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Full Length Research

Evaluation of different moisture conservation practices on growth, yield and yield components of sorghum at Alduba, southern Ethiopia

Tekle Yoseph* and Wedajo Gebre

Crop Science Research Process, Southern Agricultural Research Institute, Jinka Agricultural Research Center, Jinka, Ethiopia.

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A field experiment was conducted on research field of Alduba, Bena Tsemay district of south Omo zone, southern Ethiopia to determine the effects of different moisture conservation practices on growth, yield and yield components of sorghum [*Sorghum bicolor* (L.) Moench] under rain fed condition in 2010. The experiment was undertaken with four improved moisture conservation practices and one farmers' practice (farmers' practice, circular pitting, half moon, tied ridge, and open ridge). The experimental design was a randomized complete block design /RCBD/ with four replications. Phenological and growth parameters such as yield and yield components, total biomass and harvest index were studied. The results of analysis of variance showed that all the studied phenological and growth parameters were significantly affected by moisture conservation practices except days to heading. The number of days required to reach at mid maturity was delayed in the case of tied ridge than the rest of the moisture conservation practices being used. The maximum and minimum number of productive tillers per plant of (5) and (3) were recorded from tied ridge and the farmers' practice, respectively. The highest (180 cm) and the least plant heights of (159.75 cm) were recorded from tied ridge and the farmers' practice, respectively. The highest (19.25 cm) and the least panicle length of (15.5 cm) were obtained from tied ridge and farmers' practice, respectively. From the above findings, tied ridge had increased number of productive tillers per plant, plant height and panicle length. The result revealed that all the yield and yield components studied were significantly affected by moisture conservation practices. The grain yield obtained from tied ridge (3.625 t ha^{-1}) was higher by 55.72% compared to farmers' practice (1.605 t ha^{-1}). Therefore, it is possible to suggest that tied ridge is the best practice of moisture conservation practices that will increase crop productivity through enhanced soil moisture retention during the crop growing period. Hence, use of tied ridge is advisable and could be appropriate for sorghum production in the test area even though further testing is required to come up with strong recommendation.

Key words: Moisture conservation practices, sorghum, yield components, yield

INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Moench] is the fifth most important cereal crop in the world (FAO, 1998 and FAO 2005). It is cultivated in wide geographic areas in the America, Africa, Asia and the Pacific. According to African Agricultural Technology Foundation (AATF) report (2011), sorghum is a viable food grain for many of the World's most food insecure people who live in marginal

*Corresponding author, Email: tganta@yahoo.com

areas with poor and erratic rains and often poor soils. In Ethiopia, sorghum is the third most important crop after tef and maize in terms of area coverage and the second most important cereal crop in total production next to maize (CSA, 2012). Sorghum production is estimated to be four million metric tons from two million hectares of land, giving the average grain yield of two tons per hectare. It accounts for 16% of the total area allocated to grain crops such as cereals, pulses and oil crops and it also accounts for 20% of the area covered by cereals (CSA, 2012). Though sorghum is the most dominant cereal crop in pastoral and agro-pastoral areas of southern Ethiopia, but its production is hampered by biotic and abiotic stresses. Out of the abiotic stresses, drought is the most pronounced problem in the study area.

Drought has major implications for global food supply because of the expected effects that it brings on gradual climatic change and the variations in climatic conditions (Edmeads, 2013). In addition to accelerated soil erosion and the alarming rate of land degradation, the loss of water as runoff is coupled with periodic drought during the cropping season on degraded lands supporting rain-fed crop production was also equally important (Tamirie, 1986; Asfaw *et al*., 1998; Heluf and Yohannes, 2002). The practice of soil water conservation undoubtedly plays an important role in increasing agricultural production in arid, semi arid and sub-humid areas where agriculture is hampered by periodic droughts (Tamirie, 1986; Heluf, 1989; Heluf and Yohannes, 2002).

The importance of the moisture conservation practices that have been demonstrated especially on soils that are periodically subjected to a perched water table (Mohamed-Saleem *et al*., 1985). The benefits associated with ridging include prevention of water logging, increased water infiltration and concentration of nutrients in and around the rooting zone (Kowal and Stockinger, 1973). Therefore; moisture conservation practices play a vital role for successful and sustainable crop production in drought prone areas. Kumar and Rana (2007) reported that adequate soil moisture is the key to successful crop production in dry land areas.

Production of sorghum with yield improvement would have a direct impact on the drought prone areas of Ethiopia in general and pastoral areas of southern Ethiopia in particular since sorghum is the dominant cereal crop in this area. Though sorghum is an important cereal crop in the study area, but its production is constrained with terminal drought due to erratic rainfall. In order to increase sorghum production in the target area, there is need to conduct a research on moisture conservation practices, out of which moisture conservation practices that will improve soil moisture status in the study area is crucial. Therefore; this study was initiated with the objective of determining the most effective moisture conservation practices that leads to better soil moisture conservation for sorghum production in agro pastoral areas of the southern Ethiopia like Alduba.

MATERIALS AND METHODS

The treatments, the study area and experimental design

Field experiment was conducted at Alduba research field in Bena Tsemay woreda of Southern Ethiopia in 2010 under rain fed condition. Alduba is located about 720 kms from South of Addis Ababa. Geographically, Alduba is found at E 36° 36' 30.8" Longitude and N 05° 25' 00" Latitude and at an altitude of 1343 meters above sea level. The experiment consisted of five treatments with a total of twenty plots. The experiment was laid out in a randomized complete block design /RCBD/ with four replications during the 2010 cropping season under rain fed condition. Five levels of moisture conservation practices (farmers' practice, circular pitting, half moon, Tied ridge, and open ridge).

Data collection

Phenological parameters and growth parameters

Phenological parameters such as days to flowering and days to maturity were recorded. Days to flowering was recorded by counting the number of days after emergence when 50% of the plants per plot had the first open flower. Days to maturity was recorded when 90% of panicles per plot. At mid flowering stages five plants from each of the plots were selected randomly and uprooted carefully to determine crop growth parameters such as plant height and number of tillers.

Grain yield, yield components, total biomass and harvest index

Three central rows were harvested for determination of grain yield. Grain yield was adjusted to 12.5% moisture content. Five plants were randomly selected from the three central rows to determine yield and yield components, which consisted of thousand seeds weight. Seed weight was determined by taking a random sample of thousand seeds and adjusted them to 12.5% moisture content. Total biomass yield was measured from the three middle rows when the plant reached harvest maturity. Harvest index was calculated as the ratio of seed yield to total above ground biomass yield.

Statistical analysis

All the agronomic data were recorded and being subjected to analysis. Analysis of variance was performed using

Table 1. Mean Square Values for Crop Phenology and Growth Parameters of Sorghum at Alduba, in 2010.

Source	DF	Days to heading	Days to maturity	Productive tiller number plant^{-1}	Plant height (cm)	Panicle length (cm)
Replication (R)	3	0.425ns	4.9333ns	0.0500ns	1.933ns	. 1.78ns
Treatments (Trt.)	4	3.300ns	40.175*	2.950***	243.58***	7.7***
Error	12	10.50	15.1416	0.21666	1.4750	0.700

*, ** and *** indicate significance at P< 0.05, P< 0.01 and P< 0.001, respectively and 'ns' indicate non significant

Table 2. Crop Phenology and Growth Parameters of Sorghum as Affected by Moisture conservation practices at Alduba, in 2010.

Treatments	Days to heading	Days to maturity	Productive tiller number (plant^{-1})	Plant height (cm)	Panicle length (cm)
Moisture conservation Practices					
Circular Pitting	76.67a	114.75ab	3.2500c	170.0000c	16.500bc
Open Ridge	76.75a	113.50ab	3.2100c	166.0000d	17.000b
Tied Ridge	78.74a	116.50a	5.000a	180.0000a	19.2500a
Half Moon	77.45a	115.50a	4.000b	174.7500b	17.5000b
Farmers' practice	75.33a	108.5b	3.000c	159.7500e	15.5000c
LSD 0.05	NS	5.3621	0.7171	1.6736	1.1529
CV (%)	4.30	3.41	12.75	0.72	4.87

Means with the same letters within the columns are not significantly different at P < 0.05.

the GLM procedure of SAS Statistical Software Version 9.1 (SAS, 2007). Effects were considered significant in all statistical calculations if the P-values were ≤ 0.05. Means were separated using Fisher's Least Significant Difference (LSD) test.

RESULTS AND DISCUSSION

The analysis of variance result for mean squares depicted that days to maturity was significantly (P < 0.05) affected by moisture conservation practices ; on the other hand, days to heading was not affected significantly by moisture conservation practices (Table 1). The analysis of variance result for mean squares also revealed that the number of productive tillers per plant, plant height and panicle length of sorghum were affected very highly significantly (P < 0.001) by moisture conservation practices (Table 1). The maximum number of productive tillers per plant of (5) and the minimum (3) were recorded from tied ridge and farmers' practice, respectively (Table 2). The highest and the least plant heights of (180 cm) and (159.75 cm) were obtained from tied ridge and farmers' practice, respectively (Table 2). The maximum panicle length of (19.25 cm) and the minimum (15.5 cm) were recorded from tied ridge and farmers' practice, respectively (Table 2). In the above findings; tied ridge gave the maximum plant height, higher panicle length and maximum number of productive tillers per plant than the other moisture conservation practices due to its relatively high efficiency in soil moisture retention capacity than the other moisture conservation practices. Generally, in this study it was observed that tied ridge had brought a dramatic improvement on all the studied growth and yield attributing parameters compared to the other moisture conservation practices.

The results of analysis of variance for mean squares, showed that grain yield of sorghum was significantly (P < 0.001) affected by moisture conservation practices (Table 3). This finding has confirmed the previous result of Heluf (2003) on sorghum. This result is also in conformity with the findings of Mudalagiriyappa *et al.* (2012) on rabi sorghum. Likewise, Tekle (2014b), reported that grain yield of pearl millet was significantly influenced by moisture conservation practices. Similarly, Solomon (2015) reported that the grain yield of early maturing maize varieties was significantly affected by moisture conservation practices. On the other hand; Tekle (2014a), reported that grain yield of cowpea was not affected significantly due to moisture conservation practices. The highest grain yield of (3.625 t ha^{-1}) and the least (1.605 t ha^{-1}) were noted from tied ridge and farmers' practice, respectively (Table 4). In this study, it was noted that the highest grain yield of sorghum obtained from tied ridges over all the moisture conservation practices. The recorded maximum yield from the tied ridge might be attributed to the efficiency of tied ridge to conserve and retain moisture when compared to the other moisture conservation practices. Similar results were reported by the previous findings of

Table 3. Mean Square Values for Yield and Yield Components and Total Biomass in Sorghum at Alduba, in 2010.

Source	DF	Grain yield (t ha^{-1})	1000 Seeds Wt (gm)	Total biomass (t ha^{-1})	Harvest index
Replication (R)	3	0.12165ns	7.77333ns	3.3236ns	0.00044ns
Treatments(Trt.)	4	2.119***	49.897***	22.956**	0.00274*
Error	12	0.12332	3.5316	3.18548	0.00087

*, ** and *** indicate significance at P< 0.05, P< 0.01 and P< 0.001, respectively and 'ns' indicate non significant

Table 4. Yield and Yield Components of Sorghum as Affected by moisture conservation practices at Alduba, in 2010.

Treatments	Grain Yield (t ha^{-1})	1000 seeds weight (gm)	Total biomass weight (t ha^{-1})	Harvest index
Moisture conservation practices				
circular pitting	2.3500b	28.000b	11.548bc	0.20434ab
Open Ridge	2.3750b	27.000bc	11.050c	0.21623ab
Tied Ridge	3.625a	33.950a	15.500a	0.23747a
Half Moon	2.625b	29.850b	14.000ab	0.18727b
Farmers' practice	1.605c	24.500c	9.525c	0.16942b
LSD 0.05	0.4839	2.5896	2.4594	0.0407
CV (%)	13.95	6.55	14.48	14.53

Means with the same letters within the columns are not significantly different at P <0.05.

Heluf (2003), on sorghum, Anteneh *et al.* (2006), on forest coffee, Tekle (2014a, b), on cowpea and pearl millet, respectively and also Legese and Gobeze (2015), on sorghum. This result is also in conformity with the findings of Mudalagiriyappa *et al*. (2012) reported that the increased yield of rabi sorghum could be ascribed due to the reduced surface runoff and reduced risk of erosion and soil nutrients and also due to increased water holding capacity of the soil in tied ridge. The grain yield advantage of 55.72% was obtained from tied ridge over the farmers' practice. This result is in agreement with the previous findings of Heluf and Yohannes (2002), reported that tied ridge, has resulted in yield increments of 15 to 50% on maize and they also stated that yield increment of 15 to 38% was recorded for sorghum on different soil types of eastern Ethiopia. Similarly, Tekle (2014b) reported that the grain yield advantage of 12.5% was obtained from tied ridge over the farmers' practice for pearl millet. Likewise, Tekle (2014a) reported that tied ridge had resulted in grain yield advantage of 26% over farmers' practice for cowpea.

The analysis of variance result for mean squares also depicted that thousand seeds weight of sorghum was significantly ($P < 0.001$) affected by moisture conservation practices (Table 3). The maximum thousand seeds weight of (33.95 gm) and the minimum (24.50 gm) were noted from tied ridge and farmers' practice, respectively (Table 4). Also the total biomass weight was significantly ($P < 0.01$) affected due to moisture conservation practices (Table 3). The highest total biomass weight of (15.500 t ha^{-1}) and the least (9.525 t ha^{-1}) were recorded from tied ridge and farmers' practice, respectively (Table 4). The analysis of variance result for mean squares also showed that harvest index was affected significantly ($P < 0.05$) by moisture conservation practices (Table 3). In general, the results of this experiment have shown that moisture conservation practices had brought a significant effect on all the studied yield and yield components. According to this result, it could be concluded that the highest grain yield and yield components obtained in this experiment might be attributed to the fact that the availability of the retained moisture at the edges of tied ridge. This result is in full agreement with the findings of Ramachandrappa *et al*. (2012) reported that the higher yield and yield components of rabi sorghum in moisture conservation treatments could be attributed to vigorous crop growth resulting from increased availability of soil moisture. Grain yield and biomass yield advantages of 55.72% and 38.55%, respectively were obtained from tied ridge over the farmers' practice. This result is in agreement with the previous findings of Tekle (2014a, b), on cowpea and pearl millet, respectively. This indicates that instead of using farmers' practices in moisture stress areas; therefore, it is imperative to use tied ridge for maximum grain and biomass yield production.

Summary and conclusion

Use of effective moisture conservation practices is the most important issue in areas where availability of soil moisture is the most limiting factor for crop production in general. According to the result of analysis of variance, out of the moisture conservation practices used in this study, tied ridge had brought a significant yield improved over the other moisture conservation practices in general and the famers' practice in particular. Generally, it is obvious that in Alduba areas of southern Ethiopia, where the rainfall is low in amount, erratic in nature and unevenly distribution during the cropping season is one of the most limiting factor for crop production. Therefore; it is critical to use and apply soil moisture conservation practices in the current agricultural production system and in order to use the available in situ water efficiently and effectively to bring improved grain and biomass yield and also improved productivity and production of sorghum in a sustainable manner. Hence; there is need to disseminate the results of the present study to the end users even though, further research should be carried out to put the recommendation on strong basis and also to come up with increased yield and improved sorghum production in areas like Alduba, where moisture is the most limiting factor for sustainable crop production.

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