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Original Research Article

Effect of varied rate of Nitrogen Fertilizer application on Phenological Parameters of Maize (*Zea Mays L.*) Hybrids the Case of Jimma Zone, South Western Ethiopia

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Abstract

Nitrogen is one the most yield-restraining crop nutrient in crop production globally. It involves many physiological processes such as photosynthesis and other phonological development process. Beside the appliance of atomic number 7 plant food it's necessary to research the response of various hybrids to nitrogen fertilizer rates for better crop productivity enhancement, which is a factor of different physiological process. Hence, the current field experiment was conducted in 2016/17 to investigate the Effect of varied rate of Nitrogen Fertilizer application on phenological Parameters of Maize (Zea Mays L.) Hybrids the Case of Jimma Zone, South Western Ethiopia. A factorial experiment involving three maize hybrid two of which were quality protein maize hybrids (BHQPY545, MH138Q) and one conventional hybrid (Shone)widely used in study area; and four rates of nitrogen fertilizer (0, 50, 100, and 150 kg ha^{-1}) were tested in Randomized Complete Block Design (RCBD) with three replications. The result indicate that main effect of hybrids was highly significant ($p<0.01$) on days to 50% emergence, as well as both main effect of maize hybrids and N - rate was significant ($p<0.05$) on days to 90% maturity, only main effect days to 50% tasseling and 50% silking. Accordingly, the minimum DFE (9.8) was recorded from the hybrid BHQPY545 and the maximum (11.0) days were recorded from the hybrid Shone. Significantly shortest DFT (79.8), was recorded from the control treatment (0 kg ha^{-1}) while, the longest day (84.0) was from 150 kg ha^{-1}nitrogen fertilizer application. On the other hand significantly maximum DFS (88.4) days was obtained from the application of 150 kg ha^{-1} nitrogen fertilizer and th e minimum (82.0) days was obtained from the control treatment (0 kg ha^{-1}N). The minimum (140.0) and the maximum (153.9) DNPM were recorded from the application of zero and 150 kg ha^{-1} N fertilizer, respectively. Regarding the main effect of the hybrids on DNPM, BHQPY545 was the earlier hybrid and shone was the delayed one with an average DNPM of 149.6 and 144.3, respectively.

Keywords: Maize hybrid, Nitrogen rate, phenology

INTRODUCTION

Maize is one among the world's leading crops hierarchic within the third position within the world cereal crop production once wheat and rice (FAO, 2018).Globally, it was known as "Queen" of cereals because it has the highest genetic yield potential among the cereals (www.syngenta.co.in/corn). Maize is a very important grain crop of the globe and it ranks third once wheat and rice in space basis and total production. In Ethiopia, maize is the major and staple food and one of the main sources of calorie in the major maize producing regions (Tolessa Debelle, 2001). Considering its importance in terms of wide adaptation, total production and productivity, maize has been hand-picked as one of the high priority crops to feed the increasing population of Ethiopia (Mosisa Worku, et al., 2001)

Past research, efforts in Ethiopia resulted in the development, release of open-pollinated, and hybrid varieties for different agro-ecologies of the country (Mosisa Worku & Habtamu Zeleke, 2009). However, the national average yield, 3387 kg ha-1 is still far below the world average 5.5 tons ha-1(CSA, 2016). The problems are attributed to low fertilizer management practice, the use of local varieties as well as poor insect pest management which causes the low productivity beside the inherent soil fertility reduction.

Therefore, fertilizer management is crucial for maize cultivation (Baral et al., 2015). Among the fertilizers, N is incredibly vital as a result of this component is chargeable for major activities for the expansion and development of maize crops (Jat et al., 2013). Nitrogen (N) could be a primary nutrient and contains a decisive role within the improvement of crop production (Szulc et al., 2016). Nitrogen plant food is universally accepted as an important plant nutrient and a significant yield deciding factor required for optimal maize production, as it is a nitro-positive crop (Adediran & Banjoko, 1995; Shanti et al., 1997). The response of maize plants to the appliance of N fertilizers varies from selection to variety, location to location, and also depends on the availability of the nutrients (Onasanya et al., 2009). Grain yield, days to flowering, plant height, ear height, kernel rows per ear, no. of kernels per row, ear length, and thousand-grain weight considerably affected because of growing seasons, the kinds of variety/hybrid used as well the rate of fertilizer application (Adhikari et al., 2016). This means that element fertilizers will affects varied physiological and organic chemistry processes in plant cells and, ultimately, affects growth and development (Brady, 1990). In Jimma and surrounding area maize is also one of the stable crops cultivated in the area. However, the knowledge connected the maturity in addition as completely different phenological parameters of various maize hybrids in response to different rate of fertilizer was scanty even though different research has been conducted on maize in the study area.

Therefore, the current experiment was conducted having the following objectives:

- To evaluate the effect of different nitrogen fertilizer rates on phenological parameters of maize hybrids
- To investigate the interaction effect of maize hybrids and nitrogen fertilizer rates on phenological parameters

MATERIALS AND METHODS

Description of Study Area

The study was conducted in Jimma Agricultural Research Center (JARC) under irrigated condition in 2016/17. The Center was one of Ethiopian Institute of Agricultural Research Center (EIAR) located in Manna woreda,Jimma zone, Oromia Region. It was placed at 365 kilometer south west of Addis Ababa associate degreed has an altitude of 1753 m a.s.l. The area has maximum and minimum temperature of 28 0c and 9 0c respectively. The climate is humid tropical with bimodal rainfall, ranging from 1200 to 2800 mm (JARC, 2016). In traditional years, the time of year extends from Feb to early Gregorian calendar month. The dominant soil type of the study area is dominated and characterized as Cambsol and Nitsol, respectively (FAO, 1994). Maize (Zea mays L.), Tef (Eragrostis tef), Sorghum (Sorghum bicolor), Coffee (Coffea arabica), and Enset(Enset ventricosum) are the most important crop dominantly growing in the study area.

Soil Physico-Chemical Properties of Study Area

Selected physical and chemical properties of the soil were analyzed from the surface composite soil sample (0-30 cm) taken from the experimental field before planting as indicated in Table 1.The soil in study space has apH value of 5.53, which is moderately acidic. According to FAO (2008) classification, the soilpH categorized asextremely acidic if soils fall below 4.6, strongly acid if pH ranges between 4.6-5.5 and moderately acidic i f pH is between 5.6 - 6.5. Organic matter content of soil in the study area was 6.11 %.According to Berhanu Debele (1980) the organic matter content of the soil was high.Berhanu Debele (1980) classified soils with > 5.20, 2.6-5.2, 0.8-2.6 and < 0.8% organic matter contentas high, medium, low and very low, severally.

Total Nitrogen of soil in study area was found to be 0.24%, which is classified as moderate according to Tekaligne (1991).

Table-1: Selected physical and chemical property of soil in study area

Soil property Particle size distribution	Value	Rating	Method of analysis	Reference
Silt (%) Clay (%) Sand (%)	14.9 47.4 37.7		Bouyoucos hydrometer	Day, (1965)
Textural classification	Clay	Suitable		
pH (1:2) H_2O	5.53	Moderate	Soil/water	Page, (1982)
Available Phosphorus mg P kg^{-1}soil	10.67	Medium	Olsen	Olsen *et al.* (1954)
CEC (cmol (+) Kg^{-1}	24.8	High	Ammonium - Acetate	Jackson, (1973).

Total Nitrogen (%)	0.24	Deficient	Kjeldhal	Jackson, (1967).
Exchangeable Potassium (cmol (+) kg^{-1}	1.96	High	Flame photometry	Snyder,*et al.*(1939)
Organic matter (%)	6.11	Medium	Walkey and Black	Walkley and Black (1954)

CEC= Cation Exchange Capacity

Exchangeable Potassium was 1.96 (cmol (+) kg-1soil which is considered as high. According to the classification of Metson, (1961), 0 – 0.1, 0.1 – 0.3, 0.3 – 0.7, 0.7 – 2.0, >2 which are categorized as very low, low, moderate, high, and very high respectively. Available Phosphorus was 10.67 mg P kg-1soil that's medium P content. According to Olsen et al. (1954) P rating (mg kg-1 soil), P content of < 3 is very low, 4 to 7 is low, 8 to 11 is medium, and > 11 is high. The cation exchange capacity of soil in study area was 25.2 cmol (+)kg-1 which is high CEC. According to Landon (1991) classification CEC of <6, 6-12, 12-25, 25-40, >40 cmol (+)/kg very low, low, moderate, high and very high. In addition, soil texture of study space was 14.9% silt, 47.4% clay, and 37.7%, which is classified under textural class of clay.

Experimental Materials

The foremost necessary experimental material that was used throughout the experiment is two-quality macromolecule maize (BHQPY545 and MH138Q) and one conventional hybrid (shone) that is widely used by farmers in study area.BHQPY545 was released in 2008 by Bakko Agricultural Research Center and adapted to an altitude of 1000-1800 m a.s.l. Its yield potential was 8.0-9.5 and 5.5-6.5 t/ha on research station and farmers field respectively. MH138Q was released by Melkasa Agricultural Research Center in 2012 and adapted to an altitude of 1000-1800 m a.s.l. Its yield potential was 7.5-8.0 and 5.5-6.5 t/ha on analysis station and farmers field, severally (Adefris Teklewoldet al., 2015). Urea (46% N) and triple super phosphate (20% P205) were used as sources of N and P, respectively.

Treatments and Experimental Design

The experiment have four nitrogen level (0 50, 100 and 150 kgha-1designated as N0, N50, N100, and N150and three maize Hybrid, BHQPY545, MH138Q and shone (PHB39G19) designated as H1, H2, and H3, respectively. The experiment was laid in a randomized complete block design (RCBD) double foldedin a 3 by 4 factorial arrangement with three replications. The gross size of each plot was 4m x 3.75m which has gross area of 15 m2 and net area of (3m x 3m)9m2 with total six rows of plants and among that, four was central rows from which important information were collected.. Spacing between blocks and plots was1.5 m each. The spacing between rows and plants were 75 cm and 25cm, respectively.

Treatment Combination

Table-2: Treatment combination between nitrogen fertilizer rate and maize hybrids

No	Possible Treatment Combination	Treatment Description
1	N_0H_1	0 $Kgha^{-1}$Nitrogen fertilizer and BHQPY545variety.
2	$N_{50}H_1$	50 Kg ha^{-1}Nitrogen fertilizer and BHQPY545variety.
3	$N_{100}H_1$	100 Kg ha^{-1} Nitrogen fertilizer and BHQPY545 variety.
4	$N_{150}H_1$	150 Kg ha^{-1}Nitrogen fertilizer andBHQPY545 variety.
5	N_0H_2	0Kg ha^{-1}Nitrogen fertilizer and MH138Q variety.
6	$N_{50}H_2$	50 Kg ha^{-1}Nitrogen fertilizer and MH138Q variety.
7	$N_{100}H_2$	100 Kg ha^{-1}Nitrogenfertilizer and MH138Q variety.
8	$N_{150}H_2$	150 Kg ha^{-1}Nitrogen fertilizer and MH138Q variety.
9	N_0H_3	0 Kg ha^{-1}Nitrogen fertilizer and Shone variety.
10	$N_{50}H_3$	50 Kg ha^{-1}Nitrogen fertilizer and Shonevariety.
11	$N_{100}H_3$	100 Kg ha^{-1}Nitrogen fertilizer and Shone variety.
12	$N_{150}H_3$	150 Kg ha^{-1}Nitrogen fertilizer and Shone variety.

N=Nitrogen fertilizer and H= Hybrid variety

Experimental Area Management

The experimental site was oxen ploughed and left for 7 days exposed to the sun, then second and third plough was also done by oxen then crushed by man power and any trash was cleared from an area, and leveled out to maintain a well leveled seed bed and then followed by ridge preparation between rows. Individual plot size was 3.75 × 4 m consisting of six ridges and then plots was grouped to six blocks each with six plots. The planting was performed on

February3, 2017 and harvested on July 15, 2017. Sowing was done manually on the ridge, two seeds of maize per hill was planted to ensure uniform emergence of seed at75 cm spacing between row and 25 cm between plants and later thinned to one plant to maintain maximum population limit. The plots were irrigated immediately after sowing and thereafter at intervals of 7 day and twice a week during flower initiation and silk formation.

The application of nitrogen fertilizer was in three-splits in accordance to the treatment rate.i.e. At time of planting, knee height and booting stage due to high evaporation capacity and leaching capacity of nitrogen fertilizer under irrigated agriculture and phosphorus at rate of 69 Kg ha-1. Plot was then hand weeded as much as needed until crop was fully matured and all the data is completed.

Crop Data Collection and Measurements

Phenological Parameters

Date to 50% emergence (DFE): This was recorded from time after planting when 50% of plant appear above ground from each plot.

Days to 50% tasseling (DFT): This was recorded as range of days from planting once 50% of the plants in every internet plot made tassel.

Days to 50% silking (DFS): This was recorded as range of days from planting to once 50% of the plants in every internet plot started shedding spore

Days to 90% maturity (DNPM): This was recorded as number of days from planting to when 90% of the plants in each net plot formed black layer at the point where the kernel is attached to the ear.

Statistical Data Analysis

Data were subjected to analysis of variance using general linear model (GLM) procedures of SAS 9.1.3 (SAS Institute, 2003). The variations between treatment means that was compared mistreatment least vital distinction (LSD) test at 5% level of significance when the ANOVA showed the presence of significant difference.

RESULTS AND DISCUSSIONS

Days to 50% Emergence (DFE)

The analysis of variance for DFE indicated the presence of highly significant difference due to the main effect of variety ($p<0.05$) on DFE. However, the main effect of nitrogen fertilizer rate and the interaction effect of nitrogen and hybrids were not significant.

Accordingly, the minimum DFE (9.8) was recorded from the hybrid BHQPY545 and the maximum (11.0) days were recorded from the hybrid Shone (Table 3).The difference in DFE among maize varieties might be attributed to the inherent genotypic difference in the stored food in endosperm of maize cultivar, which can influence germination speed of hybrid and their performance under the climatic condition and edaphic factor of study area.

Table-3: Main effect of maize hybrids on days to 50% emergence (DFE) under irrigated condition

Hybrids	**DFE**
BHQPY545	9.8[c]
MH138Q	10.3[a]
Shone	11.0[b]
LSD	**0.44**
CV (%)	**5.02**

Means in columns followed by the same letters are not significantly different at 5% level of significance. DFE=Days to 50% Emergence, LSD=Least Significant Difference at 5% probability level, CV (%) =Coefficients of Variation in percent

In line with this finding of Shafi et al. (2012) reported a significant difference between maize genotypes on days to emergence. Similar finding was reported by Shaban, (2013) on the experiment carried to see effect of different seed priming on maize phenological parameter that showed the presence of significant difference among the maize genotype to emerge. Zahra et al. (2013) also carry out an experiment on three-sorghum genotype and they concluded that sorghum genotypes are different in days to germination due to genetic factor.

Days to 50% Tasseling (DFT)

The data analysis regarding the DFT reveal that presence ofhighly significant difference ($p<0.01$) due to main effect of nitrogen fertilizer rate. Neither the main effect of maize hybrids nor the interaction between nitrogen fertilizer rate and maize hybrids for DFT was found significant at $p<0.05$.

As to the fertilizer rate, significantly shortest DFT (79.8), was recorded from the control treatment (0 kg ha-1) while, the longest day (84.0) was from 150 kg ha-1nitrogen fertilizer application. However, there is no statistically significant difference nitrogen rate of 50 and 100 kg ha-1(Table 4). In general, there was an increase in DFT with the increased rate of nitrogen from 0kg ha-1 to 150 kg ha-1 by 5.0%. The delayed days to tasselling with corresponding increment in nitrogen rate application attributed to the fact that increase in nitrogen rate might have increased the rate of photosynthesis in the plant that resulted in the leaf durability and delayed phenological characteristics in the crop (Imran et al. (2015). In line with this finding, Jiban, (2013) found that plant receiving high dose of nitrogen remain non-senescence and succulent and so delayed days to anthesis.

Similar result was reported by Moges Asefa (2015) who reported an increment in maize phenological parameter including days to tasseling, silking, and maturity with increasing rate of nitrogen fertilizer application. However, the present result was not agreed with the finding Masresha Mitiku (2014) who reported plant receiving high dose of nitrogen the earlier to reach tasselling stage and vice versa.

Days to 50% Silking (DFS)

The data analysis on DFS revealed the presence of highly significant difference ($p<0.01$) resulted from the main effect of nitrogen fertilizer application. The main effect of hybrids and the interaction between nitrogen and the maize hybrids was not significant. Considering the different levels of nitrogen fertilizer application, significantly maximum DFS (88.4) days was obtained from the application of 150 kg ha-1 nitrogen fertilizer and the minimum (82.0) days was obtained from the control treatment (0 kg ha-1N). As for DFT an increase in nitrogen fertilizer rate from 50kg ha-1 to 100kg ha-1 did not resulted in a significant difference both for DFT and DFS. As nitrogen rate increases from 0 to 150 kg ha-1, there is an increase in days to form silk by 7.2%(Table 4).

The significant delay in DFS under increasing rate of nitrogen might relate to nitrogen fertilizer that promote vigorous vegetative growth and delayed productive stage of plant (Ewnetie Takele et al. 2017). Similarly, Gungula et al. (2003) concluded that increase in nitrogen rate might have effect on days to silking by promoting high rate of photosynthesis that resulted in the leaf longevity and delayed phenological characteristics in maize.

In agreement with this result, Kashif et al. (2016) reported that treatments with higher nitrogen levels took more number of days to silking. Furthermore, Shahzad et al. (2015) reported that increment in nitrogen level consistently delayed days to silking and recorded maximum number of days to silking (75.92) from plot receiving 210 kg N ha-1 and minimum numbers of days to silking (71.50) from the control treatment.

Table-4: Main effect of nitrogen fertilizer rate on maize days to 50% tasseling (DFT) and silking (DFS) under irrigated condition

Nitrogen rate (kg ha^{-1})	DFT	DFS
0	79.8^{c}	82.0^{c}
50	81.2^{b}	84.4^{b}
100	82.2^{b}	85.6^{b}
150	84.0^{a}	88.4^{a}
LSD	**1.28**	**1.4**
CV (%)	**1.60**	**1.69**

Means in columns followed by the same letters are not significantly different at 5% level of significance. DFT=Days to 50% Tasselling, DFS= Days to 50% Silking, LSD=Least Significant Difference at 5% probability level, CV (%) =Coefficients of Variation in percent

Days to 90% Physiological Maturity (DNPM)

DNPMwasfound to be directlyrelated to DFT and DFS. The analysis of variance ($p<0.05$) indicated the presence of highly significant difference with regard to DNPM both for the main effect nitrogen fertilizer and maize hybrids at $p<0.01$. However, the interaction effect between nitrogen fertilizer rates and maize hybrids was found insignificant.

The minimum (140.0) and the maximum (153.9) DNPM were recorded from the application of zeroand 150 kg ha-1 N fertilizer, respectively. The DNPM in response to 50 and 100 kg ha-1nitrogen fertilizer rates was at par (Table 5). It

was observed that DNPM was shorter at nil and prolonged at nitrogen rate of 150 kg ha-1.An increase the application of N fertilizer from zero to150 kg ha-1delayed days to physiological maturity by 9%.

The delayed DNPM on low N fertilizer receiving treatments could be related to stunt and short leaved growth of leaf senescence. In the same way, application of high dose nitrogen delayed leaf senescence, sustained leaf photosynthesis during active crop growth stage and extended the duration of vegetative growth. This clearly indicated that ever increasing nitrogen levels had momentous effect on growth, development, and yield parameters (Amanullah et al., 2009).In agreement with the result of Akbar et al. (2002) found that more number of days to tasseling, silking, and maturity and longer plant height at the highest level of nitrogen fertilizer application.

Table-5: Main effect of nitrogen fertilizer rate and maize hybrids on maize days to 90% physiological maturity (DNPM) under irrigated condition

Nitrogen rate (kg ha^{-1})	DNPM
0	140.0^{c}
50	144.8^{b}
100	147.0^{b}
150	153.9^{a}
LSD	**2.8**
Hybrids	
BHQPY545	144.3^{b}
MH138Q	145.4^{b}
Shone	149.6^{a}
LSD	**2.4**
CV (%)	**1.96**

Means in columns followed by the same letters are not significantly different at 5% level of significance. DNPM = Days to 90% Physiological Maturity LSD =Least Significant Difference at 5% probability level, CV (%) =Coefficients of Variation in percent

Hafizet al. (2012) and Akmalet al. (2010) also observed that maize plant treated with higher level of nitrogen took maximum days for tasseling, reached late to silking and physiological maturity as compared to the control. Similar result was also reported by Kidist Abera(2013) increased nitrogen rate delayed days to physiological maturity in maize.

With regard to the main effect of the hybrids on DNPM, the analysis variance reveal that hybrids BHQPY545 was the earlier hybrid and Shone was the delayed one with an average DNPM of 149.6 and 144.3, respectively. BHQPY545 and MH138Q was statistically at par and they was significantly lower on DNPM compared to the conventional hybrid, Shone (Table 5). The difference in maize hybrid with regards to their DNPM, might related to the inherent genetic difference among different maize genotype (Khan 2016). Similarly, Abeba Woilamo(2012) and Raouf et al. (2009) concluded that maize genotypes had different time duration to reach at maturity.

SUMMARY AND CONCLUSION

Fertilizer management supplemented with the right crop variety has significant impact in increasing the productivity of crops. Among the important fertilizers, Nitrogen (N) is a primary nutrient and has a decisive role in the improvement of crop production. It is yield limiting macro- nutrient, which is needed by the plant to complete their life cycle. It means that nitrogen has significant effect on phenology of crops.

Therefore, the present study was undertaken in order to evaluate effect of varied rate of nitrogen fertilizer application on phenological parameters of maize (zea mays L.) hybrids the case of Jimma zone, south western Ethiopia. A factorial combination of consisting of four nitrogen fertilizer rate 0, 50, 100 and 150 kg ha-1 and three maize hybrids one conventional hybrid maize widely used by farmer in the study area, Shone and two quality protein maize hybrids,BHQPY545 and MH138Q were tested under randomized complete block design (RCBD) in 2017.

The result has indicated that result main effect of hybrids was highly significant ($p<0.01$) on days to 50% emergence, as well as both main effect of maize hybrids and N - rate was significant ($p<0.05$) on days to 90% maturity, only main effect days to 50% tasseling and 50% silking. Regarding the DFE, minimum (9.8) was recorded from the hybrid BHQPY545 and the maximum (11.0) days were recorded from the hybrid Shone. Likewise, significantly shortest DFT (79.8), was recorded from the control treatment (0 kg ha-1) while, the longest day (84.0) was from 150 kg ha-1nitrogen

fertilizer application. On the other hand significantly maximum DFS (88.4) days was obtained from the application of 150 kg ha-1 nitrogen fertilizer and the minimum (82.0) days was obtained from the control treatment (0 kg ha-1N). The minimum (140.0) and the maximum (153.9) DNPM were recorded from the application of zero and 150 kg ha-1 N fertilizer, respectively. Regarding the main effect of the hybrids on DNPM, BHQPY545 was the earlier hybrid and shone was the delayed one with the average DNPM of 149.6 and 144.3, respectively. For further confirmation the current result, it is important to conduct the experiment involving the current research material under the current situation for multi season and year since the current research is a single year with the single location.

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