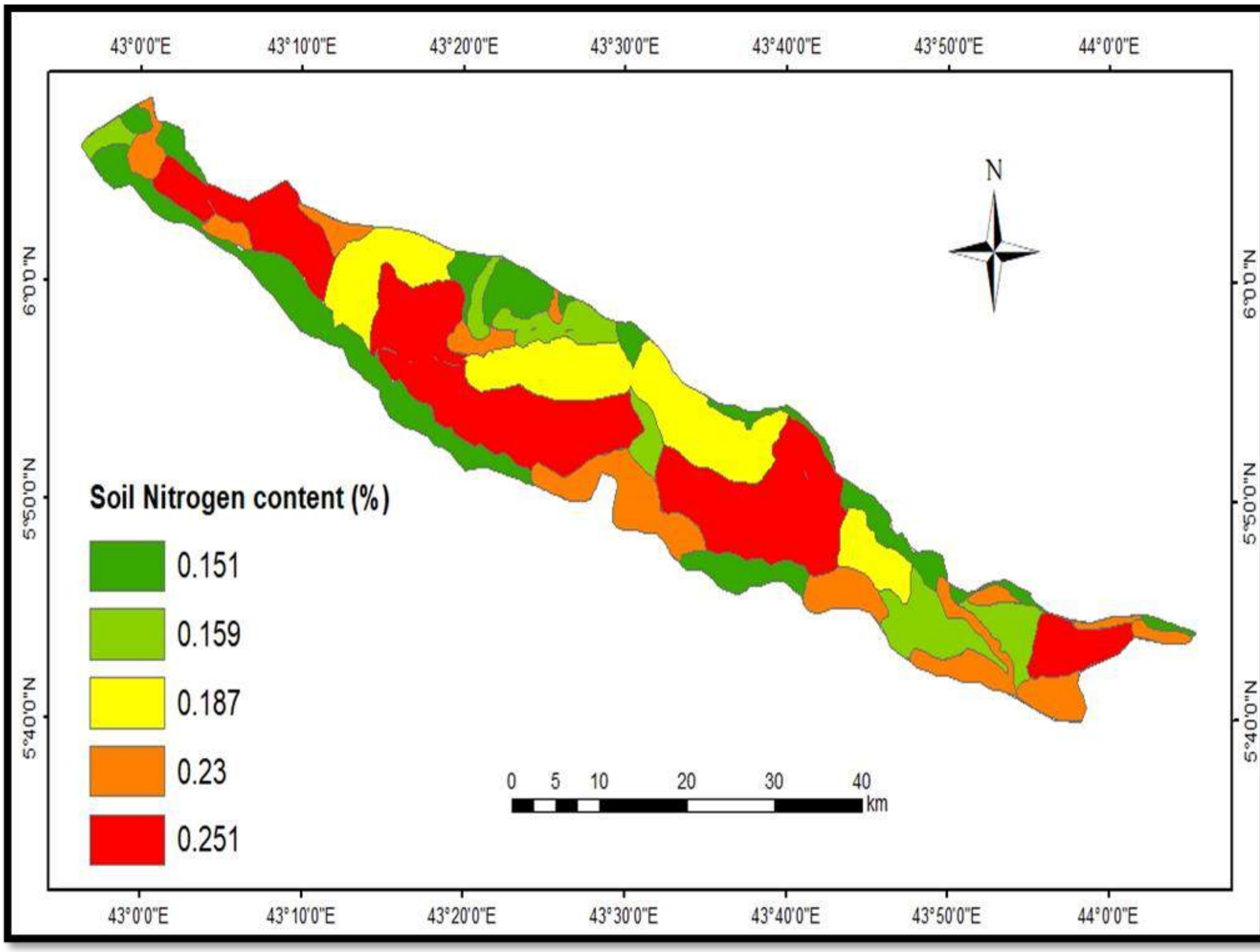

Figure 9 Soil N (%) spatial variability map in lover Shebelle basin of Somali Region, Ethiopia

Available phosphorus (AP)

The results on AP in (Table 3) revealed that, there was certain variation for the different land use and land cover on the values of *AP*. The highest *AP* was obtained from dens shrubland followed by potential cropland and current cropland. While the lowest was recorded from bare land and sparse shrub land respectively (Table 3). Generally entire area under all land use and cover characterized as low level in terms of available phosphorous (Table 3 and Figure 6). Despite the low overall *AP* content, there was a variation across different land use systems.

Table 3: Available phosphorous descriptive statistics of lower Shebelle basin Ethiopia

Land use & cover	Parameter					**Area coverage**	
	Available Phosphorus (*AP*) (ppm)					**Area**	**Percent**
	Minimum	**Maximum**	**Mean**	**SD**	**CV (%)**	**Ha**	**%**
Cropland	2.209	9.186	5.982	2.287	38.23	14945.7	10.56
Potential cropland	4.535	9.884	6.607	1.461	22.12	7516.3	5.31
Dense shrub	5.698	8.721	7.279	1.179	16.20	15005.1	10.61
Sparse shrub	0.814	1.512	1.202	0.355	29.57	27806.2	19.66
Woodland	4.535	8.256	5.956	1.010	16.96	49942.8	35.30
Bare land	1.512	4.302	3.081	1.192	38.67	26249.5	18.56
Total						141465.6	100

The highest *AP* in shrub land could be attributed to P return through litter fall to soil surface (Sabiela et al., 2020). The low soil *AP* contents observed in the lower Shebelle basin are in agreement with the results reported by Fekadu et al. (2018) who reported that *AP* of in most Ethiopian soils has been declining due to fixation, crop removal and erosion. Hence, the variation in this parameter might be caused by due to variation in land use and cover differences.

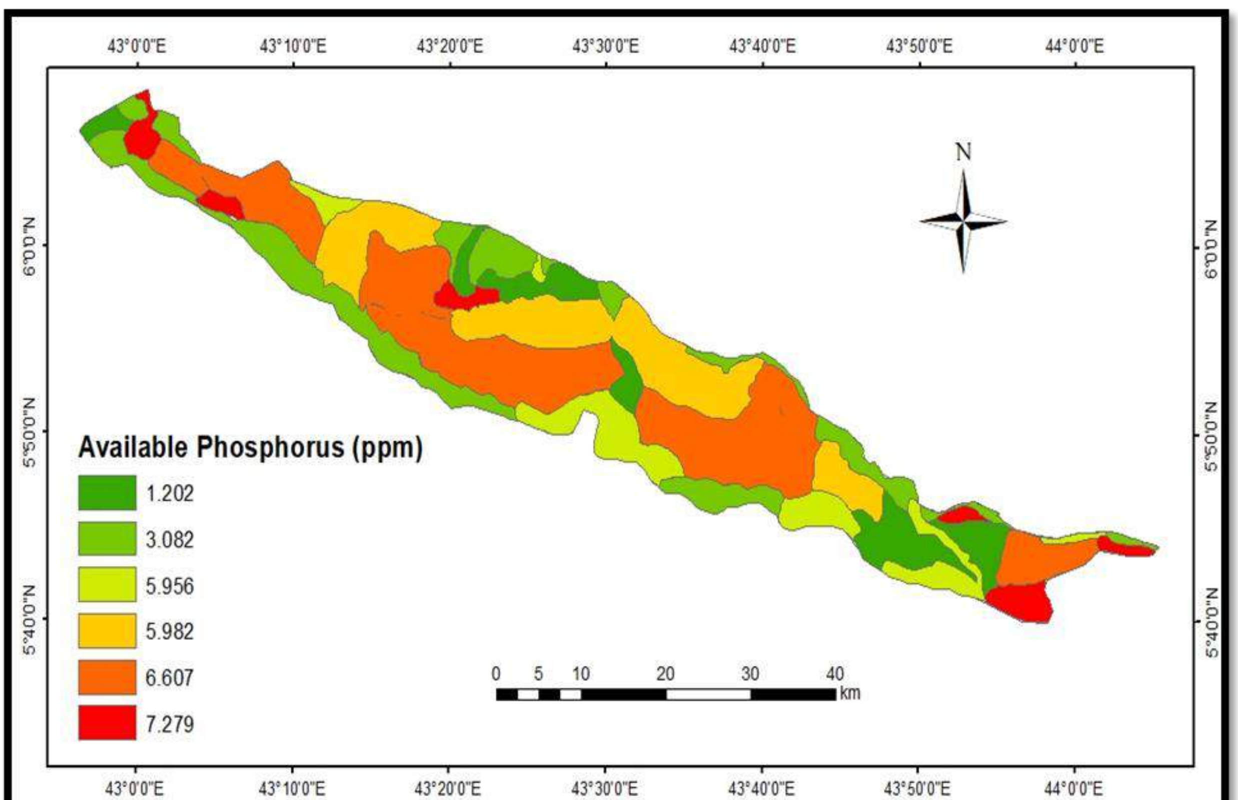

Figure 10 Soil *AP* spatial variability map in lower Shebelle of Somali region, Ethiopia.

Exchangeable potassium (*AK*)

The *AK* content in current study area found to be low to medium and it was highly influenced by land use and cover (Tables, 4 and Figure 11). In this parameter dense shrub land exhibited with higher mean value of *AK* followed by crop land and wood land. Similarly, the lowest *AP* mean value was recorded from bare land, sparse shrub land potential crop land (Table, 4 and Figure 7). This finding in line with (Chauhan et al., 2014; Sudarshan et al., 2018) who reported available (K) was significantly affected by the land use systems. Similarly, Bista (2010) reported significantly higher K level in forest land than crop and bare land. In general, the study area was dominated by medium (70.83%) and followed by low (29.17%) soil AP status. The *AK* values observed in this study area were above the critical levels of (0.4cmol/kg) which is optimum range for many crops except for bare land and sparse shrub land. Hence the *AK* value recorded in the sub basin from different land use found to be sufficient for the production of most crop plants.

Table 4: Soil *AK* descriptive statistics of lower Shebelle basin of the Somali region Ethiopia

Land use and cover	**Parameter**					**Area coverage**	
	Available Potassium (*AK*) (ppm)					**Area**	**Percent**
	Minimum	**Maximum**	**Mean**	**SD**	**CV (%)**	**Ha**	**%**
Cropland	0.429	0.706	0.559	0.096	17.08	7516.3	5.31
Potential cropland	0.348	0.757	0.455	0.134	29.54	49942.8	35.30
Dense shrub	0.545	0.681	0.614	0.062	10.16	26249.5	18.56
Sparse shrub	0.814	1.512	0.227	0.067	29.40	15005.1	10.61
Woodland	0.404	0.631	0.517	0.071	13.68	27806.2	19.66
Bare land	0.116	0.192	0.151	0.033	21.60	14945.7	10.56
Total						141465.6	100

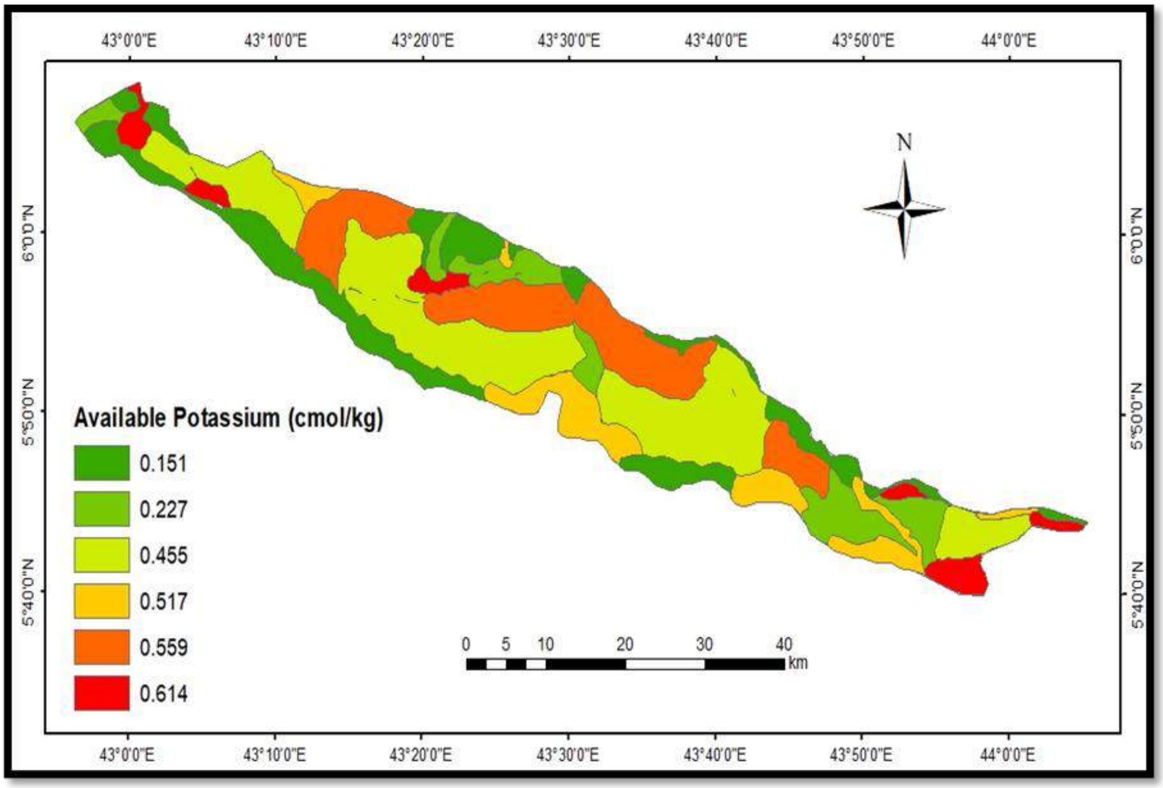

Figure 12 Soil K spatial variability map in lower Shebelle Somali region, Ethiopia

4. Conclusion

This study revealed land use and land cover influenced major soil chemical properties of the lower Wabi-Shebelle river sub-basin. Majority of soil in the sub-basin exhibited slightly alkaline soil *pH* while about 70% of the sub-basin had low level of soil *AP*. Large proportion of the sub-basin had medium content of *TN* and low to medium content of *EK*. Therefore, based on the information obtained to properly manage the soils of the lower Wabi-Shebelle sub-basin according to the land cover and land use detail maps were generated. Soil productivity and other related problems of the sub-basin can be managed through implementation appropriate and area specific intervention. Therefore, the findings of this study can be used as baseline information to develop and implement appropriate soil management intervention for soils of lower Wabi-Shebelle sub-basin Somali region of south eastern Ethiopia.

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