Journal of Agriculture
Vol. 1, No. 1, October 2013, PP: 01 - 07
Available online at http://acascipub.com/Journals.php

Research article

Effect of Different Planting Methods and Nitrogen Fertilizer Rates on Growth and Yield of Maize under Rain-fed Condition

Mahamed Badel Mahamed and Awale Degewione Shirdon

Department of Soil and Water Research, Somali Region Pastoral and Agro-Pastoral Research Institute, P.O.Box:398, Jijiga, Ethiopia. Email: mahamedbadel@hotmail.com ,Tel: +251 915744822

Department of Dry-Land Crop Research, Somali Region Pastoral and Agro-Pastoral Research Institute, P.O.Box:398, Jijiga, Ethiopia. Tel: +251 915737685
Corresponding author: Awale Degewione, E-mail: awale.deg@gmail.com

---

ABSTRACT

Maize is one of most important food crop grown in Somali region of Ethiopia and is produced in different agro-ecologies in the region. However, its productivity is constrained by a number of problems out of which planting methods and nitrogen application is the most important ones. A field experiment was conducted at Jijiga Agricultural research center during 2011 and 2012 cropping season using rain-fed and supplementary irrigation with the objective of investigating the effects of different nitrogen fertilizer rates and planting methods on growth, yield and yield components of Maize. Four planting methods (Flatbed planning, closed end tie ridge-planting in furrows, open end furrow-planting in furrows, Furrow planting in furrow) and four levels of nitrogen (80, 100, 150, and 180kg N ha^{-1}) were applied. The experiment was laid out in split plot and arranged in a RCBD design with 4 replications. Planting methods were allotted to main plots while nitrogen levels were allotted to sub-plots. Result showed different planting methods had significantly affected all characters studied. Similarly, various rate of nitrogen had significantly affected number of grain per cobs and length of cobs, whereas interaction between planting methods and nitrogen rate were non-significant for all characters except harvest index. Maximum grain yield of 31.24 qt ha^{-1} was recorded in plots treated with nitrogen dose of 100 kg ha^{-1} when compared to other treatments. Similarly, maximum grain yield of 38.20 qt ha^{-1} was recorded in open end furrow while minimum grain yield of 11.56 and 25.24 qt ha^{-1} was harvested from plots sown with flatbed planting methods and application of 80 kg N ha^{-1} respectively. The highest number of 327.56 grain $cobs^{-1}$ was recorded in treatments with 100 kg N ha^{-1}. On other hand, maximum number of 342.47 grain $cobs^{-1}$ was recorded in the plot having open end furrow and minimum number of 199.07 grain $cobs^{-1}$ was recorded in the plot having flatbed planting. Maximum lengths of cobs, harvest index in open end furrow and application of 100 kg N ha^{-1} when compared with other treatments. Whereas close end tie ridge gave maximum thousand seed weight. Maximum number of grain $cobs^{-1}$ were recorded in open end tie ridge planting and application of 100 kg N ha^{-1} when compared with other N levels. It can be concluded from these results that open end furrow and closed end tie ridge planting method and fertilizer N at the rate of 100kg ha^{-1} produced economical crop of maize under climatic conditions of Jijiga area.

Keywords: maize, tillage practices, nitrogen, ridge, flatbed, yield.

---

1. INTRODUCTION

Maize (Zea mays L.) is one of the most important cereal crops used in the human diet in large parts of the world and it is an important feed component for livestock (McDonald and Nicol, 2005). Maize is one of the most important cereals cultivated in Ethiopia. It ranks second after teff in area coverage and first in total production. The results of the year 2011/12, Meher season post-harvest crop production survey indicate that total land areas of about 12,086,603.89 hectares were covered by grain crops. Out of the total grain crop areas, 79.34% (9,588,923.71 hectares) was under cereals. Of this maize covered 17% (about 2,054,723.69 hectares) and gave 6069413 tonnes of grain yields (CSA, 2012). Despite the large area under maize, the national average yield of maize is about 20.95 qt/ha (CSA, 2012). This is by far below the world's average yield which is about 50.21qt/ha (FAO, 2011). The low productivity of maize is attributed to many factors like frequent occurrence of drought, declining of soil fertility, poor agronomic practice, limited use of fertilizers, technology generation, disease, insect, and pests (CIMMYT, 2004). Several studies have been conducted to understand soil degradation processes in Ethiopia (Holden and Shiferaw, 2002; Sonneveld, 2002). Among the soil degradation processes, nutrient depletion, surface sealing/crusting and soil erosion are the most prominent ones (Morin, 1993; Holden and Shiferaw, 2002). In order to limit further degradation and the associated production losses, assessing the impact of potential agronomic practices such as tillage and fertilizer practices on crop production is thus too crucial. Hence, this study was initiated with the objective of investigating the effect of different nitrogen fertilizer rates and different tillage practices on growth, yield and yield components of Maize.

2. MATERIALS AND METHODS

Experimental site: The study was conducted in the research site of Jijiga (latitude: 42^o49.417'N, longitude: 09^o 21.255'E, and altitude: 5498 ft m.a.s.l) located in the Eastern part of Ethiopia from 2011 to 2012 cropping season using rain-fed and supplementary irrigation. The annual rainfall of 2011 and 2012 was 540 and 504 mm, respectively, while the mean maximum and minimum annual temperature of the areas is 28^0c and 19^0c, respectively. Soil site analyze results indicated that the soil pH ranges between 7.9 to 8.4, organic matter ranges between 0.84 to 3.19%, total N % ranges between 0.055 to 0.18 %, Available P ranges 2 to 8 ppm and CEC ranges between 23.4 to 38.5 me /100 g soil.

Experimental Design and Treatment: The experiment will be conducted in two consecutive years (2011-2012). Main plot was planting methods and sub-plot was N fertilizer rates and was laid down in split plot in randomized complete block design with 3 replications. The treatments consist in this study were tillage practices (Flatbed planting, Closed end tie ridge, planting in furrows, Open end furrow planting in furrows, and Furrow planting) in main plot and N fertilizer (80 kg / ha,100 kg / ha and 150 kg / ha, and 180 kg / ha) as sub-plot. The land was ploughed and then the ridges were made manually. Improved maize (*var.* malkassa-1) was used as test crop. Planting was done at the beginning of the *karan* rainy season in 8 August both years in the furrow between the ridges as per the treatment. Maize was planted on plot size of 5 m x 3.5 m with spacing of 20 cm and70 cm between plants and rows, respectively. Di-ammonium phosphate (100 kg / ha) fertilizer was side dressed at plating. Half of nitrogen fertilizer was added at the planting and other half at tillering stage. Three times was irrigated the farm when no rain fall within 18 days both years.

Data collected and analysis: nine quantitative characters (Plant height at harvest, Biological yield, Grain yield, Number of row per cob/ear, number of grains per rows and number of grain per ear, Length of cobs, Harvest index, and Thousand seed weight) were collected from middle row of each plot excluded the border rows. Plant height was measured above the ground to the highest point of plant. A sample of 10 plants were randomly selected from each plot to measure plant height, length of cobs, no of rows per cobs, no. of grains per row and no. of grains per cobs. The harvested area was 5.6 m^2. Data collected for each character were subjected to analysis of variance (ANOVA). Analysis of variance was done using Proc GLM procedures of SAS version 9.2, (SAS Institute, 2008) after testing the ANOVA assumptions. The mean comparison was uses Fisher's least significant difference (LSD) at 1% and 5% probability levels.

3. RESULTS AND DESCUSSION

The pooled analysis of the data revealed that different planting methods had high and significantly affected all characters studied (Table 1). Similarly, result showed that various rate of nitrogen had significantly affected number of grain per cobs and length of cobs and its diameter whereas interaction between planting methods and nitrogen rate were non-significant for all characters except harvest index.

Plant height

The pooled analysis of the data revealed different planting methods had highly significantly ($p < 0.01$) affected plant height (Table 1) whereas the effect of various levels of nitrogen and their interaction were non-significant. It is clear from the mean values of the data that taller plant (130cm) was recorded in treatments having nitrogen dose of 150 kg ha^{-1} as compared with other treatments including control. Similarly, the taller plant (141.35cm) was recorded in plots having open end furrow (Table 2). The increase in plant height with respect to increased N application rate indicates maximum vegetative growth of the plants under higher N availability. These results are in conformity with the results obtained by Akbar *et* al., (1999) who found that plant height in maize increased with increase in N rate. However, in contrast to the results of this study, Sadeghi and Bahrani (2002) reported that increase in N rate had no significant effect on plant height. Also Taye and Yifru (2010) reported that the smallest plant height was achieved from flatbed planting.

Table 1. The pooled analysis of variance for yield and yield components of maize (Melksass-1)

	Mean squares for source of variation			
Character	Ridge tillage (FA)	N fertilizer (FB)	FA*FB	Error (78)
Plant height (cm)	8468.34**	64.39^{ns}	243.56^{ns}	584.34
Biological yield per plot (quintal/ha)	18602.10**	702.91^{ns}	767.69^{ns}	678.78
Grain yield per plot (quintal/ha)	3435.88**	167.10^{ns}	40.82^{ns}	93.26
Number of cobs per plant	0.23*	0.06^{ns}	0.08^{ns}	0.05
Number of row per cob/ear	10.62**	1.54^{ns}	0.39^{ns}	1.05
Number of grains per rows	88242.34**	21320.31*	5267.43^{ns}	5203.86
Length of cobs (cm)	57.97**	15.15*	4.32^{ns}	2.17
Harvest index (%)	567.17**	24.47^{ns}	136.48**	29.17
Thousand seed weight (gm)	18083.77**	2011.91^{ns}	1724.44^{ns}	1356.36

Figures in parentheses = Degrees of freedom; ** = Significant at P = 0.01; * = Significant at P= 0.05; ns = Non-significant.

Number of cobs per plant, Number row per cob/ear and Number of grains per rows

Statistical pooled analysis of the data indicated that different planting methods had highly significantly ($p < 0.01$) affected on the number row per cob/ear. The effect of planting methods and interaction between nitrogen and planting methods was non-significant (Table 1). Maximum number of 12.50 rows per cobs/ear was recorded in treatment with 180 kg N ha^{-1}. Similarly, maximum number of rows per cobs/ear (12.84) was observed in treatments of Furrow planting when compared with other tillage methods (Table 2). Statistical pooled analysis of the data showed that different planting methods had significantly ($p < 0.05$) affected cobs plant^{-1}. The maximum number of 1.37 cobs per plant was recorded in those plots which were fertilized with 100 and 180 kg N ha^{-1}, whereas minimum number of 1.1 cob per plant was recorded in treatment with 80 kg N ha^{-1}. Likewise, the maximum number of 1.44 cobs per plant was recorded in plot having open end furrow, followed by close end tie ridge 1.4), while the minimum of 1.22 cobs per plant was recorded in the plot having flatbed planting (Table 2).

The pooled analysis of the data revealed that various levels of nitrogen and different planting methods had significantly affected Number of grain cobs^{-1}at $P< 0.05$ and $P<0.01$, respectively, whereas the effect of their interaction were non-significant (Table 1). The highest number of 327.56 grain cobs^{-1} was recorded in case of those treatments which were treated with 100 kg N ha^{-1}, whereas minimum number of 265.28 grain cobs^{-1} was recorded in treatments with 180 kg N ha^{-1}. Similarly, the maximum number of 342.47 grain cobs^{-1} was recorded in the plot having open end furrow, followed by close end tie ridge (303.75), while the minimum number of 199.07 grain cobs^{-1} was recorded in the plot having flatbed planting (Table 2).This results is in agreement with the result of Hassen *et al*., (2005).

Length of cobs

Statistical pooled analysis of the data showed that various levels of nitrogen and different planting methods had significantly affected length of cobs at $P< 0.05$ and $P<0.01$, respectively, whereas the effect of their interaction were non-significant (Table 1). The tallest length of cobs plant^{-1} (12.29 cm) was produced by plots treated with N dose of 100 kg N ha^{-1} while the shortest cob plant^{-1} (10.5 cm) was in treatments 180 kg N ha^{-1}. Similarly, the maximum length of cobs plant^{-1} (12.55 cm) was recorded in plots having open end furrow, followed by close end tie ridge of 11.78 cm. Also the shortest length of cobs plant^{-1} (8.94) was recorded in flatbed planting method (Table 2).

Grain yield and biological yield

The pooled analysis of the data revealed different planting methods and N levels had highly significantly at the level ($p < 0.01$) affected grain and biological yield (Table 1) whereas their interaction were non-significant. The highest grain yield of 31.24 qt ha^{-1} was recorded in plots treated with nitrogen dose of 100 kg N ha^{-1} when compared with other N levels (Table 2). These results agree with those reported by Fedotkin and Kravtsov (2001). Likely, maximum grain yield of 38.20 qt ha^{-1} was recorded in open end furrow, while minimum grain yield of 11.56 qt ha^{-1} was harvested from plots sown with flatbed planting methods. Shaikh *et al*. (1994) and Majid *et al*. (1986) reported that grain yield was significantly affected by different planting methods. Similarly, Taye and Yifru (2010) reported that tie ridges and planting in furrow produced the highest grain yield of maize.

Maximum biological yield of 87.18 qt ha^{-1} was recorded in control treatments of 150 kg N ha^{-1} while minimum biological yield of 75.03 qt ha^{-1} was recorded in treatment with 80 kg N ha^{-1} (Table 2). Powal (1998), Shaikh *et al.* (1994) and Majid *et al.* (1986) reported that biomass was increased with each incremental dose of nitrogen. The highest biological yield of 102.99 qt ha^{-1} was recorded in the treatment of furrow planting method. The lowest biological yield of 42.61 qt ha^{-1} was recorded in the treatment of flatbed planting method (Table 2).

Harvest index and thousand seed weight

Statistical pooled analysis of the data pointed out that different planting methods had significantly ($p < 0.01$) affected harvest index, whereas the effect of various levels of nitrogen were non-significant, but their interaction were highly significant ($p < 0.01$) Table 1. Maximum harvest index of 45.50% was recorded in the treatment combination of closed end tie ridge and 100 kg N ha^{-1} when compared with other treatment combinations (Table 3). Similarly, open end furrow planted in furrow produced highest 38.51 % when compared with other planting methods, followed by close end tie ridge of 37.24 % (Table 2). These results agree with those reported by Ali *et al*. (2002). Similar result showed that the tied ridges highest and lowest grain was obtained from tie ridge and flat bed planting system (Hassen et al., 2005)

The pooled analysis of the data showed that different planting methods had highly significantly ($p < 0.01$) affected thousand seed weight (Table 1) whereas the effect of various levels of nitrogen and their interaction were non-significant. Maximum thousand seed weight of 186.12 g which was not significant achieved from the treatment of 100 kg N ha^{-1} when compared with other nitrogen levels. Similarly, close end tie ridge sown crop produced maximum thousand seed weight (201.62 g), followed by open end furrow (191.58 g) but also the minimum thousand seed weight (140.54 g) was recorded with plot having flatbed planting method (Table 2).

Table 2. Effect of different planting methods and nitrogen fertilizer rates on growth and yield components of maize (Melkassa-2)

Treatment	PH	BioY	GYD	No.CPP	No. GPC	LC	No.RPC	HI	TSWT
Ridge tillage	(cm)	(qt)	(qt)			(cm)			(gr)
FBP	100.88b	42.61c	11.56c	1.22b	199.07c	8.94c	11.27c	27.62c	140.54b
CETRP	135.11a	84.17b	30.92b	1.40a	303.75ab	11.78ab	12.24b	37.24ab	201.62a
OEFP	141.35a	100.15a	38.20a	1.44a	342.47a	12.55a	12.40ab	38.51a	191.58a
FP	137.8a	102.99a	35.06ab	1.37a	287.39b	11.28b	12.84a	34.332b	190.29a
LSD (0.05)	**13.89**	**14.97**	**5.55**	**0.13**	**41.46**	**0.85**	**0.59**	**3.10**	**21.17**
N level (kg/ha)									
80	126.40a	75.03b	25.24b	1.10a	273.33b	10.79b	12.09ab	33.63a	184.63a
100	129.13a	85.66a	31.24a	1.37a	327.56a	12.29a	12.26ab	35.85a	186.12a
150	130.03a	87.18a	30.31ab	1.29a	266.51b	10.97b	11.90b	33.79a	167.31a
180	129.61a	82.07a	28.98ab	1.37a	265.28b	10.50b	12.50a	34.44a	185.98a
Mean	**128.79**	**82.48**	**28.94**	**1.36**	**283.17**	**11.14**	**12.19**	**34.43**	**181.00**
CV (%)	**18.77**	**31.59**	**33.37**	**17.23**	**25.47**	**13.23**	**8.41**	**15.69**	**20.35**
LSD (0.05)	**13.89**	**14.97**	**5.55**	**0.13**	**41.46**	**0.85**	**0.59**	**3.10**	**21.17**

BioY: biological yield , GYD=grain yield per plot, HI=harvest index, No.CPP=numb of cobs per plant, No.GPC=number of grain per cobs, No.RPC=number of row per cob / ear, LC=Length of cobs and its diameter, 1000SWT=thousand seed weight, and PH=plant height. FBP=Flatbed planting, CETRP=Closed end tie ridge, OEFP=open end furrow , and FP=Furrow planting.

4. CONCLUSION

Sustaining soil and soil fertility in intensive cropping systems for higher yields and better quality can be achieved through optimum levels of N fertilizer application and appropriate planting methods. Thus, information on fertility status of soils and crop response to different soil fertility and planting methods is very crucial to come up with profitable and sustainable crop production.

The different rain water harvesting techniques like open end Furrow, tied ridge and furrow planting methods gave the highest yield of maize under rain fed with supplementary irrigation. Whereas, the farmers practice tillage (flatbed planting) gave lowest yield of maize. This is because the tied ridges conserve more rain water during rainy season and increase soil moisture content which supported plant growth. For enhancing the livelihood of farmers, reduce food insecurity and improve the income level of household, we recommend that tie ridges and furrow planting is the best practice to harvest rain water, increase soil moisture content and maximize the yield of maize under rain fed condition.

.

ACKNOWLEDGMENT

We wish to thank Somali regional state by providing financial assistance to conduct the field experiment. We also acknowledge Somali region pastoral and agro-pastoral research institute researchers' who participated in field data collection.

5. REFERENCE

[1] Abdulaahi, Hassen, Ed sarobol, Vichan Vichukit and Chairerk Suwannarat 2005. The effect og planting methods systems nitrogen and phosphorus combined fertilizer on yield and yield components of maize (Zea maize L.) in Eastern Ethiopia. Kasetsart J. (Nat. Sci.) 39 : 560-568.

[2] Ali, J., Bakht J, Shafi M, S. Khan and W. Ali. 2002. Uptake of nitrogen as affected by various combination of nitrogen and phosphorous. Asian J. Plant Sci. 1: 367-369.

[3] Asnake, F. (1998). Effect of plant density on yield and yield components in varieties of maize (Zea mays). Msc. Thesis, School of Graduate Studies, Alemaya University of Agriculture.

[4] Abdulaahi, Hassen, Ed sarobol, Vichan Vichukit and Chairerk Suwannarat 2005. The effect og planting methods systems nitrogen and phosphorus combined fertilizer on yield and yield components of maize (Zea maize L.) in Eastern Ethiopia. Kasetsart J. (Nat. Sci.) 39 : 560-568.

[5] Belachew, Taye and Yifru Abera 2010. Response of maize (Zea maize L.) to tied ridges and planting methods aat Goro, southern Ethiopia. American-Euroasian J. Agronomy 3(1): 21-24.

[6] CIMMYT (International Maize and Wheat Improvement Center), 2004. Second Semi-Annual Progress Report for the Quality Protein Maize Development Project for the Horn and East Africa (XP 31519). July 1- December 31, 2003.

[7] CSA (Central Statistical Agency), 2012. Agricultural Sample survey: report on area and production of major crops (private peasant holdings, Meher season). Statistical Bulletin, (1).Addis Abeba.

[8] Fedotkin, I. V. and I. A. Kravtsov. 2001. Production of grain maize under irrigated conditions. Kukuruza-I-Sorgo. 2001. 3: 5-8.

[9] Holden, S.T & Bekele Shiferaw. 2002. Poverty and Land Degradation: Peasants' Willingness to Pay to Sustain Land Productivity. In: C.B. Barrett, F.M. Place and A.A. Aboud (eds.), The Adoption of Natural Resource Management Practices: Improving Sustainable Agricultural Production in Sub-Saharan Africa.CABI Publishing, NewYork, 91-102pp.

[10] Majid, A., M. Shafiq and M. Iqbal. 1986. Deep tillage and sowing techniques in maize production under high rainfed conditions. Pak. J. Agric. Res. 7: 181-185.

[11] McDonald, AH. Nicol, JM, 2005. Nematode Parasites of Cereals. pp. 131-191.In: Luc, M., Sikora, R.A. and Bridge, J. (Eds). Plant parasitic nematodes in subtropical and tropical agriculture, 2nd edition. Wallingford, UK, CABI Publishing.

[12] Morin, J.1993. Soil crusting and sealing in West Africa and possible approaches to improved management. In: FAO (ed.) Soil tillage in Africa: needs and challenges, FAO Soils Bulletin, 69: 95-128.

[13] Muurinen, S., 2007. Nitrogen dynamics and nitrogen use efficiency of spring cereals under Finnish growing conditions. Yliopistopaino, 29: 1-38. Nitrogen use efficiency in Ethiopian barley. Elsever, Amesterdam. 43-60p.

[14] Shaikh, A. A., A. S. Jadhav, B. D. Koli and M. J. Wattamwar. 1994. Effects of planting layouts, mulching and fertilizers on dry matter accumulation and energy relationship in rainfed pearl millet. J. Mah. Agric. Univ. 19: 421-423.

[15] Sonneveld, B.G.J.S. 2002. Land under pressure: The impact of water erosion on food production in Ethiopia. PhD Thesis, Shaker Publishing, the Netherlands.