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Effects of Nitrogen and Potassium Fertilizers on Rice (*Oryza sativa* L.) Genotypes Processing Characteristics

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Abstract: In order to consider effects of various levels of nitrogen and potassium application on kernel processing characteristics of rice cultivars, an experiment was developed in 2004 and 2005 using Tarrom (a local Iranian landrace) and Neda (an Iranian improved cultivar). In this experiment 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 using a split factorial design with 3 replications. Nitrogen fertilizer have been applied in three stages (1/3 in transplanting stage, 1/3 in tillering stage and finally 1/3 in flowering initiation stage) and potassium fertilizer have been applied in two stages (1/2 in transplanting stage and 1/2 in shooting stage). Results showed that application of nitrogen cause an increase in amount of bran production and have shown significant effects on percentages of bran, head and brewers rice, husking efficiency and transformation degree. However, potassium application has increased percent of bran and husking efficiency and has decrease percentages of brewers rice and has not demonstrated significant effects on percentages of husk, head rice and transformation degree. Furthermore, simultaneous application of nitrogen and potassium in Tarrom genotype has not shown significantly effects on percentages of husk, head and brewers rice and transformation degree. In Neda, cultivar has not also shown significant effects on percentages of bran production, head and brewers rice and husking efficiency, respectively. In Tarrom genotype amount of husk, bran, brewers rice and transformation degree were higher than in Neda cultivar, however, amount of head rice and husking efficiency in Neda cultivar were higher than in Tarrom genotype.

Key words: Husked rice, brewers rice, head rice, nitrogen, potassium, processing characteristics

INTRODUCTION

Optimizing grain yield, reducing production costs and minimizing pollution risks to the environment are considered as the most important in rice production worldwide (Koutroubas and Ntanos, 2003). Iranian end users are interested in consuming high quality rice. Rice is mostly consumed as a whole grain. Therefore, physical properties like size, shape, uniformity and general appearance are highly important (Chaturvedi, 2005). The first step of judging for positive and good quality for a rice genotype in consumers' desired is good appearance of rice kernel (Perez *et al*., 1996). Quality, in turn, is based on a combination of subjective and objective factors. Consumers play key roles for determining the rank of importance of a fixed set of criteria for evaluating quality (Dipti *et al*., 2003). Rice quality is not only controlled genetically but also severely affected by environmental factors and processing techniques. Rice breeders improve genetic traits of new cultivars required to produce the most desirable products.

Selection for improving milling and processing qualities is an essential component of breeding programs designated for meeting industry standards or husking and bran removal and efficiency of head rice production which are preferred by consumers in Iran's traditional markets. Husking involves the removal of the husk from rough rice by shear of impact force and modern husking methods involve the use of impeller and rubber roll huskers (Juliano, 1985; Yamashita, 1993). During husking, rice kernel is subjecting to several different factors, which depends on the direction of grain feed into husker machine, apart from husking rough rice, may also make more or less damages on rice kernel (Yoshizaki and Miyahara, 1984). Therefore, a clear understanding of the kernel husking characteristics is vital for reducing brewer rice production for obtaining more head rice.

Application of nitrogen and potassium fertilizers may variously affecting on some of key characters for determining contribution of husk and bran and/or even contribution of broken kernels in comparison with whole paddy rice production. Genotypes producing heavier

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husk with thicker diameter and higher percentage of bran contribution needs to enter into a breeding program to increase ratio of white rice to paddy rice. If applied fertilizers play role to make husk and bran layer thicken, then experiments should be directed for finding new recommendation of using these fertilizers.

The objective of current study was to determine the effects of N and K application on grain market quality of milled rice in two most cultivated improved (Neda) and non improved (Tarrom) Iranian rice genotypes.

MATERIALS AND METHODS

The present experiment was conducted at Sari experimental station of Iran in years 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% 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 1/3 of the amount of nitrogen fertilizer was used in transplanting time, 1/3 was added in tillering stage and the rest was added in flowering initiation stage. A split-factorial plot experimental 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 each plot and the kernel's husk and bran were removed by an experimental milling factory, namely Amalagator (WIG. L. BUG.), to reach white kernel either broken or head rice. Husk ratio and percentage of bran removal were calculated as the ratio of husks or bran weight on total paddy rice weight, respectively. Broken rice and head rice ratio were calculated as the ratios of broken or whole kernel weight on total white kernel weight, respectively. Transformation degree and husking efficiency were calculated as division of head rice on paddy rice and division of white kernel production on paddy rice multiplied by 100, respectively.

RESULTS AND DISCUSSION

Data demonstrates that cultivars differentially reflect for different processing characteristics when levels of nitrogen and potassium fertilizers have been applied variously. Several activities are needed to change rough rice into white polished kernel which is considered here as processing characteristics.

Rice kernels need to be processed until obtaining head rice for introducing to consumers in market. Practices correlated with white kernel production have affecting on husk and bran removal, production of brewer kernel and head rice and efficiency of husking and transformation degree of paddy rice into head rice. In present study these properties have been considered as processing characteristics. Analysis of variance has demonstrated that there are highly significant differences between genotypes for all the processing traits. Nitrogen affecting significantly on percentages of bran removal and head rice production and potassium showed significant effects on husk and bran ratios, brewers rice and transformation degree. However, interactions of genotype×nitrogen, enotype×potassium, nitrogen×potassium and genotype×nitrogen×potassium have significantly differed in most characters (Table 1 and 2).

Husk and bran ratios: Husk ratio was not under influence of nitrogen application; however, potassium application, interactions of genotype × nitrogen, genotype × potassium and also simultaneous application of nitrogen and potassium showed significant effects on the present trait (Table 1). Husk ratio in Tarrom genotype was higher when compared to Neda cultivar (Table 2). There were significant differences between studied genotypes for husk trait and so, the amount of husk production in Tarrom genotype was higher than Neda cultivar (19.96 and 19.40%, respectively). Nitrogen application in Tarrom genotype has reduced husk percentage, so that, N3 treatment showed minimum husk production. In contrast, husk production has been increased by application of potassium fertilizer (Table 3). In Neda cultivar, application of nitrogen and potassium have not been significantly affected on husk production characteristics, but using nitrogen and potassium simultaneously showed significant effects on current trait. Furthermore, interaction of nitrogen and potassium had significantly affected on amount of husk production by Tarrom with minimum and maximum production of 18.50 and 21.83% in treatments N3K3 and N3K0, respectively (Fig. 1a).

Application of nitrogen and potassium have tremendously significant effects on bran production and also there has been observed significant differences of bran production between examined genotypes. Interactions of genotype×potassium and nitrogen×potassium have demonstrated significant differences for amount of bran production (Table 1). Tarrom genotype has produced more bran (13.60%) than Neda cultivar (11.53%). Application of nitrogen increased ratio of bran production from 12.2 to 13.1% and this trait has been firstly increased from 12.16 to 13.19% by application of potassium and then decreased from 13.19

Table 1: Analysis of variance of a number of processing characteristics related with two Iranian rice genotypes

		Means of squares					
Source of Variation	df	Husk ratio (%)	Bran ratio (%)	Brewers rice (%)	Head rice (%)	Husking efficiency (%)	Transformation degree (%)
Replication	2	0.16	0.19	5.07	6.52	0.64	0.9
Gen	1	7.55**	103.31**	340.36**	1018.23**	121.59**	95.74**
Error (a)	2	0.09	1.01	16.95	3.33	0.76	0.4
N	3	0.88	4.31*	8.47	26.60*	1.06	4.71
Gen×N	3	2.20**	2.96	1.17	8.59	1.8	1.58
K	3	3.16**	5.24*	21.54*	10.72	4.51	9.83*
Gen×K	3	2.16**	9.72**	9.51	8.93	7.62**	3.84
N×K	9	0.72*	3.79*	17.87**	32.87**	3.82*	5.04
Gen×N×K	9	0.66	3.77*	7.68	22.13**	1.96	2.40
Error (bc)	60	0.35	1.48*	5.31	8.31	1.85	2.97
CV		3.02	9.70	18.13	5.23	2.02	2.06

Gen = genotype; N = Nitrogen; K = Potassium; *; ** Significant at 5 and 1% levels, respectively; df = Degree of freedom

Table 2: Means of processing qualities of two Iranian rice genotypes for N and K application

Treatment	Husk ratio (%)	Bran ratio (%)	Brewers rice (%)	Head rice (%)	Husking efficiency (%)	Transformation degree (%)
Tarrom	19.96a	13.60a	14.56a	51.81b	82.80b	80.22b
Neda	19.40b	11.53b	10.83a	58.32a	84.80a	81.06a
N0	19.76a	12.20b	12.55a	55.34ab	83.68a	80.89a
N1	19.83a	12.26b	12.08a	56.10a	84.43a	80.58a
N2	19.72a	12.71ab	12.70a	55.24ab	83.69a	80.41a
N3	19.40a	13.10a	13.51a	53.60b	83.40a	80.70a
K0	19.60b	12.16b	13.64a	54.62a	82.97b	80.42a
K1	19.41b	13.19a	11.39ab	55.77a	83.64ab	80.83a
K2	19.49b	12.66ab	12.10ab	54.38a	84.17ab	80.92a
K3	20.21a	12.25b	11.71b	55.49a	84.42a	80.39a
Mean	19.68	12.57	12.21	55.07	83.8	80.64

Different letter(s) shows significant effects, N_0, N_1, N_2 and N_3 = Control, 50, 100 and 150 kg N ha^{-1}, respectively, K_0, K_1, K_2 and K_3 = Control, 75, 150 and 225 kg K_2O ha^{-1}, respectively

Table 3: Interactions of cultivar and applied nitrogen and potassium for processing qualities of two Iranian rice genotypes

Treatments	Husk ratio (%)	Bran ratio (%)	Brewers rice (%)	Head rice (%)	Husking efficiency (%)	Transformation degree (%)
Tarrom						
N0	20.23a	13.15a	14.66a	52.19a	80.87a	82.57a
N1	20.33a	12.84a	13.98a	52.51a	79.96ab	83.80a
N2	20.03ab	13.96a	14.64a	51.41a	79.54b	82.47a
N3	19.25c	14.45a	15.09a	51.13a	80.41ab	82.38a
K0	19.84b	12.99bc	14.82a	52.27a	79.98a	83.38a
K1	19.39b	15.11a	13.24a	52.26a	80.44a	81.43a
K2	19.71b	13.65b	15.72a	50.92a	80.50a	82.83a
K3	20.90a	12.66b-d	14.59a	51.80a	79.86a	83.56a
Neda						
N0	19.29a	11.25a	10.44a	58.49a	80.90a	84.80a
N1	19.33a	11.68a	10.18a	59.68a	81.11a	85.07a
N2	19.42a	11.43a	10.75a	59.07a	81.26a	84.92a
N3	19.56a	11.76a	11.93a	56.06a	80.98a	84.42a
K0	19.37a	11.34a	12.46a	56.98a	80.83a	85.46a
K1	19.43a	11.27a	10.18ab	57.29a	80.87a	84.51a
K2	19.27a	11.67a	11.06ab	57.85a	81.22a	84.46a
K3	19.52a	11.84a	9.61b	59.18a	81.33a	84.77a

Different letter(s) shows significant effects, N0, N1, N2 and N3 = Control, 50, 100 and 150 kg N ha^{-1}, respectively, K0, K1, K2 and K3 = Control, 75, 150 and 225 kg K2O ha^{-1}, respectively

to 12.25% (Table 2). Although application of nitrogen in Tarrom genotype causes an increase from 13.15 to 14.45% in bran production, it had no significant effects on bran production of both genotypes. Also, application of potassium in Tarrom genotype showed significant differences in both characteristics with maximum of 20.90 and 15.11% for husk and bran ratios, respectively (Table 3). Simultaneously application of nitrogen and potassium in Tarrom and Neda genotypes have significantly affected on bran production, so that, minimum amount of bran produced in Tarrom genotype was belong to treatment N3K3 with 11.63% and in Neda was belong to treatment N0K2 with 9.66% (Fig. 1b).

The more husk and bran ratio the less white rice would be produced and this character can candidate a genotype as containing poor processing properties to be included in a breeding program (Chaturvedi, 2005). Previous studies indicated that judicious and proper

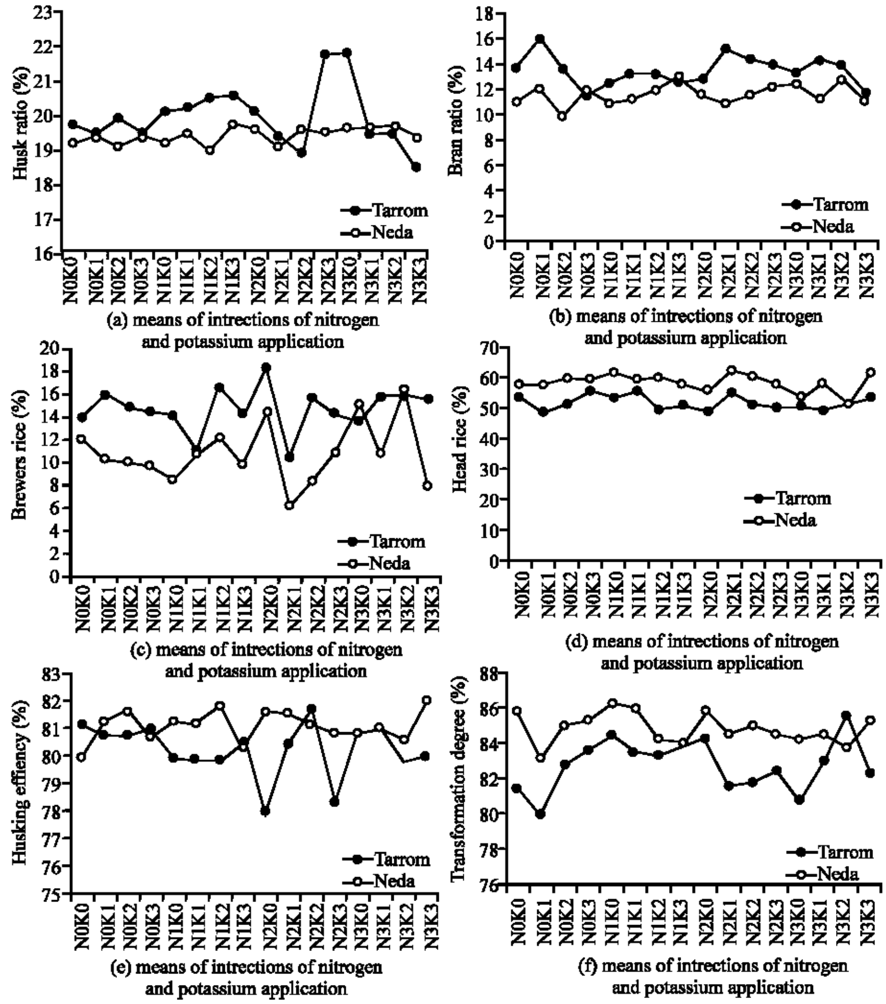

Fig. 1: Effects of various levels of simultaneous application of nitrogen and potassium fertilizers on processing characteristics of rice genotypes

application of nitrogen and potassium fertilizers can markedly increase the yield and improve the quality of rice (Place *et al*., 1970).

Brewers and head rice ratios: Brewers rice has been variously produced in current studied genotypes. Potassium application and interaction of potassium and nitrogen have significantly affected brewers rice production (Table 1). Tarrom genotype with average of 14.56% produced more brewers rice than Neda cultivar with average of 10.83% (Table 2). Although application of nitrogen showed no significant effect on brewers rice production, increasing in potassium application cause reduction in the amount of brewers rice production (Table 2). Brewers rice production was not under influence of nitrogen application in Tarrom genotype, however, in Neda cultivar it was increased insignificantly by application of nitrogen and decreased significantly by application of potassium fertilizers (Table 3). Also, interaction of nitrogen × potassium has significantly affected brewers rice production. Minimum brewers rice production in both genotypes were attributed to treatment N2K1 with 6.06 and 10.33%, respectively (Fig. 1c).

Production of head rice as one of the main objectives of rice producers and researchers, has illustrated significant differences between studied genotypes. Applied nitrogen showed significant effects on head rice production and moreover simultaneous application of nitrogen and potassium were effective in head rice production (Table 1). Head rice production was higher in Neda cultivar than in Tarrom genotype with 58.32 and 51.81%, respectively (Table 2). Application of 50 kg N per hectare increased head rice production but increasing the amount of nitrogen application decreased head rice production, so that, application of 150 kg N ha^{-1} head rice production has decreased down to minimum amount of 53.60% (Table 2).

Potassium application has no significant effects on head rice production (Table 2). Although in Tarrom genotype production of head rice was not under influence of nitrogen and potassium application, in Neda cultivar showed increasing trend for head rice production until 50 kg N ha^{-1} nitrogen was applied but has been decreased by extra nitrogen application. Meanwhile, application of potassium has no significant effects on head rice production of Neda cultivar (Table 3). Interaction of nitrogen×potassium was effective on head rice production of both genotypes, so that maximum head rice production in Tarrom and Neda genotypes were belong to treatments N1K1 and N2K2 with 55.54 and 62.66%, respectively (Fig. 1d).

Rice grain quality is tremendously important because of two different aspects, obtaining higher percentage of head rice and its cooking quality (Merca and Juliano, 1981). Regardless cooking quality which is very many important in Iranian custom markets, beauty of rice kernel appearance is also of importance for all customers worldwide (Khush *et al*., 1979). Having more polished head rice is the ultimate objective of husking activities which starts stepwise from husk removal to polishing head rice (Adair *et al*., 1973). What is important in current experiment results is defining differences between an Iranian high quality landrace and an Iranian improved cultivar for rice post harvest processing characteristics.

Overall, the present experiment results showed that Tarrom genotype produces high ratios of husk and bran and thus low percentages of broken, head, or total white rice. Because of customers' desired some activities should be organized for breeding of this valuable high quality landrace exclusive for our province. Also, it should be emphasized that all activities like how dried pre milling processing, type of drier and huskers are mostly important to get higher results for less broken rice and high head rice (Shitanda *et al*., 2000). Shitanda *et al*. (2006) in their consideration on type of huskers found that performance of impeller husker for producing less brewers rice is much better than a rubber roll husker. Actually, one reason for higher brewers rice production of landrace genotype is behind on grain length and shape.

Husking efficiency and transformation degree: Studied genotypes were different for husking efficiency. Interactions of genotype×potassium and nitrogen×potassium were significant for husking efficiency (Table 1). Neda cultivar showed better results for husking efficiency than Tarrom genotype (Table 2). Application of nitrogen and potassium have no significant effects on husking efficiency, however, in Tarrom genotype, nitrogen application reduced husking efficiency but potassium application showed non significant (Table 3). Also, application of nitrogen and potassium showed no significant effect on husking efficiency of Neda cultivar but simultaneous their applications have significantly affected husking efficiency in both genotypes. Maximum husking efficiencies in Tarrom (80.98%) and Neda (81.95%) genotypes were demonstrated by receiving 150 kg N ha^{-1} and 75 kg K_2O ha^{-1} and 150 kg N ha^{-1} and 225 kg K_2O ha^{-1}, respectively (Fig. 1e).

Neda cultivar with 81.06% showed better transformation degree than Tarrom genotypes with 80.22% (Table 2). In contrast with nitrogen application that has no significant effect on transformation degree, potassium application cause an increase in this trait (Table 2). Although in both genotypes none of nitrogen and potassium application showed significant effects on trait transformation degree, simultaneous application of nitrogen and potassium was effective on transformation degree. Maximum transformation degree was obtained in treatment N3K2 in Tarrom genotype, whilst it showed no significant in Neda cultivar (Fig. 1f).

Genotype Tarrom with more husking efficiency may produce less final head rice. Nitrogen application showed to be effective on husking efficiency of Tarrom genotype so that the more utilization of nitrogen the more husking efficiency has obtained (Table 3). Also, it has been shown that in our studied genotypes none of fertilizers were effective for creating different transformation degree (Table 3). We severely recommend that the present theory should be tested using more genotypes by several separate experiments to define exactly if nitrogen, potassium or their interactions are effective on ultimate transformation efficiency.

CONCLUSIONS

The main objectives of researchers and rice producers are obtaining higher results for head rice and transformation efficiency by producing lower ratio of brewers rice. Application of chemical fertilizers can compensate current needs for rice growth and increase its yield performance; they are also effective on rice kernel transformation processes. Application of nitrogen causes an increase in bran and head rice ratios. Although application of potassium increases husk ratio and husking efficiency, decreases brewers rice ratio, too. Application of nitrogen in Tarrom genotype can result in reducing husk ratio and husking efficiency; however, in Neda cultivar causes an increase in husk ratio. Potassium utilization in Tarrom genotype has reduced husk ratio and transformation degree, but husk ratio has been increased in Neda cultivar. Maximum head rice has been produced using 50 kg N ha^{-1} and 75 kg K_2O ha^{-1} and using 100 kg N ha^{-1} and 75 kg K_2O ha^{-1} in Tarrom and Neda genotypes, respectively. Both genotypes have produced minimum brewers rice ratio by treatment N2K1 (100 kg N ha^{-1} and 75 kg K_2O ha^{-1}).

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