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Grain Yield of Common Bean (*Phaseolus vulgaris L*) as Influenced by Different Moisture Conservation Practice in Eastern Dry land of Ethiopia

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Abstract

Study was conducted to investigate effect of different moisture conservation practices growth and grain yield of three common bean cultivars. The experiment was laid out in split-split plot design and treatments were straw mulch at 2ton/ha and 0ton/ha, two different planting bed patterns (flat and furrow planting bed) and three varieties namely *Nassir (Dicta-105), Awash-1 and Melka Awash-98*. Planting bed assigned as main plot, straw mulch assigned as sub plot and three varieties assigned as sub-sub plots. The interaction effects of planting bed pattern, straw mulch application was very highly significant ($p<0.005$) on yield and yield components of three common bean verities. Crop growth and drought survival and grain yield was significantly high in furrow bed with mulch. Number of pod/plant increased by 40% and number of seed/pod increased in the range of 35-68% and grain yield increased by 45-60% compared to flatbed planting patterns with or without mulch for all tested varieties. Based on this finding it could be recommended that in the semiarid agro-ecosystem the use of furrow bed planting pattern and straw mulch application at 2 ton/ha can reduce the effect of heat and moisture stress thereby increasing crop yield of common bean.

Keywords: Grain yield; Straw mulch; Flat and furrow bed; Common bean; Moisture stress

Introduction

Common bean (*Phaseolus vulgaris L*) is an important source of food throughout the world and contains protein, fiber and vitamins that increased food value of this product [1]. Production of this crop in many regions of the world is carried out under drought stress conditions, due to insufficient water supply by rainfall and/or irrigation. This is because more than 60% of the bean growing area in the tropics is affected by terminal or intermittent drought stresses [2].

Arid regions are characterized by the precipitation that, most of the time, is insufficient to replenish losses of soil moisture by evaporation, transpiration, and other mechanisms [3]. Drought stress is one of the limiting factors in crop growth and yield which reduces dry matter production, grain yield and yield components through decreasing leaf area and accelerating leaf senescence and plant death [4,5].

The dry land of Ethiopia consist of a wide range of agro-ecologies including the arid, semi arid and dry sub-humid and cover about 75 percent of the total land mass [6]. As in most dry land areas of the world Ethiopian dry land experiences critical moisture shortages. In such conditions it is crucial to conserve soil moisture to minimize crop failure produce substantial yield. This can be achieved though practicing appropriate moisture conservation and crop management practices. According to Allolli [7] yield of dry land cluster bean significantly increased by employing furrow and tide-ridge planting patterns. Mulch can be termed as protective coverings for plants and used them against extreme temperature changes and loss of soil, ground water protection. In the semi-arid areas of Ethiopia tied-ridges have been found to be very efficient in storing the rain water and lead to substantial grain yield increases in some of the major dry land crops [8].

Planting pattern has a direct effect on yield, due to its affects on solar energy capture and soil water evaporation and thus an indirect effect on water use efficiency [9]. To tackle the problem of water loss by evaporation in dry land areas the use of different

straw mulch significantly reduces losses water from the soil and provides batter conduction for growth and yield of the crops under drought stress [10,11]. The correct method of planting according to the site moisture availability or other factors can help to increase the yield. Heluf [8] Indicated that compared to maize planted in flat planting pattern those crops planted in tide-ridge and furrow had significant yield advantage. Current study area lies in semi arid agro ecology were water conservation is key activity to minimize the impact of high temperature and low moisture availability. However there are no clear recommended agronomic practices that could be applied to conserve soil moisture sustainable production of common bean. Therefore this study was designed to investigate effect of planting pattern, application locally available straw mulch on growth and yield of three common bean cultivars.

Material and Methods

Description of study area

Study was conducted in Eastern Ethiopia in Ethiopian Somali region Fafen administrative zone. The area is characterized by bimodal rainfall pattern it is characterized by quasi double maxima with a small peak in April and the main peak in August. The area is belongs to the warm semi arid agro-climatic zone with the elevation of 1780 meter above sea level and located at geographical coordinates of 912,270-1,058,809.8 UTM north and 877449.1-975,927.2 UTM East. The average annual temperature ranges from 14.73 °C and 28.1 °C with the average annual rainfall ranges from 200 to 870 mm and the potential evapo-transpiration is estimated to be 1438 to 2099mm [12,13].

Field experiment

Field experiment was conducted at Jigjiga District in rainfed condition. There treatments were includes three common bean verities namely *Nasir (Dicta-105), Melka Awash-98* (PAN-182) and *Awash-1*, two different types of planting patterns flatbed and furrow planting pattern and application of dried grass mulch at 0ton/ha and 2ton/ha.

Experimental design and treatment layout

The experiment was laid out in split-split plot design and was randomized and replicated three times. Planting bed patterns (flat and furrow) were laid as main plot, straw mulching (0, 2ton/ha) was sub plot and verities (*Nasir (Dicta-105), Melka Awash-98* (PAN-182) and *Awash*-1 were sub-sub plot. Each sub-sub-plots were (1.6mx1.10m) in size there were four rows per plot, and distance between rows and between plants was 40cm and 10cm, respectively. There was also 0.8m gap between sub-sub plots, 1 m between sub-plots and 1.5m between main plots respectively. Growth data (days to 50% emergence, % plant stand density/plot, plant height, and number of branch/plant) was collected from each sub-sub plot from pre-tagged ten plants/plot. The two central rows from each sub-sub plot were harvested for determining yield and other agronomic traits.

Methods of data analysis

The data on yield and yield component was analyzed using analysis of variance (ANOVA) though R-Statistical Package V. 3.3.4 [14]. Treatment effects were assessed and means were separated using Least Significant Difference (LSD at P< 0.05) significance.

Result and Discussion

Interaction effect of planting pattern and straw mulch application on growth

Response of common bean varieties: There was significant interaction effect of planting pattern and straw mulch application on three common bean varieties at p<0.05 (Table 1). All growth parameters were positively responded for mulch application on furrow and flat planting patterns (Table 1). Days to emergence was significantly at (p<0.05) affected by planting pattern and mulch application at 2ton/ha. Days to emergence reduced significantly when crops were planted on furrow bed with straw mulch application by 15-37% compared to flat planting with and without mulch and 18-48%. The longest days to emergence was recorded from those crops grown on flat bed with or without mulch. Mulch application did not significantly affected days to emergence of flat planting patterns (Table 1). Reduction in days to emergence could be associated with the availability and consistency of moisture in the soil. Furrow beds relatively keeps moisture for extended time since it had advantage over water harvesting and less exposure to heat compared to the flat. Straw mulch application also provides soli protection from heat stress and moisture losses. Current finding is in agreement with that of Shuhuaian [15] who reported that furrow and mulched ridge combined farming practices are able to improve soil moisture of thereby exerting influence on the growth and development of the crop. The availability of mulch cover also prevented evaporation and reduced soil temperature there by providing good condition for seedling emergence [16,17]. In flatbed planting patterns seedling emergence was significantly lower it was due to high heat and moisture stress suppressed the seedling emergence. Shenkut [18] reported that depression of plant emergence can be resulted from severe influence of environmental factors such as water stress in the arid areas.

Days to flowering and maturity was significantly affected by the interaction effect to planting bed and straw mulch application at 2ton/ha (Table 1). Shortest days to flowering and maturity was observed on those crops planted on furrow and supplied with straw mulch at 2ton/ha. There was also significant interaction effect of flat be planting with mulch application on days to flowering and maturity. Compared to all treatments the longest days to flowering and maturity was observed on those crops grown on flat bed planting pattern without straw mulch.

Stand density was significantly affected at (p<0.05) by the interaction effect of planting pattern and much application (Table

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1). Percent of plant stand survived was grater on interaction effect of furrow planting pattern and straw mulch compared to other treatment. Plant survival gone decline at 60 DAE for all treatments (Table 1). The highest survival rate was observed on crops grown on furrow with straw mulch applied at 2ton/ha. There was also more pronounced survival rate on crop grown on flat be with mulch at 2ton/ha. Maximum crop failure due to heat and moisture stress was recorded from those crops grown on flat bed planting pattern without straw mulch. There was significant interaction effect of varieties with planting pattern at ($p<0.05$) in which variety Melka Awash performed better compared to others varieties however variety Awash-1 showed lower performance in crop survival due to heat and moisture stress. Percent of stand density after 45 days emergence was also significant at $p<0.05$ according to the result in (Table 1) nearly all crops those planted in furrow with or without mulch survived were as those crops which planted on flat bed with mulch also survived till 45 days after emergence. However those plants planted in flat bed without mulch crop stand density significantly reduced about 60-75% in average. The result indicated that effect of planting pattern and mulch application significantly affected number of branch/plant. This result was in agreement with that of Allolli7 who reported that vegetative growth of cluster bean significantly affected by moisture conservation practices. The highest number of branch/plant observed on those plants which were planted on furrow bed and flat bed with mulch. The result also reviled that crops planted in flat bed without mulch showed significantly reduced number of branches/plant. The high number of branches/plant in crops planted in furrow and flat with mulch could be due to the mulch reduced evaporation and relatively furrow beds collected good amount of moisture. Similarly Arash [16] indicated that straw mulch application significantly affected the growth of common bean under irrigated condition. Furthermore, furrow and mulched ridge rainwater micro-collecting practices remarkably improved water conditions in soil during dry growth period [15].

Number of branches/plant was highly significantly ($p<0.05$) affected by the interaction effect of planting pattern and straw mulch for all three varieties. The result indicated that straw mulch application at 2 ton/ha with furrow and flat planting pattern positively influenced branch formations. Furrow planting with straw mulch at 2ton/ha resulted in production maximum branch number/plant compared to the others. There was significant difference among planting patterns interaction with straw mulch application (Table 1). There result indicated that crops which were planted in furrow resulted in taller plants compared with sowing with flat planting patterns. The plant height increased by 20% in average in crops planted in furrow planting pattern with mulch compared to flat planting pattern for three cultivars. Babiker [19] concluded that planting sorghum crop in furrow bed resulted in significantly taller plants compared to those planted in wider flat sowing bed [13]. Similarly Saeed [20] reported that straw mulch potentially increased the soil moisture content which in turn led to improved crop growth. Significant increase in plant height increment on crops planted in furrow planting pattern with straw mulch could be attributed to moisture conservation and weed suppression activity of furrow bed and the straw mulch [7,15,21].

Table 1: Interaction effect of planting pattern and straw mulch application on growth response of common bean varieties.

Treatments Interaction			Days to Emergence	Stand Density (%) 45DAE	No. of Branches/ Plant	Plant Height (cm)
Planting bed pattern	Straw mulch	Varieties				
Flat	0 ton/ha	Nassir (Dicta-105)	13.89^{a}	30.38^{a}	5.21^{a}	42.14^{a}
		Awash 1	12.67ab	23.75^{a}	4.59^{a}	40.19^{a}
		Melka Awash-98	12.89^{ab}	37.38^{ab}	5.21^{a}	48.33^{a}
	2ton/ha	Nassir (Dicta-105)	11.70^{b}	40.25^{ab}	6.73^{ab}	46.35^{a}
		Awash 1	10.70^{bc}	38.92^{ab}	7.36^{b}	45.87^{a}
		Melka Awash-98	10.70^{bc}	45.92^{b}	6.78^{ab}	53.92^{b}
Furrow	0 ton/ha	Nassir (Dicta-105)	11.71^{b}	54.00^{c}	7.54^{b}	45.05^{b}
		Awash 1	10.04^{ab}	48.39^{bc}	7.87^{b}	47.99^{ab}
		Melka Awash-98	10.04^{ab}	60.39^{d}	7.54^{b}	55.37^{b}
	2ton/ha	Nassir (Dicta-105)	8.70^{bc}	58.22^{cd}	10.44^{c}	59.22^{bc}
		Awash 1	7.73^{c}	54.99^{cd}	10.11^{c}	61.01^{bc}
		Melka Awash-98	7.03^{c}	63.39^{e}	10.44^{c}	68.72^{c}
$LSD_{0.05}$			2.28	17.74	6.72	10.24
CV % PP x SM x V			5.30	11.19	24.37	9.26

PP, planting pattern, SM straw mulch, V variety, DAE days after emergence. Means followed by the same letter are not statistically significant at $p<0.05$.

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Interaction effect of planting pattern and straw mulch application was highly significant on plant height at ($p<0.05$). Significantly taller plants were recorded from those crops grown on furrow bed with straw mulch application at 2ton/ha. There was also significant interaction effect flat planting with straw mulch application at 2ton/ha on plant height. The shortest plants were observed on crops which were grown on flat bed planting pattern without mulch application.

Interaction effect of planting pattern and straw much application yield and yield components

The interaction effects of planting pattern, mulch application was very highly significant ($p<0.05$) on yield and yield components of three common bean verities. Maximum grain yields were obtained from the combinations of furrow planting pattern and application of mulch at 2ton/ha for all varieties. All three varieties responded tremendously for applied mulch and furrow planting pattern.

Crops planted in furrow planting pattern mean number of pod/plant increased by 40 and 72 % compared to those planted in flat planting pattern with or without straw mulch respectively. Variety named *Melka Awash-98C* produced higher number of pod/plant flowed by *Nassir (Dicta-105)* and Awash-1 under all circumstances. Number of seed/pod also responded to planting pattern and straw mulch applications. Straw mulch application and furrow planting pattern positively and significantly affected seed production of all the three varieties. Number of seed/pod increased in the range of 35-68% when crop was planted in furrow and supplied with straw mulch compared to flatbed planting pattern respectively. The result of this study indicated that that seed weight was significantly influenced by moisture conservation practices like other agronomic parameters (Table 2). Average weight for 100 seeds was tremendously increased for seeds harvested from the furrow planting pattern and straw mulch application. All varieties positively responded for moisture conservation practices that induced water availability. Mulch application increased average seed weight by 9, 14 and 8% respectively for the three varieties planted in flat bed *Melka Awash-98C, Nassir (Dicta-105)* and *Awash-1*. At the same time mulch application with furrow planting pattern increased seed weight by 28, 23 and 25% respectively for three varieties of common bean *Melka Awash-98C, Nassir (Dicta-105)* and *Awash-1.*

Table 2: Interaction effect of planting pattern and straw mulch application on grain yield response of common bean cultivars.

Treatments interaction					Yield and yield components	
Planting Pattern	Dry Grass Mulch	Varieties	Pod/plant	Seed/pod	100 seed weight (g)	Yield (tons/ha)
Flat	0 ton/ha	Nassir (Dicta-105)	3.33^{a}	2.66^{a}	10.13^{a}	0.95^{a}
		Awash 1	2.00^{b}	2.00^{a}	11.12^{ab}	0.87^{a}
		Melka Awash-98	4.33^{c}	3.33^{a}	14.84^{ab}	0.91^{a}
	2ton/ha	Nassir (Dicta-105)	4.33^{c}	3.66^{ab}	15.97^{b}	1.13^{ab}
		Awash 1	3.00^{a}	2.00^{a}	12.32^{ab}	1.04^{a}
		Melka Awash-98	6.00^{d}	4.00^{b}	21.05^{c}	1.72^{ab}
Furrow		Nassir (Dicta-105)	6.33^{d}	5.33^{c}	15.45^{d}	1.28^{ab}
		Awash 1	4.66^{c}	4.53^{cb}	13.73^{d}	1.35^{ab}
		Melka Awash-98	6.33^{d}	5.52^{c}	18.60^{cd}	2.10^{b}
	2ton/ha	Nassir (Dicta-105)	7.33^{de}	5.33^{c}	20.46^{c}	1.58^{ab}
		Awash 1	5.44^{cd}	4.00^{b}	17.51^{cd}	2.13^{b}
		Melka Awash-98	10.33^{f}	6.00^{d}	25.22^{e}	2.32^{b}
LSD0.05			15.34	8.19	13.14	4.95
CV% PP x SM x V			10.64	12.84	7.02	19.11

PP, planting pattern, SM straw mulch, V variety. Means followed by the same letter are not statistically significant at $p<0.05$.

In this study grain yield was positively and significantly responded to furrow planting pattern and straw mulch application (Table 2). Furrow planting pattern with mulch increased grain yield in the range of 25-54% compared to flat planting bed patterns respectively. These results are in agreement with Allolli [7] who reported that grain yield of cluster bean was significantly increased due to moisture conservation practice involving furrow planting and straw mulch application in semi-arid dry land. Similar report indicated that that application of straw mulch considerably increased grain yield over control

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in common bean [20]. The maximum grain yield was obtained when variety *Melka Awash-98* which was planted in furrow planting patter and straw mulch applied at 2ton/ha. The result of this study agrees with that of Shuhuaian [15] indicated that furrow and mulched ridge combined farming practices are able to improve soil moisture of spring Mung bean thereby improving growth and yield of the crop. Significant yield reduction was noticed in flatbed planting pattern without mulch application it was due to flat beds cannot conserve moisture compared to the furrow planting pattern and this resulted in low plant growth, survival and grain yield. However crops planted in flat bed responded remarkably when straw mulch was applied. The result is in consistent with that of Allolli [7] who concluded that yield obtained in flat bed method was reduced to nearly 19.5% (2.46 ton/ha) as compared to ridges and furrows + mulch.

Conclusion

According to the result from this study it can be conclude that:

i. Furrow planting pattern and application of straw mulch increased moisture availability and reduced heat stress

ii. Among tested common bean varieties variety named Melka Awash-98C performed best and produced higher yield.

iii. Therefore common bean productivity in eastern Ethiopian dryland can be improved through the utilization of straw mulch with furrow seed bed.

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