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Effect of Nitrogen Levels and Plant Population on Yield and Yield Components of Maize

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Abstract

Field experiment was conducted to study the effect of nitrogen levels and plant population on maize. Maximum number of days to tasseling (71), silking (76) and maturity (108) were recorded with the application of nitrogen at 210 kg ha^{-1}. Higher plant height (202 cm), leaf area plant^{-1} (2757 cm^2), leaf area index (2.16), ear length (18.0 cm), ear weight (150 g), grains ear^{-1} (548), thousand grain weight (258 g) and grain yield (2673 kg ha^{-1}) were recorded with application of 210 kg N ha^{-1} which was statistically similar to 180 and 150 kg N ha^{-1}. Higher biological yield (7189 kg ha^{-1}) was recorded from 150 kg N ha^{-1} which was similar to 210 kg N ha^{-1}. Plant population of 95000 plants ha^{-1} took more number of days to tasseling (70), silking (75) and maturity (107). Taller plants (197 cm) were measured for plant population of 95000 plants ha^{-1}. Maximum number of leaves plant^{-1} (10.45) was recorded for plant population of 80000 plants ha^{-1}. Higher leaf area plant^{-1} (2585 cm^2) and leaf area index (2.59) were recorded for 65000 plants ha^{-1} which was statistically at par with 80000 plants ha^{-1}. Higher ear length (17.71 cm), ear weight (145 g), grains ear^{-1} (515) and thousand grain weight (252 g) were recorded from 65000 plants ha^{-1} which was similar to 80000 plants ha^{-1}. Plant population of 95000 plants ha^{-1} produced maximum biological yield (7276 kg ha^{-1}) while plant population of 80000 plants ha^{-1} produced maximum grain yield (2551 kg ha^{-1}) and harvest index (35.95%). It is concluded from the study that application of 150 kg N ha^{-1} produced maximum grain yield and plant population of 80000 plants ha^{-1} produced higher grain yield.

Keywords: Nitrogen level; Plant population; Grain yield

Introduction

Maize is the most important cereal crop of the world after wheat and rice, growing everywhere in the irrigated as well as in rain-fed areas. Botanically, it is known as *Zea mays* L. and belongs to family Poaceae. It is an annual cross pollinated crop. Its stem or stalk is thick and strong. The stalk bears leaf at each node. The leaf consists of a sheath and a broad, large blade. The sheath covers the stem. The male or terminal inflorescence is called tassel. The female inflorescence is known as ear in the middle [1]. The internodes are straight and nearly cylindrical in the upper part of the plant, but alternatively grooved on the lower part [2]. In spite of high yielding potential of maize, its yield per unit area is very low in Pakistan as compared to advanced countries of the world. In Pakistan, maize was cultivated on an area of 1042.0 thousand hectares with the annual production of 3109.6 thousand tons with an average yield of 2984 kg ha^{-1}. In KP, it was grown on about 492.2 thousand ha with production of 782.4 thousand ton annually. The average yield of this crop was 1590 kg ha^{-1} [3]. Maize is grown as food as well as fodder crop and is the second most important crop after wheat in Khyber Pakhtunkhwa (KP). It is staple food of rural population in Pakistan. As a grain crop, maize is a rich source of food and it is also used on large scale in industries for manufacturing of corn oil, corn flakes and corn sugar [4]. Nitrogen fertilization plays significant role in improving soil fertility and increasing crop productivity. Nitrogen fertilization results in increased grain yield (43-68%) and biomass (25-42%) in maize [5]. Nitrogen fertilization increase corn yield when N supply by soil is low [6]. Chemical fertilizer application could not be avoided completely since they are the potential sources of high amount of nutrients in easily available forms and maize is more responsive to it [7]. An increase in yield of maize with increasing rate of nitrogen has been reported by many researchers [8] primarily due to its favorable effect on yield components of maize [9]. Plant population is another factor which affects the plant yield. Yield was increased by 4% with increasing plant density [10]. Higher plant population produce 25% more grain yield and 38% more biomass as compared with low plant population and early sown crop produce 19% more grain yield and 11% more biomass than late planted crop [11]. Keeping in view the importance of plant density and nitrogen fertilization, the study was conducted to find out optimum plant population and appropriate level of nitrogen for obtaining higher yield of maize.

Materials and Methods

A field experiment was conducted at New Developmental Farm, the University of Agriculture, Peshawar during spring 2014. The experiment was conducted in split pot randomized complete block design having four replications. The plot size of 3 m by 5 m (15 m^2) with row to row distance of 75 cm was used. For cultivation of maize crop field was ploughed two times using cultivator. Azam variety was sown at a higher seed rate of 60 kg ha^{-1} using drill. The required plant population i.e. 65000, 80000 and 95000 plants ha^{-1} was maintained by thinning after emergence. Number of plants per row was determined according to the respective plant population and then each row was thinned to achieve the respective plants per row (26 plants per row for 65,000 plants ha^{-1}, 32 plants per row for 80,000 plants ha^{-1}, 38 plants per row for 95,000 plants ha^{-1}). Nitrogen levels (0, 120, 150, 180 and 210 kg ha^{-1}) was applied in three split doses i.e. 1/3 at the time of sowing, 1/3 at knee height (5-6 leaf stage) and 1/3 at pre-tassling stages. Urea was used

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as source of N. Phosphorus was applied at the rate of 100 kg ha^{-1} before sowing. SSP was used as source of phosphorus. Weeds were removed through herbicides and hand howing. Irrigation was done through canal water as per crop water demand. Insecticide 'chloropirophide' was applied for controlling stem borer. All the other agronomic and cultural practices were done uniformly.

Statistical analysis

The data were statistically analyzed using analysis of variance technique appropriate for split plot randomized complete block design. Means were compared using LSD test at 0.05 level of probability, if the F-values are significant [12].

Results

Emergence m^{-2}

Data regarding emergance^{-2} are presented in Table 1. Analysis of the data revealed that nitrogen levels and plant densities had non-significant effect on emergence m^{-2} of maize. Likewise, the nitrogen x plant density interaction was also non-significant.

Days to tasseling

Data regarding days to tasseling are reported in Table 2. Analysis of the data showed that nitrogen levels and plant densities had significant effect on days to tasseling of maize. However, interaction of nitrogen x plant density was non-significant. Mean values of the data showed that increasing nitrogen level consistently increased days to tasseling. Plots received 210 kg N ha^{-1} took higher numbers of days to tasseling (71) while control plots took lower numbers of days to tasseling (66). The data further revealed that higher plant density of 95000 plants ha^{-1} took more numbers of days to tasseling as compared to lower plant density of 65000 plants kg ha^{-1}.

Days to silking

Data regarding days to silking are given in Table 3. Analysis of the data revealed that nitrogen levels and plant densities significantly affected days to silking of maize. However, interaction of nitrogen x plant density was non-significant. Mean values of the data revealed that each increment in nitrogen level consistently delayed days to silking. Maximum number of days to silking (75.92) was recorded for 210 kg N ha^{-1} while control treatment took minimum numbers of days to silking (71.50). In case of planting densities, higher plant density of 95000 plants ha^{-1} took maximum numbers of days to silking (74.65). Minimum numbers of days to silking (72.80) was recorded for lower plant density of 65000 plants kg ha^{-1}.

Plant height (cm)

Data on plant height are given in Table 4. Statistical analysis of the data revealed that nitrogen levels and plant densities had significant effect on plant height of maize. However, interaction of nitrogen x plant density was non-significant. Application of nitrogen at the rate of 210 kg ha^{-1} produced taller plants (202 cm) which were statistically at par with 180 and 150 kg N ha^{-1}(201 and 198 cm, respectively). Minimum plant height (181 cm) was recorded from control plots. Similarly, higher planting density of 95000 plants ha^{-1} produced taller plants (197 cm) as compared to lower plant density of 65000 plants ha^{-1}.

Number of leaves plant^{-1}

Analysis of the data revealed nitrogen levels had non-significant effect on number of leaves plant^{-1} however planting density had significant effect on number of leaves plant^{-1} (Table 5). Interaction of N x PD was non-significant. Mean values of the data revealed maximum number of leaves plant^{-1} (10.45) was recorded for planting density of 80000 plants ha^{-1}. While minimum number of leaves plant^{-1} (10.20) was recorded for planting density of 65000 plants ha^{-1}.

Days to maturity

Data on days to maturity of maize are given Table 6. Analysis of data revealed that nitrogen levels and planting densities had significant effects on days to maturity of maize. Interaction was found non-

N-levels (kg ha^{-1})	Plant density (plants ha^{-1})			Mean
	65000	80000	95000	
0	139	131	65.5	112
40	128	136	145	137
50	136	146	133	139
60	70.0	146	72.0	96
70	142	141	119	135
Mean	123	140	107	

Table 1: Emergence m^{-2} of maize as affected by nitrogen levels and plant population.

N-levels (kg ha^{-1})	Plant density (plants ha^{-1})			Mean
	65000	80000	95000	
0	66	67	66	66 e
120	67	68	69	68d
150	68	69	70	69c
180	70	70	72	71b
210	71	71	72	71a
Mean	68c	69b	70a	

$LSD_{(0.05)}$ for Nirogen=0.5527; $LSD_{(0.05)}$ for Plant density=0.4281.
Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test.

Table 2: Days to tasseling of maize affected by nitrogen levels and plant population.

N-levels (kg ha^{-1})	Plant density (plants ha^{-1})			Mean
	65000	80000	95000	
0	70	71	72	71e
120	72	73	73	73d
150	72	74	75	74c
180	73	75	76	75b
210	76	75	76	76a
Mean	73c	74b	75a	

$LSD_{(0.05)}$ for Nitrogen=0.5478; $LSD_{(0.05)}$ for Plant density=0.4243.
Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test.

Table 3: Days to silking of maize as affected by nitrogen and plant population.

N-levels (kg ha^{-1})	Plant density (plants ha^{-1})			Mean
	65000	80000	95000	
0	102	103	104	103e
120	104	105	106	105d
150	104	106	107	106c
180	105	107	108	107b
210	108	107	108	108a
Mean	105c	106b	107a	

$LSD_{(0.05)}$ for Nitrogen=0.55; $LSD_{(0.05)}$ for Plant density=0.42.
Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test.

Table 4: Days to maturity of maize affected by nitrogen levels and plant population.

N-levels (kg ha^{-1})	Plant density (plants ha^{-1})			Mean
	65000	80000	95000	
0	176	186	183	182c
120	189	193	198	193b
150	199	195	201	198a
180	200	200	203	201a
210	200	202	204	202a
Mean	193b	195ab	198a	

$LSD_{(0.05)}$ for Nitrogen=3.337; $LSD_{(0.05)}$ for Plant density=2.585.
Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test.

Table 5: Plant height (cm) of maize as affected by nitrogen and plant population.

N-levels (kg ha^{-1})	Plant density (plants ha^{-1})			Mean
	65000	**80000**	**95000**	
0	10.05	10.50	10.50	10.35
120	10.20	10.00	10.00	10.07
150	10.25	9.75	10.25	10.08
180	10.00	11.75	10.00	10.58
210	10.50	10.25	10.50	10.42
Mean	10.20b	10.45a	10.25b	

$LSD_{(0.05)}$ for Plant density=0.29.
Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test.

Table 6: Number of leaves plant^{-1} of maize affected by nitrogen and plant population.

significant. Mean values of the data showed constant increase in days to maturity with each increment in nitrogen level. Maximum days to maturity were taken by nitrogen level of 210 kg ha^{-1} followed by nitrogen level of 180 and 150 kg ha^{-1} with days to maturity of 106 and 105, respectively. Minimum days to maturity were recorded in control treatment. Maturity delayed with increasing plant density. The highest planting density of 95000 plants ha^{-1} took more days to maturity (107) while minimum days to maturity (105) were observed in planting density of 65000 plants ha^{-1}.

Leaf area plant^{-1}

Data on leaf area plant^{-1} are presented in Table 7. Nitrogen levels and planting densities significantly affected leaf area plant^{-1}. However, interaction of nitrogen x plant density was non-significant. Maximum leaf area plant^{-1} (2757 cm^2) was recorded with application of nitrogen at the rate of 210 kg ha^{-1} which is statistically at par with 180 and 150 kg N ha^{-1} with leaf area of 2523 and 2544 cm^2, respectively. Likewise, leaf area decreased with increasing plant density. Higher leaf area plant^{-1} (2585 cm^2) was recorded for 65000 plants ha^{-1}. Minimum leaf area plant^{-1} (2316 cm^2) was recorded from planting density of 95000 plants ha^{-1}.

Leaf area index

Data on leaf area index (LAI) of maize are presented in Table 8. Nitrogen levels and planting densities had significant effects on leaf area index. However, interaction of nitrogen x plant density was non-significant. Mean values of data revealed that application of nitrogen at the rate of 210 kg ha^{-1} produced maximum leaf area index (2.76) which is statistically at par with 180 and 150 kg N ha^{-1} with the LAI of 2.52 and 2.54, respectively. Lower planting density (65000 plants ha^{-1}) produced maximum LAI (2.59) and minimum LAI (2.32) was recorded from higher plant density 95000 plants ha^{-1}.

Ear length (cm)

Data on ear length of maize are shown in Table 9. Statistical analysis of the data showed that nitrogen levels and planting densities had significant effects on ear length of maize. However, interaction of nitrogen x plant density was non-significant. Higher ear length (18.20 cm) was recorded from 180 kg N ha^{-1} which is statistically at par with 210 and 150 kg N ha^{-1} with the ear length of 17.28 cm and 17.09 cm, respectively. In case of planting densities, maximum ear length (17.71 cm) was recorded from lower plant density (65000 plants ha^{-1}) which is at par with higher plant density of 95000 plants ha^{-1}. Minimum ear length (16.84 cm) was recorded from 80000 plants ha^{-1}.

Ear weight (g)

Data regarding ear weight of maize as affected by nitrogen and plant densities are showed in Table 10. Analysis of the data showed significant effect of nitrogen levels and planting densities on ear weight. However, interaction of nitrogen x plant density was non-significant. Mean values of the data revealed that higher ear weight (150 g) was recorded from the treatment of nitrogen at the rate of 210 kg ha^{-1} which is statistically at par with 180 and 150 kg N ha^{-1} with the ear weight of 148 and 138 g, respectively. Similarly, maximum ear weight (145 g) was recorded from lower plant density which is statistically at par with

N-levels (kg ha^{-1})	Plant density (plants ha^{-1})			Mean
	65000	**80000**	**95000**	
0	2112	1943	1865	1973c
120	2410	2409	2550	2456b
150	2561	2716	2355	2544ab
180	2787	2505	2277	2523ab
210	3055	2683	2532	2757a
Mean	2585a	2451ab	2316b	

$LSD_{(0.05)}$ for Nitrogen=199.78; $LSD_{(0.05)}$ for Plant density=154.75.
Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test.

Table 7: Leaf area plant^{-1} (cm^2) of maize as affected by nitrogen levels and plant population.

N-levels (kg ha^{-1})	Plant density (plants ha^{-1})			Mean
	65000	80000	95000	
0	2.11	1.94	1.87	1.97c
120	2.41	2.41	2.55	2.46b
150	2.56	2.72	2.36	2.54ab
180	2.79	2.51	2.28	2.52ab
210	3.06	2.68	2.53	2.76a
Mean	2.59a	2.45ab	2.32b	

$LSD_{(0.05)}$ for Nitrogen=0.1995; $LSD_{(0.05)}$ for Plant density=0.1546.
Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test.

Table 8: Leaf area index of maize as affected by nitrogen levels and plant population.

N-levels (kg ha^{-1})	Plant density (plants ha^{-1})			Mean
	65000	80000	95000	
0	16.5	16.6	17.1	16.7b
120	16.3	16.5	17.6	16.8b
150	17.8	16.9	16.5	17.0ab
180	19.4	17.2	17.9	18.2a
210	18.4	16.7	16.6	17.2ab
Mean	17.7a	16.8b	17.1ab	

$LSD_{(0.05)}$ for Nitrogen=0.8637; $LSD_{(0.05)}$ for Plant density=0.6690.
Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test.

Table 9: Ear length (cm) of maize as affected by nitrogen and plant population.

N-levels (kg ha^{-1})	Plant density (plants ha^{-1})			Mean
	65000	80000	95000	
0	130	121	116	123c
120	135	130	131	132bc
150	144	138	133	139ab
180	158	143	143	148a
210	158	149	143	150a
Mean	145a	136ab	133b	

$LSD_{(0.05)}$ for Nitrogen=10.912; $LSD_{(0.05)}$ for Plant density=8.4526.
Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test.

Table 10: Ear weight (g) of maize affected by nitrogen levels and plant population.

80000 plants ha^{-1} with the ear weight of 136 g. Minimum ear weight (133 g) was recorded from higher plant density (95000 plants ha^{-1}).

Number of plants at harvest ha^{-1}

The effect of nitrogen and plant population on plant at harvest ha-1 is reported in Table 11. The effect of N had non-significant while plant population had significantly affected plants at harvest. Its interaction was also non-significant. Highest number of (92984) plant ha^{-1} were observed at 95000 plant population fallowed by 77037 plant ha^{-1} at 80000 plant population while lowest number of (59986) plant ha^{-1} was observed at 65000 plant population.

Grains ear^{-1}

Grains ear^{-1} of maize as affected by nitrogen and plant densities are presented in Table 12. Statistical analysis of the data showed that nitrogen levels and plant densities had significant influence on grains ear^{-1} of maize. However, interaction of nitrogen x plant density was non-significant. Maximum grains ear^{-1} (548) was recorded from nitrogen application at the rate of 210 kg ha^{-1} which is at par with 180 kg N ha^{-1} with 531 grains ear^{-1}, respectively. Minimum grains ear^{-1} was recorded from control plots. In case of planting densities, maximum grains ear^{-1} (515) was recorded from lower plant density (65000 plants ha^{-1}) which is statistically at par with 80000 plants ha^{-1} with 497 grains ear^{-1}. Minimum grains ear^{-1} (470) was recorded from 95000 plants ha^{-1}.

Thousand grain weight (g)

Data on thousand grain weight of maize as affected by nitrogen and planting density are presented in Table 13. Analysis of the data revealed significant effect of nitrogen levels and planting density on thousand grain weight. Interaction of nitrogen and planting density was non-significant. Maximum thousand grain weight of 259 g was recorded from 210 kg N ha^{-1} which is statistically at par with 180 and 150 kg N ha^{-1} with thousand grain weights of 258 and 250 g, respectively. Thousand grain weights decreased with increasing planting density. Maximum thousand grain weight of 253 g was recorded from lowest plant density of 65000 plants ha^{-1} which is at par with 80000 plants ha^{-1} with thousand grain weight of 250 g. Minimum thousand grain weight of 242 g was recorded from the highest planting density of 95000 plants ha^{-1}.

Thousand grain weight (g)

Data on thousand grain weight of maize as affected by nitrogen and planting density are presented in Table 13. Analysis of the data revealed significant effect of nitrogen levels and planting density on thousand grain weight. Interaction of nitrogen and planting density was non-significant. Maximum thousand grain weight of 259 g was recorded from 210 kg N ha^{-1} which is statistically at par with 180 and 150 kg N ha^{-1} with thousand grain weights of 258 and 250 g, respectively. Thousand grain weights decreased with increasing planting density. Maximum thousand grain weight of 253 g was recorded from lowest plant density of 65000 plants ha^{-1} which is at par with 80000 plants ha^{-1} with thousand grain weight of 250 g. Minimum thousand grain weight of 242 g was recorded from the highest planting density of 95000 plants ha^{-1}.

Biological yield (kg ha^{-1})

Biological yield of maize as affected by nitrogen levels and planting density are given in Table 14. Statistical analysis of the data showed that nitrogen levels and planting density had significant effects on biological yield of maize. Interaction of nitrogen and planting density was significant. Mean values of the data revealed that application of nitrogen at the rate of 150 kg ha^{-1} produced maximum biological yield (7189 kg ha^{-1}) which is statistically at par with 120 and 210 kg N ha^{-1} with biological yields of 6517 and 7863 kg ha^{-1}, respectively. Minimum biological yield (5884 kg ha^{-1}) was recorded from control plots. Higher biological yield of 7276 kg ha^{-1} was recorded for planting

N-levels (kg ha^{-1})	Plant density (plants ha^{-1})			Mean
	65000	80000	95000	
0	60006	77007	93004	76672
120	60006	77006	93004	76672
150	59993	77244	92991	76743
180	60000	77001	92998	76667
210	59923	76924	92921	76590
Mean	59986 c	77037 b	92984 a	

$LSD_{(0.05)}$ for Plant density=84.34.
Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test.

Table 11: Number of plants at harvest ha^{-1}of maize as affected by nitrogen levels and plant population.

N-levels (kg ha^{-1})	Plant density (plants ha^{-1})			Mean
	65000	80000	95000	
0	448	439	411	433c
120	494	482	418	465bc
150	523	484	467	492b
180	545	528	519	531a
210	561	551	531	548a
Mean	515a	497ab	470b	

$LSD_{(0.05)}$ for Nitrogen=37.317; $LSD_{(0.05)}$ for Plant density=28.906.
Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test.

Table 12: Grains ear^{-1} of maize as affected by nitrogen levels and plant population.

N-levels (kg ha^{-1})	Plant density (plants ha^{-1})			Mean
	65000	80000	95000	
0	228	245	223	232c
120	253	222	253	243bc
150	247	260	242	250ab
180	267	258	250	258a
210	270	267	240	259a
Mean	253a	250a	242b	

$LSD_{(0.05)}$ for Nitrogen=9.0032; $LSD_{(0.05)}$ for Plant density=6.9739.
Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test.

Table 13: Thousand grain weight (g) of maize affected by nitrogen and plant population.

N-levels (kg ha^{-1})	Plant density (plants ha^{-1})			Mean
	65000	80000	95000	
0	5246	6070	6338	5884c
120	5370	6981	7200	6517ab
150	6949	7045	7572	7189a
180	6724	7154	7394	7091 b
210	7319	8392	7879	7863 ab
Mean	6321 b	7128 a	7276 a	

$LSD_{(0.05)}$ for Nitrogen=646.20; $LSD_{(0.05)}$ for Plant density=500.54.
Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test.

Table 14: Biological yield (kg ha^{-1}) of maize as affected by nitrogen levels and plant population.

density of 95000 plants ha^{-1} which is statistically at par with highest planting density of 80000 plants ha^{-1} with biological yield of 7128 kg ha^{-1}. Minimum biological yield of 6321 kg ha^{-1} was recorded for 65000 plants ha^{-1}.

Grain yield (kg ha^{-1})

Data on grain yield of maize as influenced by nitrogen levels and planting density are reported in Table 15. Nitrogen levels and planting density had significant effects on grain yield of maize. Interaction of nitrogen and planting densities was non-significant. Mean values of the data revealed that application of nitrogen at the rate of 210 kg ha^{-1} produced maximum grain yield of 2673 kg ha^{-1} which is statistically at par with 180 and 150 kg N ha^{-1} with grain yield of 2475 and 2461 kg ha^{-1}, respectively. Minimum grain yield of 1803 kg ha^{-1} was recorded in control plots. The plant density of 80000 plants ha^{-1} produced maximum grain yield of 2551 kg ha^{-1} while minimum grain yield of 2143 kg ha^{-1} was recorded from 95000 plants ha^{-1}.

Harvest index (%)

Data on harvest index of maize are presented in Table 16. Statistical analysis of the data showed that planting density had significant effects on harvest index of maize. Maximum harvest index (35.95%) was recorded from planting density of 80000 plants ha^{-1} which is at par with planting density of 65000 plants ha^{-1} with harvest index of 34.52%. Minimum harvest index (29.54%) was recorded from 95000 plants ha^{-1}.

Discussion

Influence of nitrogen levels and planting density was found non-significant for emergence^{-2} of maize. These results are in line with Le Gouis who reported that nitrogen had little or no effect on emergence m^{-2} [13]. Nitrogen and planting densities significantly affected days to tasseling of maize. Plots received 210 kg N ha^{-1} took higher numbers of days to tasseling in comparison to control plots. These results are in line with Amanullah et al. who stated that delay in days to tasseling was observed with increase in N rate and number of N splits [14]. The data further revealed that higher plant density of 95000 plants ha^{-1} took more numbers of days to tasseling as compared to lower plant density of 65000 plants kg ha^{-1}. Our results agreed with Shafi et al. who reported that higher plant population took more numbers of days to tasseling compared to optimum and lower plant population [15]. Influence of nitrogen levels and planting density significantly affected days to silking of maize. Maximum number of days to silking was recorded from the treatment of nitrogen at 210 kg ha^{-1} in comparison to control treatment. These results are consistent with the finding of Amanullah et al. who stated that increasing N application delay silking in maize [14]. In case of planting densities, higher plant density of 95000 plants ha^{-1} took more numbers of days to silking. Minimum numbers of days to silking was observed in lower plant density of 65000 plants kg ha^{-1}. These results are similar with Bhatt delayed silking were observed at more dense population as compare less dense population [16]. Nitrogen levels and planting densities had significant effect on days to maturity of maize. Maximum days to maturity were observed in the treatment of nitrogen at 210 kg ha^{-1} followed by treatment of nitrogen at 180 and 150 kg ha^{-1}. Shrestha observed delay maturity with increase in nitrogen rate because nitrogen delay vegetative growth and as a result delay maturity [17,18]. Minimum days to maturity were recorded in control treatment. The data further revealed that highest planting density of 95000 plant ha^{-1} took more number of days to maturity. Minimum days to maturity were observed in planting density of 65000 plants ha^{-1}. Our results are in line with Bhatt who stated that optimum plant population completes their life cycle earlier due to the enough water and nutrients availability [16].

Influence nitrogen levels and plant densities had significant effect on plant height of maize. Maximum plant height was recorded with the application of nitrogen at the rate of 210 kg ha^{-1}. Minimum plant height was recorded from control plots. These results agreed with Wajid et al. who investigated that higher nitrogen level influence plant height [18]. In case of planting density maximum plant height was recorded from 95000 plants ha^{-1} while minimum plant height was recorded from 65000 plants ha^{-1}. Our results are supported by Malaviarachchi et al. who reported higher plant height with increase in plant population [19]. The planting density had significant effect on number of leaves plant^{-1}. Maximum number of leaves plant^{-1} was recorded from planting density of 80000 plants ha^{-1}. Minimum number of leaves plant^{-1} was recorded from planting density of 65000 plants ha^{-1}. These results are in agreement with Zandi who observed highest number of leaves plant^{-1} at optimum planting density. The effect of nitrogen levels and planting densities had significant effect on leaf area index. Mean values of data revealed that application of nitrogen at the rate of 210 kg ha^{-1} produced

N-levels (kg ha^{-1})	Plant density (plants ha^{-1})			Mean
	65000	80000	95000	
0	1726	1929	1755	1803 c
120	1678	2467	2158	2101 b
150	2383	2917	2083	2461 a
180	2325	2675	2425	2475 a
210	2957	2767	2295	2673 a
Mean	2214 b	2551 a	2143 b	

$LSD_{(0.05)}$ for Nitrogen=335.31; $LSD_{(0.05)}$ for Plant density=259.73.
Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test.

Table 15: Grain yield (kg ha^{-1}) of maize as affected by nitrogen levels and plant population.

N-levels (kg ha^{-1})	Plant density (plants ha^{-1})			Mean
	65000	80000	95000	
0	32.90	32.11	27.72	30.91
120	30.86	36.06	30.14	32.35
150	33.87	41.36	27.59	34.27
180	34.35	37.33	32.93	34.87
210	40.64	32.89	29.32	34.28
Mean	34.52 a	35.95 a	29.54 b	

$LSD_{(0.05)}$ for Plant density=3.09.
Means of the same category followed by different letters are significantly different at 0.05 level of probability using LSD test.

Table 16: Harvest index (%) of maize as affected by nitrogen and plant population.

higher leaf area index which is statistically at par with 180 and 150 kg N ha^{-1} with the LAI of 2.52 and 2.54, respectively [20]. These results are similar with Jasemi et al. who reported that higher LAI associated with nitrogen treated plants have been probably due to increased leaf production and leaf area duration [21]. In case of plant density the lower planting density (65000 plants ha^{-1}) produced higher LAI. Lower LAI was recorded from higher plant density (95000 plants ha^{-1}). These results are similar with the finding of Maddoni et al. who stated that lower plant population got more nutrients and water compared to higher population and in turn increased growth and LAI [22]. It can be inferred from the data showed that nitrogen levels and planting densities had significant effect on ear length of maize. Maximum ear length was recorded from 180 kg N ha^{-1} which is statistically at par with 210 and 150 kg N ha^{-1} with the ear length of 17.28 cm and 17.09 cm, respectively. These results are similar with the results of Akram et al. who reported that cob length increases with increase in nitrogen level [23]. In case of planting densities, higher ear length was recorded from lower plant density (65000 plants ha^{-1}) which is at par with higher plant density of 95000 plants ha^{-1}. Minimum ear length was recorded from 80000 plants ha^{-1}. Similar results were also obtained by Khah et al. reported that ear length reduced with increasing plant population [24]. Influence of nitrogen levels and planting densities had significant effects on ear weight. Mean values of the data revealed that higher ear weight was recorded from the treatment of nitrogen at the rate of 210 kg ha^{-1} which is statistically at par with 180 and 150 kg N ha^{-1} with the ear weight of 148.06 and 138.52 g, respectively. These results are in line with Bhatt In case of planting density maximum ear weight was recorded from lower plant density which is statistically at par with 80000 plants ha^{-1} with the ear weight of 136.33 g [16]. Minimum ear weights was recorded from higher plant density (95000 plants ha^{-1}). Our results are supported by Hoshang who concluded that ear weight decreased with increasing plant population [25]. The effect of N had non-significant while plant population had significantly affected plants at harvest. Its interaction was also non-significant Highest number of (92984) plant ha^{-1} were observed at 95000 plant population fallowed by 77037 plant ha^{-1} at 80000 plant population while lowest number of (59986) plant ha^{-1} was observed at 65000 plant population. It may be the higher plants population having higher plant at harvest as compare to other plant population. Influence of nitrogen levels and plant densities had significant effects on grains ear^{-1} of maize. Higher grains ear^{-1} was recorded from the treatment of nitrogen at the rate of 210 kg ha^{-1} which is at par with 180 kg N ha^{-1} with 531 grains ear^{-1}. Lower grains ear^{-1} was recorded from control plots. These results are in line with Rizwan et al. who observed that number of grains per cob increased significantly with increasing nitrogen rates [26]. In case of planting densities, maximum grains ear^{-1} was recorded from lower plant density (65000 plants ha^{-1}) which is statistically at par with 80000 plants ha^{-1} with 497 grains ear^{-1}. Minimum grains ear^{-1} was recorded from 95000 plants ha^{-1}. These results are further endorsed by Abuzar et al. who reported that increase in plant population decreased grains ear^{-1} [27]. Thousand grain weight was significantly affected by nitrogen levels and planting density. Maximum thousand grain weight was recorded from 210 kg N ha^{-1} which is statistically at par with 180 and 150 kg N ha^{-1}. These results are in line with Arif et al. who reported maximum thousand grains weight (254.1 g) with 160 kg N ha^{-1} [28]. In case of planting densities, maximum thousand grain weight was recorded from lowest plant density of 65000 plants ha^{-1} which is at par with 80000 plants ha^{-1}. Minimum thousand grain weights was recorded from highest planting density of 95000 plants ha^{-1}. These results are in agreement with the finding of Radma and Dagash who reported that thousand grain weight increases with the increase in nitrogen level [29]. Influence of nitrogen levels and planting densities had significantly affected biological yield of maize. Application of nitrogen at the rate of 150 kg ha^{-1} produced maximum biological which is statistically at par with 210 kg N ha^{-1} with biological yield of 7863. Minimum biological yield was recorded from control plots. These results are in line with Arif et al. who found that increase in nitrogen levels increased biological yield [28]. The data further revealed that higher biological yield was produced in the planting density of 95000 plants ha^{-1} which is statistically at par with highest planting density of 80000 plants ha^{-1} with biological yield of 7128 kg ha^{-1}. Minimum biological yield was recorded from 65000 plants ha^{-1}. These results are in line with Bhatt who reported higher biological from higher planting density [16]. Influence of nitrogen levels and planting densities had significant effect on grain yield of maize. Mean values of the data revealed that application of nitrogen at the rate of 210 kg ha^{-1} produced maximum grain yield which is statistically at par with 180 and 150 kg N ha^{-1} with grain yield of 2475 and 2461 kg ha^{-1}, respectively. These results are in line with Sharifi et al. who reported that increase in nitrogen significantly increased grain yield [30]. Minimum grain yield was recorded in control plots. The data further revealed that plant density of 80000 plants ha^{-1} produced maximum grain yield. Minimum grain yield was recorded from 95000 plants ha^{-1}. These results are supported by Aziz et al. who stated that increase in grain yield at optimum planting densities may be due to the availability of more nutrients which led to more growth and higher assimilates translocation to grains [31]. The influence of planting densities had significant effect on harvest index of maize. Maximum harvest index was recorded from planting density of 80000 plants ha^{-1}. Minimum harvest index was recorded from 65000 plants ha^{-1} which is at par with planting density of 95000 plants ha^{-1} with harvest index of 29.54%. These results are supported by Bahadar et al. who reported higher harvest index with optimum plant population [32].

Conclusion and Recommendation

From the results of the study it is concluded that, application of nitrogen at the rate of 150 kg ha^{-1} produced highest grain yield while plant population of 80000 plants ha^{-1} produced maximum yield and yield components. Application of 150 kg N ha^{-1} on the basis of higher grain yield is recommended. Plant population of 80000 plants ha^{-1} is recommended on the basis of higher grain yield and other parameter.

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