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Yield and Yield constraints Assessment of Pearl millet (*Pennisetum glaucum* (L.) in Sub Zoba-Hamelmalo, Eritrea, East Africa

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ABSTRACT
The survey was conducted during 2016 in Hamelmalo Sub Zoba, Zoba Anseba. This research project was conducted to assess pearl millet production and constraints in five villages namely Hamelmalo, Basheri, Wazntet, Hitsats and Gam. The main objective of the study was to estimate the yield of pearl millet per unit area, to assess the agronomic performance of pearl millet, to recognize the production constraints as well as to identify which village has the highest production potential among the five villages during the year of 2016. The assessment was conducted on 15 farmer's land in the sub zoba Hamelmalo. Data was collected in two ways by taking a sample area of quadrant (1m²) where different agronomic parameters were measured and some questions were asked regarding to the production potential and main constraints of pearl millet production in this sub zoba. The result showed that the major constraints were unequal distribution of rainfall, weeds, insect pest& diseases damage, poor field management and poor application of inputs. The grain yield was higher in Hamelmalo village (1014.83kg/ha) and the lowest yield was recorded in Hitsats (476.27kg/ha). As a recommendation it is advisable to introduce high yielding and pest resistance varieties timely distribution of inputs so as their productivity can be enhanced. An effort should also be assure provision of inputs as well as awareness of farmers and also the varieties should be popularized and demonstrated to farmers so that they can grow them properly in their field.
Key: *Pearl millet, Production constraints and Hamelmalo*

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INTRODUCTION

Pearl millet (*Pennisetum glaucum* (L.) R .Br.) is one of the most extensively cultivated cereals in the world ranking sixth after wheat ,rice, maize, barley and sorghum in terms of area planted to these crops [9]. It is the most important crop in Eritrea economic diet and ranks second in area and production after sorghum followed by barley and taff [9]. Pearl millet has wide adaptability to local environment. It is hardy crop and can be grown in area which are very hot and dry and on soil too poor for crops like maize and sorghum [3, 4]. Pearl millet is usually grown with low or no external inputs. It is considered more efficient in utilization of soil moisture and has ability to tolerate soil toxicity and extreme temperature than other cereals [9]. Pearl millet is an introduced, annual, warm-season crop widely grown throughout the United States for grazing, hay, cover crop, and wild life. There are approximately 1.5 million acres in production in the US [5-6]. It is a bunch grass growing 4-8 ft tall, on smooth 0.5 -1 inch diameter[1-2, 8-10].

Pearl millet is the second most important cereal crop in Eritrea, grown mainly by small farmers in low lands and mid lands. It is predominantly grown in less favorable environments where rainfall is variable and low (250-300 mm). Landraces currently grown contain the traits that farmers have selected over the past generations, and thus represent very valuable resource. However, because of the cross-pollinated nature of the crop, desirable traits may not exist in a high frequency in landrace populations and maybe accompanied by various undesirable traits, such as susceptibility to downy mildew. The pearl millet breeding program was begun in 2000 by National Agricultural Research Institute (NARI) based upon the improvement of local landraces by crossing these with introduced varieties/ populations with disease resistance, early maturity, and improved plant or panicle type. The process has resulted in the introduction of an ICRISAT variety (ICMV 221) (Kona), and the release of new cross-bred variety (Hagaz),

which is across between Kona and a local Eritrean landrace (Tokroray), and by a range of other new varieties in on-station and on-farm trials, involving a number of different Eritrean landraces.[6-7].
In Eritrea pearl millet is not grown throughout the country, mainly grown in midland and lowland but not in highland. The main reason to grow in lowland is because the crop requires less water as compared to highland crops during the growing season. Pearl millet is the highest in terms of total area and production in Anseba Zoba. Hamelmalo and its surrounding areas have an ideal climatic for pearl millet production. Since the area is found in the lowland with 1280m above sea level. In the previous five years the yield is low due to many reasons such as low and inadequate distribution of rainfall, poor crop management and cultural practice and inadequate availability of input. The yield of pearl millet in Hamelmalo sub zoba has not been adequately identified through crop assessment .The assessment was helped the yield potential of pearl millet along with other character. It was also assisted to identify the constraints affecting the productivity of pearl millet. The objective of the study was to assess the productivity level of pearl millet in Hamelmalo sub zone and also to identify the production constraints that affect the yield of pearl millet.

MATERIAL AND METHODS

The assessment was done in sub zoba Hamelmalo which is 15 km North East from Keren. Its elevation is about 1440m above sea level with an average annual rainfall of 497.2mm.The total population reaches up to 25,562.The total area of the sub zoba Hamelmalo reaches about 8900 ha under cultivation and about 5858 ha is cultivated under pearl millet. The climatic condition is nearly similar to that of Keren, which ranges 16°C-38°C temperature. Assessment was conducted on 15 farmer's land in five villages of sub zoba Hamelmalo. The five villages were evaluated separately in order to compare their production per annum. The villages where the study conducted were Hamelmalo, Basheri,Wazntet, Hitsats and Gam.The soil type of sub zoba is sand to sandy loam. The most important crops grown in the sub zoba are Pearl millet, Sorghum, Groundnut and Cowpea. Most of its residents belong to Tigre ethnic groups while the rest are Belen and Tigrigna ethnic group. The crop assessment and data collection were started from October 21,2016.The primary data was collected by preparing questioners using interviews for discussion. The house hold interview was conducted with questionnaire. The secondary data was collected by making desk review of reports and other materials on pearl millet.The questionnaire or the data collection on house hold interview concentrated mainly on seed bed preparation, sowing, seeding rate, crop rotation, fertilizer, weeding, disease, insect, time and method of harvesting, time and method of threshing, land races and their characteristics, seed source and selection, grain and biomass yield. At the time of survey, the questionnaires were filled from each site. Then data was collected from field using a quadrant (1m*1m) in five villages. In each village a sample of three farmers' plot were taken to care out the assessment of the pearl millet in sub zoba Hamelmalo. The farmers ' were selected at random and some of the parameters were taken using quadrant from each farmer's field. The data collected from farmers' field were divided as growth parameters and yield parameters.

RESULT AND DISCUSSION

Education opens up the minds of farmers for greater understanding of the complex of agricultural production technology and change the attitude to overcome different obstacles and constraints of their production. Since majority of the farmers are illiterate the management aspect they use for producing crops are mostly traditional and does not help them to get high yields and good quality seeds of Pear millet. As a result of this economic potential of the crop is not well exploited by the farmers and usually face a problem of producing it efficiently. Land is the major production factor in agriculture particularly its size, fertility, slope and tenure system have greater influence in production of crops. About 75% of the total area of the interviewed farmers is located for pearl millet. The area located for Hitsats and Wazntet for the production of pearl millet is much higher than other villages. This was due to adoption of intercropping in Hamelmalo and Basheri. The soil is sandy loam and well drained, which is more suitable of pearl millet production. The remaining land allocated to sorghum and groundnut. The land allocated for sorghum is less than that of pearl millet due to heavy infestation of striga and smut the farmers do not prefer.Farmers use family labor specially for farming operations. Majority of the farmers do not use external labor. The main reason for that was due to lack of manpower and financial problem. Farmers indicated that crop productivity has been affected due to low soil fertility. Growers do not use inorganic fertilizer because of lack of availability and due to higher price they don't afford to pay and apply fertilizers to cereals like pearl millet. Traditionally, farmers apply organic manure through spending their livestock in night in their field for depositing the dung and urine which become important source of nutrients after decomposition. De Rouw and Rajot (2004) also found that the most common soil fertility management practice with pearl millet is fallowing. Sometimes, manure is practiced either through corralling (the animals spend the

nights on the field during the dry season) or spreading the manure across the fields. In the study area indicates that those farmers they own animals has apply organic manure. Farmers use other practice to maintain the fertility of the soil such as crop rotation, intercropping and terracing.

All the farmers in the study area use seeds from their own stock for planting except one farmer in Hitsats use Kona variety (improved variety). They also exchange seeds with their friends and relatives. They do not use seeds from market, because it is difficult to be sure on the quality of seed bought and there may be a mixture of different types. Farmers also practice plant selection in the field to be used as a source of seed. They select a bigger panicle with larger seed size while the crop is in the field. The panicle selected are threshed separately and stored separately to be used as seed for the next growing season. Sometimes , some farmers get seeds from other sources when seeds are not available from own stock, when they want high yielding, early maturing and drought tolerant varieties.

Farmers rank millet as the first food staple crop and it is grown by almost all the farmers in this sub-zoba Hamelmalo of Zoba Anseba locality (80%) while sorghum ranked as the second stable food crop and grown by 12% of respondents. Groundnut ranked number three and adopted by 8% of the households with respect to the villages. The average Pearl millet grown area is about 5858ha. The average Pearl millet yield is very low, estimate about 724.21 kg/ha. The varieties of Pearl millet which are grown in our study area are Baryay, Tokrri, Zibedi and Kona (improved variety). From those varieties Baryay variety is the most preferable by all farmers of the study area in terms of its adaptation, tastes and marketability. The main factors that contribute to low yields are climate change as reflected in the amount and distribution of the rainfall and the rising temperatures, use of traditional low-yielding varieties due to unavailability and very low adoption rate of improved varieties, unavailability of essential inputs (improved seeds & fertilizers), poor seed production and distribution, low adoption rate of the recommended technologies (poor agronomic practices), poor technology transfer, poor research-extension- farmer linkages, decline in soil fertility, susceptibility to biotic constraints, unavailability of labor, institutional constraints. Other constraints limit pearl millet production and value addition and have a serious implication on food insecurity include limited markets, inefficiency of the marketing, inefficiency of crediting systems, lack of proper mechanization, poor harvesting, threshing and cleaning technologies, poor farm level preprocessing technologies, storage pests, poor storage facilities, limited processing and utilization and lack of diversity in value added product, unfavorable pricing and production policy. These have severe negative impact on food security of rural household, their livelihood outcomes and on natural resource base. Results indicated that there is a food shortage in the sense that households are not able to feed their families through low-yielding subsistence production; and loss of the economic opportunity that these people would otherwise have to alleviate their poverty by producing grain for sale, due to poor grain yields, quality and the constrained market demand for these crops. The majority of the households were found to be vulnerable since large proportion of their average income is used on food consumption.

Very few amount of pearl millet is sold to consumers, urban traders. In addition to that, households had no collective action for marketing their produce. Millet is passed from farmers to farmer, village and urban traders to consumer and it is stored above ground and packed in sacks with a capacity of 50kg up to 100 kg, transported by camels, donkey and some farmers using cars during threshing time.

This necessitate the intervention of the project in the area of improved seeds that adapted to these problems to enhance the productivity of the main staple food crop such as millet and sorghum and achieve food sufficiency and food security.

The major insect pests & diseases that were commonly appear in the study area were birds, ants, and chafer beetles, diseases like downy mildew, rust, ergot and anthracnose that have a devastating effect on the production of the crop. Downy mildew caused by *Sclerospora graminicola* is the most widespread and destructive disease of pearl millet causing severe economic losses (Picture 1). Farmers approximated that the local varieties were up to 20 to 60% affected by this disease. Kona was the most resistant to downy mildew and the local varieties were scored highest disease incidence of downy mildew. Farmers in this area have called the disease 'AIDS in plants'; an indication as to the seriousness with which they consider it. Local landraces are susceptible to downy mildew (30 to 70% susceptible, Eyob, 2000) and as late maturing types they are more prone to the prevailing unreliable climatic conditions, resulting in increased chances of lower grain yields or a risk of complete yield failure. The weeds mentioned are *Convolvulus sagittatus, Amaranths spp, Dactyloctenium aegyptium* and *Setaria pumila*. Other insect pests identified were *Sitotroga ceralella* affect stored grain. Bird damage is a well recognized problem in Hamelmalo (picture 2). The days to maturity of the different varieties, the surrounding maturity of wild grasses (main source of food), the population of birds, owing to their earliness Kona was relatively more susceptible to bird damage.

Picture 1: Pearlmillet infested by downy mildew

Picture 2: losses of pearlmillet grain due to bird

There were also other environmental constraints that have a negative impact on the yield of pearl millet in selected villages the detail result discussed in(table 1).

Table 1:Factors that affect yield losses

Biotic constraints	**Stage of attack**
Harvester ants	at the time of seed sowing
Birds	at the time of seed setting
Downy mildew	At young stage and heading stage
Rust	At leaf stage
Ants	After harvesting and during threshing
Anthracnose	All aerial parts of plant
Ergot	At time of flowering (non fertilized flower)

The major abiotic factors that were commonly affectthe production in the study area were drought, lack of sufficient inputs, inadequate crop managements and unpredictable distribution of rainfall that have a devastating effect on the production of the crop. Moreover, diseases like downy mildew, rust, ergot and smut were appeared whose control was difficult. There were also other environmental constraints that have a negative impact on the yield of pearl millet in selected villages the detail result discussed in (table 2).

Table 2: Abiotic factors that affect Yield

Constraints	Causes	Solution
Drought	Erratic distribution of rain fall	Sowing early maturing varieties, drought tolerant and use of water conservation practices
Lack of inputs	Shortage of supply	-Supply of inputs at the right time and place. -Supply of improved seeds(varieties)
Inadequate crop management	Mono cropping of pearl millet without proper crop rotation, inter cropping and inappropriate cultural practices	-Timely weeding and supply of herbicides. -Crop management practices including crop rotation, right planting date, optimum seeding rate, inter cultivation, fertilizer application and control methods.

Data collected from farmers field

Growth studies

The following growth parameters were recorded:

Table 3:Growth parameters from each respective villages

Villages	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Plant population /m^2	Weed count/m^2
Hamelmalo	181.08	47.02	2.67	7.55	3.78
Basheri	186.72	47.48	3.10	7.45	2.44
Hitsats	160.08	41.81	2.89	7.43	1.11
Wazntet	182.55	50.27	2.85	5.89	2.26
Gam	178.19	52.42	3.25	5.33	1.44
G.mean	**177.72**	**47.80**	**2.95**	**6.71**	**2.29**

Plant height (cm)

Plant height in the five villages showed different mean values and this is due to varies in the management aspect of the farmers. The highest mean value of plant height was found in Basheri with a value of 186.72cm followed by Wazntet with a value of 182.55cm and the lowest plant height was scored by Hintsats with a value of 160.72cm. This lowest result of plant height in Hintsats was due to late sown and the varieties were the farmer used local variety which is not late release.(Table 3)

Leaf length and leaf width (cm)

Leaf length and leaf width taken as growth parameters indicated in (Table 5) the leaf area and leaf width which occurred in different villages were different. The leaf length and leaf width showed difference in mean value as a result the highest leaf length and leaf width was scored by Gam with a value of 52.42cm and 3.25 cm respectively followed by Wazntet with a mean value of 50.27cm and Basheri with a mean value of 3.10cm respectively. The lowest leaf length observed in Hitsats with a mean value of 41.81cm while in the case of leaf width Hamelmalo scored the lowest with a mean value of 2.67cm.

Plant population

Plant population could relate with the seeding rate of the crop, the higher the seeding rate could have more population. The total number of plant in $1m^2$ in different village observed different in meter square. The more plant population was observed in Hamelmalo with a number of 7.55 plant per meter square followed by Basheri with number of plant per meter square 7.45 plants while the lowest number of plants were scored by Gam with the lowest number of plant population per meter square was with a mean value of 5.33. The plant population could have a positive correlation with the grain yield and biomass that is the more number of plants have more biomass as well as more grain yield per hectare(Table 3)

Yield and yield parameters

Table 4:Yield and yield attributes from each respective villages

Villages	Yield and yield parameters					
	Panicle length (cm)	Number of panicle/plant	Panicle weight (gm)	Biomass yield (Kg/ha)	Grain Yield (kg/ha)	Harvest index (%)
Hamelmalo	22.52	2.77	41.86	7928.10	1014.83	12.80
Bashiri	20.61	2.33	43.32	4676.00	567.97	12.15
Hitsats	18.97	1.89	33.11	4265.92	476.27	11.16
Wazentet	20.19	2.22	39.56	4514.07	694.03	15.37
Gam	20.92	2.58	46.56	5160.74	867.93	16.82
Mean	**20.64**	**2.63**	**40.88**	**5308.97**	**724.21**	**13.66**

Panicle length (cm)

The panicle length in five villages of different farmers showed different mean value and this is due to varies in the management aspect. The highest panicle length was found in Hamelmalo with a mean value of (22.52cm) followed by Gam with a mean value of (20.92) and the lowest panicle length was scored by Hitsats with a value of 18.97cm. According to the recorded data those villages with higher panicle length showed a satisfactory grain yield obtained during this experimental study.

Number of panicle per Plant(No.)

The number of panicle per plant in five villages and in different farmers showed different mean value and this is due to varies in the management aspect, seeding rate, lack of inputs and downy mildew etc. The highest number of panicle per plant was recorded in Hamelmalo with a value of 2.77 and followed by Gam with a value of 2.58.The lowest panicle number was recorded in Wazntet with a mean value of 2. The result of higher panicle number per plant in Hamelmalo was attributed due to lower plant population which resulted to have more tillers and less number of weeds than in the other farmers field. (Table 4).

Panicle weight (gm)

The panicle weight showed different mean value in five villages of different farmers. The highest mean was found in Gam with a value of 46.56gm followed by Basheri with a value 43gm and the lowest panicle weight was scored by Hitsats with a value of 33.11gm. The panicle weight could have a correlation with grain yield. The highest the panicle weight will have the highest grain yield but also depends on the grain weight. This reason could be attributed due to better performed in the growth parameters(Table 4).

Biomass yield (Kg/ha)

There statistical difference in Biomass yield among the villages of different farmers was presented in(Table 6). The highest biomass yield was recorded in Hamelmalo with a value 9180 kg/ha. The lowest was in Wazntet with a value of 3397kg/ha. The highest biomass yield in Hamelmalo was resulted due to good management, availability of FYM, machiners like tractors, threshers, land (flat area helps to use machinery, machinery like tractors, threshers) than in the other villages and his good management and cultural practice within the village farmers. The type of weeds in the field of were mainly broad leaved weeds such as *Amaranthus virudus, Xanthium strumarium* etc which have less stress effect due to proper managements provided by the farmers in this village.

Grain yield (Kg/ha)

Grain yield was significantly higher in Hamelmalo with a mean value of 1014.83kg/ha which is presented in(Table 6). The lowest was in Hitsats with a value of 476.27kg /ha. In Hitsats there was lower yield potential because of its lower panicle weight, lower panicle number and lower plant population as compared to Hamelmalo. Yields vary widely depending up on the cultivar and location. This difference was as a result of various cultural and management practices. In Hamelmalo the farmers used animal manures and appropriate cultural practices such as land preparation, and crop rotation, using tractors ,threshers and also availability of labor.

Harvest Index (%)

Harvest index is the ratio of the economic yield by the total biomass. The ratio is from 0-1 but the harvest index for the value of 1 maybe get from the forage crops. In our study the highest harvest index was recorded in Gam with a value of 16.82%. The lowest was found in Hitsats with a value of 11.16%. There is a positive correlation between the harvest index and the grain yield, but in our study, according to this relation the less value of HI in Hamelmalo than in Gam and Wazintet was resulted due to high biomass yield and more number of tillers which did not reached to its maturity stage of the panicle(Table 4)

Conclusion

The result of the assessment conducted in the experimental study indicated that, subsistence agriculture is the principal economic activity in this sub zoba Hamelmalo crop production and livestock account for the main share in local income of households. The most dominant crop grow in this area were pearl

millet, sorghum and groundnut. Production potentials and productivity levels have decreased yearly and each household faced with shortage of food consumption and marketable income continues. Productivity of pearl millet is very low due to many factors of which unavailability and very low adoption rate of improved varieties and other recommended technology which can enhance their productivity. The farmers of this sub zoba requested that there less access pesticides, fertilizers and improved seeds to with stand the moisture stress and other infestation of pests and weeds as well. The result of this investigation showed that the main constraints that caused to reduce the productivity of pearl millet in the study areas were the biotic (downy mildew) and abiotic. The grain yield was higher in Hamelmalo area with a mean value of (1014.83kg/ha) comparing with other villages and this result was attributed due to good agronomic practices carried in Hamelmalo village like intercropping, crop rotation and also application of manure to improve soil fertility to enhance the yield potential of pearl millet. It is recommended that the farmers of the study area urgently demanded to get continuous extension service, in addition this training, timely providing of good quality seeds, planting materials, pesticides and fertilizers to lead to more income and to win the target of food security.

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