Evaluation of Improved Sorghum Agronomic Options in the Moisture Stress Areas of Abergelle District, Northern Ethiopia

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Abstract
A field experiment was conducted for two years, during 2012/2013 and 2013/2014 cropping seasons using a randomized complete block design with four replications to identify best agronomic option techniques for enhancing sorghum productivity in moisture stress conditions at Abergelle agricultural research center on station. The treatments were direct sowing at onset of rainfall, seedling transplanting (raising on nursery site) and seed priming. The result of the experiment indicated that the highest mean grain yield was recorded from the seedling transplanting (3.03 t/ha), while the lowest mean grain yield was obtained from direct sowing (1.49 t/ha). This study revealed that seedling transplanting was the best option to reduce risks associated with the direct sowing of sorghum through facilitating earliness to flowering and maturity, which in turn enables it to escape early cessation of rain fall, as the flowering stage is sensitive to moisture stress. Generally, it can be recommended that sorghum transplanting technology should be a first choice option of small scale subsistence farming community in the moisture stress areas of Abergelle and other districts having the same agro-ecologies in the region, Northern Ethiopia.
Keywords: Agronomic option, Grain yield, Moisture stress, Sorghum, Transplanting

INTRODUCTION

Sorghum [*Sorghum bicolor* (L) moench] is one of the crops that tolerate drought in stressed environments (Haussmann *et al*., 2007), and is an excellent model for drought tolerance in higher plants (Hummer *et al*., 2002; Saxena *et al*., 2002). This cereal has unusual and superior tolerance to excessive heat conditions (Blum and Sullivan, 1986), and produces reasonable grain yield in poor soils (Dollin *et al.,* 2007). It can also withstand long exposure to water logged soil conditions (Netondo *et al.,* 2004). Sorghum originated from Eastern Africa (Lupien, 1990) and was probably first domesticated in horn of Africa, Ethiopia between 5000 and 7000 years ago (Purseglove**,** 1972; ICRISAT, 2005). The greatest diversity of sorghum in both cultivated and wild species is found in the North Eastern quadrant of the continent (House, 1985). Sorghum is recognized as the fifth most important cereal (Grenierlo *et al.,* 2001).

In Africa, sorghum is ranked second in terms of production (Belton and Taylor, 2003) and in Kenya it is listed as an important traditional crop (Kute *et al.,* 2002). Sorghum is a basic staple food for many rural communities, especially in drought prone areas, characterized by shallow and heavy clay soils; thus, it is a subsistence food crop for many food insecure people (Waniska *et al*., 1992). The solution to perennial food crisis in Sub Saharan African lies in the improvement of sorghum by enhancing its adaptation to both biotic and abiotic stresses (Taylor *et al.,* 2006).

Sorghum one of the major crops in dry land regions of Ethiopia, Aberegelle area in particular is often limited by moisture stress. Moisture stress is one of the important drought factors. Over 80% of sorghum in Ethiopia is produced under sever to moderate moisture stress conditions. Most farmers grow long maturing local landraces some of which take 7-8 months to mature further complicating the drought problem. Although extent of grain yield loss due to drought was no studied in Ethiopia, compete grain yield loss was observed in some parts of northern Ethiopia such as Mehoni area, while the national average sorghum productivity in Ethiopia is <2.5 t/ha (CSA, 2015)

In the dry land environments, drought is not only the result of limited annual rainfall, but is also due to the rainfall characteristics, mainly the delay in onset, dry spell after sowing, and drought during crop stage and to early stop. In general in these regions, the number of rainy days is often very limited, even in normal years when the total annual amount of rainfall is fairly enough the short rainy season does not allow a long enough season for the crop to mature, thus it ends up with crop failure.

One way of achieving the above goal in the sorghum production system in the region is to use the transplanting technique instead of direct sowing, on the premise that a small amount of water can be used most efficiently at nursery at the beginning of the season to extend the effective growth of the season Transplanting cereal seedlings from irrigated nurseries has been adopted in several areas as a means of improving food security by extending the growing season in areas with patchy and unreliable rainfall. In most rice growing countries, the use of cereal nurseries is common practice (Dereje et al., 2007).

In general, indigenous information (Ibid) suggests that where transplanting is practiced a better stand is established, more grain yield may be obtained per hectare and a greater degree of food security is experienced by the people. Raising sorghum in nurseries using small amounts of water and transplanting seedlings could be a way of extending the growing season in the short duration rainfall areas of Northern Ethiopia (Dereje *et al*., 2007). Therefore the primary solution to improve the livelihood of small scale farmers in moisture stress area is through developing and promotion of agronomic option techniques.

Objective

- To identify best agronomic option techniques for enhancing sorghum production in moisture stress conditions.

MATERIALS AND METHODS

Site Description

The field experiment was carried out under rain-fed conditions at Abergelle Agricultural Research Center (AbARC) testing site, during 2012/2013 and 2013/2014 cropping seasons respectively. It is located in central zone of Tigray at about of 903 km north of Addis Ababa and 120 km south west of Mekelle and situated at $13^0$14'06" N latitude and $38^0$58'50" E longitudes. It is agro-ecologically characterized as hot warm sub-moist lowland (SMl-4b) below 1500 meter above sea level (m.a.s.l). The rainfall is a uni-modal pattern. Its long average annual rainfall and temperature is 350–700 mm and 24–42 ^{0}c, respectively.

Experimental Design and Crop Management

The experiment was laid out a randomized complete block design (RCBD). There were three treatments with four replications. The treatments were direct sowing at onset of rainfall, seedling transplanting (raising on nursery site) and seed priming.

The sorghum was planted at a seed rate of 10 kg/ha with blanket recommended Diammonium Phosphate (DAP) 100 kg/ha applied at planting time and 50 kg/ha urea applied at vegetative stage. The spacing between blocks, plots, rows and plants were 100 cm 50 cm, 75 cm, and 20 cm respectively. Seed of sorghum was raised at Ariqua in a bed size of 1 x 10 m. The seedlings were transplanted to the permanent field after three weeks of nursery life time. Other treatment was seed priming. The seed was soaked in water for 10 hours. Other agronomic activities like weeding, hoeing, fertilizer and pesticide application were uniformly applied for all plots.

Data Collection and Sampling Techniques

Data were collected on some phenological (days to 50% flowering and maturity), growth (plant height and panicle length) and yield and yield related components of sorghum such as thousand seed weight, grain yield, biomass yield and harvest index.

The parameters were determined in the following ways:

Data on days to 50% flowering and 50% maturity of sorghum were recorded by counting the number of days from planting to the time when 50% of the plots reached each of phenological stage, respectively.

Plant height: This was taken from a sample of five randomly selected sorghum plants marked within each plot from the central rows. A carpenter's tape was used for measuring the height from the ground level to the top-most leaf. The mean from the five plants was then taken. **Panicle length:** This was also taken from five randomly taken sorghum plants in each plot. Finally the average panicle length was determined.

Thousand seed weight: One Thousand number of grain were counted manually from each plot and weighed.

Grain yield (t/ha): The grain yield was measured kilogram per plot then converted from quintal to ton per hectare.

Note: 1ton=10 quintal

Biomass yield (t/ha): It was measured by harvesting the sorghum plants in each plot from ground level and then weighed finally converted to ton per hectare.

Harvest index: This was determined by dividing the grain yield to the biomass yield.

Data Analysis:

The collected data were subjected to statistical analysis using SAS version 9.1computer software. The significance of means differences were tested by LSD test at 5% level of probability using Fishery's comparison procedure as stated in Gomez and Gomez (1984).

RESULTS AND DISCUSSIONS

Growth and Phenological Parameters

The three treatments differed significantly $p \leq 0.05$ for panicle length and plant height, days to flowering and maturity. The taller plant height (238.3 cm), panicle length (32 cm), earliness to flowering (73 days) and maturity (95 days) were recorded from seedling transplanting, while the shorter plant height (213.8 cm) and panicle length (25 cm); late to flowering (91 days) and maturity (119 days) were recorded from direct sowing at onset of rain fall. However, relatively medium plant height (216.4 cm), panicle length (26.7 cm), days to flowering (86 days), and maturity (114 days) was observed in the treatment seed priming (Table 1). This indicates that growing of seedlings at nursery site will help the crop as if it has grown normally in the regular sowing time that were impossible due to the erratic and uneven distribution of rain fall.

This result is much higher than the report (Dereje et al., 2007) that indicates at Agbe, the transplanted sorghums flowered 10-14 earlier than the direct sown sorghums at the time of transplanting ,but the result indicated (Table 1), the transplanted sorghum flowered 14-21 earlier than the direct sown sorghum at the time of transplanting .

Generally seedling transplanting is the best option to reduce risks associated with the direct sowing of sorghum through facilitating earliness to flowering and maturity, which in turn enables it to escape early cessation of rain fall, as the flowering stage is sensitive to water stress.

Figure 1: Transplanting facilitating earliness to flowering due to seedlings age at time of transplanting (Abergelle on station).

Table 1. The effect of agronomic option techniques on phenological and growth parameters of sorghum

TRT	DTF			DTM			PH			PL		
	Y1	Y2	M	Y1	Y2	M	Y1	Y2	M	Y1	Y2	M
T1	96	86	91	120	118	119	239	188.5	213.8	22.3	27.7	25
T2	75	72	73	97	93	95	262.3	214.3	238.3	29.3	33.7	31.5
T3	88	84	86	113	115	114	247	185.8	216.4	25	28.4	26.7
LSD (5%)	7.3	3.1		8.5	6.1		37.4	26.5		10.4	4.3	
CV (%)	4.3	1.9		3.9	2.8		7.5	6.8		19.3	7.1	

Where TRT=treatment, T1=direct sowing, T2= seedling transplanting, T3=seed priming, DTF= days to 50% flowering, DTM= days to 50% maturity, PH= plant height (cm), PL= panicle length (cm), M= mean, Y1= 2012/2013 cropping season, Y2= 2013/2014 cropping season, LSD=least significance difference, CV (%) = coefficient of variation in percent.

Yield and Yield Related Components

The analysis of variance indicates there was a significant $p \leq 0.05$ among the treatments with respect to grain yield and biomass yield, thousand seed weight and harvest index (Table 2).

Farooq *et al.* (2009) reported that grain yield is the result of the expression and association of several plant growth components. The results of the present study indicated that the highest mean grain yield (3.03 t/ha), biomass yield (9.82 t/ha), thousand seed weight (32.7gram) and harvest index (0.31) were recorded from seedling transplanting, while the lowest mean grain yield (1.49 t/ha), biomass yield (7.18 t/ha), thousand seed weight (25 gram), and harvest index (0.21) were obtained from direct sowing at onset of rain fall. This was due to seedlings raised at nursery site during the dry period and late transplanted to their actual field at the onset of rain fall. It creates favorable conditions to grow crops that mature enough to provide production. This result was supported with a study conducted in Northern Ethiopia, indicated that sorghum grain yield can be increased significantly by transplanting (Dereje et al., 2007).

Table 2. The effect of agronomic option techniques on yield and yield related components of sorghum

TRT	BY			GY			TSW			HI		
	Y1	Y2	M	Y1	Y2	M	Y1	Y2	M	Y1	Y2	M
T1	69.8	73.8	71.8	12.5	17.3	14.9	27	23	25	0.18	0.24	0.21
T2	98.1	98.3	98.2	28.5	32	30.3	32.8	32.6	32.7	0.29	0.33	0.31
T3	89.5	72.3	80.9	16.6	17.6	17.1	29.7	23.7	26.7	0.19	0.25	0.22
LSD (5%)	26.9	15.2		6.1	5.2		9.2	10.1		0.04	0.03	
CV (%)	15.7	9.4		23.3	11.6		15.4	18.5		0.01	5.1	

Where TRT=treatment, T1=direct sowing, T2=seedling transplanting, T3=seed priming, BY=biomass yield (qt/hectare), GY=grain yield (qt/hectare), TSW=thousand seed weight (gram), HI=harvest index (grain yield/biomass yield), M=mean, Y1=2012/2013 cropping season, Y2=2013/2014 cropping season, LSD=least significance difference, CV (%) = coefficient of variation in percent. Note: 1ton=10 quintal

CONCLUSIONS AND RECOMMENDATIONS

The result showed that the yield and yield components of sorghum were significantly affected by different agronomic option techniques. The taller plant height, panicle length; earliness to flowering and maturity, and high grain yield, biomass yield, thousand seed weight and harvest index were observed in the treatment seedling transplanting. This study further confirms the role of agronomic options in increasing yield and yield components of sorghum crop.

Generally, from farmers opinion during field day and results obtain from the experiment it was revealed that the sorghum transplanting technology is the best agronomic option to reduce risks associated with the direct sowing of sorghum through facilitating earliness to flowering and maturity, which in turn enables it to escape early cessation of rain fall, as the flowering stage is sensitive to water stress. It can be recommended that sorghum transplanting technology should be a first choice option of small scale subsistence farming community in the moisture stress areas of Abergelle and other districts having the same agro-ecologies in the region.

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