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Evaluation of Level Bund Conservation Structure for Maize and Sorghum Production in Moisture Deficit Areas of Hawi Gudina District, Eastern Ethiopia

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Abstract
The experiment was conducted in 2011-2012 cropping seasons in moisture deficit area of Hawi Gudina district Dhega Dheba PA, Western Hararghe Zone. The study was conducted to evaluate effect of level bund conservation structure on grain yield of maize and sorghum in moisture deficit areas for improving productivity. The treatments were level bund and farmer's practice with testing crop maize (melkasa-4 variety) and sorghum (Abshir variety) on three farms used as replication. The data on yield (Qt ha^{-1}), stand count at harvest & number of cobs/heads per hectare were collected for maize and sorghum varieties. The study revealed that, the mean number of stand count at harvest and cobs/heads per hectare directly affected the yield obtained from both crops; and cultivars receiving treatment level bund conservation structure matured later (i.e. from 1-3 days later) compared to farmers' practice. It was also found that the mean yields of maize and sorghum (Qt ha^{-1}) on treatment level bund were 28.5% and 51% more than farmers practice respectively, in 2011 cropping season. Likewise, during second growing season (2012), it was found that the mean of maize yield (Qt ha^{-1}) on treatment level bund conservation structure was 26.8% more over farmers practice and mean yield of sorghum (Qt ha^{-1}) was 53% over farmers practice. Thus, this conservation structure is found promising to be used in moisture deficit areas and recommended with early maturing crops for their improved productivity.
Keywords: Level bund, days to maturity, moisture stress, yield

1. Introduction

Ethiopian agriculture is mainly rain fed agriculture with only about 5% of the total arable land under irrigation. Although the average annual rainfall is about 848mm with a maximum over 2000mm, it is highly erratic and often falls intensively (Mikael & Teklu, 2006; Ragasa et al., 2006). Despite the high average annual rainfall & favorable environmental variables for agriculture, the performance of rain fed crop production is very poor which attributed to high temporal and spatial variations in rainfall, wide spread nutrient deficiencies and improper soil, water & crop management (Tamirie, 1986; Heluf and Yohannes, 2002; Mikael &T eklu, 2006). As a result agricultural production is affected and crop yields reduced and persistent crop failure occurs (Keating et al., 1992; Miriti et al., 2012). Further, the loss of soil nutrients through plant mining, removal of crop residues, erosion, leaching or volatilization, and the deterioration of soil physical properties can independently or interactively result in yield reduction (Bielders et al., 2002).

Ethiopian semi-arid and arid areas are also experiencing low crop yield due to a combination of biophysical problems such as low rainfall, unavailability of high quality manure, declining soil fertility due to continuous cultivation and crust formation that reduces soil water availability to crops (Gicheru, 2002; Gitau, 2004). In these areas, increasing the productivity of smallholder agriculture requires bringing to scale several practical interventions. The key ones are the use of improved seeds, soil moisture conservation practices and use of fertilizers to realize the benefits from increased production and productivity.

Level bund conservation structure is an embankment along the contour, made of soil and /or stones with a basin at its upper side. It is usually constructed to reduce or stop the velocity of overland flow and consequently soil erosion. It is the most suitable conservation structure used for field crop production in dry areas were altitude varied in between 500-1500 m.a.s.l, annual rainfall of 300-900 mm and average temperature over 25 ^{o}C (Hurni, 1986). In these drier areas, since the rainfall is usually low and erratic; the main purpose of the structure is to cut longer slopes into series of smaller ones, increase time of concentration and thus allows good infiltration rate so that the soil retains enough moisture (Taffa, 2011).

Hawi Gudina district is among the districts in West Hararghe Zone where moisture deficit is the primary problem, which highly constrains the productivity of smallholder farmers particularly of the lowland areas (priority problem raised in REFLAC-research extension farmers linkage advisory council meeting). Extreme dry spells and recurrent drought is usual. Late start, early finish and little in amount is becoming main characteristics of rainfall in the area. Crops fail at vegetative stages before seed setting, livestock lost in absence of feed and watering due to drought that prevails. As a result, the population living in the district is food insecure and is under aid by Safety Net programs, United Nations World Food Program and other NGOs (Eshetu et al., 2010). To cope with prevailing moisture deficit problem of the district and so that ensure food security of the region; promoting and evaluating different adaptable soil and water conservation technologies is essential. Therefore, this study was carried out to evaluate the effect of level bund conservation structure on yield of maize & sorghum in moisture deficit areas of Hawi Gudina district.

2. Materials and Method

2.1. Description of study area:

The field experiment was conducted at Hawi Gudina district, Western Hararghe zone, eastern Ethiopia. It is located at a distance of 519 and 180 kms from Addis Abeba and Chiro (Zonal capital), respectively. The district is bordered with Daro Labu district in the North, Boke district in the East, Bale zone in the South and Arsi zone in the west. The total area of the district is estimated to be 3041.19 km^2. The district is situated in-between 7˚52'15'' to 9˚25'43'' North latitude and 40˚34'13'' to 41˚9'14" East longitude respectively. The topography of the district is mainly flat lowland with altitudes ranging from 976 to 2077 m.a.s.l. Agro-ecologically it is divided in to semi-arid (83.8%), midland (12.9%) and highland (3.3%). Annual rainfall of the district varied in between 500-900 mm whereas minimum and maximum temperatures reach 14˚C to 35˚C, respectively with an average of 25˚C. The pattern of rainfall is bimodal and its distribution is mostly uneven. Generally, there are two rainy seasons: the short rainy season 'Belg' lasts from mid-February to April whereas the long rainy season 'kiremt' is from June to September. The rainfall is erratic; onset is unpredictable, its distribution and amount is also quite irregular. Consequently most PAs frequently face shortage of rainfall (HGPDO, 2011). Figure 1 shows the physical map of the district.

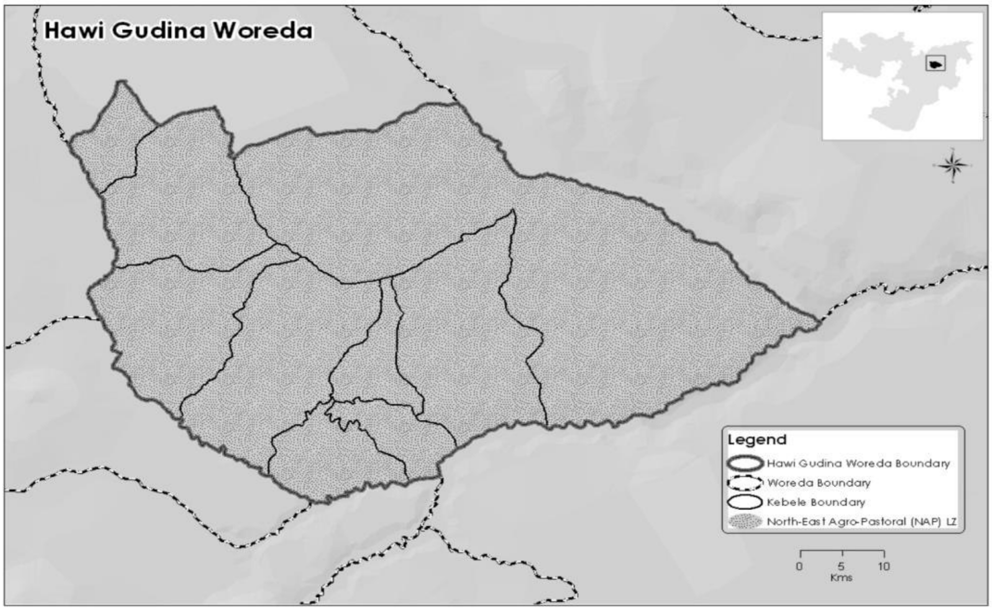

Figure 1: Map of Hawi Gudina district (adapted from Oromia Livelihood Zone Reports)

2.2. Experimental design, data collection and analysis:

The study was conducted during period of 2011-2012 for testing effect of level bund conservation structure on grain yield of maize & sorghum in moisture deficit area of Hawi Gudina district. One PA was selected in H/gudina district where moisture stress is the problem. Three farmers were selected based on willingness who participates on construction of the structure. Level bund conservation structure was constructed on a plot size of 10mx10m with bottom and top width of 75cm and 30cm respectively and 30cm height of an embankment on a land of <5% slope. After the bund was constructed, early maturing sorghum (*Abshir variety*) and maize (*mekasa-4 variety*) were planted in between bund and farmers practice in randomized manner considering every space between contours as block using recommended fertilizers rate and spacing of 25x75 cm intra- and inter-row spacing for both crops. Data on yield (Qt ha^{-1}), stand count at harvest & number of cobs/heads per hectare were collected for both crops. The yield advantage (%) from using level bund conservation structure is also calculated (*eq*-1) and analyzed using descriptive statistics.

$$Yield\ advantage\ (\%) = \frac{yield\ with\ structure - yield\ without\ strucutre}{yield\ without\ strucutre} x100 \qquad eq-1$$

3. Results and Discussion

The study was conducted to evaluate effect of level bund on grain yield of maize and sorghum in moisture deficit areas of Hawi Gudina district for two consecutive years (2011-2012). However, the study area was affected by severe drought during these years of practice. As a result, one experimental site was failed totally. But depending on two location data, some promising results were obtained even though the yields were not to their potential.

The study revealed that the number of stand count at harvest and cobs/heads per plot had a direct relationship with the yield obtained for both crops; i.e., the higher the number of stand count at harvest and cobs/heads the higher the yield obtained for maize and sorghum planted on treatment level bund conservation structure and farmers' practice when compared among seasons (Tables 1&2). But there was no regularity in relationships of number of stand count at harvest and cobs per hectare with yield obtained during 2011 & 2012 cropping seasons in case of maize crop; signaling that the yield does not necessarily depend on its number of stand count and cobs, but rather depend on size of the cobs and seed weight. The yields obtained for sorghum during two cropping seasons were found directly related to number of stand count and heads in contrast to maize crop. This might be due to better resistance of the sorghum cultivars to stress conditions. Crops grown on level bund conservation structure matured 1-3 days later than those on farmers' practice or without the structure since these plots relatively retained more moisture (Tables 1&2).

When we compare the means of maize yield (Qt ha^{-1}) on treatment of level bund was 28.5 % more over farmers practice. And also the yield advantage of sorghum on treatment of level bund was 51% over farmers practice during 2011 cropping season (Table 1). The yield of maize significantly reduced during second cropping season (2012) because of prevailing climatic condition (i.e insufficient rainfall). During this season, the mean yield of maize (Qt ha^{-1}) of treatment level bund had 26.8% more yield than farmers practice and that of sorghum had 53% more over the same during second year of practice (Table 2). The yield advantage obtained is more pronounced for sorghum when compared to maize which is attributed to more resistance of sorghum cultivars to moisture stress as compared to maize crop. Similar with this study, the plots with bunds were found more productive than those without such technologies in semi-arid areas. This is apparently due to the moisture conserving benefits of this technology being critical in drier areas (kassie et al., 2007*)*. Also, improved in-situ water harvesting can increase time required for crop moisture stress to set in and thus can result in improved crop yield and have resulted in positive effects on soil fertility, moisture conservation and agricultural productivity (Alamu and Kidane, 2014). Similarly, report from ETWWA (2010) showed that better water management, coupled with improved soil and crop management, can more than double agricultural productivity in moisture stress areas with current low yields.

Table 1: Mean yield, stand count at harvest & number of cobs/heads in 2011 cropping season

Parameters collected	Types of field crop used			
	Maize (Melkasa-4)		Sorghum (Abshir)	
	Conservation structure			
	Level Bund	Farmers practice	Level Bund	Farmers practice
Stand count at Harvest/ha	53,000	60,000	29,000	25, 400
No. Cobs (heads)/ha	61,300	58,100	28,100	23,000
Days to maturity	114	112	113	112
Yield (Qt/ha)	45	35	13	8.6
Yield advantage (%)	28.57	-	51.1	-

Table 2: Mean yield, stand count at harvest & number of cobs/heads in 2012 cropping season

Parameters collected	Types of field crop used			
	Maize (Melkasa-4)		Sorghum (Abshir)	
	Conservation structure			
	Level Bund	Farmers practice	Level Bund	Farmers practice
Stand count at Harvest/ha	15,300	16,800	58,000	50,800
No. Cobs (heads)/ha	11,000	11,100	56,300	47,900
Days to maturity	115	112	120	119
Yield (Qt/ha)	8.5	6.7	23.5	15.32
Yield advantage (%)	26.8	-	53.3	-

4. Conclusion and recommendations

Depending on parameters collected from crops (i.e. maize & sorghum) planted on the structure, mean yield (Qt ha^{-1}) obtained from treatment level bund conservation structure was higher as compared to farmers practice. It was also observed that, the mean number of stand count at harvest and cobs/heads per hectare, directly affected the yield obtained for both crops especially among cropping seasons and cultivars receiving treatment level bund conservation structure matured 1-3 days later compared to farmers' practice. Even if the yields obtained from both crops were not to their potential during two years of practice which was due to unfavorable climatic condition of the area, the yield obtained from treatment level bund is yet better (i.e., yield increment up to 53.3%). Thus, level bund conservation structure is recommended integrated with early maturing crops in moisture deficit areas of Hawi

Gudina district for their increased productivity.

This study has limitations that it was not supported by soil moisture and other soil parameter analysis so that it is also recommended that repeating the study by including other soil moisture conservation structures by including soil parameters is important.

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