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Comparison of Agronomical Nitrogen Use Efficiency in Three Cultivars of Corn as Affected by Nitrogen Fertilizer Levels

[1]Saeid Hokmalipour, [2]Manochehr Shiri-e-Janagard,
[2]Maryam Hamele Darbandi, [2]Fariborz Peyghami-e-Ashenaee,
[2]Mohammad Hasanzadeh, [2]Mir Naser Seiedi and [3]Reza Shabani

[1]Young Researchers Club, Islamic Azad University, Ardabil Branch, Ardabil, Iran
[2]Islamic Azad University, Ardabil Branch, Ardabil, Iran
[3]Payam Noor University, Ardabil Branch, Ardabil, Iran

Abstract: In order to Comparison of agronomical nitrogen use efficiency in three cultivars of corn as affected by nitrogen fertilizer levels, a split plot experiment based on randomized complete block design with three replications was conducted in research field of Islamic Azad University, Ardabil branch, Ardabil, Iran, in 2009. Factors were: nitrogen levels in main plots (0, 60, 120 and 180 Kg N ha^{-1} and corn cultivars in sub plots (Kenez410, Korduna and Konsur). Traits of NUE, HI, kernels yield, 1000 kernels weight and numbers of kernels per ear and row and row per ear numbers studied. Most of the traits were affected by treatments. Maximum yield was obtained at Korduna×180 kg N ha^{-1}. Maximum nitrogen use efficiency was obtained at Korduna×60 kg N ha^{-1}. Also, results showed that whit increasing nitrogen levels, Nitrogen use efficiency significantly decreased. Increasing of nitrogen levels led to significantly increase in number of kernels per row, number of kernel per ear and 1000-kernels eight. In all traits except numbers of row per ear Korduna cultivars was superior.

Key words: Corn cultivars % Nitrogen use efficiency % Yield and yield component

INTRODUCTION

Maize (*Zea mass* L.) is the third most important cereal crop in the world after wheat and rice and known as "King of grain crops". Approximately 8 to 10% of the corn crop is used as food for human consumption. It is not only a source of food, fodder and feed but also many by-products likes glucose, starch and corn oil, etc are prepared from it. Maize is extensively grown in temperate, subtropical and tropical regions of the world. Maize grains have greater nutritional value as it contains 72% starch, 10% protein, 4.8% oil, 8.5% fiber, 3.0% sugar and 1.7 % ash [1]. The highest maize yield production depended on many factors i.e. cultivars, nitrogen and potassium fertilization [2]. Nitrogen fertilizer is a key nutrient in the production of non legume crops. It is a component in many biological compounds that plays a major role in photosynthetic activity and crop yield capacity [3, 4]. And its deficiency constitutes one of the major yield limiting factors for cereal production [5]. Over N fertilization is a common problem for the wheat-maize rotation system [6] nitrogen has significant effects on the yield as a result of increase in the number of seeds ear^{-1} [7]. Efficient use of N for maize production is important for increasing grain yield, maximizing economic return and minimizing NO3 leaching to ground water [8]. maize grain yield was significantly increased as N-rate increased and maximum figure was obtained due to the addition of 140 kg N and each increase in level of nitrogen up to 140 Kg N/fed results in significant increased in stem 100 grain weight, grain yield, plant and grain yield [9]. El-Bana and Gomaa [2] found a significant increase in grain yield as results of increasing nitrogen levels from 100 to 125kg N. Increasing nitrogen fertilization rates led to a significant increase in ear length, number of kernel per rows, ear weight and grain yield [10-13]. Increase in grain yield with an increase in nitrogen rates was also observed by others [14, 15]. In general, cultivars developed by breeding programs are highly productive and respond to applications of N, but have low efficiency in the use

Corresponding Author: Saeid Hokmalipour, Young Researchers Club, Islamic Azad University, Ardabil Branch, Ardabil, Iran
Tel: +989143550310

of this nutrient [16]. The development of maize cultivars with greater N use efficiency would make a great contribution to plant breeding for sustainable agriculture [17]. Nitrogen supply positively enhances grain yield in all hybrids, primarily by increasing kernel number [18].

MATERIALS AND METHODS

This experiment was conducted in research field of Islamic Azad University, Ardabil branch, Ardabil, Iran, in 2009. The climate is semi-arid. It has 1350 meters altitude from sea level. Based on the soil test, PH was about 7.2, soil texture was loamy-sand and the depth of top soil was 70 cm. This investigation was arranged as split-plot experiment based on the randomized complete block design with three replications. Main-plots were assigned to nitrogen levels (0, 60, 120 and 180 kg ha^{-1}) and sub-plots to corn cultivars (Kenez410, Korduna and Konsur). Each sub-plot included five rows which their length and spaces from each other were 5 and 0.75 meters. Seeds of three cultivars were sown at depth of 3 to 5 cm. Starter nitrogen was applied at 7 and 9-leaves stages. Other agronomy practices did according to soil test (Table 1).

In order to measure yield and yield components, plants of middle rows of each plot randomly were harvested in the surface of 2.5 m^2 at the physiological maturity. Ears were husked, dried and weighed. In order to evaluate harvest index economical yield divided into biological yield and multiplied at 100 (Eq. 1). Nitrogen use efficiency estimated by Eq 2 [19].

Eq 1 ***: HI= economical yield/biological yield ×100***

Eq 2 ***: E_e= (Ydf- Yef)/F***

E_e : Nutrient use efficiency (kg kg^{-1})

Ydf : Produced dry matter by crops which have received the nutrient (kg ha^{-1})

Yef : Produced dry matter by crops which haven't received the nutrient (kg ha^{-1})

F : Amount of applied nutrient (kg ha^{-1})

RESULTS

Analysis of variations, means comparison of main effects and their interaction effects were shown in Table 2, 3 and 4, respectively.

Table 1: status of experimental farm

K PPm	P PPm	T.N. (%)	Os (%)	Tex (%)	Sand (%)	Silt (%)	Clay (%)	Sp (%)	PH	EC (Mmhos)	Sampling depth (cm)
355.2	29.9	0.02	0.2	Clay-loam	21	44	35	54	7.7	1.37	0-30

Table 2: Main comparison of yield, yield component and other traits

Traits Treatments	Levels	Kernel yield (kg h^{-1})	Number of rows/ears	Number of kernel/row	Number of kernel per ear	1000 kernel weight (gr)	HI (%)	NUE (%)
Cultivars	Kenez410	4763.0b	14.00b	29.9b	413.3c	152.9b	26.3b	11.9b
	Korduna	5876.2a	14.00b	31.6a	450.6a	172.2a	26.8a	25.3a
	Konsur	4098.7c	15.66a	28.3c	442.6b	123.2c	24.4c	5.24c
Nitrogen levels (kg h^{-1})	0	3758.0d	14.44a	26.4c	398.8d	125.7d	27.9a	-
	60	4882.6c	14.66a	28.8b	418.7c	155.3c	26.2b	18.7a
	120	5343.6b	14.44a	31.8a	450.3b	157.8b	24.9c	13.2b
	180	5666.2a	14.66a	32.6a	474.2a	159.6a	24.3d	10.6c

* Numbers with the same letter, have no significant difference

Table 3: Analysis of variance of yield, yield component and other traits

Source of variation	df	Kernel yield ha^{-1}	Kernel yield m^{-2}	Kernel yield per plant	1000 kernel weight	Number of kernel per ear	Harvest index
Replication	2	2523	2275	0.45	6.04*	14.1**	2.2**
Nitrogen	3	6263286**	62639**	1113**	2307**	10018**	23.5**
Experimental error	6	11898	12.7	0.21	1.01	0.26	0.12*
cultivar	2	9679156**	96721**	1720**	7444**	4336**	19.2**
Cultivar×Nitrogen	6	755790**	7577**	134**	676**	244**	10.5**
Experimental error	19	2247110	22470	399	1362	2.66	9.35
Cv.	-	39	5.06	0.66	1.5	0.4	0.022

*,** Significant in 5 and 1 persantage probablity respectivily

Table 4: Analysis of variance of Nitrogen Use Efficiency for nitrogen levels and cultivars

Main of squares		
Source of variation	df	Nitrogen use efficiency
Replication	2	0.2180
Nitrogen	2	155.59**
Experimental error	4	0.2953
cultivar	2	942.62**
Cultivar×Nitrogen	4	122.94**
Experimental error	12	192.13
Cv.	-	3.22

*,** Significant in 5 and 1 persantage probablity respectivily

Kernels Yield: Kernels yield was significantly affected by nitrogen fertilizer levels, cultivars and their interaction at 1% probably (Table 3). Korduna, Kenez410 and Konsur significantly produced maximum kernels yield, respectively. Values of yield were 5876.2, 4763 and 4098.75 kg for above cultivars, respectively. Control produced the lowest kernels yield. With increase in N levels amounts of the yield markedly enhanced and N level of 180 kg haG^{1} obtained the highest kernels yield (Table 2). In case of interaction effect, kernels yield raised with increase in N rate in all three cultivars but slope of increase for Kenez410 was more than Konsur. Korduna cultivar significantly produced more yield at all three N levels than others. Maximum yield belonged to Korduna cultivar at 180 kg N haG^{1} and differences between control and the other N levels were greater for it (Figure 1).

Number of Kernel Rows per Ear: There was no significant effect of N levels on this trait. But, cultivars showed significant differences from each other. Konsur cultivar remarkably produced highest values than Kenez410 and Korduna cultivars which were in the same group.

Number of Kernels per Row: Increasing of applied N fertilizer had significant effect on trait of Number of kernels per row at 1% probably. Levels of 180 and 120 Kg N haG^{1} placed at the same and superior group. 60 kg N haG^{1} gained the second group and control had the lowest value. Number of kernels per row was markedly influenced by cultivars, too. Korduna cultivar produced the highest kernels per row with production of 31.66 kernels. Cultivars of kenez410 and Konsur gained the following groups, respectively.

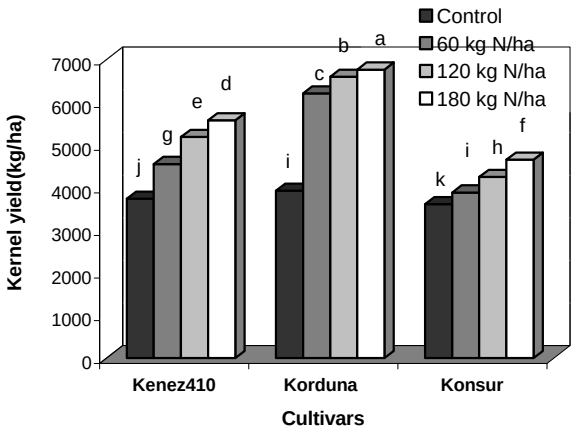

Fig. 1: Interaction effect of Nitogen levels and Cultivars on kernel yield

Kernels Number Per Ear: This trait was significantly affected by cultivars, N levels and their interaction. Cultivars of Korduna, Konsur and Kenez410 produced 450.6, 442.6 and 413.3 kernels per ear, respectively. Control level had the lowest value. With increase in N fertilizer levels kernels number per ear multiplied and 180 kg N haG^{1} produced the highest number. Interaction effect of cultivars and N levels showed that in all cultivars kernels number per ear raised and lowest and highest value belonged to control and 180 kg N haG^{1} but the highest and the lowest amounts was significantly obtained at interaction effect of Konsur×180 kg N haG^{1} and Kenez410×control treatment.

1000 Kernels Weight: Korduna cultivar markedly produced the highest (172.17 gr) 1000 kernels weight. Following Kenez410 with 152.95 gr and Konsur with 123.25 gr placed. Among the N levels control treatment produced the lowest 1000 kernels weight. Increase in N applied from 60 to 180 kg N haG^{1} significantly led to increase in 1000 kernels weight and 180 kg haG^{1} gained the highest value. When we focus on interaction effect of N levels and cultivars showed that there were very low differences among N treatments plus control in cultivar of Konsur. Increasing of nitrogen in cultivars of Korduna and Kenez-410 remarkably caused to increase in 1000-kernels weight and this increase for Korduna was more than Kenez410. Therefore, Korduna was the cultivar that its 1000-kernels weight sharply increased by N levels.

Harvest Index: Harvest index was markedly affected by main and interaction effects of N levels and cultivars. Effect of cultivars on harvest index was the same as their effect on number of kernels/row, 1000-kernels.cultivars of

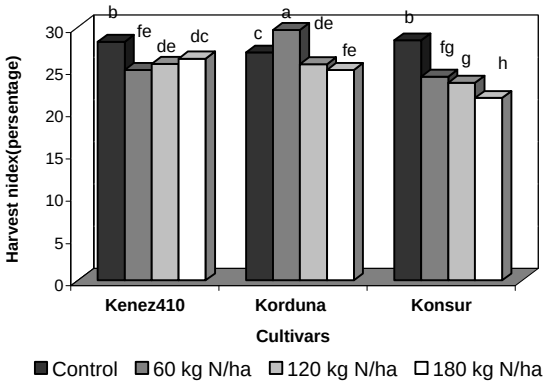

Fig. 2: Harvest index under interaction of Nitrogen levels and Cultivars

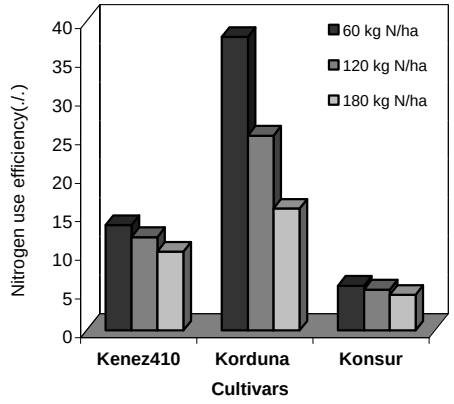

Fig. 3: Interaction of Nitrogen levels and Cultivars on Nitrogen use eficiency

Korduna, Kenez410 and Konsur significantly obtained minimum harvest index, respectively. Increase in nitrogen fertilizer adversely affected harvest index and the lowest and the highest harvest index gained at 180 kg N haG^{1} and control treatments. In case of interaction effect, increase in N levels for Korduna and Konsur cultivars in spite of Kenez410 caused to decrease in Harvest index. In cultivars of Kenez410 and Konsur control treatment had the maximum harvest index but in Korduna the highest amount belonged to 60 kg N haG^{1} (Figure 2).

Nitrogen Use Efficiency: Main effects on NUE were significant (Table 4). Cultivars of Korduna, Kenez 410 and Konsur obtained 25.34, 11.97 and 5.24 kg kgG^{1}, respectively. Therefore, Korduna cultivar which had the highest HI, kernels number/row, kernels number/ear and weight of 1000 kernels gained the highest NUE. Review of N levels showed that raise in amounts of N applied led to decrease in Nitrogen use efficiency and lowest and highest value were gained at 60 and 180 kg N haG^{1}, relatively. Interaction effect of N levels with cultivars demonstrated that in all cultivars enhancing of N fertilizer led to decline in NUE but amount of differences weren't same. Interaction effects of Korduna cultivar with three N levels significantly were higher than the other two cultivars. Also, differences among N levels in cultivar of Korduna were very higher and treatment of Korduna×60 kg N haG^{1} and Konsur×180 kg N haG^{1} had the maximum and minimum values (Figure 3).

DISCUSSION

The results showed that cultivars of Korduna, Kenez410 and Konsur significantly had the highest, middle and the lowest values, respectively in traits of NUE, HI, 100 kernels weight, kernel numbers per row and kernels yield. Also, Korduna had the highest kernels number per ear. There fore, Korduna was superior in all traits except numbers of kernel row per ear. Above yield of Korduna perhaps related to much 1000 kernels weight, number of kernels per ear, numbers of kernels per row in it .With increase in N values 1000 kernels weight, number of kernels per ear, numbers of kernels per row and yield increased. There was no significant effect of N on numbers of rows per ear. Therefore increase in mentioned items led to increase in yield. Sabri *et al.* [20] reported that Nitrogen application didn't affect the number of grains per ear. The effect of different maize hybrid on number of grains per cob was highly significant [21]. Significant difference among hybrids in grain yield was reported by Khaliq *et al.* [22]. Increasing nitrogen fertilization rates led to a significant increase in 100 grain weight and grain yield of maize as compared with control treatment [23]. Nitrogen application significantly resulted in increase number of grains per ear, 100 grain weight and grain yield [24]. Application of 120kgNha+40kgP/ha produced the maximum number of grains per ear which was significantly different from all other treatments [25]. Effect of nitrogen fertilizer on grain yield, kernel number per ear and Maximum grain yield was obtained at 276 Kg/ha nitrogen [26]. The maximum No of grains/cob, the highest 1000 grain weight, Grain yield increased with increasing of N rates and maximum grain yield were produced by application of 120 Kg N haG^{1} [27]. Kernel number per ear in spite of 1000 kernel weight had the largest proportion in kernel yield variation [28]. Sabri *et al.* [20] also reported similar result. 1000 grain weight was affected by cultivars and nitrogen levels. The treatment of (120kgN/ha+40kgP/ha) produced the maximum 1000-grain weight which was significantly

different from the rest of all the treatments. The minimum weight of 1000 grains was obtained in control [25]. Maximum 1000-grain weight was attained by 250 Kg N haG¹ which was statistically at par with treatment 200 Kg N haG¹ [21]. These observations are fully reported by Sharar *et al.* [29]. Patel *et al.* [30] reported that Nitrogen levels had pronounced effect on grain yield and dry matter production. They also mentioned the variation in grain yield due to different levels of nitrogen was related to the differences in size of photosynthetic surface and to the relative efficiency of total sink activity. The higher yields were due to higher number of grains per cob and higher weight of grains [31]. Kostandi and Soliman [32] said that Increasing N rate from 30 to 60 and or 90 kg per acre produced greater response on the N uptake and yield, followed by a limited response at 120 kg N per acre. Increase in grain yield with an increase in nitrogen rates was also observed by others [14, 15]. Nitrogen supply positively enhances grain yield in all hybrids, primarily by increasing kernel number [18]. There was no significant difference in harvest index at flowering between N-deficient and control plants of all hybrids [33]. Agronomic nitrogen use efficiency decreased due to increase in N rate in second season only [24]. There were Significant effects among cultivars and highly significant effect among fertilizer levels on harvest index and HI increased from 150 to 250 Kg N per hectare. They suggest that an optimum supply of nitrogen is essential for favorable partitioning of dry matter between grain and other parts of maize plant [21]. Sabir *et al.* [14] presented similar results. Significant differences of harvest index depended on year [31]. Pablo et al gained adverse result and noted that NUE decreased with increasing of N rates [34]. This result is the same as our findings.

CONCLUSION

In this investigation the highest kernel yield (7679 kg haG¹) was acquired at interaction effect of Korduna × 180 kg N haG¹. Above yield was the more than kernel yield of others cultivars in all N levels. Hence, it is able to say that Korduna cultivar genetically has more potential to produce yield and its response to higher N level is positive. Because of higher kernels number per row and 1000 kernels weight, which have important role in kernels yield, Korduna cultivar had the higher yield than others. Konsur cultivar had very low Nitrogen use efficiency than the others and with regard to NUE in other cereals it is not acceptable. Also, Kenez410 had low NUE and this is not comparable to NUE in other cereals, too. In spite of Konsur and Kenez410 cultivars, nitrogen use efficiency for Korduna cultivar was relatively acceptable. In general, if the goal of cultivation of corn is increase in nitrogen use efficiency we must opt Korduna cultivar. Because it has acceptable nitrogen uses efficiency at all three nitrogen levels. Nitrogen use efficiency for Korduna at levels of 60, 120 and 180 kg N haG¹ were about 40, 23 and 16 kg kgG¹. Result from this research revealed that highest NUE obtained at lowest N level. So, it is recommendable that we must utilize lower N fertilizer to achieve higher NUE. Differences among cultivars in NUE were clearer. So, election of efficient cultivar could reduce waste of N fertilizers and pollution of environment. For the purpose and with regard to our investigation Korduna cultivar is advisable.

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