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On-Farm Evaluation of Sorghum (*Sorghum bicolor* L. Moench) Varieties Under Tie Ridge and NP Fertilizer at Mekeredi, Moisture Stress Area of Amaro, Southern Ethiopia

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Abstract

In low moisture stress areas, low productivity of crops has been attributed to low moisture stress, low soil fertility, lack of improved varieties and lack of appropriate moisture conservation practices in most areas of the region. Field experiment was conducted under rain-fed conditions between 2005-2008 to evaluate five improved sorghum varieties (Seredo, Teshale, Meko, 76T1#23, Gambell 1107) and one local(landrace) with $46kgP_2O_5+18kgNha^{-1}$ and an improved moisture conservation practices (tie ridge) was laid out in a randomized complete block design with three replications for growth, yield and yield component. The data were combined over year after carrying out analysis of variance for each year separately and homogeneity tested (the ratio of larger error mean square to smaller error mean squares). Means were separated using Fisher's Least Significant Difference (LSD). There was significant variation observed among varieties to the tested parameters. Varieties 76T1#23 gave the highest sorghum grain yield (5877kg ha^{-1}) whereas the landrace with traditional management gave the least (1901kg ha^{-1}). Yield advantage of 56% to 68% improved varieties with fertilizer and conservation practice over traditional sorghum cultivation (local cultivar without fertilizer sown in flat planting) could be an attractive option to boost sorghum yield under moisture stress environment. Furthermore, the results indicate that soil and water conservation with improved crop varieties is indispensable for increasing crop yield. Based on these results, therefore, sowing improved varieties 76T1#23 in ridge tied three meters apart with $46kgP_2O_5+18kgNha^{-1}$ fertilizer is an attractive option and recommended for sorghum production in areas where there is short and erratic rain fall.

Keywords

Tied Ridge, Varieties, Moisture Stress

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1. Introduction

In low moisture stress areas, low productivity of crops has been attributed to low moisture stress, low soil fertility, lack of improved varieties and lack of appropriate moisture conservation practices in most areas of the region. Sorghum (*Sorghum bicolor* L. Moench) is the third most important crop after teff and maize in terms of area and the second in total production next to maize in Ethiopia [1]. Currently sorghum is produced by 5 million holders and its production is estimated to be 4 million metric tons from nearly 2 million hectares of land giving the potential average grain yield of around 2 tons per hectare. It covers 16% of the total area allocated to grains(cereals, pulses, and oil crops) and 20% of the area covered by cereals [1]. The obtained yield is much lower than global average. In Ethiopia sorghum provides

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more than one third of the cereal diet and is almost entirely grown by subsistence farmers to meet needs for food, income, feed, brewing and construction purposes [2].

Sorghum grain is mostly used for local markets and most of the sorghum produced in Ethiopia is consumed at household levels. It is the second most important crop for injera quality next to teff. The grain is also used for the preparation of other traditional foods and beverages like tella and areke. It is also consumed boiled and roasted. Other countries experience showed that it can also be used as raw material for industry and can be processed in to malted foods, beverages and beer [3]. Drought is one of the major yield limiting factors. It is manifested by delay in onset, dry spell after sowing, drought during critical crop stage and too early stop. Over 80 % of sorghum in Ethiopia is produced under sever to moderate drought stress condition [4].

In dry land agriculture, limited water availability is usually the factor that ultimately limits crop production. The moisture stress areas of the region, the mean annual rainfall sometimes drops down to less than 100mm which in turn narrows down the length of growing period below 45 days. Rainfall begins and finishes early leaving short duration for the crop to grow [5]. In these parts of the region, some years were so favourable and could give higher yields while other years were so dry that yields were very low or total crop failure observed.

Gebreyesus Berhane *et al*. [6] reported that the beneficial effects of tillage such as tied-ridging on crop yield vary due to differences in amount and distribution of rainfall, soil type, slope, landscape position, crop type, time of ridging, and the condition where rainfall events to result in significant runoff . They also pointed out that tied-ridging increased sorghum grain yield and soil water by more than 40 and 25%, respectively, as compared to the traditional tillage practice (*shilshalo*) in northern Ethiopia.

Different types of tillage methods have been used for soil and moisture conservation and control of runoff and erosion. These include contour ploughing, open ridges, and tie ridges (furrows tied at interval) and ridges tied but alternative furrows left open [7].Tie ridges have been found to be very effective. Grain yield increases of upto 145% were found compared to the traditional practices(depending on soil types, slop, rainfall and crop) in some of the dryland areas [8]. There is also sorghum varieties developed which tolerates moisture stress and give reasonable yield. Based on these facts, therefore, this study was elucidated to evaluate varieties under moisture conservation practice (tie ridge) and NP fertilizer in low moisture stress areas of Amaro.

2. Materials and Methods

2.1. Site Description

Field experiment was conducted for three cropping seasons from 2006 to 2008 at Mekiredi (Amaro district of Southern Ethiopia) on clay loam textured soil with a pH of 6.5, 0.26% total Nitrogen (N), 39 ppm available phosphorous (P), 40.4 ppm available Potassium (K) and located in an altitude of 1400 m.a.s.l. The annual average temperature is 21 to 27.5°C. The site has mean annual rain fall ranges from 400 to 800 mm and is bimodal with very short rain season which starts from the last week of February to the end of March and the second season from September to October. The onset of rain may sometimes vary, either too late or too early with erratic nature, uneven distribution and was with low amount (Table 1); whereas, the annual evapo-transpiration was from 1400 to 1700 mm.

2.2. Experimental Design and Procedure

Five improved varieties (Seredo, Teshale, Meko, 76T1#23, Gambell 1107) including one local check were evaluated with recommended DAP fertilizer ($46kgP_2O_5$ $+18kgNha^{-1}$) and recommended moisture conservation practices (the tied ridge) laid out in *a r*andomized complete block design with three replications. Sorghum varieties were sown on a plot size of 3.75m x 6m (22.5m2) in rows of five per plot at a spacing of 75cm wide and plant spacing of 15cm. Net plot size of three rows by 6 meter long containing 40 plants per row and a total of less than or equal to 120 plants. For tie ridges, the ridges tied manually at 3 meters interval closed at both ends and the local cultivar sown in flat bed without fertilizer as control.

2.3. Data Collection and Analysis

Plant height (the average height of five randomly selected plants per plot measured from the base of a plant to the base of sorghum head), above ground biomass weight (the weight of total above ground biomass of the middle three rows of 6 meter long plot), thousand seed weight (weight of 1000 clean seeds from each plot), and grain yield (the middle three rows harvested, threshed cleaned and weighed) were estimated. The measured yield was adjusted to recommended storage moisture of 12.5% using digital moisture tester. All the data collected when the crop reached to physiological maturity during each season. These data were subjected to analysis of variance using the GLM procedure of SAS software version 9.2 [9]. Effects were considered significant in all statistical calculations if the P-values were < 0.05. The data were combined over season after carrying out ANOVA for each year separately and homogeneity tested (the ratio of larger mean square to smaller mean squares) as suggested by

[10]. Means were separated using Fisher's Least Significant Difference (LSD).

Table 1. Amount of precipitation in millimeter (mm) for the growing seasons.

Month	*Season*			
	*2005**	*2006*	*2007*	*2008*
January	*10.7*	*1.1*	*26.8*	*2.1*
February	*11.8*	*43.7*	*10.9*	*3.5*
March	*128.1*	*107.8*	*67.4*	*32.7*
April	*125.1*	*146.9*	*116.1*	*94.8*
May	*311.2*	*310.9*	*167.4*	*72.8*
June	*44.7*	*39.4*	*211.6*	*57.9*
July	*31.6*	*8.5*	*51.2*	*48.9*
August	*11.6*	*131.9*	*111.3*	*26.4*
Total	*674.8*	*790.2*	*762.7*	*339.1*

3. Results

Mean square values of combined analysis of variance for sorghum plant height, above ground biomass, thousand seed weight and grain yield shown in table 2. As indicated in the table, there was highly significant variation observed among years. There was also highly significant ($p<0.01$) difference observed among varieties to tested parameters.

Table 2. Mean square values of plant height, biomass, thousand seed weight and grain for sorghum varieties under tie ridge and NP fertilizer.

Source	*df*	*ht*	*bio*	*sdw*	*yld*
Year	*2*	*9938.7****	*4480.6****	*2743.6****	*158656351.7****
Rep	*2*	*341.9ns*	*4.2ns*	*3.5ns*	*182011.5ns*
Treat	*5*	*2493.6****	*136.8****	*114.6****	*16511887.8****
*y*treat*	*10*	*474.7ns*	*27.43ns*	*59.7****	*9618456.5****
Error	*34*	*248.9*	*22*	*10.7*	*196476.3*
Total	*53*				
CV		*14.05*	*25.6*	*11.16*	*9.94*
R2		*0.82*	*0.93*	*0.95*	*0.99*

*Significant at $P<0.05$, whereas *** significant at $P< 0.001$

Yearly mean values of plant height, above ground biomass, seed weight and grain yield presented in table 3. As illustrated in table 2, there was significant variation among years.

Table 3. Mean values of sorghum plant height, biomass, seed weight and grain yield over years

Year	*plant height(cm)*	*biomass (ton ha-1)*	*Thousand seed weight(gm)*	*yiled(kg ha-1)*
2006	*86.2c*	*6.3c*	*23.9b*	*2716b*
2007	*131.8a*	*36.2a*	*43.6a*	*7889a*
2008	*118.7b*	*12.5b*	*20.8c*	*2779b*
LSD 0.05	*10.7*	*3.2*	*2.2*	*300*

NB: Figures with the same letters are not statistically significant

3.1. Plant Height

Statistically significant height variation observed among years. The year 2007 was better (131cm) while the first year(2006) it was 86.2cm and during 2008, it was 118.7cm. There was also significant height variation observed among the varieties. The variety Teshale found to be highest in plant height with mean height of 144cm while the variety 76T1#23 was the least (95cm). the most probable reason for the variation among years was to rainfall distribution throughout the season.

3.2. Above Ground Biomass

Combined analysis of variance indicated that there was significant biomass variation observed among the years. The year 2007 was the highest (36.2 ton ha-1) and followed by the year 2008 with mean values of 12.5 ton ha-1 while the year 2006 was the least (6.3 ton). There was also significant above ground biomass difference observed among the varieties. The variety Gambella1107 weighed the highest aboveground biomass (23.9ton ha-1) followed by Seredo (22.5 tons ha-1) while landrace (16 tons ha-1) was the least.

3.3. Thousand Seed Weight

The variation among years was statistically significant (table 2). As shown in table 3, the year 2007 provide the highest seed weight (43.6gm) followed by 23.9gm of the year 2006 while the year 2008 was the least seed weight of 20.8gm. The varieties Teshale, Meko and 76T1#23 were statistically not varied in seed weight, however the variety Meko weighed the highest (33.4gm) followed by the variety Teshale which weighed 32.6gm and the variety seredo found to be the least (24.9gm).

3.4. Grain Yield

Similarly to plant height, biomass, and seed weight, there was significant grain yield variation observed among years. As the other parameters shown above, the year 2007 found to be the year of highest grain yield observed(7889kg ha-1) and the year 2006 and 2008 gave statistical not different yield of 2716kg ha-1 and 2779kg ha-1, respectively (table 3). The variation among varieties was also significant. As indicated in table 4, the variety 76T1#23 found to be highest in grain yield with mean value of 5877kg ha-1 whereas the variety local sown without fertilizer in flat field was the least (1901kg ha-1). Yield advantage of 56% to 68% improved varieties with fertilizer and conservation practice over traditional sorghum cultivation (local cultivar without fertilizer sown in flat planting) could be an attractive option to boost sorghum yield under stress environment.

Table 4. Mean values of plant height, biomass, seed weight and grain yield of sorghum varieties

Variety	*plant height (cm)*	*biomass (ton ha-1)*	*Thousand seed weight(gm)*	*Grain Yield (kg ha-1)*
Teshale	*144.0a*	*17.0b*	*32.6a*	*4840bc*
Gambella1107	*111.8b*	*23.9a*	*28.9b*	*4370d*
Seredo	*105.1bc*	*22.5a*	*24.9c*	*5111b*
Meko	*110.4b*	*14.8b*	*33.4a*	*4667cd*
76T1#23	*95.0c*	*15.2b*	*30.9ab*	*5877a*
*Control**	*107.2bc*	*16.4b*	*25.6c*	*1901e*
LSD 0.05	*15.1*	*4.5*	*3.1*	*300*

NB: Figures with the same letters are not statistically significant

Table 5. Correlation coefficient values for growth and yield of sorghum

	plant height	**biomass**	**thousand seed weight**	**grain yield**
plant height		0.53***	0.40***	0.33*
Biomass			0.72***	0.74***
thousand seed weight				0.81***
grain yield				

• Significant at P<0.05 whereas *** significant at P< 0.001

4. Discussion

The significant Mean values variation among years indicate that in moisture stress areas some years are good years receiving better rainfall resulting good crop performance and better yield while the other years receive less rain and are bad years resulting bad crop performance and poor yield. Vigorous growth of sorghum varieties is the most important parameter in terms of importance next to grain yield due to the varieties of uses like animal feed, fencing material, fuel wood and for making traditional storage and shelter. This parameter (plant height) varied significantly among treatments. The variety Teshale with fertilizer sown in tie ridge found to be the highest while the variety 76T1#23with the same management was the least.

Biomass variation among treatments was also significant. The highest above ground biomass was obtained when the variety Gambella 1107 sown with fertilizer in tie ridges. Similarly, thousand seed weight significantly differed due to the treatments. The variety Meko found to be highest followed by the variety Teshale.

Concerning grain yield, the highest yields of sorghum recorded for the variety 76T1#23 when planted in ridges with fertilizer. Generally, local cultivar with traditional practices (flat planting without fertilizer) is the least as compared to other varieties. The present study is in full agreement with the finding of [11]. Similarly, Heluf Gebrekidan and Yohannes Uloro [12] observed maize yield increments of 15 to 50% due to tied ridges and 15 to 38% for sorghum on different soil types of eastern Ethiopia. Kowal [13] also reported that ridges that are not tied at intervals are not effective in controlling runoff and soil loss in the Savannah region of northern Nigeria. In Upper Volta, tied ridges led to only 0.9% runoff as compared to 6.3% with open graded ridges and 12.2% in the case of flat cultivation [14]. Regardless to fertilization, the variety Meko gave the highest thousand seed weight on tie ridges. This result also agrees to the finding of Tekle Yosef and Zemach Sorsa[15], who found out that the variety Meko provided the highest thousand seed weight.

5. Conclusion

Combined analysis of variance over years indicated that there was variation among years for the parameters tested. Year two provided best performance followed by year three while year 1 was the least in plant height, biomass. But seed weight of year 1 was better than year three. There was significant variation observed among varieties to the tested parameters. Varieties 76T1#23 gave the highest sorghum grain yield (5877kg ha^{-1}) whereas the landrace with traditional management gave the least (1901kg ha^{-1}). Yield advantage of 56% to 68% improved varieties with fertilizer and conservation practice over traditional sorghum cultivation (local cultivar without fertilizer sown in flat planting) could be an attractive option to boost sorghum yield under stress environment. The results indicate that soil and water conservation with improved crop varieties is indispensable for increasing crop yield. Therefore, sowing improved varieties in tied ridge with NP fertilizer recommended for sorghum production in areas where there is short and erratic rain fall.

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Biography

Legesse Hidoto Gerbu

The author was born in small rural village called Gillo bisare in Soddo zuria district, Wolayita zone of Southern Nnations Nationalities and Peoples Regional state of Ethiopia in July 19, 1963. The author joined local universities to pursue bachelor degree, MSc degree and currently for PhD degree.

He is married and has three children one is female and the other two are boys. Professionally, he is an agronomist working for southern agricultural research institute with MSc (Agronomy) educational back ground.

Mr. Legesse currently doing his PhD study in local university called Hawassa in collaboration for finance with Saskatchewan university.