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Effect of Plant Density and Nitrogen Rates on Morphological Characteristics Grain Maize

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ABSTRACT

Nitrogen and plant density are considered some of the most important factors affecting on grain yield. So the effects of plant density and nitrogen on yield and yield components of maize (*Zea mays* L.) were evaluated during spring 2005 in Koohdasht region, Lorestan, Iran. The experimental design was designed as Randomized Complete Block arrangement in split plot with three replications. Three nitrogen levels (160, 200 and 250 kg N ha^{-1}) applied to main plots and three plant densities (65000, 70000, and 75000 plants ha^{-1}) allocated to sub plots. The results showed that, there was significant difference among nitrogen levels regarding ear weight. The lowest ear weight was related to the lowest nitrogen level while the highest ear weight was observed the highest nitrogen level. In contrast there was not significant difference among nitrogen levels on harvest index. Increase of nitrogen levels enhanced final seed yield due to increase of seed number in each ear. Also, plant density had not any significant effect on harvest index. Increase of plant density decreased number of seed in ear and ear weight. Therefore, enhancement of seed yield was due to increase of plant density. This increase compensates yield reduction in each plant. In general, the highest seed yield (14827.3 kg.ha^{-1}) was achieved from 240 kg.ha^{-1} nitrogen and the highest plant density (75000 plants.ha^{-1}).
Keywords: Maize, Plant density, Nitrogen, Seed number, Seed yield.

INTRODUCTION

Maize is one of the most important cereal crops in the world. It ranks the third position among other cereals after wheat and rice. Many factors affect grain yield of maize such as fertilization and plant population density. Maize plants are sensitive to density and increase its density to increase grain yield usually is accompanied with how to use elements such as nitrogen (Lemcuff and Lemmas 1986). Usually seed yield will reaches to maximum in range of plant density and then decreases (Lemcuff and Lemmas 1986). Lost of seed yield in high plant density conditions may be due to infertile ear. The previous research shows that, appropriate select of agronomic factors such as nitrogen and plant density can be increased seed yield (Oikeh et al., 1988; Widdicombe, 2002). On the other hand, expanding of process of environmental pollution caused by human intervention in nature and increase world population, leads to increase of pollution. Therefore, more careful in use of chemical fertilizers and agricultural products is necessary (Hashemi–Dezfouli and Herbert, 1992). Among the main nutrients required for plans, nitrogen had significant effect on growth and development also direct relationship of nitrogen with plant growth and yield of maize has been proven (Andrade et al., 1993). Cultivation of plants with desirable density has positive effect on crop yield components, so that the suitable will be achieved by optimum plant density (Cox, 1996; Widdicombe, 2002). Seed number per ear is of the most important yield components in grain corn, and it is affected strongly by plant density. In maize number of seed per ear suddenly reduces with increase of plant density. It has been reported that, nitrogen application to 109 kg.ha^{-1} increased seed yield while more increment to 120 kg.ha^{-1} had not significant effect on seed yield (Oikehe et al., 1988). In other report, final seed yield was increased due to rising of nitrogen fertilizer from 200 to 350 kg.ha^{-1}; because of improved of yield components (Ulger et al., 1997). In recent years, prices of chemical fertilizers has been increased thus optimizing of fertilizer application is required by farmers. The aim of this study is determine of the best maize plant density and the best nitrogen rate to earn desirable yield in grain maize.

MATERIALS AND METHODS

Site of study and soil properties

The experiment was conducted in Koohdasht region during 2005 growing season (Longitude: 47º, 40' E; Latitude: 33º, 36' N and Altitude: 1200 m). According to climatic classification, experiment site has semitropical climate with hot and dry summers. Analysis of soil samples showed that, the soil was loamy textured with pH 7.7 and total nitrogen 0.97.

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Experimental design and treatments

The experimental design was a Randomized Complete Block arrangement in split plot arrangement with three replications. Three levels of nitrogen that is 160, 200 and 240 $kg.ha^{-1}$ net nitrogen from urea (46% nitrogen) were allocated to main plots. The sub plots were cultivated by three levels of plant density i.e. 65000, 70000 and 75000 plants per hectare.

Filed and plots preparation

After plough in fall and two disks in middle of May, 200 $kg.ha^{-1}$ phosphorous as super phosphate triple was broadcasted on soil surface and then mixed into the soil. The land was flatted by leveller and then plots were prepared. The sub plots had 6 m length and 3 m width consisted of four rows, 0.75 m apart. Between main plots, 1.5 m distance was kept to eliminate all influence of lateral water movement. One third of urea were distributed in plots and mixed with surface soil before seed sowing. Rest of urea was used when plants have 4 or 6 leaves.

Seed sowing and irrigation

In order to attain desirable plant density seed sowing was done at end of May by hand. Disinfected seed of maize (single cross 704) were used in this study. In each hole three seed was sowed in depth of 5cm. After seed sowing irrigation was performed immediately. Irrigation interval was three days. At 2 or 3 leafy stages the plants were thinned to one plant in each hole.

Weed control

Weed control was done by using of 3-4 $kg.ha^{-1}$ Atrazine prior to seed sowing and 2.5 $liter.ha^{-1}$ 2, 4-D at 6 leafy stages. The crop was weeded by hand during growth season too.

Harvesting and sampling

At physiological maturity stage 7.5 square meters of each plot was harvested. The middle plants were harvested in order to omit border effect.

The plants were transferred to the laboratory, ears were separated and yield and yield components were determined. In order to measurement of seed and straw moisture percentage and total dry matter a sample was selected randomly from plants of each plot. The samples were dried in oven at 72°C during 48 h. According to fresh weight and dry weight, total dry matter yield and dry seed yield was corrected. Yield components included; number of seed in ear, 1000 seed weight and number of seed row in ear were measured too. Biological yield (total above ground parts of plant) and harvest index was calculated. Note that, seed yield was determined on based of 14% seed moisture.

Analysis of the data

All data were analyzed from analysis of variance (ANOVA) using the MSTAT-C. Duncan's Multiple Range Test was used to measure statistical differences between treatments.

RESULTS AND DISCUSSION

Yield and yield components

The results of analysis of variance demonstrated that, the effect of nitrogen and plant density was significant on seed yield (Table 1). Also, there was positive and significant correlation between seed yield and rate of nitrogen as increase of nitrogen application increased seed yield. However, there was no significant difference between 200 and 240 $kg.ha^{-1}$ nitrogen on seed yield (Table 2). It seems that, this increment was due to increase of seed number in each ear. Seed number is one of the most important components of final seed yield. It's reported that, nitrogen application improves seed yield through increscent of seed number in ear (Costa et al., 2002). Different plant density had significant difference from each regarding seed yield (Table 2). Increases of plant population density increased seed yield. Main reason of this enhancement is related to increase of ear number because increase of plant number in surface unit leads to reduction of seed number in each ear and 1000 seed weight (Table 2). Similar this result have been reported by many researchers (Below and Gentry, 1992; Hashemi–Dezfouli and Herbert, 1992). Interaction effect between nitrogen and plant density was not significant on seed yield (Table 1). The highest seed yield (14827 $kg.ha^{-1}$) was achieved from the highest plant density and the highest nitrogen application (Table 3). This result demonstrates that, high plant density is benefit when all of conditions are favourable. High plant density, complete irrigation, fertilizer application and high temperature are essential to attain the highest seed yield in maize (Hanway, 1992). In low plant population density, increase of nitrogen rate was not effective on seed yield it seems that; extra nitrogen was leached from root around zone. Under conditions of high plant population density, seed yield will be increased due to increase of ear number but it is essential that in terms of other factors, there is no limitation such as water, light and nitrogen availability. The results showed that, there was significant difference among nitrogen rates on ear weight. The highest ear weight was observed in treated plants with 240 $kg.ha^{-1}$ nitrogen (Table 2). The result of other researchers shows that, ear weight was increased by increase of nitrogen level (Ulgeret al., 1997). Bangarwa et al (1998) have been reported that, leaf area index, photosynthesis and finally dry matter accumulation were increased due to high level of nitrogen. The ear weight was affected by plant density as ear weight was decreased due to high plant density. Similar this result was found by (Ulgeret al., 1997). Shading and increase of competition is the most important reason for decrease of ear weight (Olsen and sander, 1988). 1000 seed weight was increased by application of nitrogen while there was not significant difference between different levels of nitrogen (Table 2). The lowest 1000 seed weight (234.5 g) was related to 160 kg.ha^{-1} nitrogen. Ulger et al (Ulgeret al., 1997) have been reported that, increase of nitrogen level had not significant effect on 1000 seed weight. In this research plant population density had not significant effect on 1000 seed weight. Although, it was observed that, 1000 seed weight was decreased when plant population density was increased. But this weight lost was not significant among different plant population densities. We found that, different between two plant population densities (70000 and 75000 plant.ha^{-1}) on 1000 seed weight is not significant its means that, 1000 seed weight had relative stability among other yield components while comparison between the lowest and highest plant population density shows that, 1000 seed weight will affected under condition of high plant population density and increase of plant density leads to lost weight of seeds. Akintoye et al (1997) reported that, high plant density decreases seed weight. It seems that, the main reason of weight lost is due to increment of competition to attain more light and nutrition uptake and other growth resources.

Yield and dry matter

Dry matter yield was affected by different nitrogen level and plant population density (Table 1). Increase of nitrogen rate from 160 to 240 kg.ha^{-1} increased dry matter yield by 421 kg.ha^{-1} (Table 2). Losses of dry matter yield under conditions of low nitrogen availability have reported by Girardin et al (1987) and Anderat and Uhart (1995). In larger amounts of nitrogen, investment of assimilates to leaves and stems increased and finally dry matter yield increased too (Table 2). There was significant difference among different plant population densities on dry matter yield (Table 1). The highest dry matter yield was obtained from the highest plant population density (Table 2). Increase of dry matter yield under conditions of high plant density is related to number of plants in each square meter. Positive effects of high plant density on dry matter have been reported by many researches (Tollenear, 1989). Interaction effect between plant population density and nitrogen application on dry matter yield was not significant (Table 1).

Difference between the highest and the lowest harvest index obtained from different levels of nitrogen was (Table 1 and 2). The results showed that, nitrogen application had not any effect on assimilate partitioning as dry matter yield and seed yield were increased as parallel with each other. Similar reports on based of this founding have been reported previously (Robinson and Murphy, 1972). The harvest index was not affected by plant population density too (Table 1). Also, interaction effect between nitrogen rate and plant density was not significant (Table 1).

The result s demonstrated that, seen number in each ear was increased by enhancement of nitrogen level (Table 2). There was significant difference between the highest and the lowest nitrogen rate that is 160 and 240 kg.ha^{-1}(Table 1). Anderat and Uhart have been reported that, critical period of seed setting is one or two week before tasseling and three weeks after tasseling (Uhart and Andrade, 1995). Tollenear showed that, assimilate transport to ear had high correlation with seed number (Tollenear, 1989). Nitrogen efficiency affects on assimilate availability, leaf are index, leaf area duration, light proficiency, photosynthesis and seed number in each ear (Uhart and Andrade, 1995). Lemcuff and Lemmas (1986) have been reported that, nitrogen fertilizer increases seed number in ear (Liang et al., 1992; Robinson and Murphy, 1972). Number of seed in each ear was affected by plant population density. Increase of plant density decreased seed umber in each ear. There was significant difference among plant population densities (Table 3). Seed number decreasing under high plant density is due to increase of competition between seed filling site also increase of interval between pollination and silk appearing is one of the most important reason to increase of infertile seeds. Ulger et al (Ulger et al., 1997) showed that, under conditions of high plant density seed number in each ear was significantly decreased. In general, the highest plant density (75000 plants.ha^{-1}) and the highest nitrogen level (240 kg.ha^{-1}) introduces as best treatment in this research to attain of high maize seed yield.

Table 1: Effect of different nitrogen rate and different plant density on some agronomical traits of maize

S.O.V	d.f	Number of seed in ear	1000 seed weight	Seed yield	Dry matter yield	Ear weight	Number of seed row in ear	Harvest index
replication	2	ns	ns	ns	ns	ns	ns	**ns**
Nitrogen	2	**	ns	**	*	**	ns	**ns**
Error (a)	4	ns	ns	ns	ns	ns	ns	**ns**
Plant density	2	**	ns	**	**	**	ns	**ns**
Plant density× Nitrogen	4	ns	ns	ns	ns	ns	ns	**ns**
Error (b)	14	ns	ns	ns	ns	ns	ns	**ns**

***, ** significant at the 0.05 and 0.01 probability levels, respectively**

Table 2: Comparison of main effect of nitrogen rate and plant density on some agronomical traits of maize

Treatments	Number of seed in ear	1000 seed weight	Seed yield	Dry matter yield	Ear weight	Number of seed row in ear	Harvest index
Nitrogen (Kg.ha^{-1})							
160	547.1c	234.5a	9793.4b	17896.7b	324.8c	16.1a	**54.9a**
200	738.4b	248.3a	12302.3a	20198.8ab	336.9b	15.9a	**60.9a**
240	837.a	255.8a	13636.2a	22111.1a	344.5a	16.0a	**62.0a**
Plant density (plants. ha^{-1})							
65000	724.1a	254.9a	10889.6c	18841.1c	345.5a	16.3a	**57.9a**
70000	708.5b	243.4a	11887.5b	19924.3b	335.4b	15.9a	**59.7a**
75000	690.4c	240.3a	12954.9a	21441.1a	325.4c	15.8a	**60.2a**

For a given means within each column followed by the same letter are not significantly differences ($p < 0.05$)

Table 3: Interaction effects between nitrogen and plant density on some agronomical traits of maize

Treatments	Number of seed in ear	1000 seed weight	Seed yield	Dry matter yield	Ear weight	Number of seed row in ear	Harvest index
N1D1	569.0e	257.9a	8742.5g	16543.3a	333.0cd	16.1a	**53.4d**
N1D2	545.8f	234.1ab	9823.6f	17786.7b	324.6e	16.2a	**55.6cd**
N1D3	526.5g	211.5b	10814.2e	19360.0bc	317.0f	16.0a	**55.8bcd**
N2D1	751.9c	254.2ab	11375.0d	19226.7bc	347.2b	16.5a	**59.3abc**
N2D2	740.2c	242.1ab	12308.8c	20299.7cd	336.8c	15.7a	**60.7abc**
N2D3	723.2d	248.6ab	13223.3b	21070.0d	326.8de	15.6a	**62.8a**
N3D1	851.4a	252.7ab	12551.2c	20753.3d	356.2a	16.4a	**61.0ab**
N3D2	839.6a	254.0ab	13530.0b	21686.7e	345.0b	15.9a	**62.9a**
N3D3	821.5b	260.7a	14827.3a	23893.3e	332.4cd	15.8a	**62.1a**

For a given means within each column followed by the same letter are not significantly differences ($p <0.05$)
N1: 160 Kg.ha^{-1} Nitrogen; N2: 200 Kg.ha^{-1} Nitrogen; N3: 240 Kg.ha^{-1} Nitrogen; D1: 65000 plants. ha^{-1}; D2: 70000 plants.ha^{-1}; D3: 75000 plants. ha^{-1}

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