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Effect of Plant Density and Nitrogen Rates on Yield and Nitrogen Efficiency of Grain Corn

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Abstract: This research was conducted to study the effects of nitrogen application rates and plant density on seed yield, dry matter, nitrogen agronomic efficiency, nitrogen use efficiency and productivity degree of grain corn in 2005 growing season. This study was consisted of spilt-plot experiments, using Randomized Complete Block Design in three replications. Main plots were included nitrogen rates that are 160, 200 and 240 kg N ha^{-1} and plant density in three levels (6.5, 7 and 7.5 plants.m^{-2}) was allocated to sub plots. The results showed that, seed yield and dry matter was increased by increase of nitrogen application rate. The response of seed yield and dry matter was positive to increment of plant density. Increase of nitrogen application rate, decreased nitrogen use efficiency. The response of these efficiencies was positive to plant density. Also it observed that, productivity degree was significantly increased due to increase of nitrogen rate.

Key words: Corn · Nitrogen · Nitrogen agronomic efficiency · Nitrogen use efficiency · Plant density · Productivity degree

INTRODUCTION

Corn (*Zea mays* L.) is one of the most important cereal crop grown principally during the summer season in the world. Many researchers investigated effect of different factors on growth and production of corn. Nutrition management is on of the most critical agronomic approaches to corn production. Nitrogen fertilizer is a major input for corn production in the world. Ideal nitrogen management optimizes grain yield, farm profit and nitrogen use efficiency while it minimizes the potential for leaching of nitrogen beyond the crop rooting zone. Efficiency of use of applied nitrogen is variable, with a mean of only 33% of applied nitrogen recovered by cereal crops [1]. Excessive nitrogen fertilization may results in low nitrogen use efficiency and potentially exerts more pressure on the environment. Therefore, applying the optimum nitrogen level is most important for raising the yield of corn and improving plant efficiency in using nitrogen. The positive effects of nitrogen application on growth and yield of corn was demonstrated by Berenguer *et al.* [2]. Estimate of nitrogen use efficiency in corn cropping systems are only 37% [3] and 33% [1] for cereal crops grown worldwide. Research showed that, corn nitrogen use efficiency had more changes in low amounts of nitrogen [4]. It has been proven that, nitrogen had major effect on growth and had direct correlation with plant growth and yield [5].

Selection of desirable plant density is affecting on crop yield components, as selected so that the optimum plant density can be to achieve a good performance [6]. Demand for nitrogen increases with biomass yield, which may be enhanced by plant density [7]. The effect of decreasing corn row spacing from a mean of 1.07 to 0.90 m was estimated to result in an overall mean yield increase of 175 kg ha^{-1} [8]. Corn yields may be further increased by reducing row spacing from 0.76 to 0.38 m [6].

Increasing the plant population density usually increases corn grain yield until an optimum number of plants per unit area is reached [9]. Fulton [10] also reported that higher plant densities of corn produce higher grain yields. Plant densities of 90,000 plants ha^{-1} for corn are common in many regions of the world [11]. However, under surface irrigation conditions in Egypt, population densities from 50,000 to 56,000 plants $ha^{-1}$are considered optimal because greater plant densities result in reduced yields because of competition between plants [12].

This experiment was carried out in order to study effects of different amounts of nitrogen fertilizer and plant density on yield, productivity degree and nitrogen use efficiency of corn hybrids S.C. 704 in Khohdasht conditions.

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MATERIALS AND METHODS

In order to study the effect of nitrogen rate and plant density on seed yield, dry matter, nitrogen agronomic efficiency, nitrogen use efficiency and productivity degree of grain corn a filed excrement was conducted in Kohdasht, Lorestan, Iran (36°33' N latitude, 40°47' E longitude and altitudes of 11200 m) in 2005 growing season. The yearly average precipitation (30-years long term period) which is mostly occurred during the autumn and winter months was xxx mm. The mean annual temperature was 33.72°C. The experimental site had loamy soil and previous crop was wheat. The field was prepared by plow and disk at fall and then plots were prepared. The plots were 6 m long and consisted of six rows, 0.75 m apart. Between blocks, 2 m and between each plot 1m alley was kept to eliminate of lateral water movement and other interferences. This study was consisted of spilt-plot experiments, using Randomized Complete Block Design in three replications. Main plots were included nitrogen rates that are 160, 200 and 240 kg N $ha^{-1}$and plant density in three levels (6.5, 7 and 7.5 plants.m^{-2}) was allocated to sub plots. Prior to seed sowing 200 kg.ha^{-1} phosphorus from super phosphate triple and 347 kg.ha^{-1} nitrogen from urea were broadcasted and incorporated into the soil. Fifty percent pf urea was used at sowing time and residual was applied as top dress at 4-6 leafy stage. Corn seeds (*Zea mays* L. S.C 704) were disinfected and sown on end of May. Irrigation was performed after sowing, immediately. Irrigation cycle of each plot was closed, to avoid runoff. The extra plants were thinned at 2-4 leafy stage. Two m^2 of each plot was hand harvested.

Samples consisted of a 2 m area of the center row of each plot after leaving two rows in the border areas to avoid border effects were hand harvested at physiological maturity stages. The ears were separated in order to determine of seed yield and yield components. Random samples were taken from each plot to determine of seed and straw moisture, seed yield, total dry matter and seed dry matter. The samples were dried in oven at 72 °C during 48 hours. Nitrogen agronomic efficiency and nitrogen use efficiency were calculated by blow equations.

Nitrogen use efficiency (Kg.kg^{-1}) = Seed yield. Applied $nitrogen^{-1}$

Nitrogen agronomic efficiency (Kg.kg^{-1}) = (eed yield with nitrogen application- Seed yield without nitrogen application). Applied $nitrogen^{-1}$

All data were analyzed from analysis of variance (ANOVA) using the MSTAT-C software. When *F*-test indicated statistical significant at the P<0.05 level, Duncan's Multiple Range Test was used to separate the means.

RESULTS AND DISCUSSION

Seed Yield: The analysis of variance on seed yield demonstrated that, effect of nitrogen and plant density was significant on this trait (Table 1). There was positive and significant correlation between seed yield and nitrogen level and it observed that increase of nitrogen application increased seed yield. However, there was not significant difference between 200 and 240 kg.ha^{-1} nitrogen regarding seed yield (Table 2). This increment was associated to enhancement of seed number in each

Table 1: Effect of different nitrogen levels and different plant density on some agronomical traits of corn

S.O.V	d.f	Number of seed in ear	1000 seed weight	Seed yield	Dry matter yield	Nitrogen agronomic efficiency	Nitrogen use efficiency	Productivity degree
Replication	2	ns	ns	ns	ns	ns	ns	ns
Nitrogen	2	**	ns	**	*	ns	ns	*
Error (a)	4	ns	ns	ns	ns	ns	ns	ns
Density	2	**	ns	**	**	**	**	**
Nitrogen ×Density	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 rates and plant density on some agronomical traits of corn

Treatments	Number of seed in ear	1000 seed weight (g)	Seed yield (kg.ha^{-1})	Dry matter yield(kg.ha^{-1})	Nitrogen agronomic efficiency (kg.kg^{-1})	Nitrogen use efficiency (kg.kg^{-1})	Productivity degree
Nitrogen rates							
160 kg.ha^{-1} N	547.1c	234.5a	9793.4b	17896.7b	27.9a	61.2a	82.6b
200 kg.ha^{-1} N	738.4b	248.3a	12302.3a	20198.8ab	34.9a	61.5a	93.4a
240 kg.ha^{-1} N	837.5a	255.8a	13636.2a	22111.1a	34.7a	56.8a	97.8a
Plant density							
6.5 plant.m^{-2}	724.1a	254.9a	10889.6c	18841.1c	54.6c	54.6c	87.7c
7 plant.m^{-2}	708.5b	243.4a	11887.5b	19924.3b	59.8b	59.8b	91.6b
7.5 plant.m^{-2}	690.4c	240.3a	12954.9a	21441.1a	65.1a	65.1a	94.7a

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

Table 3: Interaction effects of nitrogen rates and plant density on some agronomical traits of corn

Treatments	Number of seed in ear	1000 seed weight (g)	Seed yield ($kg.ha^{-1}$)	Dry matter yield($kg.ha^{-1}$)	Nitrogen agronomic efficiency ($kg.kg^{-1}$)	Nitrogen use efficiency ($kg.kg^{-1}$)	Productivity degree
N1D1	569.0e	257.9a	8742.5g	16543.3a	21.4d	54.6cd	78.7g
N1D2	545.8f	234.1ab	9823.6f	17786.7b	28.2c	61.4b	83.3f
N1D3	526.5g	211.5b	10814.2e	19360.0bc	34.3b	67.5a	85.9ef
N2D1	751.9c	254.2ab	11375.0d	19226.7bc	30.3a	56.8c	89.9de
N2D2	740.2c	242.1ab	12308.8c	20299.7cd	34.9b	61.5b	93.3cd
N2D3	723.2d	248.6ab	13223.3b	21070.0d	39.5a	66.1a	97.1abc
N3D1	851.4a	252.7ab	12551.2c	20753.3d	30.1c	52.3d	94.3bc
N3D2	839.6a	254.0ab	13530.0b	21686.7e	34.2b	56.4c	98.1ab
N3D3	821.5b	260.7a	14827.3a	23893.3e	39.6a	61.7b	99.8a

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

N1: 160 $kg.ha^{-1}$ N N2: 200 $kg.ha^{-1}$ N N3: 240 $kg.ha^{-1}$ N D1: 6.5 $plant.m^{-2}$ D2: 7 $plant.m^{-2}$ D3: 7.5 $plant.m^{-2}$

ear. Already, Hanway [13] has been reported that, number of seed is one of the most important components of final yield and positive effect of nitrogen is due to increase of seed number in ear.

Also, there was significant effect on seed yield due to different plant density (Table 1). Increase of plant density was parallel with improve of seed yield. This increase was due to increase of ear number in area because increase of plant density decreased significantly seed number in ear and 1000 seed weight (Table 2). Other researchers have been reported that increase of plant density decreases seed number and seed weight [14]. Regarding seed yield, interaction effect was not significant between nitrogen application and plant density (Table 1). The highest seed yield was achieved from plants which had the highest plant density and were treated with 240 $kg.ha^{-1}$ N (Table 3). These results suggest that, high plant density is useful under favorite condition. High plant density, complete irrigation, nitrogen availability and suitable temperature are necessary to get maximum seed yield in corn [15]. Conjunctive effects of plant density and nitrogen rate were positive and increased seed yield. In low plant densities, seed yield was decreased; it seems that this reduction is related to limitation of plant capacity in usage of nitrogen. Increase of plant density increases seed yield through increase of ear number in each square meter. Note that it is provisional to presence of favorite growth conditions such as moisture and nutritious elements. In this reason, when plant density is increased nitrogen application should be increase.

Dry Matter Yield: Fry matter yield was affected by nitrogen rate and plant density (Table 1). Results showed that, there was significant difference between 240 $kg.ha^{-1}$ N and 160 $kg.ha^{-1}$ N treatments on dry matter yield (Table 2). Decrease in dry matter yield in low nitrogen treatments has been observed by Girardin *et al* [16]. It seems that, in high level nitrogen treatments assimilates are allocated to leaves and stems and finally shoot dry matter will be increase (Table 2). There was significant difference among different plant densities (Table 2). The highest plant density (7.5 $plant.m^{-2}$) produced the highest dry matter yield (Table 2). Increase of dry matter yield in high plant density can be connecting to number of plants in square meter. Positive effect of high plant density on dry matter yield has been founded by other researchers [17]. Interaction effect between plant density and nitrogen rate was not significant on dry matter yield (Table 1).

Nitrogen Agronomic Efficiency and Nitrogen Use Efficiency: Nitrogen agronomic efficiency as a simple indicator to evaluate nitrogen use efficiency is defined for each unit of nitrogen consumed. This index is a suitable criterion for determining nitrogen use efficiency under field conditions. Nitrogen use efficiency can be considered as a ratio to seed yield to amount of nitrogen consumed and considered a key factor in the management of nitrogen for crop production [4]. Effect of different levels of nitrogen was not significant on nitrogen use efficiency. But this component was decreased due to more nitrogen application (Table 2). Usually, the highest efficiency will be obtained with the first element of nutritious elements. Moll *et al.* [4] have been reported that, with increasing fertilizer, seed yield will be less increase according to Micherlikh law. This situation reduces fertilizer use efficiency. Goodroad and Jellum [18] believe that, sublimation, denitrification and leaching are main reasons of nitrogen loss. Greef [19] showed that, when nitrogen consumption is higher than optimal amounts, plant is not capable for utilize of C_4 mechanism and nitrogen usage. The interaction of nitrogen and plant density on nitrogen use efficiency was not significant (Table 1) while, effect of different levels of plant density was significant on nitrogen use efficiency (Table 1). The highest nitrogen agronomic efficiency and nitrogen use efficiency were belonged to the highest density

(Table 2). This situation demonstrates a good potential for S.C. 704 in nitrogen use and seed production under higher plant densities. Interaction effects of nitrogen and plant density showed that in lower levels of nitrogen consumption, higher densities had higher nitrogen agronomic efficiency and nitrogen use efficiency (Table 3). In high densities, plants are needy to nitrogen supply in order to achieve their potential for seed production. Comparison of means of nitrogen and plant density showed that, application of 240 kg.ha^{-1} nitrogen in the highest density (7.5 plants per square meter) conditions in terms of nitrogen agronomic efficiency and nitrogen use efficiency was better than other treatments (Table 3).

Productivity Degree: Productivity degree is calculated by summation yield, biomass and harvest index. Productivity degree is a useful index to identification of sensitive plants under environmental stresses. With this index, high potential cultivars are identified easily. Analysis of variance (Table 1) showed that, there was significant effect among different nitrogen levels in term of productivity degree. The highest productivity degree was belonged to 240 kg.ha^{-1} nitrogen applications. It may be due to effective use resources such as water and nutritious elements. Thus, with productivity degree, selection of the best nitrogen level will be possible. Productivity degree is easily understood by farmers and to see a wider adoption to creation of management methods. Our results showed that, high plant density increased productivity degree as the highest productivity degree was obtained from the highest density that is 7.5 plant per meter square (Table 2).

REFERENCES

1. Raun, W.R. and G.V. Johnson, 1999. Improving nitrogen use effi ciency in cereal crops. Agron. J., 91: 357-363.
2. Berenguer, P., F. Santiveri, J. Boixadera and J. Lloveras, 2009. Nitrogen fertilization of irrigated maize under Mediterranean conditions. Europ. J. Agron., 30: 163-171.
3. Cassman, K.G., A. Dobermann and D.T. Walters, 2002. Agroecosystems,nitrogen use effi ciency and nitrogen management. Ambio, 31: 132-140.
4. Moll, R.H., E.J. Kamprath and W.A. Jackson, 1982. Analysis and interpretation of factors which contribute to efficiency of nitrogen utilization. Agron. J., 740: 262-264.
5. Kogebe, J.O.S. and J.A. Adediran, 2003. Influence of nitrogen, phosphorus and potassium application on the yield of maize in the savanna zone of Nigeria.African J. Bio., 2: 345-349.
6. Widdicombe, W.D. and K.D. Thelen, 2002. Row width and plant density effects on corn grain production in the northern Corn Belt. Agron. J., 94: 1020-1023.
7. Jordan, H., K. Laird and D. Ferguson, 1950. Growth rates and nutrient uptake by corn in a fertilizer-spacing experiment. Agron. J., 42: 261-268.
8. Hanway, J.J., 1992. How a Corn Plant Develops . Iowa Coop . Ext . Ser . Spec. Rep., 48.
9. Holt, D.F. and D.R. Timmons, 1968. Influence of precipitation, soil water and plant population interactions on corn grainyields. Agron. J., 60:379-81.
10. Fulton, J.M., 1970. Relationship among soil moisture stress plant population, row spacing and yield of corn. Can. J. Plant Sci., 50: 31-38.
11. Al-Kaisi, M.M. and X. Yin, 2003. Effects of nitrogen rate, irrigation rate and plant population on corn yield and water use efficiency. Agron. J., 95: 1475-1482.
12. Griesh, M.H. and G.M. Yakout, 2001. Effect of plant population density and nitrogen fertilization on yield and yield components of some white and yellow maize hybrids under drip irrigation system in sandy soil. In: Proceedings of the International Conference on Plant Nutrition – Food Security and Sustainability of Agro-ecosystems, Madrid, Spain, pp: 810-811.
14. Hashemi –Dezfouli, A. and S.J. Herbert, 1992. Effect of leaf orientation and density on yield of corn. Iran Agric. Res., 11: 89-104.
15. Liang, B.C., M.R. Millard and A.F. Machenzie, 1992. Effects of hybrid, population densities, fertilization and irrigation on grain corn (zea mays L.) in Quebec. Can. J. Plant Sc., 72: 1163-1170.
16. Girardin, P., M. Tollenaar, A. Deltour and J. Muldoon, 1987. Temporary N starvation in maize (*Zea mays* L.): effects on development, dry matter accumulation and grain yield. Agronomie (paris.). 7: 289-296.
17. Akitoy, H.A., E.O. lucas and J.G. Killing, 1997. Effect of planting density and time of nitrogen application on maize varieties in different ecological zones of west Africa. Commum. Soil Sci. Plant Anal., 28: 2263-1175.
18. Goodroad, L.L. and M.D. Jellum, 1988. Effectof N fertilizer rate and soil PH on N efficiency in corn. plant and soil, 106: 85-89.
19. Greef, J.M., 1994. Productivity of maize (*Zea mays* L.) in relation to morpholog ical physiological charactrristics under varying amounts of nitrogen supply. J. Agron. and Crop Sci., 172: 317-326.