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Study of Agronomical Nitrogen Use Efficency of Durum Wheat, Affected by Nitrogen Fertilizer and Plant Density

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Abstract: In order to study agronomic nitrogen use efficency of durum wheat cultivar Seimareh, as affected by nitrogen fertilizer and plant density, an experiment based on randomized complete block design was conducted at the agricultural research station of the Islamic Azad University, Ardabil branch, Ardabil, Iran in 2008-2009 growing season. The experiment had three replications. Factors included nitrogen levels: 0, 60, 120 and 180 kg ha^{-1} and plant densities: 300, 350 and 400 plant m^{-2}. Results showed that increase in the application of the nitrogen caused the decline of the agronomical nitrogen use efficiency. The highest and the lowest agronomical nitrogen use efficiencies were obtained in the 60 and 180 kg ha^{-1} nitrogen. With increasing nitrogen application, the lengths of the growth vegetative, reproductive, and ripening periods, were increased. Also, the highest the number of spikes, 1000 grain weight, and grain yield and harvest index were achieved using the 120 kg ha^{-1}. whereas, in the majority of the traits such as yield, 1000 grain weight, harvest index and the number of the spike per unit area, application of 120 kg ha^{-1} was similar to 60 kg ha^{-1} and increase in the nitrogen application more than 120 kg ha^{-1} led to lower trait values. With increasing plant density per unit area, the length of the vegetative growth period, 1000 grain weight and harvest index decreased but the length of the reproductive growth period, number of spike, grain yield per unit area and agricultural nitrogen use efficiency increased. Generally, to prevent environmental pollutions and excess cost, 60 kg ha^{-1} nitrogen with a population of 400 plant m^{-2} is recommended to gain the highest yield with optimum nitrogen use efficiency.

Key words: Agricultural nitrogen use efficiency · Plant density · Yield · Nitrogen fertilizer and durum wheat

INRTODUCTION

Efficiency is defined as the amount of product produced per unit of input by consumption. This means that the nutritional efficiency is an expression of dry matter per unit of nutrient consumed or absorbed [1]. With increasing plant density per unit area there will be decreased nitrogen agronomic efficiency [2]. Lowe nitrogen use efficiency with increased plant density can be related to the increased number of plants per unit area and accordingly fixed nitrogen availability, therefore competition for nitrogen use efficiency will increase [3]. Meanwhile, the Hamidi and Dabagh Mohammadinasab [4], studied the effect of plant density on agronomic use efficiency of corn hybrid varieties, and reported that single cross hybrid 601 has the highest density of agronomic N use efficiency. Raesi and Khajehpour [5] reduced the efficiency of fertilizer and increased the amount of nitrogen fertilizer. Highest efficiency units is obtained to attract first food element, typically and used units food element next, shall create a lower increase, ie by increasing food intake element has less grain yield increase [6]. With increasing plant density per unit area decreased nitrogen agronomic efficiency will occur [7]. Lowe nitrogen use efficiency with increased plant density can be justified so that the increasing number of plants per unit area and according to fixed nitrogen availability, competition for nitrogen use has increased and it will decreases [3]. Hokmalipour [8] also studied the effect of plant density and nitrogen levels on nitrogen use efficiency of crop and reported that increasing plant density per square meter and nitrogen fertilizer, agronomic N use efficiency is reduced. Hamidi and Dabagh Mohammadinasab [4]. Studied effects of plant density on the crop nitrogen use efficiency of corn hybrids in the range of treatments studied in fewer than 10 have reported

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up to 24.86 kg kg^{-1}. Different studies have shown that increased nitrogen intake decreased N use efficiency [9]. Uncontrolled use of nitrogen fertilizers in the cultivation of crops, in addition to compromising the quality and reduce the consumption of healthy donors over time also cause environmental pollution. Therefore, determining the optimum level of nitrogen in which the maximum yield and nitrogen use efficiency and the environmental pollution is redused is very important [6]. Plant density on morphological characteristics of most crops, including cereals are an important influence, for example, corn can be said about the increased congestion, ear diameter, number of grains in rows and many other traits, decreased [10]. Nitrogen also had significance infuence on tillering, number of grains and grain weight increased. N in the grains, pods, grains per pod and grain weight increases [11]. Since the density, dry weight and plant aerial parts is increased and a major proportion of the total dry weight are allocated to, so it seems logical that the density increased harvest index on amount be added [12]. Also, in some plants, the results obtained a photograph, thus the Reddy *et al*. [7] reported that increasing plant density in corn, harvest index decreased. Cox and Cherny [13]. Effect of plant density on corn silage, two densities of 8 and 11.6 plants per square meter was examined and was observed with increasing density, harvest index decreased. While some scholars have expressed the harvest index were affected by plant density. Including other factors affecting the value of harvest index, genotype and rate of nitrogen fertilizer is used. Nitrogen effect on harvest index has meaning. So that with increasing nitrogen fertilizer rate and harvest index decreased in the nitrogen effect on biological yield and economic performance more than the increase of harvest index therefore decreased [14]. Because of the arid and semi arid region located, naturally the amount of soil organic matter was low and most plants are nitrogen deficient. So this problem with nitrogen fertilizer is needed to be resolved. Unfortunately, nitrogen fertilizers are not used as effectively and their efficiency is low [15]. The highest density in cereal crop leads to excessive competition between plants for light, moisture resulting in small amounts of grain being produced. Distribution of nitrogen fertilizers on the level and distribution of nitrogen in plants is effective [16]. High soil fertility and nitrogen consumption, increased growth and finally increas yield [17]. Plant densities have been severe effect during different phenological stages of corn [18]. With increasing plant density delayed emergence flowers, spike bloom and reduced reproductive period is observed [19]. Lang *et al*. [20] reduced the percentage of sterile plants with reduced nitrogen consumption and density. Rudha and Al-younis [21] observed an increase in nitrogen consumption significantly decreased the time needed for the emergence of flowers.

The aim of this study was to investigate of agronomical nitrogen use efficency of durum wheat cultivar Seimareh as affected by nitrogen fertilizer and plant density.

MATERIALS AND METHODS

In order to study of agronomical nitrogen use efficency of durum wheat cultivar Seimareh, as affected by nitrogen fertilizer and plant density, an experiment based on randomized complete block design was conducted at the agricultural research station of the Islamic Azad University, Ardabil branch; Ardabil, Iran in 2008-2009 growing season. The trial had three replications. Factors included nitrogen levels: 0, 60, 120 and 180 kg ha^{-1} and plant densities: 300, 350 and 400 plant m^{-2}. The research center in which the work was carried out was located in north-western of Iran with the elevation of 1350 meters of sea level (48°, 20' E, 38°, 5' N). The weather of the region is very cool in winters and rather warm in summers. Soil of the location was loamy-clay with a PH of 7.7 and the depth of 70 cm. Grains were prepared from the agricultural organization, Germy, Iran. Surface sterilization of grains was performed using Diniconazol fungicide before planting. Grains were placed at the depth of 3-4 cm by spacing 15-25 cm apart on 10 rows each 4 meter length. The first irrigation was done after planting and the rest, as the plant needed, based on the different plant requirements and environmental conditions. Mechanical and chemical weed controlling were executed during the season. Amount of $^1/_3$ total applied nitrogen was applied at the planting time and the rest, was used as surface spread in the spring after the weather began to be warmer coincide with the tillering stage, at 2 times of application. To investigate the date of appearance of several growing stages, following records were performed [22]:

Vegetative Growth Period: From the planting date to the 50 percent flowering stage.

Reproductive Growth Period: from the flowering date to the physiological maturity.

Ripening Period: from the planting to the beginning of 50 percent plants turn to yellow.

At the end of the growing plant and the plant fully matured, measuring yield and yield components, followed by calculation of nitrogen agronomic performance of durum wheat, one of our most important goals in this project. About 1.5 m of each plot to remove the margins, on the floor and put into bags and were transferred to the laboratory and using these samples yield and yield components of some morphological traits, plant dry weight and some other traits were measured.

Amount of Harvest Index Was Calculated as Follows [23]:

$$\text{Harvest index} = (\text{Economical yield/Biological yield}) \times 100$$

Agronomical nitrogen use efficiency was calculated from Hashemidezfooli *et al*. [1]:

$$NAE = [(Y_{f1} - Y_{f0})/N_f]$$

NAE: Agronomical N efficiency (kg ha^{-1}), Y_{f1}: Tuber yield per plot with N application (kg ha^{-1}), Y_{f0}: Tuber yield per plot without N application (kg ha^{-1}), N_f: N rates (kg ha^{-1}).

Data were subjected to analysis by SAS and mean companions were performed using the Duncan's multiple range test procedure. Also, graphs were drawn in Excel software.

RESULTS AND DISCUSSIONS

Agronomical Nitrogen Use Efficiency: The analysis of agronomic data for nitrogen efficiency produced a significant effect of plant density and nitrogen levels on 1 percentage level of agronomic N use efficiency. The results showed that the increased use of nitrogen fertilizer decreased N use efficiency. So that the highest and lowest efficiency in the fertilizer treatments 60 and 180 kg nitrogen per hectare respectively. Also, plant density of 400 and 300 m respectively highest and lowest level of this trait was obtained (Fig 1). Study has shown that different sources of nitrogen fertilizer plants were not used as effectively and their performance is down slightly due to efficiency of nitrogen waste that went through bleaching nitrate, ammonium leaching and is sublimation. With previous average nitrogen use efficiency for cereal in the world have noted that 33-30 percent prevalence for the developed and developing countries respectively, 29 and 42 percent [24]. Hamidi and Dabagh Mohammadinasab [4]. Effects of plant density on the crop nitrogen use efficiency in crop nitrogen use efficiency of corn hybrids in the range of treatments studied in fewer than 10 have reported up to 24.86 kg kg^{-1}. Different studies have shown that increased nitrogen intake reduced nitrogen use efficiency [25-27]. Highest efficiency units typically attract first element will be obtained by dietary intake and subsequent units of food elements, shall create a lower increase, ie by increasing food intake element had less grain yield increases and eventually reaches the line from descending into law yields Mychrlykh has been expressed [6].

Vegetative Growth Period: The length of the growth period of the under study wheat was affected by the plant populations and nitrogen levels. (Table 1). Results of the analysis of variance (data not shown) showed that there is a significant difference ($p<0.01$) between the nitrogen levels and plant populations but there was no significant difference for the interaction effect of these treatments.

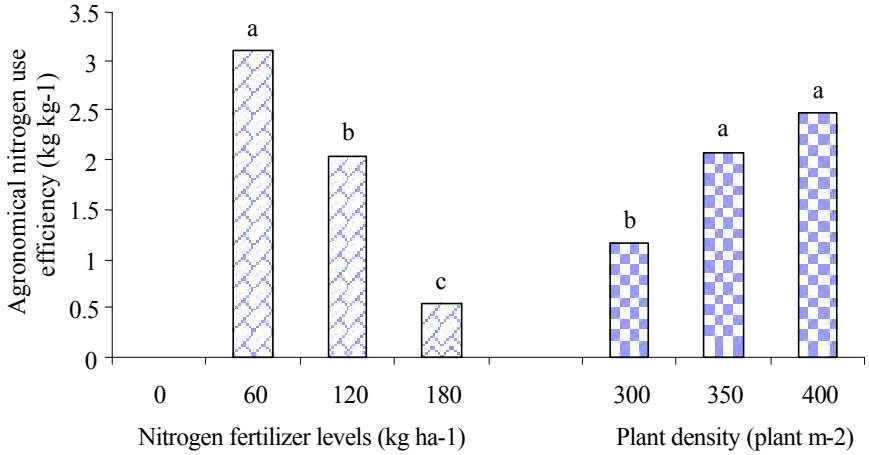

Fig. 1: Main effect of nitrogen fertilizer and plant density for agronomical nitrogen use efficiency.

Table 1: Effects of plant density and nitrogen levels on measured traits.

Tratments		Vegetative growth period (day after planting)	Reproductive growth period (day after planting)	Ripening period (day after planting)	Number of spike in one square	1000 grain weight (g)	Grain yield per square meter (g)	Harvest index (%)
Nitrogen	0	173.66c	55.66b	227.94c	404.83b	48.66c	647.08c	42.44c
fertilizer	60	177.44b	56.55ab	241.05b	476.79a	52.33ab	833.81a	49.88ab
levels	120	178.00b	58.33a	243.94b	493.17a	54.33a	892.65a	51.93a
(kg ha^{-1})	180	183.77a	56.88ab	259.63a	447.91ab	51.22b	745.71b	47.86b
Plant	300	181.07a	53.00c	240.22a	386.06c	53.66a	676.40c	46.31b
density	350	177.50b	57.58b	242.97a	432.67b	50.83b	753.42b	51.02a
(plant m^{-2})	400	176.08b	60.00a	246.22a	548.28a	50.41b	909.63a	46.76b

*Numbers with the same words in each column, have no significant differences to each other

The longest and the shortest vegetative growth period were gained at the 300 and 400 plant m^{-2}, respectively. With increasing the nitrogen amounts, length of this period was increased so that, the longest one was obtained by application of 180 kg ha^{-1} nitrogen. However, there was no significant difference between the 60 and 120 kg ha^{-1} nitrogen on this trait, but with increasing the nitrogen levels and decreasing the plant populations, the length of vegetative growth period was increased (Table 1). Higher amounts of nitrogen resulted in the increase in the growth of the aerial parts and delayed the period [28, 29]. Lang *et al*. [20] observed that with increasing the plant population over the favorable point, this period is delayed one day.

Reproductive Growth and Ripening Period: Results revealed that plant populations and nitrogen levels significantly ($p<0.05$) affected the reproductive growth period, respectively. With increasing plant population, this period was decreased so that, in 300 plant m^{-2}, the shortest and in 400 plant m^{-2}, the longest one was achieved (Table 1).

Based on some research performed on the reduction of the mentioned period caused by the higher rates of plant population, it seems that in the lower populations, the stronger growth of the leaves and lateral stems may result and hence, the incident light radiation needed for the better photosynthesis is increased and eventually, the more suitable growth of the flowering buds is prepared [20, 29]. Accordingly, the beginning of the reproductive period starts with the flowering so, it is logical that with increasing plant population, the length of the reproductive growth period increases.

Also, it was found that nitrogen amount up to the 60 kg ha^{-1} decreased this period but increase in nitrogen application higher than this amount increased the period so that, the longest one was achieved at the level of 120 kg ha $^{-1}$ (Table 1).

Nitrogen significantly ($p<0.01$) affected the length of the ripening period and simple effect of plant population and interaction effect of plant population × nitrogen level was not significant on this trait. Increase in the nitrogen application increased the length of this period, but there was no significant difference between the 60 and 120 kg ha^{-1} usage. The longest and the shortest time to the ripening were gained at the levels of 180 kg ha^{-1} nitrogen and control, respectively (Table 1). It seems that increase in nitrogen application may improve the vegetative growth and hence, plant come to senescence later and ripening happens with delay.

Number of Spike in One Square: ANOVA results showed that among different levels of nitrogen fertilizer, density and interaction density levels of nitrogen fertilizer per unit area for a number of spikes on 1 percentage level there are significant differences. Most spike plants in the density of 400 square meters and the lowest density of 300 plants per square meter was obtained. Increasing levels of nitrogen increased the number of spikes and most use of spike in the 120 kg N ha^{-1}. Increasing the level of nitrogen fertilizer to 120 kg ha^{-1} and with increasing plant density per unit area, most were spike (Table 1). Hashemidezfooli *et al*. [1] also spike increased the number per unit area due to increased nitrogen fertilizer have reported pollen. The interaction density for levels of nitrogen fertilizer, which was also open most spike combined treatments on the density of 120 kg ha^{-1} of nitrogen fertilizer plant in the 400 meters and the lowest value of this trait in combination treatments plant density of 300 m in the fertilizer control respectively (Fig. 2).

1000 Grain Weight: Wheat 1000 grain weight studied in this experiment affected the density and nitrogen levels, variance analysis shows that between different levels of nitrogen fertilizer, density and interaction density of nitrogen levels 1 percent probability level there are

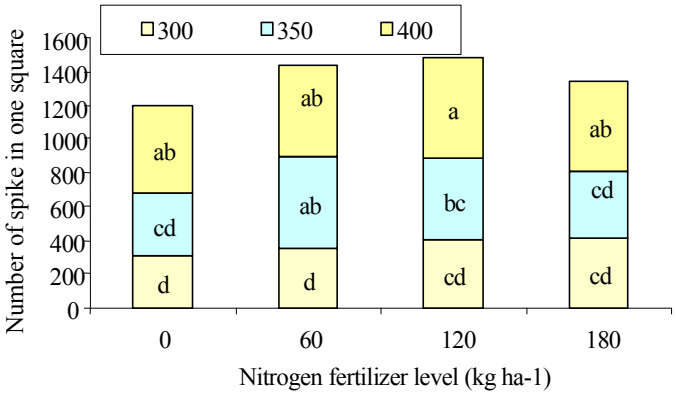

Fig. 2: Number of spike in one square meter as affected by N and plant density

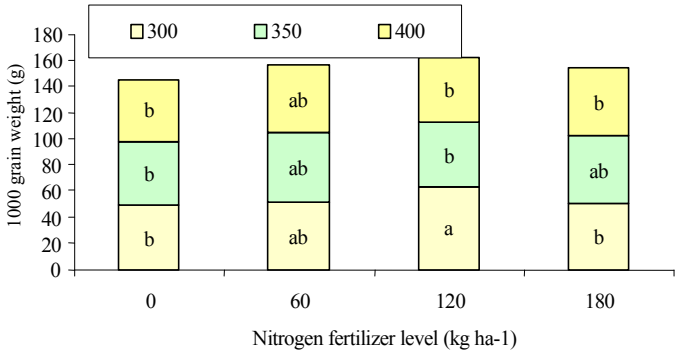

Fig. 3: 1000 grain weight as affected by N and plant density

significant differences. The highest density of 1000 grain weight in 300 plants per square meter and the lowest density of 400 plants per square meter was obtained and this was while the density of 350 plants with 400 plants were in a statistical group. Some researchers to reduce the effect of 1000 grain weight with increased plant density [19]. The interaction density for levels of nitrogen fertilizer was also the highest 1000 grain weight in the composition of 120 kg nitrogen fertilizer treatments on plant density 300 per square meter and the lowest value of this trait in combination treatments plant density of 400 m in control fertilizer respectively (Fig. 3). Increasing levels of nitrogen increased 1000 grain weight and 1000 grain weight in the highest use of 120 kg N ha^{-1} respectively. In fact, with increasing levels of nitrogen fertilizer up to 120 kg ha^{-1} and with increasing plant density per unit area, the highest 1000 grain weight was obtained (Table 1). Nitrogen influenced the different growth stages of wheat by increasing the number of tillers per plant, ear number per unit area, number of grains per spike, 1000 grain weight dry matter accumulation yield [22, 29].

Grain Yield per Square Meter: ANOVA analyses showed that there is a significant difference among different levels of nitrogen fertilizer and plant density in 1 percent level in main effect and for interaction effect of plant density × nitrogen fertilizer there is significant difference in 5 percent level for grain yield m^{-2}. Highest yield in density 400 plants per square meter and the lowest density 300 plants m was obtained. The effect of N fertilizer increased grain yield increased. The highest yield was obtained in the use of 120 kg N ha. Meanwhile, the levels of 120 kg with 60 kg nitrogen level in one group were analyzed. Whit increased nitrogen fertilizer more than 120 kg grain yield was reduced. Increasing the level of nitrogen fertilizer to 120 kg and with increasing plant density per unit area was obtained the highest grain yield.

(Table 1). Jamaati-e-Somarin *et al*. [25, 28] and Panahyan-e-Kivi and Jamaati-e-Somarin [29] also reported results are quite similar. The interaction density levels of nitrogen fertilizer also observed that the open highest yield in the combined treatments of 60 and 120 kg of nitrogen density 400 plants per square meter and the lowest value of this trait in combination treatments density 300 plants per square meter in the control fertilizer was obtained (Fig. 4). Mazaheri [30] reported that increasing N increased the grain yield. Cuomo *et al*. [31] reported that increasing plant density per hectare

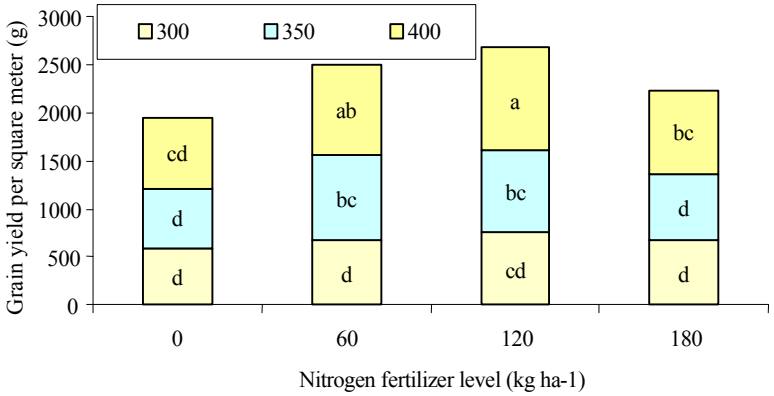

Fig. 4: Grain yield per square meter as affected by N and plant density

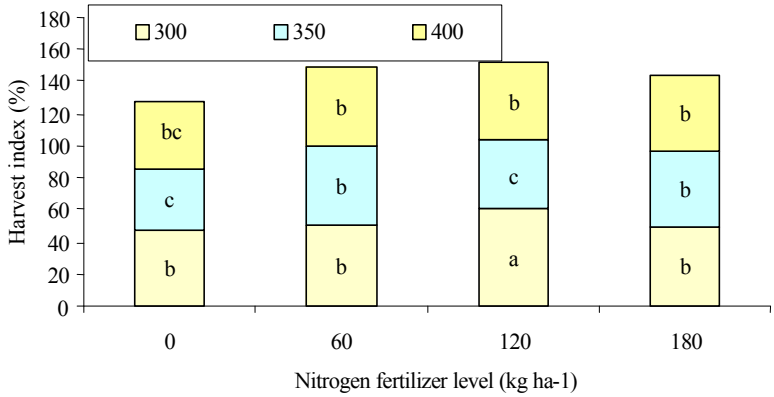

Fig. 5: Harvest index as affected by N and plant density

increases yield. Hamidi and Dabagh Mohammadinasab [4] also argue that the gap between high density and peak bloom corn pollination and therefore increases the rate of inoculation of grains per plant decreased, but the loss per unit area yield per plant, increasing number of plants increases.

Harvest Index: Analysis of variance related to harvest index showed that plant density in the 5 percent level, nitrogen levels and plant density in the interaction of nitrogen levels 1 percent probability level was statistically significant. Density for the interaction of nitrogen fertilizer levels were determined in the combined treatments in 180 kg nitrogen per hectare in the density of 350 plants m highest harvest index was obtained (Fig 5). With increasing plant density, harvest index was significantly decreased. So, the highest harvest index, plant density at 350 m, and densities were 300 and 400 plants m jointly lowest harvest index showed (Table 1). Reddy *et al*. [7] reported that increasing plant density in corn, harvest index decreased. Cox and Cherny [13] were observed with increasing density, harvest index decreased. While some scholars have expressed the harvest index were affected by plant density [2]. Pooruoseph *et al*. [32], the effect of planting pattern and plant density on yield and yield components of two varieties of hybrid corn were investigated and concluded that the density does not affect harvest index. The observed increase in nitrogen harvest index is increased and thus the maximum of harvest index was obtained in the level of 120 kg fertilizer per hectare. Although the control level of nitrogen, allocated to the lowest (Table 1).

Nitrogen fertilizer improves plant growth, the production is more photoassimilate to the stage of grain development, grain production and therefore allocated on the biological yield of grain than to grow. Reddy *et al*. [7] and Panahyan-e-Kivi and Jamaati-e-Somarin [29] reported that nitrogen fertilizer increased harvest index is significant. Meanwhile, the Hamidi and Dabagh Mohammadinasab [2] in their study reported that increasing nitrogen fertilizer, and harvest index decreased because it was mentioned that this kind of nitrogen fertilizer stimulates growth and increases been growing sector and thus to reproductive parts in plants increases. Including other factors affecting the value of harvest index, genotype and rate of nitrogen fertilizer is used.

Nitrogen effect on harvest index has meaning, so that with increasing nitrogen fertilizer rate and harvest index decreased in the nitrogen effect on biological yield was higher than the Americas since the economic practice increases therefore harvest index decreased [14].

CONCLUSION

According to the most efficient nitrogen use efficiency decreased acording the Mychrlykh law, the first unit of nitrogen intake was the highest performance in jointly taking 60 and 120 kg N ha was obtained. Therefore, excessive amounts of nitrogen reduce efficiency and consequently will reduce performance. Therefore, the optimal level of nitrogen consumption in accordance with the highest efficiency and highest performance. After taking more than 60 kg nitrogen per hectare is not only desirable but also by increasing nitrogen intake (more desirable), yield and yield components, followed by nitrogen use efficiency also decreases. At levels 60 to 120 kg fertilizer (fertilizer desirable), the use of nitrogen was efficient and well. Therefore, wheat farmers work with inappropriate application of nitrogen fertilizer while not sleeping that high yield, but increased costs and led to low quality product is produced. Increasing levels of nitrogen up to 120 kg ha increased grain yield per hectare and the fact that the levels of 60 and 120 kg nitrogen per hectare for many traits related to yield, yield components and so statistically significant differences did not show. Therefore, it is recommended to prevent environmental pollution and additional costs, 60 kg of nitrogen fertilizer per hectare the highest agronomic efficiency of nitrogen fertilizer isused. The increase in density per unit area, increase yield and yield components and nitrogen use efficiency, and the density of 400 plants per square meter for the fastest start time of reproductive period and the highest yield and yield components and nitrogen use efficiency was, therefore, recommends, the density of 400 plants per square meter be used.

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