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Effects of N and K Applications on Agronomic Characteristics of Two Iranian and Landrace Rice (*Oryza sativa* L.) Cultivars

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Abstract: Nutrition elements like nitrogen and potassium are restricting yield performance of rice cultivars and affecting on their characteristics. In order to consider effects of different amount of nitrogen and potassium on yield and chemical compounds of two rice cultivars (Tarrom and Neda which are landrace and improved Iranian genotypes, respectively), current experiment has been undertaken in 2004 and 2005. Four levels of nitrogen fertilizer (0, 50, 100 and 150 kg N ha^{-1} from urea source) and four levels of potassium fertilizer (0, 75, 150 and 225 kg K_2O ha^{-1} from potassium sulfate source) have been applied in a split-factorial based on randomized block design with three replications. Nitrogen fertilizer has been applied in three different stages of plant growth (⅓ in transplanting, ⅓ in tillering and ⅓ in flowering initial stages) and potassium fertilizer has also been applied in two growth stages (½ in transplanting and ½ in shooting stages). Results indicated that application of nitrogen has increased plant height, number of tiller, length and width of flag leaf, length of panicle, number of grain per panicle, grain yield, amount of dry matter, biological yield, harvest index, leaf potassium, leaf nitrogen, 1000 grain weight and reducing percentage of hallow grain. Also, applied potassium has positive effects on all of above mentioned yield components except harvest index and 1000 grain yield. Neda cultivar was better than Tarrom genotype for most of the measured traits. Interaction of nitrogen and potassium were affected significantly on number of tiller per plant, grain yield, amount of dry matter and biological yield in Neda cultivar and on length of flag leaf, number of grain per panicle, grain yield, amount of dry matter, biological yield, harvest index and 1000 grain yield in Tarrom genotype.

Key words: Nitrogen, potassium, rice, yield components, nitrogen efficiency, potassium efficiency

INTRODUCTION

Rice plays the most important role for feeding of millions of Asian people, where more than 90% of the world's rice is grown and eaten (IRRI, 1989). Also, north of Iran as one of the main areas for producing rice inside the country, plays a critical role for feeding Iranian consumers. Rice is the second important crop both in crop production and in human nutrition worldwide. One of the main problems of rice production in about 500,000 ha of northern riceland of Iran is soil deficiency for most of macronutrients. Two of these elements are nitrogen and potassium. FAO (2000) has predicted that the demands for rice will outstrip its production. For overcoming this problem breeders in Asia tries severely to release higher yielding cultivars and for further increasing rice production, Chinese rice breeders developed rice hybrid cultivars, which claims that they gave a 20-30% higher yield in comparison to the best high yielding varieties (Lin and Yuan, 1980).

For higher production of yield using new hybrid cultivars, nitrogen is one of the main parts of rice production technology and also potassium is an important component for some of quality characteristics of rice (Prasad and De Datta, 1979; De Datta and Craswell, 1982; Kropff *et al*., 1993). The main reasons of nitrogen deficiency which is widely reported in lowland rice growing soils worldwide (Kundu *et al*., 1996; Fageria and Baligar, 1996), are loss of nitrogen through leaching, volatilization, surface runoff and denitrification (Prakasa Rao and Prasad, 1980; Fillery *et al*., 1989; Buresh and De Datta, 1990; Prasad, 1998; Prasad *et al*., 1999; Fageria and Barbosa Filho, 2001; Kumar and Prasad, 2004).

Generally, forms and amounts of applied fertilizers influence to a great extent on the yield and quality of rice (Wery *et al*., 1988; Gunes *et al*., 1995; Sidiras *et al*., 1999). Also, use of nitrogen and potassium efficient genotypes is one of the critical complementary strategies in improving rice yield and reducing cost of production. Nitrogen and potassium efficiency should be taken into

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account for improving new cultivars. Increasing high quality rice yield per unit area through use of appropriate nitrogen and potassium management practices has become an essential component of modern rice production technology (Fageria and Barbosa Filho, 2001). Practice of proper management strategies like adequate rate and timing of application and use of efficient crop genotypes, may increase rice yield and influence cost of production, simultaneously. The objective of present study was to evaluate yield components of rice cultivars when receiving different amounts of nitrogen and potassium fertilizers.

MATERIALS AND METHODS

This experiment has been undertaken on field trial, on rice cultivars Neda and Tarrom (two Iranian improved and landrace rice cultivars, respectively) in 2004 and 2005. The farm soil contained 515 g kg^{-1} clay, 295 g kg^{-1} silt, 90 g kg^{-1} sand, 23.4 g kg^{-1} total nitrogen, 213 mg kg^{-1} available potassium and 23.6 percent lime. Four levels of potassium fertilizer (0, 75, 150 and 225 kg k_2O ha^{-1} from potassium sulfate source) and four levels of nitrogen fertilizer (0, 50, 100 and 150 kg N ha^{-1} from urea source) have been applied. Half of the amount of potassium fertilizer was added in transplanting date and the rest was added in shooting stage and ⅓ of the amount of nitrogen fertilizer was used in transplanting time, ⅓ was added in tillering stage and the rest was added in flowering initiation stage. A split-factorial design with 3 replications based on a randomized complete block design with sub-plot size of 3×4 m and plant space of 25 cm have been used and 3 seedlings were transplanted per a hill. Samples were taken from flag leaf in heading stage to determine the amount of leaf mineral elements. Amount of leaf potassium and nitrogen were measured and plant height, panicle length, length and width of flag leaf, number of tillers, number of grains per panicle, number of hollow grains, 1000 grain weight, grain yield, biological dry matter and shoot dry matter were also determined.

To calculate grain harvest index, the grain yield at 14 humidity percent were divided on biological dry matter which is summation of grain yield and shoot dry matter. Nitrogen and potassium efficiency for plant height, number of tiller, length of flag leaf, number of grain per panicle, grain yield, shoot dry matter, biological dry matter and harvest index were calculated using the following formulas (Fageria, 1998; Fageria and Barbosa Filho, 2001):

$$\text{Nitrogen efficiency for each trait (NE)} = (N_f\text{-}N_U/N_a)$$

where, N_f is the measure of corresponded trait of high level of nitrogen fertilized plot, N_u is the measure of corresponded trait of low level of unfertilized plot and N_a is the quantity of N applied (kg).

$$\text{Nitrogen efficiency for harvest index} = (NE_Y/NE_{TDM})$$

where, NE_Y is the nitrogen efficiency of grain yield and NE_{TDM} is the nitrogen efficiency of biological dry matter.

$$\text{Potassium efficiency for each trait (KE)} = (K_f\text{-}K_U/K_a)$$

where, K_f is the measure of corresponded trait of high level of potassium fertilized plot, K_u is the measure of corresponded trait of low level of unfertilized plot and K_a is the quantity of K_2O applied (kg).

$$\text{Potassium efficiency for harvest index} = (KE_Y/KE_{TDM})$$

where, KE_Y is the nitrogen efficiency of grain yield and KE_{TDM} is the potassium efficiency of biological dry matter.

The statistical analyses of data were conducted by analysis of variance and the F-test was used to determine treatment significance using MSTATC statistical software. Duncan's multiple range test was used to compare treatment means at 5 and 1% probability levels.

RESULTS AND DISCUSSION

Table 1 demonstrates significant and non significant effects of N and K applications for tested rice cultivars within two years on 14 agronomic important traits. Cultivars, nitrogen and potassium affect significantly on all of considered traits including plant height, number of tillers, leaf length, leaf width, panicle length, number of seeds per panicle, grain yield, shoot dry matter, straw plus grain dry matter, harvest index, leaf potassium contents, 1000 grain weight, leaf nitrogen contents and percentage of hallow grain. Although the effects of these three factors were highly significant, there was seldom significant effects for their interaction with year or with each other. The differences among interaction of cultivar and nitrogen were significant for all traits except K uptake in leaf (Table 2). However, only plant height, K uptake in leaf, hollow grain and number of tillers showed significant differences in interaction of cultivar and potassium. Interaction of nitrogen and potassium illustrated non significant effects for most of measured traits except for plant height, number of grain per panicle and biological dry matter. Finally, significant results have been achieved only for number of tillers, shoot and biological dry matter and harvest index due to effects of three way interactions among nitrogen, potassium and cultivar.

Table 1: Significance of F values derived from analysis of variance of yield and yield components of two cultivars, four N and four K levels

Characters	Y	C	YC	N	YN	CN	CYN	K	YK	CK	YCK	NK	YNK	CNK	YCNK	CV(%)
Plant height	ns	**	ns	**	ns	**	ns	**	ns	**	ns	**	ns	ns	ns	3.16
Number of tiller	ns	**	ns	**	ns	**	ns	**	ns	*	ns	ns	ns	*	ns	9.03
Length of flag leaf	ns	**	*	**	**	*	ns	**	ns	ns	ns	ns	ns	ns	ns	5.78
Width of flag leaf	ns	**	ns	**	**	*	ns	**	ns	ns	ns	ns	ns	ns	ns	3.36
Length of panicle	ns	**	ns	**	ns	**	ns	**	ns	ns	ns	ns	ns	ns	ns	8.22
No. of grain per panicle	ns	**	ns	**	**	**	ns	**	ns	ns	ns	**	ns	ns	ns	4.48
Grain yield	ns	**	ns	**	**	**	ns	**	ns	ns	ns	ns	ns	ns	ns	2.72
Shoot dry matter	ns	**	ns	**	ns	**	ns	**	ns	ns	ns	ns	ns	ns	ns	4.18
Biological dry matter	ns	**	ns	**	ns	**	ns	**	ns	ns	ns	**	ns	**	ns	2.95
Harvest index	ns	**	ns	**	**	**	ns	*	ns	ns	ns	ns	ns	**	ns	2.43
K uptake in leaf	ns	**	ns	**	ns	ns	ns	**	ns	ns	ns	ns	ns	ns	ns	2.85
1000 grain weight	ns	**	*	**	**	*	ns	**	ns	ns	ns	ns	ns	ns	ns	1.94
N uptake in leaf	ns	**	*	**	ns	**	ns	**	ns	**	ns	ns	ns	ns	ns	3.01
Hollow grain (%)	ns	**	ns	**	ns	**	ns	**	ns	**	ns	ns	ns	ns	ns	9.71

Y = Year C = Cultivar N = Nitrogen K = Potassium ** ($p<0.01$) * ($p<0.05$) ns = not significant

Table 2: Reaction of yield and yield components of rice cultivars to different levels of N and K application

Variable	C	N0	N1	N2	N3	K0	K1	K2	K3
Plant height	T	67.42c	73.65b	77.92a	79.38a	71.90c	74.21b	76.04a	76.21a
	N	92.75c	102.10c	102.40b	108.40a	94.67b	102.60a	104.10a	104.30a
Number of tiller	T	18.88d	23.83c	24.08b	31.38a	23.83b	15.25a	26.08a	26.00a
	N	23.08	28.83b	32.58a	33.04a	26.88c	29.04b	30.46a	31.17a
Length of flag leaf	T	19.63d	23.75c	24.46b	29.25a	22.79c	24.33b	25.67a	26.29a
	N	24.83b	27.21a	28.25a	28.13a	25.54b	26.88ab	28.13a	27.88a
Width of flag leaf	T	1.31a	1.30a	1.32a	1.31a	1.29a	1.31a	1.33a	1.32a
	N	1.28a	1.30a	1.29a	1.29a	1.28a	1.29a	1.29a	1.29a
Length of panicle	T	17.88c	23.29b	23.08b	27.42a	20.96b	23.00a	23.79a	23.92a
	N	22.71b	26.79a	26.58a	26.50a	24.08b	26.13a	26.00a	26.38a
No. of grain per panicle	T	94.33b	99.79c	126.54b	130.46a	101.29c	112.96b	126.17a	115.71a
	N	109.20d	122.40c	143.30a	130.00b	118.00b	126.30a	129.60a	130.90a
Grain yield	T	3099d	4439c	5695b	5915a	4527c	4774b	4875a	4971a
	N	3193c	4588b	6104a	5964a	4651b	4867ab	5162a	5196a
Shoot dry matter	T	5035c	4957c	5881b	6089a	5386b	5430b	5522ab	5624a
	N	4633c	5818b	6773a	6857a	5807b	5882b	6216a	6176a
Biological dry matter	T	8130d	9385c	11590b	12000a	9926c	10200b	10390ab	10580a
	N	7908c	10530b	12920a	12820a	10500c	10920bc	11420a	11350ab
Harvest index	T	0.381c	0.473b	0.493a	0.493a	0.451b	0.461a	0.463a	0.464a
	N	0.409d	0.448c	0.474a	0.463b	0.439c	0.455b	0.449b	0.451ab
K uptake in leaf	T	1.924c	1.952bc	1.992ab	2.007a	1.852b	1.936c	2.003b	2.083a
	N	1.848a	1.896a	1.933a	1.934a	1.745b	1.849b	1.966a	2.044a
1000 grain weight	T	24.08a	24.12a	24.13a	24.29a	24.13a	24.04a	24.27a	24.19a
	N	27.65ab	28.05ab	28.04ab	28.08a	27.83a	27.89a	28.03a	28.15a
N uptake in leaf	T	2.939ab	2.990a	2.924a	2.980a	2.861b	2.969a	3.001a	3.003a
	N	2.597b	2.576b	2.734ab	2.798a	2.602a	2.693a	2.705a	2.698a
Hollow grain (%)	T	23.40a	19.57b	11.15c	10.15c	20.95a	16.79b	14.24c	12.28d
	N	7.81a	7.06a	5.98b	6.16b	8.61a	6.94b	6.12b	5.35c

Mean values with the different letter(s) are significantly different, C = Cultivar, T = Tarrom, N = Neda N0 = without N N1 = 50 kg N ha^{-1} N2 = 100 kg N ha^{-1} N3 = 150 kg N ha^{-1} K0 = without K K1 = 75 kg K_2O ha^{-1} K2 = 150 kg K_2O ha^{-1} K3 = 225 kg K_2O ha^{-1}

Nitrogen and potassium efficiency for 10 considered traits showed that there are differences between Neda and Tarrom cultivars for both of macronutrients (Table 3). Nitrogen efficiencies were higher than potassium efficiencies in all of studied traits, except in width of flag leaf. These efficiencies were not high enough for height, number of tillers, length of flag leaf, length of panicle, number of grain per panicle and harvest index, however, for grain yield, shoot dry matter and biological dry matter they were high enough. Nitrogen plays an efficient role with 18.77 and 18.47 for Tarrom and Neda, respectively. However, role of potassium with 2.378 and 2.919, respectively for Tarrom and Neda seems not to be so efficient. Similar trends have governed on N- and K-efficiencies of Tarrom and Neda for traits shoot and biological dry matter (Table 3).

Plant height and number of tiller: Plant height and number of tiller per plant in both cultivars were different and nitrogen and potassium have significantly affected on these two characters. Number of tiller per plant in Neda was greater than Tarrom. Also, interactions of cultivar and nitrogen and cultivar and potassium on these two traits were significant. Three way interactions of cultivar, nitrogen and potassium were significant only on number of tiller per plant but not on plant height (Table 1).

Table 3: Efficiency of nitrogen and potassium application in different rice cultivars for measured traits

	N-efficiency		K-efficiency	
Character	Tarrom	Neda	Tarrom	Neda
Plant Height	0.08	0.10	0.023	0.050
No. of tiller	0.08	0.07	0.012	0.023
Length of flag leaf	0.06	0.02	0.019	0.013
Width of flag leaf	0.00	0.00	0.000	0.000
Length of panicle	0.06	0.03	0.016	0.012
No. of grain per panicle	0.24	0.14	0.050	0.069
Grain yield	18.77	18.47	2.378	2.919
Shoot dry matter	7.03	14.83	1.275	1.976
Biological dry matter	25.80	32.75	3.503	4.553
Harvest Index	0.73	0.56	0.68	0.64

Cultivars Tarrom and Neda showed different trends for various levels of nitrogen and potassium applications for the measured traits. By increasing nitrogen level plant height increased from 67.42 to 79.38 cm and from 92.75 to 108.40 cm in Tarrom and Neda, however, increasing potassium level increased plant height from 71.90 to 76.21 cm and from 94.67 to 104.30 cm in Tarrom and Neda, respectively (Table 2).

The efficiency of nitrogen application for plant height in Neda (0.10) was greater than Tarrom (0.08). The same trend has governed on the efficiency of potassium application on plant height, means that Neda with 0.050 has used potassium fertilizer more efficient than Tarrom with 0.023 (Table 3).

Due to nitrogen application, number of tiller per plant in Tarrom and Neda changed from 26.88 to 31.88 and from 31.08 to 33.04 tillers per plant, respectively (Table 2). A number of researchers have reached into a result that application of nitrogen can increase number of tillers in rice cultivars (Imam and Nicknejad, 1994; Fageria and Barbosa Filho, 2001; Shen *et al*., 2003; Qian *et al*., 2004). Nevertheless, potassium application also increased number of tillers per plant from 23.83 to 26.00 and from 26.88 to 31.17 in Tarrom and Neda, respectively (Table 2). The result of increasing number of tillers due to potassium application has also been supported by some other considerations (Bansal *et al*., 1993; Pandey *et al*., 1993; Kalita *et al*., 1995; Ojha *et al*., 2000).

Interactions of nitrogen and potassium on plant height and number of tillers per plant showed no significant effect with the exception of significant outcome for number of tiller per plant in Neda (Table 4).

Length and width of flag leaf and length of panicle: There were significant variations in two studied cultivars for length and width of flag leaf and length of panicle so that, these characteristics have been affected by nitrogen and potassium application. Also, interaction effects of cultivar and nitrogen on length and width of flag leaf and length of panicle were significant (Table 1). Length of flag leaf has significantly increased by nitrogen application from 19.63 to 29.25 cm and from 24.83 to 28.13 cm in Tarrom and Neda, respectively (Table 2). Potassium application has also changed length of flag leaf from 22.79 to 26.29 and from 25.54 to 27.88 cm in Tarrom and Neda, respectively (Table 2). Length of panicle has been influenced by nitrogen and potassium applications, so that; it changed from 17.88 to 27.42 and from 22.71 to 26.50 and also from 20.96 to 23.92 and from 24.08 to 26.38 cm in Tarrom and Neda by nitrogen and potassium applications, respectively (Table 2). Bansal *et al*. (1993) have also measured an increase in length of panicle because of nitrogen application.

The efficiency of nitrogen application for length of flag leaf in Neda (0.02) was smaller than Tarrom (0.06). The same trend has governed on the efficiency of potassium application on length of flag leaf, means that Neda with 0.013 has used potassium fertilizer less efficient than Tarrom with 0.019; however, these efficiencies were not important in width of flag leaf in both genotypes (Table 3).

Grain number per panicle and grain yield: There were significant differences in traits grain number per panicle and grain yield between both of the studied cultivars. These two characters were under influence of nitrogen and potassium applications. Interaction effects of cultivar and nitrogen on both traits and interaction of nitrogen and potassium on grain number per panicle were significant (Table 1). Application of nitrogen causes an increase in grain number per panicle from 94.23 to 130.46 in Tarrom and from 109.20 to 143.30 in Neda and in grain yield from 3099 to 5915 kg ha^{-1} in Tarrom and from 3193 to 6104 kg ha^{-1} in Neda, respectively (Table 2). These results are in accordance with the results of Bansal *et al*. (1993), Fageria and Barbosa Filho (2001), Fageria and Baligar (2001) and Shen *et al*. (2003).

Application of potassium cause also an increase in grain number per panicle from 106.29 to 116.17 in Tarrom and from 118.00 to 130.90 in Neda and in grain yield from 4527 to 4971 kg ha^{-1} in Tarrom and from 4651 to 5196 kg ha^{-1} in Neda, respectively (Table 2). Bansal *et al*. (1993), Sreemannarayana and Sairam (1993), Pandy *et al*. (1993), Kalita *et al*. (1995), Brouhi *et al*. (2000) and Ojha and Talukdar (2000) have measured an increase in both traits using potassium fertilizer.

Nitrogen and potassium interactions on grain number per panicle and grain yield were significant ($p<0.05$). Treatment N3K3 produced greatest number of grain and grain yield in both cultivars with 136 and 137.5 grains and 6136 and 6293 kg ha^{-1}, respectively (Table 4). Increasing in grain yield because of simultaneous application of nitrogen and potassium has been reported by Zhan and Wang (2005).

Table 4: Interactive effect of N and K on yield and yield components

	No. of tiller		Length of flag leaf (cm)		Grain yield		Shoot dry matter		Total dry matter		Harvest index		1000 grain weight (g)		Hollow grain (%)	
Treat	T	N	T	N	T	N	T	N	T	N	T	N	T	N	T	N
N0K0	8.83a	21.67j	17.17f	23.33a	2993h	3017f	5135ef	4377f	8128g	7393g	0.368g	0.368a	23.65c	27.35a	28.36a	10.17a
N0K1	10.67a	23.50j	18.50f	25.17a	3049h	3153f	4999f	4517f	8048g	7991fg	0.379fg	0.412a	23.74bc	27.63a	29.94ab	8.19a
N0K2	11.50a	24.33j	20.83e	25.17a	3165h	3324f	5024f	4970de	8174g	8299f	0.387f	0.401a	24.43a	27.65a	21.78bc	6.94a
N0K3	12.50a	23.83j	22.00de	25.67a	3189h	3281f	4983f	4670ef	8172g	7951fg	0.390f	0.413a	24.50a	27.95a	18.53cd	5.95a
N1K0	15.33a	26.50hi	23.50cd	26.33a	4211g	4347e	5017f	5350d	9228f	9697e	0.456e	0.449a	24.34ab	27.89a	27.22a	8.74a
N1K1	14.67a	28.33gh	22.67de	26.50a	4424f	3985e	4953f	5384d	9378f	9869e	0.471de	0.454a	24.20ab	27.84a	20.33c	7.19a
N1K2	16.83a	29.83e-g	24.50c	28.17a	4555f	4958d	5008f	6143c	9563f	11100d	0.476cd	0.446a	24.01a-c	28.02a	16.15de	6.61a
N1K3	16.50a	30.67d-g	24.33c	27.83a	4565f	5061cd	4848f	6396bc	9362f	11460d	0.487a-d	0.441a	23.95a-c	28.44a	14.57e-g	5.69a
N2K0	17.50a	30.17d-g	23.33cd	26.50a	5273e	5665b	5440de	6585ab	10760e	12420c	0.493ab	0.455a	24.04a-c	27.96a	14.85d-f	7.38a
N2K1	19.67a	32.83b-e	28.00b	28.17a	5661cd	6357a	5768bc	7018a	11430d	13210ab	0.495ab	0.479a	24.01a-c	27.01a	10.71g-j	5.80a
N2K2	19.50a	33.00b-d	27.17b	29.67a	5850bc	6068ab	5857bc	6728ab	11710b-d	12960a-c	0.499a	0.480a	24.31ab	28.07a	10.01h-j	5.61a
N2K3	19.67a	34.33a-c	27.33b	28.67a	5998ab	6325a	6458a	6761ab	12460a	13090a-c	0.482b-d	0.482a	24.18a-c	28.11a	9.05ij	5.16a
N3K0	21.67a	29.17f-h	27.17b	26.00a	5631d	5574bc	5952bc	6915a	11580d	12490bc	0.486a-d	0.443a	24.49a	28.13a	13.39e-h	8.14a
N3K1	24.00a	31.50c-f	28.17b	27.67a	5963ab	5983ab	5998bc	6612ab	11960a-c	12600a-c	0.498ab	0.475a	24.23a-c	28.11a	11.19f-I	6.56a
N3K2	24.50a	34.67ab	30.17b	29.50a	5931ab	6292a	6199ab	7022a	12130ab	13310a	0.488a-c	0.467a	24.32ab	28.38a	9.03ij	5.33a
N3K3	23.33a	36.83a	31.50a	29.33a	6134a	6007ab	6207ab	6879a	12340a	12890a-c	0.497ab	0.465a	24.13a-c	28.11a	6.98j	4.62a

Mean values with the different letter(s) are significantly different, T = Tarrom, N = Neda

The efficiency of nitrogen application for length of panicle and grain yield in Neda (0.03 and 18.47) was smaller than Tarrom (0.06 and 18.77), respectively. The same trend has governed on the efficiency of potassium application on grain number per panicle, means that Neda with 0.016 has used potassium fertilizer more efficient than Tarrom with 0.012. However, the trend in grain yield is vise versa with 2.919 and 2.378 in Neda and Tarrom, respectively (Table 3).

Shoot and biological dry matter: There were significant differences among cultivars for amount of shoot and biological dry matter (Straw + Grain). Nitrogen and potassium application and interactions between cultivar and nitrogen and among cultivar, nitrogen and potassium were significant ($p<0.01$) in production of amount of shoot and biological dry matter (Table 1). Application of nitrogen in Tarrom causes an increase in the amount of shoot dry matter from 5035 to 6089 kg ha^{-1} and biological dry matter from 8130 to 12000 kg ha^{-1} whereas, in Neda shoot dry matter increased from 4633 to 6857 kg ha^{-1} and biological dry matter increased from 7908 to 12920 kg ha^{-1} ($p<0.01$). The same results were obtained from Bansal *et al.* (1993), Fageria and Baligar (2001), Fageria and Barbosa Filho (2001) and Shen *et al.* (2003). However, potassium increased shoot dry matter from 5386 to 5624 kg ha^{-1} and biological dry matter from 9926 to 10580 kg ha^{-1} in Tarrom. Shoot dry matter have been increased from 5807 to 6216 kg ha^{-1} and biological dry matter from 10500 to 11420 kg ha^{-1} (Table 2). The outcomes were in accordance with the achievements of Brouhi *et al.* (2000).

The efficiency of nitrogen application for shoot and biological dry matter in Neda (14.83 and 32.75) was greater than Tarrom (7.03 and 25.80), respectively. The same trend has governed on the efficiency of potassium application on shoot and biological dry matter, means that Neda with 1.976 and 4.553 has used potassium fertilizer more efficient than Tarrom with 1.275 and 3.503, respectively (Table 3).

Simultaneous application of nitrogen and potassium had significant effects on shoot dry matter and biological dry matter. In Tarrom, the highest amount of shoot dry matter was obtained from treatment N2K3 (6458 kg ha^{-1}) and the highest amount of biological dry matter was measured by 12340 kg ha^{-1} in treatment N3K3. Meanwhile, in Neda, both of the highest amount of shoot and biological dry matter were obtained from treatment N3K2 (7022 and 13310 kg ha^{-1}, respectively) (Table 4). This finding was emphasized by Zhang and Wang (2005) that interactions between nitrogen and potassium could increase the amount of dry matter.

Harvest Index, 1000 grain weight and percentage of hollow grain: Harvest index, 1000 grain weight and percentage of hollow grain in Tarrom and Neda were significantly different in present experiment (Table 1). Nitrogen and potassium application and interaction of cultivar and nitrogen had a significant effect on these traits. Harvest index was significantly influenced by interaction of cultivar, nitrogen and potassium and percentage of hollow grain was significantly affected by nitrogen and potassium application, respectively. In Tarrom cultivar application of nitrogen increases harvest index from 0.381 to 0.493 and reduces percentage of hollow grain from 23.4 to 10.15%. Also, in Neda cultivar, harvest index has increased from 0.409 to 0.474 and percentage of hollow grain reduced from 7.81 to 5.98%. However, 1000 grain weight which was not influenced by nitrogen application in Tarrom has increased from 27.65 to 28.08 g in Neda (Table 2). Application of potassium have increased harvest index from 0.451 to 0.464 and from 0.439 to 0.455 and reduced percentage of hollow grain from

20.95 to 12.28% and from 8.61 to 5.35% in both Tarrom and Neda cultivars, respectively (Table 2). Simultaneous application of nitrogen and potassium has significantly affected on harvest index, 1000 grain weight and percentage of hollow grain. Highest amount of harvest index was obtained from treatment N2K2 with 0.499, highest 1000 grain weight was obtained from N3K0 treatment with 24.49 g and lowest percentage of hollow grain was obtained from treatment N3K3 (4.62 g) in Neda cultivar (Table 2).

The efficiency of nitrogen application for harvest index in Neda (0.56) was smaller than Tarrom (0.73). The same trend has governed on the efficiency of potassium application on harvest index, means that Neda with 0.64 has used potassium fertilizer less efficient than Tarrom with 0.68 (Table 3). The efficiencies of nitrogen and potassium were ignorable for 1000 grain weight and percentage of hollow grain in both genotypes.

Leaf nitrogen and potassium: The amount of leaf nitrogen and leaf potassium was different in both of the studied cultivars. Meanwhile, cultivar by nitrogen and cultivar by potassium interactions showed significant differences (Table 1). Increasing the potassium application increased the leaf potassium contents from 1.852 to 2.083% and from 1.745 to 2.044% in Tarrom and Neda, respectively (Table 2). Although there have been shown increasingly changes in leaf nitrogen contents by nitrogen application, none of cultivars showed significant variation. Also, non significant effects have been exhibited when nitrogen and potassium were simultaneously applied (Table 2).

CONCLUSIONS

Nitrogen and potassium application have significantly affected on economic, agronomic and physiological plant characteristics. Grain yield, shoot and biological dry matter, plant height and other components of yield are positively under influence of nitrogen or potassium application; however, hollow grain is an exception. Efficiencies of nitrogen or potassium application play different roles in various traits. Nitrogen or potassium may increase grain yield, shoot and biological dry matter, number of grain per panicle, length of panicle, length and width of flag leaf in both tested genotypes. Neda as an improved cultivar which carries a number of agronomical important genes showed better performance than Tarrom as a landrace cultivar. Application of 150 kg N ha^{-1} with 225 kg K_2O ha^{-1} (treatment N3K3) showed higher results in most of studied traits. Doing experiment with more genotypes and precise levels of N and K applications may result in more clear achievements.

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