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Nitrogen-Use Efficiency in Maize (*Zea mays* L.) on Fluvisol Soils in Afgoi District, Southern Somalia

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AAM and HNI laid down the experimental lay out, data collection procedure, data analysis, interpretation and wrote the manuscript. Authors FK, LB and SAS reviewed the article and proofread. All authors read and approved the final manuscript.

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ABSTRACT

In this study, an experiment was conducted to determine the best rate of nitrogen fertilization on maize grain yields and interaction of nitrogen levels and application methods of nitrogen on growth and yield of maize.
For this purpose, the maize experiment was designed in the experimental farm of Somali Ministry of Agriculture, in Afgoi, Lower Shabelle, Somalia in 2017 spring and autumn. The treatments consisted of eight rates (0 kg N ha^{-1}; 25 kg N ha^{-1}; 50 kg N ha^{-1}; 75 kg N ha^{-1}; 100 kg N ha^{-1}; 125 kg N ha^{-1}; 150 kg N ha^{-1} and 175 kg N ha^{-1}.) Nitrogen and three applying methods (broadcasting, row placement, and hill placement). The layout of the experiment was designed in Randomized Complete Block Design with three replications. A total of 9 parameters *viz.* plant height (cm), number of cobs $plant^{-1}$, cob length (cm), cob weight (gr), 1000 grain weight (gr), stover yield (t ha^{-1}), grain yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%), were collected. The collected data were analyzed statistically and means were adjudged by Duncan's Multiple Range Test at 1 and 5% level of probability.

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Both in the spring season and In the autumn season, according to the nitrogen rates, the result showed that there was significantly different in all characters among the different application rates of nitrogen the maximum stover yield was recorded in 100 kg N ha^{-1} while the maximum grain yield was noted from 100 kg N ha^{-1}. Both in the spring season and In the autumn season in the methods of application, there was no significant variation in all parameters measured but the interaction effect was significantly different among the treatments, the maximum stover yield and grain yield were recorded in 100 kg N ha^{-1} and hill placement. Thus, applying 100 kg N ha^{-1} and the method of row placement is promising to increase the maize yield and the study is required to be repeated for one more season.

Keywords: Corn; urea; di-ammonium phosphate; Southern Somalia; fertilization.

1. INTRODUCTION

Based on area and production, maize is the 3rd most important cereal crop after wheat and rice in the world [1]. In Latin America and Africa, maize is an important food and also a basic ingredient for local drinks; it is also an outstanding feed for livestock, high in energy content, low in fiber and easily digestible. As a source of starch, it is a major component in industrialized food products [2].

Maize is an important cereal cropped by many farmers in small-scale farms in Somalia [3]. In the past twenty years, many farmers have repeated maize cropping on the same land for long and without fertilization, and yet were able to obtain several good yields [4]. However such practice causes reduction of maize yields over time. The high demand of maize for nitrogen and other major nutrients such as phosphorus and potassium must be taken into account to maintain high maize productivity [5].

Maize productivity in Somalia is limited in irrigated areas and is very low if compared to other countries [6]. One of the major problems constraining the development of economically successful agriculture is nutrient deficiency [7]. The efficient use of nitrogen addresses the problem of widespread nutrient deficiencies in Sub-Saharan Africa and other developing countries [8]. However, as a grain yield per nitrogen fertilizer used, it is widely defined in different terms and at different scales [9]. In addition, increased yield should be accompanied to feed the Somali population, which continues to grow in direct proportion with the increase in nitrogen use efficiency in cereals [3].

Nitrogen quantities in Somali soils are usually low, moreover, nitrogen assimilation depends also on the cultivars cropped, and after the start of the civil war, all the plant breeding efforts done before were lost and there is now a consistent mess in the genotypes used [10]. Therefore this research was done with the objective of determining the best rate of nitrogen fertilization on maize grain yields and interaction of nitrogen levels and application methods of nitrogen on growth and yield of maize to determine the minimum rate nitrogen needed to achieve maximum yields, and to determine which method of fertilizer application of nitrogen can be applied maize grain yields. The results of the study are intended to provide practical applications to reduce the loss of maize production in the Afgoi Region, which is the most important agricultural production zone, especially for small-scale farmers. Findings are expected to facilitate the discovery of economic losses of small-scale farmers. In addition, the finding of this study may provide a basis for further research of the country's agricultural areas in other regions

2. MATERIALS AND METHODS

2.1 Materials

The experiment was conducted at the experimental farm of Somali Agriculture Research Centre (SARC), in Afgoi, Lower Shabelle, Somalia. The geographical coordinate of the site is 2°08’34.54” North, Long 45°07’00.24” East and located along the River Shabelle, about 30 km northwest of the Country's capital Mogadishu . Afgoi had an annual mean rainfall of 479 mm and the average annual temperature is 26.8°C [11] The experimental site had been used over the two growing seasons (spring) in 2017 (May to September) and autumn (October to February). The climate in Lower Shabelle is hot and dry all year. The annual average temperature is between 26 and 28 °C [12].

In the experiment area, textural class of the surface soil was loam. pH of 8.15 (moderately alkaline), total nitrogen of 0.13 % (low), organic carbon of 2.20% (Medium), available phosphorus 6.12 mg kg^{-1} (low) and CEC of 37.6 me 100 g^{-1}(or 37.6 cmol kg^{-1}) (high) of soil.(Soil samples were taken from 0-30 cm range. Soil Analysis was conducted following standard procedures by Crop nutrition Laboratory services Ltd., Nairobi, Kenya).

The maize variety is somehow considered local maize (Somtux). The seeds treated with pesticides (Gaucho, Monocerene) which function as insecticide/ fungicide to minimize soil insects and other soil-borne diseases at early stages of seedling emergence and for healthy growth of the crop were used for the experimental purposes. Nitrogen fertilizer in the form of urea (46% N) was used for the study. N- Fertilizer applied at different rates constituted the treatments, while the recommended rate of phosphorus-fertilizer (80 kg P ha^{-1}) was applied uniformly to all plots at disc harrowing period. Diammonium phosphate (DAP) was used as a source of phosphorous in the form of $(NH_4)_2HPO_4$.

2.2 Methods

The treatments consisted of eight rates of N (0 kg N ha^{-1}; 25 kg N ha^{-1}; 50 kg N ha^{-1}; 75 kg N ha^{-1}; 100 kg N ha^{-1}; 125 kg N ha^{-1}; 150 kg N ha^{-1} and 175 kg N ha^{-1}.) and three applying methods (broadcasting, row placement, and hill placement).The nitrogen applications on maize were in two stages: at 30 days from emergence for the 1st application and 50 days from emergence for the second application. The method utilized for the nitrogen application on maize was Row Placement of N, three/four days after irrigation depending on moisture condition of the experimental area. The layout of the experiment was designed in RCBD with three replications. The plot size was 5 rows of 10m length. The plot area was approximately $38m^2$. The distances between plants were 0.30m and after thinning one plant were left/hill.

All field activities were carried out following standard production practices. Planting was done on 7 May 2017 by spacing furrows of 0.75m were opened after the disc harrow operation and the distances between plants were 0.30m.The land was prepared by using disc plow in both the seasons of the experiment. The land was further exposed for days to dry up the clods of the soil. Hand weeding five times and Bulldock granular and liquid were utilized for the control of maize borers and aphids. Number of irrigation was more than five times due to poor rainfall during The Gu (spring) 2017. The four central rows were harvested (22.5 m^2) after 110 days from crop emergence.

2.3 Data Collection, Measurements and Analysis

The parameters of plant height (cm), number of cobs $plant^{-1}$, cob length (cm), cob weight (g), grain yield (t ha^{-1}), 1000 Seed Weight: (gr), stover yield (t ha^{-1}), biological yield (t ha^{-1}), harvest index (%) were collected and measured. The ratio of economic yield to biological yield and was calculated [13].

All the data were analyzed using the procedure for analysis of variance (ANOVA) for Randomized Complete Block Design (RCBD) by using R language software and means were separated by the least significant difference (LSD $P<0.05$) [14]. The cost of cultivation of the maize was worked out on the basis of per hectare. The total cost of production included the cost items like human labor and mechanical power cost; materials cost (including the cost of seeds, fertilizers, gapping, thinning, irrigation, pesticide, transportation cost and etc.). In general, the profits of the companies mean net return. Net return was computed by subtracting the total cost of production from the gross and income [15].

3. RESULTS

According to the effect of nitrogen on growth and yield of maize, there was significantly different ($p<0.01$) in plant height in both seasons. The effect of nitrogen on growth and yield of maize in the spring season and in the autumn season was shown in Table 1 and Table 2.

In both seasons, the highest plant height, number of cobs $plant^{-1,}$ cob length, cob weight, 1000-grain weight, stover yield, grain yield, and biological yield were received from N_5 (100 kg N ha^{-1}) in contrary highest harvest index was observed from the N_8 (175 kg N ha^{-1}). It is concluded that 100 kg nitrogen ha^{-1} application (A5) is the most appropriate amount when only nitrogen is evaluated. These results are in agreement with the findings Lawrence et al. [16] and Zeidan et al. [17] reported that the harvest index in corn increases when N rates increase. However, this result contradicts with the result obtained by Abdo [18] reported the highest harvest index from treatments with the lowest rate of nitrogen application.

The effect of the method of application of nitrogen on growth and yield of maize in the spring season and in the autumn season was shown in Table 3 and Table 4. No significant difference was found in all parameters measured according to nitrogen application methods. This difference was found statistically significant in the highest plant height, in the spring season the highest plant height was recorded in the method of row placement .In autumn season the highest plant height was noted in hill placement. The number of cobs plant^{-1} was not varied significantly among Methods of application of nitrogen in both seasons. In the spring season, the maximum number of cobs plant^{-1} was documented in hill placement which was statistically similar with the row placement and broadcasting. In the autumn season, the maximum number of cobs plant^{-1} was received from hill placement.

Cob length and cob weight were no any statistically significant effect among the methods of application of nitrogen in both seasons. The maximum cob length and cob weight were documented in row placement. The 1000-grain weight was found significant, the maximum 1000-grain weight was produced by row placement in both seasons. In spring season there was no any significant different effect in stover yield, the maximum stover yield was documented in row placement. In autumn season, the stover yield was found significant ($p<0.5$), the maximum stover yield was noted in broadcasting. In the spring season, the grain yield was found significant ($p<0.01$), the maximum grain yield was noted from row placement. In the autumn season, There was significantly different ($p<0.5$), the maximum grain yield was noted from hill placement. There was significantly different ($p<0.5$) in biological yield in both seasons. In the spring season, the highest biological yield was received from row placement. In autumn season, the highest biological yield was received from broadcasting. In the spring season, the harvest index had no any significant effects, the highest harvest index was documented in hill placement. In the autumn season, the harvest index was found significant ($p<0.01$), the highest harvest index was recorded in row placement method. These results are in agreement with the findings of Kaiser et al. [19] and Ahmad et al. [20] who found more grain yield of maize with row placement of nitrogen over broadcast.

The interaction effect of nitrogen rates and method of application on growth and yield of maize in the spring season and in the autumn season was shown in Table 5 and Table 6. According to the interaction effect of nitrogen rates and method of application on growth and yield of maize, there was significantly different ($p<0.01$) in plant height in both seasons. In the spring season, the highest plant height was recorded in N_5 and the method of row placement. In the autumn season, the highest plant height was recorded in N_5 and the method of hill placement. The maximum number of cobs plant^{-1}, cob weight, and 1000-grain weight were documented in N_5 and row placement in both seasons, in spring there was a statistically significant effect but in autumn had no any significant effects. In the spring season, the cob length was found significant ($p<0.5$), the tallest cob length was noted from N_5 hill placement. In autumn season, the cob length was found significant ($p<0.01$), the tallest cob length was noted from N_5 and hill placement. In the spring season, There was significantly different ($p<0.5$) in stover yield, the maximum stover yield was recorded in N_5 and hill placement. In the autumn season, the stover yield was found significant ($p<0.01$), the maximum stover yield was recorded in N_5 and hill placement.

In the spring season, the grain yield was found significant ($p<0.5$), the maximum grain yield was noted from N_5 and row placement. In autumn season, the grain yield was found significant ($p<0.01$), the maximum grain yield was noted from N_5 and hill placement. In the spring season, There was significantly different ($p<0.5$) in biological yield, the highest biological yield was received from N_5 and row placement. In autumn season, the biological yield was found significant ($p<0.01$), the highest biological yield was received from N_5 and hill placement. In the spring season, the harvest index was found significant ($p<0.5$), the highest harvest index was observed from the N_8 and row placement. In the autumn season, the harvest index was found significant ($p<0.01$), the highest harvest index was observed from the N_8 and row placement.

4. DISCUSSION

The interaction effect of nitrogen rates and method of application on growth and yield of maize yield is significantly affected by both methods of application and nitrogen rates. Nitrogen levels significantly increase the grain yield and stover yield. In the spring season, the maximum stover yield (7.02 t ha-1) was recorded in N5 and hill placement. In the autumn season, the maximum stover yield (6.51 t ha-1) was recorded in N5 (100 kg N ha-1) hill placement.

Table 1. The effect of nitrogen on growth and yield of maize in the spring season

N levels	Plant height (cm)	Number of cobs plant-1	Cob length (cm)	Cob weight (g)	1000-grain weight	Stover yield (t ha^{-1})	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
N1	174.03 h	1.56 e	19.75d	116.70c	187.09f	6.00d	3.30e	9.30 de	35.48e
N2	180.58 g	1.67de	21.62d	123.45c	190.20e	6.03d	3.39d	9.42 d	35.99cde
N3	186.85f	2.00cd	21.59d	131.4bc	195.10d	6.40c	3.68c	10.08 c	36.51bcd
N4	201.56d	2.33bc	25.98b	122.77c	198.60c	6.55bc	3.80b	10.35 b	36.71abc
N5	234.00 a	3.00a	29.60a	148.72a	216.57a	6.98a	3.99a	10.97 a	36.37bcd
N6	219.17 b	2.44b	24.43bc	139.05ab	200.79b	6.60b	3.70c	10.29 b	35.96 de
N7	207.19c	2.00cd	22.23cd	132.34bc	189.69e	5.92de	3.44d	9.36 de	36.75ab
N8	192.27e	2.00cd	21.82d	128.94bc	186.12f	5.76e	3.43d	9.19 e	37.32 a
Level of significant	**	**	**	**	**	**	**	**	**
CV (%)	1.13	6.46	3.83	4.12	0.39	3.18	1.72	0.76	0.61

Values having same letter (s) do not differ significantly by DMRT at P<5% level
*** Highly significant (p≤ 1%), CV= Coefficient of Variation*

Table 2. The effect of nitrogen on growth and yield of maize in the autumn season

N levels	Plant height (cm)	Number of cobs plant^{-1}	Cob length (cm)	Cob weight (g)	1000-grain weight	Stover yield (t ha^{-1})	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
N1	164.98 h	1.33 d	16.71 e	110.82 f	177.92 f	5.32 d	2.90 e	8.22 de	35.28 e
N2	171.62 g	1.44 d	18.49 d	117.48 e	181.03 e	5.34 d	3.00 d	8.34 d	35.97cde
N3	178.19 f	1.89 bc	20.35 c	125.47 c	185.93 d	5.72 c	3.28 c	9 c	36.44bcd
N4	192.38 d	2.11 b	23.14 b	132.20 b	189.43 c	5.87 bc	3.41 b	9.28 b	36.75 abc
N5	223.63 a	2.56 a	26.83 a	142.75 a	207.40 a	6.31 a	3.59 a	9.9 a	36.26bcd
N6	209.85 b	2.00 bc	22.36 b	133.08 b	191.62 b	5.91 b	3.31 c	9.22 b	35.90 de
N7	196.07 c	1.89 bc	19.98 c	126.36 c	180.52 e	5.23 de	3.05 d	8.28 de	36.84 ab
A8	183.15 e	1.67 cd	19.59 c	122.97 d	176.95 f	5.08 e	3.03 d	8.11 e	37.36 a
Level of significant	**	**	**	**	**	**	**	**	**
CV (%)	0.38	8.01	1.72	0.42	0.40	3.57	1.93	0.85	2.38

Values having same letter (s) do not differ significantly by DMRT at P<5% level
*** Highly significant (p≤ 1%), CV= Coefficient of variation*

Table 3. The effect of the method of application of nitrogen on growth and yield of maize in the spring season

Method of application	Plant height (cm)	Number of cobs plant-1	Cob length (cm)	Cob weight (g)	1000-grain weight	Stover yield (t ha-1)	Grain yield (t ha-1)	Biological yield (t ha-1)	Harvest index (%)
Row	201.53a	2.13a	23.85a	134.07a	196.82a	6.33a	3.62 a	9.95a	36.41a
Broad	197.49c	2.08a	23.23a	131.52a	194.51b	6.24a	3.56 b	9.79b	36.35a
Hill	199.35b	2.17a	23.043a	126.41a	195.24b	6.27a	3.59ab	9.86ab	36.42a
Level of significant	**	NS	NS	NS	**	NS	**	*	NS
CV (%)	1.13	6.46	3.83	4.12	0.39	3.18	1.72	0.76	0.61

Values having same letter (s) do not differ significantly by DMRT at P<5% level
*** Highly significant (p≤ 1%), * Significant (p≤ 5%), NS= Non-significant, CV= coefficient of variation*

Table 4. The effect of the method of application of nitrogen on the growth and yield of maize in the autumn season

Method of application	Plant height (cm)	Number of cobs plant-1	Cob length (cm)	Cob weight (g)	1000-grain weight	Stover yield (t ha-1)	Grain yield (t ha-1)	Biological yield (t ha-1)	Harvest index (%)
Row	190.12b	1.79a	21.47a	128.37a	189.81a	5.23b	3.07b	8.3b	36.99a
Broad	186.49c	1.83a	20.89ab	126.12b	185.01b	5.78a	3.25a	9.03a	35.99b
Hill	193.35a	1.95a	20.43b	124.68c	184.23b	5.76a	3.26a	9.02a	36.14b
Level of significant	**	NS	NS	*	*	*	*	*	**
CV (%)	0.38	8.01	1.72	0.42	0.40	3.57	1.93	0.85	2.38

Values having same letter (s) do not differ significantly by DMRT at P<5% level
*** Highly significant (p≤ 1%), * Significant (p≤ 5%), NS= Non-significant, CV= coefficient of variation*

Table 5. The interaction effect of nitrogen rates and method of application on growth and yield of maize in the spring season

Interaction effect	Plant height	Number of cobs plant-1	Cob length (cm)	Cob weight (g)	1000-grain weight	Stover yield (t ha-1)	Grain yield (t ha-1)	Biological yield (t ha-1)	Harvest index (%)
N1 Row	174.89 l	1.67 cd	19.72 hi	118.98 bcd	187.71 h-l	6.013fghi	3.30ij	9.31 fg	35.44 g
N1 Broad	172.59 l	1.33 d	19.53 hi	115.48 cd	185.91 kl	5.94ghi	3.28j	9.22 fg	35.56 e-g
N1 Hill	174.59 l	1.67 cd	20.01 ghi	116.42 cd	187.65 h-l	6.03efgh	3.32hij	9.35 fg	35.48 f-g
N2 Row	181.25 k	1.67 cd	21.93 c-h	124.21 abc	190.71 ghi	6.12defg	3.40fghi	9.51 f	35.71 d-g
N2 Broad	179.25 k	1.67 cd	21.30 f-h	122.68 bc	189.73 hij	6.02fghi	3.37ghij	9.39 fg	35.90 b-g
N2 Hill	181.25 k	1.67 cd	21.63 d-h	123.45 bc	190.17 hi	5.95ghi	3.41fgh	9.36 fg	36.44 b-g
N3 Row	188.57 ij	2.00 bcd	24.18 c-g	132.23 abc	196.62 ef	6.53bc	3.70de	10.23cde	36.22 b-g
N3 Broad	184.99 j	2.00 bcd	23.78 c-h	130.50 abc	194.33 fg	6.32cdef	3.65e	9.97 e	36.67 a-g
N3 Hill	186.99 ij	2.00 bcd	16.81 i	131.58 abc	194.35 fg	6.35cde	3.67de	10.02 de	36.67 a-g
N4 Row	202.67eg	2.33 abc	26.23abc	138.83 abc	199.72 cde	6.71ab	3.82c	10.54bc	36.31 b-g
N4 Broad	200.01gh	2.33 abc	25.72 a-e	137.00 abc	197.85 def	6.45bcd	3.76cd	10.21cde	36.86 a-d
N4 Hill	202.01 fg	2.33 abc	25.98 a-d	92.47 d	198.24 de	6.50bc	3.81c	10.31cde	36.99abc
N5 Row	235.83 a	3.00 a	29.67 ab	150.67 a	218.91 a	6.98a	4.07a	11.0 a	36.80 a-e
N5 Broad	232.08 b	3.00 a	29.06 ab	147.51 ab	215.16 b	6.95a	3.93b	10.89ab	36.13 b-g
N5 Hill	234.08ab	3.00 a	30.06a	148.00 ab	215.65 ab	7.02a	3.97ab	10.98 a	36.11 b-g
N6 Row	220.65 c	2.33 abc	24.17 c-g	139.86 abc	202.59 c	6.62bc	3.75cde	10.36bc	36.16 b-g
N6 Broad	217.44 c	2.33 abc	23.79 c-h	138.92 abc	199.16 cde	6.57bc	3.67de	10.24cde	35.86 b-g
N6 Hill	219.44 c	2.67 ab	25.34 b-f	138.38 abc	200.62 cd	6.60bc	3.68de	10.28cde	35.80 c-g
N7 Row	210.32 d	2.00 bcd	22.85 c-h	134.00 abc	191.01 gh	5.99ghi	3.47f	9.46 fg	36.72 a-f
N7 Broad	204.89 ef	2.00 bcd	21.42 e-h	131.67 abc	188.92h-k	5.88ghi	3.41fgh	9.29 fg	36.73 a-f
N7 Hill	206.34 e	2.00 bcd	22.42 c-h	131.34 abc	189.14 h-k	5.88ghi	3.44fg	9.32 fg	36.88 a-d
N8 Row	198.08 h	2.00 bcd	22.087 c-h	128.74 abc	187.26i-l	5.69i	3.47f	9.17 fg	37.90 a
N8 Broad	188.64 ij	2.00 bcd	21.27 f-h	128.41 abc	185.04 l	5.76hi	3.39fghi	9.15 g	37.07ab
N8 Hill	190.09 i	2.00 bcd	22.09 c-h	129.67 abc	186.07jkl	5.82ghi	3.42fg	9.24 fg	37.03abc
Level of significant	**	*	*	NS	*	*	*	*	*
CV (%)	1.13	6.46	3.83	4.12	0.39	3.18	1.72	0.76	0.61

Values having same letter (s) do not differ significantly by DMRT at P<5% level
*** Highly significant (p≤ 1%), * Significant (p≤ 5%), NS= Non-significant, CV= coefficient of variation*

Table 6. The interaction effect of nitrogen rates and method of application on growth and yield of maize in the autumn season

Interaction effect	Plant height (cm)	Number of cobs plant-1	Cob length (cm)	Cob weight (g)	1000-grain weight	Stover yield (t ha-1)	Grain yield (t ha-1)	Biological yield (t ha-1)	Harvest index (%)
N1 Row	164.74 pq	1.33 c	16.30 k	113.48 n	180.70ijk	4.91gh	2.75l	7.66 f	35.90 cd
N1 Broad	161.59 q	1.33 c	16.73 jk	110.08 o	176.41mno	5.49d	2.97ij	8.46 e	35.11 d
N1 Hill	168.59 o	1.33 c	17.11ijk	108.92 o	176.65l-o	5.53de	2.99hıj	8.52 de	35.09 d
N2 Row	171.35 no	1.33 c	18.23 hij	119.21 l	183.71g-j	5.01fg	2.84kl	7.85 f	36.18bcd
N2 Broad	168.25 op	1.67 bc	18.50g-j	117.28 lm	180.23jkl	5.56cde	3.07ghi	8.63 de	35.57 cd
N2 Hill	175.25lm	1.33c	18.73ghi	115.95 mn	179.17k-n	5.45d	3.09gh	8.54 de	36.18bcd
N3 Row	179.60 k	1.67 bc	20.15efg	127.23 gh	189.62 de	5.43d	3.15fg	8.58 de	36.71 bc
N3 Broad	173.99mn	2.00 abc	20.98def	125.10hij	184.82fgh	5.86bc	3.35d	9.21 bc	36.37bcd
N3 Hill	180.99 jk	2.00 abc	19.91fgh	124.08ijk	183.34hij	5.85bcd	3.35d	9.2 bc	36.41bcd
N4 Row	192.12gh	2.00 abc	23.42 bc	133.83cd	192.72 cd	5.61cde	3.27de	8.88 cd	36.82 bc
N4 Broad	189.01hi	2.33 ab	22.92 bc	131.60def	188.35 ef	5.99b	3.46bc	9.45 b	36.61 bc
N4 Hill	196.01 f	2.00 abc	23.08 bc	131.17 ef	187.23 efg	6.00b	3.49b	9.49 b	36.78 bc
N5 Row	221.74 b	2.67 a	27.07 a	145.67 a	211.90 a	5.88bc	3.51b	9.39 b	37.38 b
N5 Broad	221.08 b	2.33 ab	26.26 a	142.11 b	205.66 b	6.50a	3.63a	10.13 a	35.83 cd
N5 Hill	228.08 a	2.67 a	27.16 a	140.50 b	204.65 b	6.51a	3.64a	10.15 a	35.86 cd
N6 Row	209.70 d	2.00 abc	23.67 b	134.86 c	195.58 c	5.51d	3.19ef	8.7 e	36.67 bc
N6 Broad	206.44 d	1.67 bc	20.99def	133.52cde	189.65 de	6.12b	3.37cd	9.49 b	35.51 cd
N6 Hill	213.44 c	2.33 ab	22.44 bcd	130.88 f	189.61 de	6.10b	3.36cd	9.46 b	35.52 cd
N7 Row	193.98 fg	2.00 abc	21.81 cde	129.00 fg	184.01ghi	4.88gh	2.92jk	7.8 f	37.44 b
N7 Broad	193.89 fg	1.67 bc	18.62ghi	126.27 hi	179.42 klm	5.42d	3.11fg	8.53 de	36.46bcd
N7 Hill	200.34 e	2.00 abc	19.52fgh	123.84ijk	178.14k-o	5.38d	3.11fg	8.49 de	36.63 bc
N8 Row	187.72 i	1.33 c	21.10def	123.74ijk	180.26 jkl	4.59h	2.92jk	7.51 f	38.88 a
N8 Broad	177.64 kl	1.67 bc	18.47g-j	123.01 jk	175.54 no	5.31ef	3.09gh	8.4 e	36.79 bc
N8 Hill	184.09 j	2.00 abc	19.19gh	122.17 k	175.06 o	5.32ef	3.10fg	8.42 e	36.82 bc
Level of significant	**	*	**	**	**	**	**	**	**
CV (%)	0.38	8.01	1.72	0.42	0.40	3.57	1.93	0.85	2.38

Values having same letter (s) do not differ significantly by DMRT at P<5% level

*** Highly significant (p≤ 1%), * Significant (p≤ 5%), NS= Non-significant, CV= coefficient of variation*

This result was in agreement with those reported by Adeniyan [21] and Karasu [22] who obtained a significant increase in various growth parameters of maize when supplied with higher rates of N fertilizer. In the spring season, the maximum grain yield (4.07 t ha-1) was noted from N5 and row placement. In autumn season, the maximum grain yield (3.64 t ha-1) was noted from N5 (100 kg N ha-1) and hill placement. These results are in agreement with the findings of Kaiser et al.[19] and Ahmad et al. [20] who found more grain yield of maize with row placement of nitrogen over the broadcast. The result was consistent with the findings of Muhammad, et al. [23] in which the maximum number of grain yield of 4000 kg ha^{-1} was attained in maize in response to the N application. While Maize productivity in Somalia especially Afgoi is limited in irrigated areas and is very low, about 1.0 t ha^{-1} against an average of 1.5 t ha^{-1} from the main maize producers. If compared to other Country. Although there are many problems that cause low yields throughout Somalia, these problems including lack or insufficient applications of fertilizer on maize, so Nitrogen availability is one of the key elements in increasing yields and mediates the utilization of potassium, phosphorus and other elements in plants and also this could be related to the fact that it is mainly being practiced under subsistence conditions by smallholder farmers. In addition to that, the majority of these farmers have repeated maize cropping on the same land for long and without fertilization and also using traditional and low-input cultivation techniques.

5. CONCLUSION

It can be concluded that the highest benefit was obtained from application of 100 kg N ha^{-1} to the method of row placement is optimal for obtaining higher grain yield of maize on Fluvisol soil under the agro-metrological conditions of Afgoi Somalia. In addition, we recommend that this dose of nitrogen can be applied to the local maize (Somtux) in regions for attaining the optimum yield of maize. Secondly, it may also be recommended that the farmers should apply to their farms 100 kg N ha^{-1} and hill placement. Further, lastly, we recommend that farm extension services should disseminate this work to farmers so that they can increase their farm income by getting the optimum yield of maize.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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