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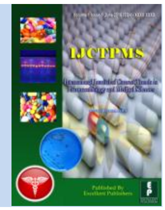

Original Research Article

Effect of Nitrogen Level and Source Management on Phenology and Growth of Maize Genotypes

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Abstract

Effect of nitrogen level and source management on phenology and growth of maize genotypes was studied at Agronomy Research Farm, The University of agriculture Peshawar Khyber Pakhtunkhwa Pakistan. Main objective of the study was to find out the effect of various N levels (0, 80, 120, 160 and 200 kg ha^{-1}) obtained from various chemical nitrogenous fertilizers (Urea and Calcium Ammonium Nitrate) on the agronomic performance of various maize genotypes (Jalal, Azam, Iqbal and Kiramat). The experiment was laid out in RCB design with split plot arrangement using three replications. Sub plot size of 4.2m × 3m (12.6m^2), having 6 rows, 3m long and 70cm apart were used. Combinations of different N levels and N sources were allotted to main plots while genotypes were assigned to subplots. Uniform basal dose of 60 kg ha^{-1} SSP and SOP each were applied to the soil at sowing. Nitrogen was applied in three splits i.e. 1/3 rd each at sowing, 1st irrigation after emergence and at knee height stage of the plants. Significant differences were observed among various genotypes and various N levels, however, N sources were found not significantly different from each other in various agronomic parameters. Results obtained showed that higher levels of N application delayed phenology and increased growth of maize genotypes. It was observed that higher nitrogen levels of 160 and 200 kg N ha^{-1} enhanced leaf area $plant^{-1}$ (3194 cm^2), increased plant height (188.08 cm) and biological yield (11043 kg ha^{-1}). Higher level of N on other hand delayed tasseling (55 days), silking (58 days) and physiological maturity (98 days). Kiramat took significantly higher days to emergence (8 days) tasseling (55 days), silking (59 days) and physiological maturity (96 days), produced maximum leaf area (3120 cm^2). It produced higher and at par values for biological yield (10697 and 10307 kg ha^{-1}) with Jalal. Jalal attained maximum and at par (185.79, 184.63 and 182.83 cm) plant height with Iqbal and Azam.

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Introduction

Nitrogen plays a very important role in crop productivity (Zapata and Cleenput, 1986) and its deficiency is one of the major yield limiting factors for cereal production (Shah et al., 2003). To maintain soil fertility and to realize our food requirement, the increase of fertilizer input should not be avoided (Nisar, 2002). Maize yield is most sensitive to nitrogen application (Mohamed, 1993). Improper nitrogen management is a major factor contributing to low yield. Plant absorbs most of its nitrogen in the NH_4^+ and NO_3^- forms. Nitrate (NO_3^-) is often the dominant source of nitrogen since it generally occurs in higher concentration than NH_4^+ (Tisdale et al., 1985). The rate of NO_3^- uptake is usually high and it occurs by active absorption. NO_3^- uptake is favored by low pH conditions. NH_4^+, ideally, is the preferred nitrogen source since energy is saved when it is used instead of NO_3^- for synthesis of protein. NO_3^- must be reduced before it can be incorporated into protein. Also, NH_4^+ is less subject to losses from soil by leaching and denitrification. Plant uptake of NH_4^+ proceeds best at natural pH values and is depressed by increasing acidity (Tisdale et al., 1985). A comparison of apparent crop recovery of applied N indicated that calcium ammonium nitrate $Ca(NH_4)_2NO_3$ generally referred to as CAN, was a more effective N source than urea under sub humid conditions but urea $[CO(NH_2)_2]$ was more effective under humid conditions (Arora et al., 1986). However, compared with other N fertilizers the efficiency of urea is relatively low because of potential losses due to ammonia volatilization and nitrogen leaching (Rochette et al., 2009).

Increase in the amount of urea application than recommended doses increases the nitrogen losses through volatilization and this loss was observed at the rate of 0.11 % in the silty loam having organic matter of 0.3% (Fu et al., 2010). Nitrogen (N) is lost from the field through three principal pathways: denitrification, leaching and surface volatilization. The nitrate ($NO3^-$) nitrogen is available immediately after its application. It is immediately absorbed in water and is taken up directly by the plant and nutrient losses are almost eliminated. CAN is a hygroscopic product and needs very low moisture to be absorbed by the plants. It is equally effective in water stressed areas where soil has low moisture. Furthermore, Calcium available in CAN is also helpful in soil reclamation (Tisdale et al., 1985).

Studies on the effect of proper combination of N sources and N levels on maize genotypes in the agro-ecological climatic conditions of Peshawar valley of KP are limited. The present research work was therefore conducted to investigate the effects of proper combinations of various N sources and N levels on the agronomic performance of popular maize genotypes including a local maize hybrid and three synthetic varieties in the agro-climatic conditions of Peshawar valley.

Materials and methods

Effect of various nitrogen levels and sources on phenology and growth of various maize (*Zea mays* L.) genotypes was studied in a field experiment conducted at Agronomy Research Farm, The University of agriculture Peshawar Khyber Pakhtunkhwa Pakistan during summer 2009. During the experiment the effects of various nitrogen levels obtained from different nitrogen sources on growth and yield of maize synthetic varieties (Jalal, Azam and Iqbal) and a hybrid (Kiramat) were studied. Sowing was done on July 10, 2009. Five N levels including control i.e., 0, 80, 120, 160 and 200 kg ha^{-1} obtained from two commercial nitrogenous fertilizer sources i.e. Urea $[CO(NH_2)_2]$ having 46% nitrogen and Calcium Ammonium Nitrate $Ca(NH_4)_2NO_3$ having 26% nitrogen were used. The experiment was conducted in RCB design with split plot arrangement using three replications. Combinations of nitrogen levels and sources were allotted to main plots while maize genotypes were assigned to sub plots. A sub plot size of 4.2m x 3m (12.6m^2), having 6 rows, 3m long and 70cm apart was used. A uniform basal dose of 60 kg ha^{-1} P_2O_5 as SSP (18% P_2O_5) and 60 kg ha^{-1} K_2O as SOP (50% K_2O) were applied and mixed with the soil during seed bed preparation. Nitrogen was applied in three splits i.e. 1/3 rd each at sowing, 1st irrigation after emergence and at knee height stage of the crop. All other agronomic practices like hoeing, irrigation and insecticide application were carried out uniformly. The experiment was harvested on October 22, 2009.

Data were recorded on the following parameters: Days to tasseling were recorded in central four rows in each sub plot. Days were counted from sowing when more then 50% plants developed their tassels. Similarly days to silking were also recorded in central four rows in each sub plot. Days were counted from sowing when more than 50% plants developed their silks. Days to physiological maturity were counted from the date of sowing to the date on which at least 50% plants developed black scar on their seeds hilum in each sub plot.

Leaf area of five randomly selected plants was measured with the help of leaf area measuring machine Li-3000A (Li-Cor, USA) and then average leaf area $plant^{-1}$ was calculated in cm^2. Plant height was recorded from the base of the plant to the tip of the tassel in randomly selected five plants in each sub plot from central four rows. Then average plant height was measured.

Biological yield was recorded by weighing all the plants harvested from central four rows in each subplot and then converted into kg ha^{-1} using the formula:

$$\text{Biological yield (kg ha}^{-1}) = \{\text{Biological yield (kg)}/\ 8.4\text{m}^2\} \times 10000$$

The data were analyzed statistically according to RCB design with split arrangement (Jan et al., 2009). Least significant difference (LSD) test was employed upon obtaining significant differences among various levels of the treatments and treatment interactions (Steel and Torrie, 1980).

Results and discussion

Days to 50% tasseling

Statistical analysis of the data showed that maize genotypes were significantly different ($p \le 0.01$) from each other in days to tasseling. The effect of N levels ($p \le 0.01$) and the interaction of N×S×G also affected days to tasseling significantly ($p \le 0.05$). However, the effects of N sources and the interactions of N×S, N×G and G×S on days to tasseling was found non significant (Table 1).

Table 1. Days to 50% tasseling and silking of various maize genotypes as affected by various nitrogen levels and sources.

Treatments		Days to 50% tasseling	Days to 50% Silking
Control vs. Rest	Control	47 b	50 b
	Rest	52 a	56 a
Nitrogen levels (N)	80	50 d	55 d
(kg ha^{-1})	120	51 c	56 c
	160	53 b	57 b
	200	55 a	58 a
LSD (0.05)		0.8142	0.8256
N Sources (S)	Urea	53	57
	CAN	52	56
LSD (0.05)		Ns	ns
Genotypes (G)	Jalal	53 b	58 b
	Azam	51 c	56 c
	Kiramat	55 a	59 a
	Iqbal	50 d	53 d
LSD (0.05)		7.198	0.7502
Interactions	N × S	ns	ns
	N × G	ns	ns
	S × G	ns	ns
	N × S × G	* (Fig 1)	ns

Mean values in the same category followed by different letters are significantly different from one another at 5% level of probability; * = significant at 5% level of probability, ns = non significant.

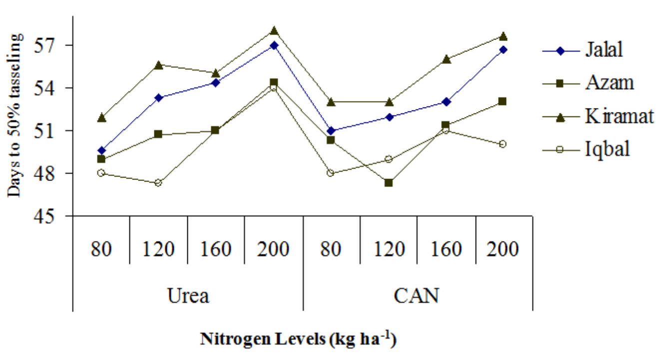

Fig. 1: Interaction of N × S × G for days to 50% tasseling of various maize genotypes as affected by different nitrogen levels and sources.

Among various maize genotypes, maximum number of 55 days to tasseling was taken by the hybrid Kiramat followed by the variety Jalal with 53 days to tasseling, while minimum number of 50 days to tasseling was taken by variety Iqbal. Generally days to tasseling increased with increase in N levels. The highest number of 55 days to tasseling was taken in plots fertilized with 200 kg ha^{-1}N followed by those plots fertilized with 160 kg ha^{-1} N which took 53 days while the lowest number of 50 days was taken in plots where 80 kg ha^{-1} N was applied. Our results were supported by Gokmen et al. (2001). They reported delay in both tasseling of maize with increase in nitrogen dose application and were of the view that increasing N levels increased vegetative growth due to which tasseling was delayed. Significant differences were observed in tasseling of various maize genotypes. It might be the genetic characteristic of the hybrid Kiramat to develop tassels late as compared with other varieties in the experiment. Similar results were also reported by Nasir (2000). Significant differences were also observed in days to tasseling of various maize genotypes in interaction with nitrogen and nitrogen sources. Kiramat showed significantly larger days to tasseling when 200 kg ha^{-1} N was applied to it from both N sources. It might be the genetic characteristic of the hybrid Kiramat to develop tassels and silks late with higher levels of nitrogen.

Days to 50% silking

Statistical analysis of the data showed that maize genotypes were significantly different from each other in days to silking ($p \leq 0.01$). The N levels ($p \leq 0.01$) affected days to silking significantly. However, the effects of N sources and interactions of N×G, N×S, S×G and N×S×G on days to silking was found non significant (Table 1). Among the maize genotypes, maximum number of 59 days to silking was taken by the hybrid Kiramat followed by Jalal with 58 days to silking, while minimum number of 53 days to silking was taken by variety Iqbal. Days to 50% silking were increased with increase in N levels. The highest number of 58 days to silking was taken in plots fertilized with 200 kg ha^{-1} N followed by plots fertilized with 160 kg ha^{-1} N (57 days) while the lowest number of 55 days was taken in plots where 80 kg ha^{-1} N was applied. Our results were supported by Gokmen et al. (2001). They reported delay in both silking of maize with increase in nitrogen dose application and were of the view that increasing N levels increased vegetative growth due to which silking was delayed. Significant differences were observed in silking of various maize genotypes. It might be the genetic characteristic of the hybrid Kiramat to develop silk late as compared with other varieties in the experiment. Similar results were also reported by Nasir (2000).

Days to physiological maturity

Statistical analysis of the data showed that maize genotypes were significantly different from each other in days to physiological maturity at ($p \leq 0.01$). N levels ($p \leq 0.01$) and the interaction of N levels and maize genotypes (N×G) also affected days to physiological maturity significantly ($p \leq 0.05$). However, the effect of N sources and interactions of N×S, S×G and N×S×G on days to physiological maturity was found non significant (Table 2).

Table 2. Physiological maturity and Plant height (cm) of various maize genotypes as affected by various nitrogen levels and sources.

Treatments		Days to Physiological maturity	Plant height (cm)
Control vs rest	Control	83 b	152.25 b
	Rest	89 a	182.40 a
Nitrogen levels (N)	80	86 d	175.29 b
(kg ha^{-1})	120	88 c	178.83 b
	160	90 b	187.92 a
	200	98 a	188.08 a
LSD (0.05)		1.241	7.198
N Sources (S)	Urea	88	183.00
	CAN	89	181.79
LSD (0.05)		Ns	ns
Genotypes (G)	Jalal	90 b	185.79 a
	Azam	86 c	182.83 a
	Kiramat	96 a	176.88 b
	Iqbal	84 d	184.63 a
LSD (0.05)		1.274	4.538
Interactions	N × S	ns	ns
	N × G	* (Fig. 2)	* (Fig. 3)
	S × G	ns	ns
	N × S × G	ns	* (Fig. 4)

Mean values in the same category followed by different letters are significantly different from one another at 5 % level of probability; * = significant at 5 % level of probability, ns = non significant.

Among the genotypes, maximum number of 94 days to physiological maturity was taken by hybrid Kiramat followed by Jalal with 90 days to maturity, while minimum number of 84 days to physiological maturity was taken by variety Iqbal The highest number of 91 days to physiological maturity was taken in plots fertilized with 200 kg ha^{-1}N followed by plots fertilized with 160 kg ha^{-1} N (90 days), while the lowest number of 86 days to maturity was taken in plots where 80 kg ha^{-1} N was applied. These finding are in accordance with Gradner et al. (1985). They reported that higher levels of nitrogen increased vegetative growth of plants due to which maturity was delayed. Significant differences were observed in the physiological maturity of various genotypes. It was observed that the hybrid Kiramat took significantly larger number of days to mature physiologically as compared with other varieties. It might be the genetic characteristic of the hybrid Kiramat to mature late (Turi et al., 2007; Nasir, 2000). Turi et al. (2007) and Nasir (2000) also reported significant differences in physiological maturity of various genotypes in interaction with nitrogen. Kiramat showed significantly larger days to maturity when 200 kg ha^{-1} N was applied to it. It might be the genetic characteristic of the hybrid Kiramat to mature late with higher level of nitrogen.

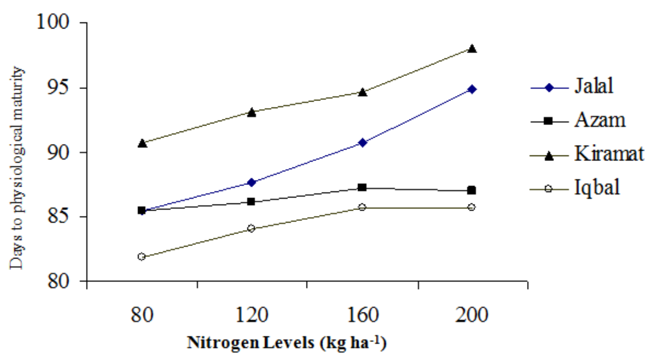

Fig. 2: Interaction of N × G for days to physiological maturity (PM) of various maize genotypes as affected by different nitrogen levels.

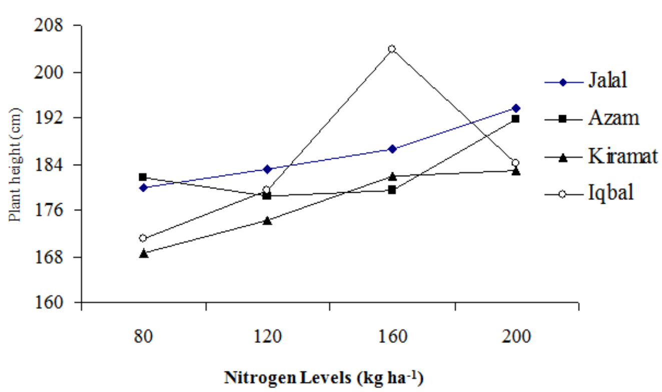

Fig. 3: Interaction of N×G for plant height (cm) of various maize genotypes as affected by different nitrogen levels.

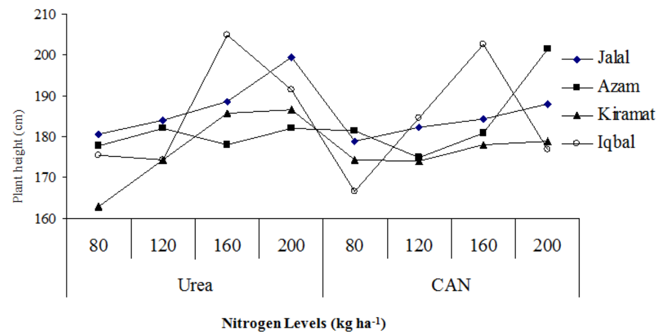

Fig. 4: Interaction of N×S×G for plant height (cm) of various maize genotypes as affected by different nitrogen levels and sources.

Plant height (cm)

Statistical analysis of the data showed that maize genotypes were significantly different from each other at $p \leq 0.01$. The N levels and the interaction of N×G affected plant height significantly ($p \leq 0.01$). The interaction of N×S×G affected plant height significantly at $p \leq 0.05$. However, the effect of N sources and the interactions of N×S and S×G on plant height was non significant (Table 2). Among maize genotypes, the largest plant height of 185.79 cm was produced by variety Jalal followed by varieties Iqbal and Azam with at par values of 184.63 and 182.83 cm, respectively. The smallest and significantly lower plant height of 176.88 cm was produced by the hybrid Kiramat. Generally plant height increased with increase in N levels. Maximum plant height of 188.08 cm was recorded in plots fertilized with 200 kg ha^{-1} N followed by plots fertilized with 160 kg ha^{-1} N which produced significantly at par value of 187.92 cm plant height, while the smallest plant height of 175.29 cm was produced in plots fertilized with 80 kg ha^{-1} N. It might be due to the sufficient nutrient availability to the plants to enhance their vegetative growth due to which plants attained height. Nunes et al. (1996) and Gokmen et al. (2001) also reported significant increase in plant heights of corn due to increase in nitrogen levels. Significant differences were observed among various maize genotypes for plant height. It might be due to its hereditary characteristics as reported for different genotypes which make them distinct to others (Turi et al., 2007). Significant differences were also observed for plant height of various maize genotypes in interaction with nitrogen levels and sources. Iqbal attained significantly higher plant height when 160 kg ha^{-1} N was applied. It might be the genetic characteristic of Iqbal to produce taller plants as compared with other genotypes used in the experiment.

Leaf area plant^{-1} (cm^2)

Statistical analysis of the data showed that maize genotypes were significantly different from each other in leaf area plant^{-1} at $p \leq 0.01$. N levels and the interaction of N levels and maize genotypes (N×G) also affected leaf area plant^{-1} significantly ($p \leq 0.01$). However, the effect of N sources and the interactions of N×S, S×G and N×S×G on leaf area plant^{-1} was found non significant (Table 3). Among maize genotypes, the largest leaf area plant^{-1} of 3120 cm^2 was produced by hybrid Kiramat followed by variety Jalal with 2837cm^2 leaf area plant^{-1}, while the smallest 2360 cm^2 leaf area plant^{-1} was produced by variety Iqbal. The largest leaf area plant^{-1} of 3194 cm^2 was produced in plots fertilized with 200 kg ha^{-1} N followed by plots fertilized with 160 kg ha^{-1} N which produced 3004 cm^2 leaf area plant^{-1}, while the smallest leaf area plant^{-1} of 2234 cm^2 was produced in plots where 80 kg ha^{-1} N was applied.

Leaf area plant^{-1}, which gives information regarding the light interception and photo-assimilates producing capability of the plant, was significantly affected by various nitrogen levels. It was observed that leaf area plant^{-1} was increased with increase in nitrogen levels. It might be due to the reason that under optimum amount of nutrients availability, plants utilize these nutrients to increase vegetative growth including plant height, number of leaves plant^{-1} and leaf area. Our findings are in agreement to those reported by Siam et al. (2008) and Mkhabela et al. (2003). Significant differences were observed for leaf area among various genotypes. It was observed that the hybrid Kiramat showed maximum leaf area plant^{-1} which might be due to its genetic characteristic to efficiently utilize nutrients and produce more vegetative growth. Significant differences were also observed for leaf area plant^{-1} of various maize genotypes in interaction with nitrogen levels. Kiramat showed larger and at par leaf area plant^{-1} with 160 and 200 kg ha^{-1} N which was not significantly different from the leaf area produced by Iqbal at 200 kg ha^{-1}. It might be the genetic characteristic of Kiramat and Iqbal to develop larger leaf area plant^{-1} to intercept more sunlight for more photosynthates production.

Table 3. Leaf area plant^{-1} (cm^2) and Biological yield (kg ha^{-1}) of various maize genotypes as affected by various nitrogen levels and sources.

Treatment		**Leaf area plant^{-1} (cm^2)**	**Biological yield (kg ha^{-1})**
Control vs rest	Control	1849 b	5382 b
	Rest	2740 a	9521 a
Nitrogen levels (N)	80	2234 c	8055 d
(kg ha^{-1})	120	2573 b	8987 c
	160	3004 a	10159 b
	200	3194 a	11043 a
LSD (0.05)		194.9	327.5
N Sources (S)	Urea	2717	9557
	CAN	2764	9485
LSD (0.05)		Ns	ns
Genotypes (G)	Jalal	2837 b	10307 a
	Azam	2689 b	9090 b
	Kiramat	3120 a	10697 a
	Iqbal	2360 c	8150 c
LSD (0.05)		148.5	404.2
Interactions	N × S	ns	ns
	N × G	** (Fig. 5)	**(Fig. 6)
	S × G	ns	ns
	N × S × G	ns	ns

Mean values in the same category followed by different letters are significantly different from one another at 5% level of probability; * = significant at 5% level of probability, ns = non significant; ** = significant at 1% level of probability.

Biological yield (kg ha^{-1})

Statistical analysis of the data showed that maize genotypes were significantly different from each other ($p \leq 0.01$) in biological yield. The effect of N levels and the interaction of N×G also affected biological yield significantly ($p \leq 0.01$). However, the effects of N sources and the interactions of N × S, G × S and N × S × G on biological yield was found non significant (Table 3). Maximum and at par biological yields of 10697 and

10307 kg ha^{-1} were recorded by the Kiramat and Jalal while minimum biological yield (8150 kg ha^{-1}) was recorded by Iqbal.

The highest biological yield of 11043 kg ha^{-1} was produced in plots applied with 200 kg ha^{-1} N while the lowest biological yield of 8055 kg ha^{-1} yield was produced in plots where 80 kg ha^{-1} N was applied. Maximum biological yield was recorded in plots fertilized with 160 and 200 kg N ha^{-1} while minimum biological yield was recorded in plots which were fertilized with low level of nitrogen. Similarly maximum and at par harvest indices were calculated for plots applied with 160 and 200 kg N ha^{-1}. Our results are supported by Gokmen et al. (2001), who reported increase in both biological yield and harvest index with increase in nitrogen application. It was also observed that the hybrid Kiramat and variety Jalal produced maximum and at par biological yields as compared with other genotypes. It might be the genetic characteristic of hybrid Kiramat and variety Jalal to produce higher biological yield.

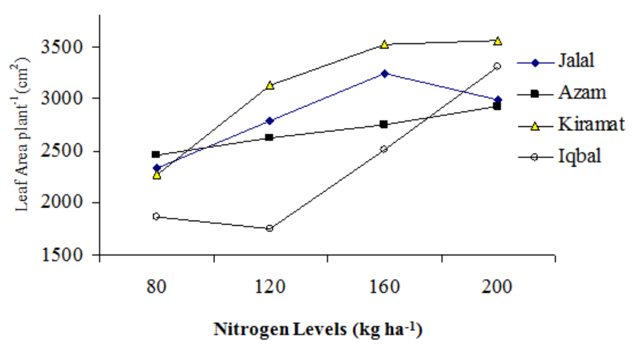

Fig. 5: Interaction of N×G for leaf area plant^{-1} (cm^2) of various maize genotypes as affected by different nitrogen levels.

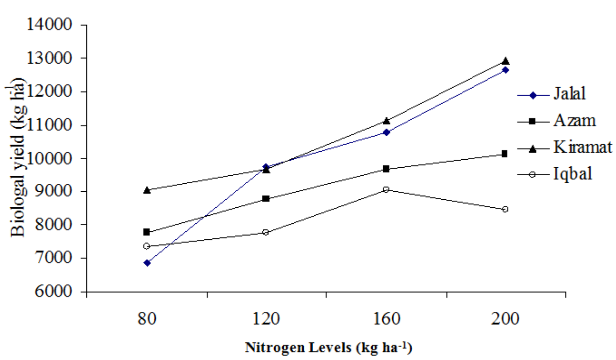

Fig. 6: Interaction of N×G for biological yield (kg ha^{-1}) of various maize genotypes as affected by different nitrogen levels.

Conflict of interest statement

Authors declare that they have no conflict of interest.

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