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Response of Maize (Zea Mays L.) To Different Nitrogen Levels and Plant Population on Economic Yield in Swabi Region

Beena Saeed[1]*, Anam Sadiq[2]

Abstract

Field experiment was laid out to study the effect of nitrogen levels and plant population on maize. Maximum leaf area plant^{-1} (2757 cm^2), leaf area index (2.16), grains ear^{-1} (548), thousand grain weight (258 g) and grain yield (2673 kg ha^{-1}) were recorded with application of 210 kg nitrogen ha^{-1} which was statistically similar to 180 and 150 kg nitrogen ha^{-1}. Higher biological yield (7189 kg ha^{-1}) was recorded from 150 kg nitrogen ha^{-1} which was similar to 210 kg nitrogen 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 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 nitrogen ha^{-1} produced maximum grain yield and plant population of 80000 plants ha^{-1} produced higher grain yield.

Keywords: *maize, nitrogen levels, plant population, yield and yield components*

Introduction

Maize in totaling to provide grains for human ingestion, it is also used as fodder for animals or for conservation through ensilage. Maize fodder is very much liked by animals due to being succulent and palatable. Fodder scarcity is considered a major limiting factor for a prosperous livestock industry in Pakistan. The fodder production is approximately 52-54% less than the actual requirement for animals [8]. It is therefore, imperious to make efforts to increase production of fodder in the country. The horizontal expansion in fodder is not possible due to human population pressure. So the only solution is to increase yield on per unit area basis. Maize is grown as food as well as fodder crop and is the second most important crop after wheat in Khyber Pakhtunkhwa. Maize is the staple food of rural population in Pakistan. As a cereal crop, maize is a best food and it is also used on large scale in industries for manufacturing of corn oil, corn flakes, corn syrup and corn sugar.

In spite of high yielding potential of maize, its yield per unit area is very low as in Pakistan as compared to advanced countries of the world. In Khyber Pakhtunkhwa, it was grown on about 492.2 thousand ha

[1] Department of Agriculture (Agronomy), University of Swabi, Swabi
*Corresponding Author's Email: drbeenasaeed@uoswabi.edu.pk
[2] Department of Human Nutrition, The University of Agriculture, Peshawar

with production of 782.4 thousand ton annually. The average yield of this crop was 1590 kg ha^{-1} [4].

Nitrogen is the most important and limiting plant nutrient. It is an indispensable constituent of amino acids and related proteins. The growth of plant primarily depends on nitrogen availability in soil solution and its utilization by crop plants. Dry matter production and its conversion to economic yield is a growing effect of various physiological processes occurring during the life cycle of plant. An increase in yield of maize with increasing rate of nitrogen has been reported by many researchers [7], primarily due to its favorable effect on yield components of maize [5].

Plant population is an important determinant of grain yield of maize [6]. In case of thick population, most plants bear barren ears, smaller ears, become susceptible to lodging and pest attack. While in case of low plant density yield per unit area is low because of lesser than optimum plants.

Keeping in view the importance of plant density and nitrogen, the proposed study was conducted to find out optimum plant population and appropriate level of nitrogen for obtaining higher yield of maize.

Materials and Methods

The experiment titled, "Response of maize to different nitrogen levels and plant population" laid out at Cereal Crop Research Institute, (CCRI) District Nowshera during spring 2016. The experiment was conducted in randomized complete block design (RCBD). The plot size of 3 m by 5 m (15m^2) with row to row distance of 75 cm was used. Azam variety at seed rate of 60 kg $ha^{-1}$was used. The required plant population i.e. 65000, 80000 and 95000 plants ha^{-1} was maintained by thinning after emergence. Number of plants per row were 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 as source of nitrogen. Phosphorus was applied at the rate of 100 kg ha^{-1} before sowing. Single Super Phosphate was used as source of phosphorus. All agronomic practices were applied uniformly to all plots.

The details of treatments are given below

Plant population ha-1

P_1 = 65000
P_2 = 80000
P_3 = 95000

Nitrogen levels

N_0 = 0 kg ha^{-1}
N_1 = 120 kg ha^{-1}
N_2 = 150 kg ha^{-1}
N_3 = 180 kg ha^{-1}
N_4 = 210 kg ha^{-1}

A random sample of thousand grains was taken from the grain yield of each plot and weighed with an electronic balance to record weight for thousand grains. For recording grain yield data, two central rows were harvested in each plot with the help of a sickle. Ears were removed from the harvested plants, dried, threshed and weighed with the help of an electronic balance and then converted into kg ha^{-1}. Each plot was harvested at their maturity, tied into bundles separately. The bundles were sun dried and weighed by spring balance for calculating biological yield and then converted to kg ha^{-1}. Harvest index, was determined for each sub plot by dividing grain yield on biological yield and then multiplied with 100 to get standard values. Number of leaf $plant^{-1}$ was counted by selecting five random plants in each plot. Length and width of each leaf of five randomly selected plants from each plot were measured and converted into leaf area plant using following formula.

LA=L x W x 0.75
Leaf area index in each plot was determined by the following formula
LAI = Leaf area/ground area

Results

Grain Ear-1

Grains ear^{-1} of maize as affected by nitrogen and plant densities are presented in (Table 1). 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 nitrogen 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

Data on thousand grain weight of maize as affected by nitrogen and planting density are presented in (Table 1). 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 nitrogen ha^{-1} which is statistically at par with 180 and 150 kg N ha^{-1} with thousand grain weights of (258 g) 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

Biological yield of maize as affected by nitrogen levels and planting density are given in (Table 1). 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 kg and 210 kg nitrogen ha^{-1} with biological yields of (6517 kg ha^{-1}) and (6347 kg ha^{-1}), respectively. Minimum biological yield (5800 kg ha^{-1}) was recorded from control plots. Higher biological yield of (6344 kg ha^{-1}) was recorded for 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

(6003 kg ha^{-1}). Minimum biological yield of (6456 kg ha^{-1}) was recorded for 65000 plants ha^{-1}.

Grain Yield

Data on grain yield of maize as influenced by nitrogen levels and planting density are reported in (Table 1). 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 nitrogen ha^{-1} with grain yield of (2475 kg ha^{-1}) 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}.

Table 1: Mean Values of Number of Grains Per Ear, One Thousand Grain Weight, Biological Yield and Grain Yield of Maize as Affected by Nitrogen Levels and Planting Densities.

Nitrogen Levels	**No. of grains /ear**	**1000grain weight**	**Biological Yield**	**Grain Yield**
0	433a	232c	5801	1803
120	465cd	243bc	6517	2067
150	492bc	250ab	7189	2461
180	531ab	258a	6079	2475
210	548a	259a	6345	2672
Plant Density				
65000	515a	253a	6456	2213
80000	497ab	250a	6003	2551
95000	470b	240b	6344	2143
LSD				
N	NS	123.7	282.16	0.2818
Plant Density	3.09	81.72	186.35	0.1861
NXPD	NS	NS	NS	NS

Harvest Index

Harvest index of maize as affected by nitrogen and planting density is presented in (Table 2). Statistical analysis of the data showed that nitrogen levels and planting densities had significant effect on harvest index of maize. Maximum harvest index of (41.50%) was recorded from 210 kg N ha^{-1} which is statistically at par with 180 kg N ha^{-1} and 150 kg N ha^{-1} with the harvest index of (40.65%) and (39.42%) respectively. In case of planting densities, maximum harvest index (44.36 %) was recorded from planting density of 80000 plants ha^{-1}. Minimum harvest index (31.42%) was recorded from 95000 plants ha^{-1} which is at par with planting density of 65000 plants ha^{-1} with harvest index of (34.54%).

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 2). Interaction of N x PD was non-significant. Mean values of data revealed maximum number of leaves plant^{-1} (10.50) was recorded for planting density of 80000 plants ha^{-1}. While minimum number of leaves plant^{-1} (10.05) was recorded for planting density of

65000 plants ha^{-1}.

Leaf Area Plant-1

Data on leaf area $plant^{-1}$ is presented in (Table 2). Nitrogen levels and planting densities significantly affected leaf area $plant^{-1}$. However, interaction of nitrogen x plant density was non-significant. Maximum leaf area $plant^{-1}$ (2683 cm^2) was recorded with application of nitrogen at the rate of 210 kg ha^{-1} which is statistically at par with 180 kg N ha^{-1} and 150 kg N ha^{-1} with leaf area of (2676 cm^2) and (2530 cm^2), respectively. Likewise, leaf area decreased with increasing plant density. Higher leaf area $plant^{-1}$ (2587 cm^2) was recorded for 65000 plants ha^{-1}. Minimum leaf area $plant^{-1}$ (2306 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 2). 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 (2.79) 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}.

Table 2: Mean Values of Harvest Index, Number of Leaves/. Plant, Leaf Area/ Plant and Leaf Area Index of Maize as Affected by Nitrogen Levels and Planting Densities.

Nitrogen Levels	**Harvest Index**	**No. of leaves/ plant**	**Leaf Area/ plant**	**Leaf Area Index**
0	31.29	10.35b	2587.8c	1.97c
120	31.00	10.07a	2570.4b	2.46b
150	39.42	10.08a	2530.5ab	2.54ab
180	40.65	10.58a	2676.9ab	2.52ab
210	41.65	10.42a	2583.9a	2.79a
Plant Density				
65000	34.54	10.2a	2587.4a	2.59a
80000	44.36	10.45a	2685.8ab	2.45ab
95000	31.42	10.25a	2306.5b	2.32b
LSD				
N	NS	123.7	282.16	0.2818
Plant Density	3.09	81.72	186.35	0.1861
NXPD	NS	NS	NS	NS

Discussion

Influence of nitrogen levels and plant densities had significant effect on number of grains ear^{-1} of maize. Higher grain ear^{-1} (548) 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 grain ear^{-1} was recorded from control plots. These results were further supported by [8]. In case of planting densities maximum grain 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}. The results were further endorsed by [1] who reported that increase in plant population decrease grains ear^{-1}.

Thousand grain weight was significantly affected by nitrogen levels and planting density. However interaction of nitrogen and planting density was non-significant. Maximum thousand grain weight of 258.86 g was recorded from 210 kg nitrogen ha^{-1} which is statistically at par with 180 and 150 kg nitrogen ha^{-1} with thousand grain weight of 258.25 and 249.72 g respectively. These results are in line with [2]. In case of planting densities thousand grain weights decreased. Maximum thousand grain weight 252.95 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 250.35 g. minimum thousand grain weight 241.73 g was recorded from highest planting density of 95000 plants ha^{-1}. These results are in agreement with the finding of [1] and [8].

Influence of nitrogen levels and planting densities had significantly effect on biological yield of maize. However interaction of nitrogen and planting densities was non-significant. Mean values of the data revealed that application of nitrogen at the rate of 120 kg ha^{-1} produced maximum biological (6764 kg ha^{-1}) which is statistically at par 150 and 210 kg N ha^{-1} with biological yield of (6347.47 kg ha^{-1}) and (6347.94 kg ha^{-1}). Minimum biological yield (5800.97 kg ha^{-1}) was recorded from control plots. These results are further endorsed by [2] who investigated that increase in nitrogen levels increase biological yield. The data further revealed that higher biological yield of (6456.15 kg ha^{-1}) was produced in the planting density of 65000 plants ha^{-1} which is statistically at par with highest planting density of 95000 plants ha^{-1} with biological yield of (6344.17 kg ha^{-1}). Minimum biological yield of (6003.60 kg ha^{-1}) was recorded from 80000 plants ha^{-1}. These results are in line with [8].

Influence of nitrogen levels and planting densities had significant effect on grain yield of maize. However, 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 (2622.78 kg ha^{-1}) which is statistically at par with 180 and 150 kg nitrogen ha^{-1} with grain yield of (2416.67 kg ha^{-1}) and (2319.44 kg ha^{-1}) respectively. These results are in line with [2] who reported that increase in nitrogen significantly increased grain yield. Minimum grain yield 0f (1803.43 kg ha^{-1}) was recorded in control plots. The data further revealed that plant density of 80000 plants ha^{-1} produced maximum grain yield of (2560.86 kg ha^{-1}). Minimum grain yield of 1963 kg ha^{-1} was recorded from 95000 plants ha^{-1}.

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 higher leaf area index (2.76) which is statistically at par with 180 and 150 kg nitrogen ha^{-1} with the LAI of (2.52) and (2.54) respectively. These results are similar with [3] who reported that LAI increased with each increment increase of nitrogen over control. In case of plant density the lower planting density 65000 plants ha^{-1} produced higher LAI (2.59). Lower LAI (2.32) was recorded from higher plant density 95000 plants ha^{-1}. These results are similar with the finding of [1].

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