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Effects of Foliar Application of Nitrogen and Potassium on Dry Matter Remobilization of Rice

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ABSTRACT
Foliar application of fertilizers is one of the effective approaches in improving absorption efficiency and reducing losses due to leaching in paddy field. To evaluate the effects of foliar application of nitrogen and potassium on morphological and physiological traits of rice varieties, this study was performed at Rice Research Institute of Iran in Mazandaran. The response of an improved variety, Shiroodi and a local landrace, Hashemi to times and doses of foliar application of nitrogen and potassium were evaluated using split-split plot experimental design. Chlorophyll content was measured in all treatments and dry matter remobilization (DMR) from stem, leaf, flag leaf and whole organ was calculated. Furthermore, the residues of nitrogen, potassium and phosphorous were measured both in rice straw and grain after harvesting. According to the results, chlorophyll content was significantly increased by once or twice foliar application. Results of analysis for DMR rate in organs clearly showed that the DMR from stem and subsequently from whole organ was higher in Shiroodi related to Hashemi. Comparing the dose of foliar application indicated that the highest DMR from the organs was achieved in Shiroodi cultivar using recommended dose. Furthermore, while the DMR in Shiroodi was higher with one time application, it was higher in Hashemi with twice foliar applications. Measuring the macro element residue indicated that while nitrogen and phosphorous content of grains was more than straw in both cultivars, potassium was highly accumulated in rice straw.

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INTRODUCTION

Rice (*Oryza sativa* L.) is the third cereal crop after maize and wheat in terms of production and harvested area ands known as a staple food for more than half of the world’s population [7]. The global area of rice cultivation is in the region of 163 × 10^6 ha producing 719 × 10^6t,withthe average yield of 4.41 t. ha^{-1} [3]. The main regions of rice cultivation are in Asia and around 65% of the world rice production has belonged to China, India and Indonesia [16]. Population growth and economic development increased the demand of rice and with the average yield of 3.5t. ha^{-1}, the demand for rice increases 1.7 percent, annually [16]. Due to the increasing consumption of rice as a source of calorie and reducing the cultivated area in the world, use of new technologies and approachesin rice cultivation is important. Rice is the principle food crop of Iran, feeding almost hundred percent of its population. Rice scientists are engaged in developing new high yielding varieties and management practices to increase the productivity per unit land area per unit time. Achieving a sustainable increase in rice production can improve global food security and contribute to poverty alleviation. The reason for such low yield is mainly associated with cultural technologies [16]. Foliar application of fertilizers is one of the techniques to improve absorption efficiency and reduce losses due to leaching in paddy field which ultimately reduces production cost. On the other hand, the capita consumption of basic fertilizers (N, P, and K) is about twice in Iran, comparing with the developed countries which cause water pollution, soil toxicity and negative effects on the environment and humans. So, foliar application of macro elements may enhance both the yield and safety of the human food supply while reducing the production cost to attain sustainable agriculture [7]. Abou El-Nour reported that foliar application can reduce environmental pollution and increase the absorption of nutrients by roots, associated with root growth by improving the nutrient usage and reduction of fertilizer usage [1]. Sharif et al. (2006) showed that foliar application of fertilizer can increase rice growth and decrease the chemical fertilizer usage [14,12].Vegetative sources [6] although a major portion of minerals in seeds are likely supplied through continuous uptake and translocation during reproductive growth to developing seeds. In wheat, Zn and

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Fe [5,14] remobilization from leaves was observed. According to Jiang et al. (2007), when 65Zn is applied to rice leaves (either the flag leaf or the lowest senescent leaf), 45-50% is transported out of the treated leaf. From that Zn, more than 90% is translocated to other vegetative organs; little is partitioned to the panicle parts and even less to the grains [8].Remobilization of vacuolar nitrate stores can be measured by removing all N supply from a growing plant [2,17] and in this work this treatment has been used to test the response of two rice cultivars that differ in their NUE. Leaf tissue or sap nitrate concentrations are used as indicators of a plant's N status and this fact is exploited by farmers when making decisions on fertilizer application rates [16]. Measurements of leaf tissue nitrate primarily determine nitrate stored in the vacuole. However, vacuolar nitrate accumulation within cereal leaf cells differs; the highest concentrations accumulate in epidermal cells [4,9].In this study, effects of foliar application of nitrogen and potassium on morphological and physiological traits of rice varieties were evaluated. In this study, effects of foliar application of nitrogen and potassium on chlorophyll content, dry matter remobilization (DMR) and the residues of macro elements were evaluated in rice cultivars.

MATERIAL AND METHODS

Two Iranian rice cultivars, Shiroodi (high-yielding variety) and Hashemi (local landrace) were sown in the seedbed and then transplanted in the main field. The field was part of the experimental field at the Rice Research Institute of Iran in Mazandaran in Amol. The experimental design was split-split plot based on a randomized complete block design with three replications. The rice varieties were set as main plot and foliar application times and dosage (concentration) were assigned as sub- and sub-sub plots, respectively. Times and dosage of foliar applications were selected according to the soil test and nutritional principles of rice plant [15]. In the case of times, once and twice foliar applications at the vegetative and panicle initiation stages were compared with no application as a check. Two doses of foliar applications were evaluated in the current study. Recommended dose including 2% nitrogen and 0.5% potassium (recommended by commercial companies) and altered dose including 4% nitrogen and 1% potassium (according to the previous experiences and observations in the field).

Nitrogen was obtained from the source of common urea (soluble) and for potassium; a commercial liquid fertilizer with 20% potassium was used. The plot size was 5 × 2 m and distances between and within rows was 20 cm. Chlorophyll was measured in all treatment using a chlorophyll meter (Minolta,Spad-502, Japan) and remobilization of dry matter was calculated in various organs including stem, leaf, flag leaf and whole organ. Furthermore, the residues of nitrogen, potassium and phosphorous were measured both in rice straw and grain after harvesting. The average of data from each plot was used for the statistical analysis using SAS software and means were compared using the least significant differences (LSD) test.

RESULTS AND DISCUSSION

Foliar application dose and times for nitrogen and potassium was evaluated in two rice varieties, Hashemi and Shiroodi. According to the analysis of variance, a significant effect on interaction of time and dose of foliar application for the trait of chlorophyll content was observed. Mean comparison of the trait using LSD test showed that the chlorophyll content was significantly increased by once and twice foliar applications (Figure 1).Change in chlorophyll content by application of micronutrient fertilizer was already reported and relation of low chlorophyll content and decrease in photosynthesis and biomass production at the flowering stage of rice was discussed[19].

Dry matter remobilization (DMR) was measured in stem, leaf, flag leaf and whole organ in rice cultivars. Analysis of variance indicated that the effect of block was significant in stem and whole organ DMR ($P<0.05$, Table 1). It is shown that effects of cultivar and all interactions were significant in stem DMR. In leaf DMR, the effects of Times of application×cultivar and cultivar × dose were significant. However, in the whole organ DMR, effects of block, cultivar and all interaction effects were significant (Table 1). The ability to remobilize dry matter from organs was compared between rice cultivars. DMR from stem and subsequently from whole organ was higher in Shiroodi related to Hashemi. According to the results, no significant differences were observed in leaf and flag leaf DMR of the cultivars. Therefore, Stem has a critical role in the remobilization in high-yielding rice variety, Shiroodirelated to the local landrace, Hashemi. According to the analysis of variance, all two-way interaction effects were significant (Table1). Mean values of the interaction effects for DMR were compared using LSD test. Table 2 shows the means of DMR of each organ for cultivar*times of application interaction effects. It is shown that Shiroodi with once foliar application had a higher DMR from stem, leaf, flag leaf and whole organ. Stem DMR of Hashemi was half of those of Shiroodi with once foliar application. Interestingly, Shiroodi and Hashemi had a diverse reaction to times of application. While the DMR in Shiroodi was higher with one time application, it was higher in Hashemi with twice foliar applications. This difference, clearly discriminate the ability of high-yielding variety and local landrace for remobilization. It also indicates the varietal differences in response to foliar application. Mean comparison of DMR for cultivar*dose interaction effect showed that the highest DMR from stem, leaf, flag leaf and whole organ was achieved in Shiroodiwith recommended dose of foliar application. In Hashemi, All DMRs except the leaf with altered dose were significantly lower than Shiroodi. It is clearly shown that the treatment of no foliar application (control) had the lowest DMR of organs in both cultivars (Table 3). Means of the DMR for interaction effect of times of application*dose were analyzed and compared with control. According to the results, DMRs from stem, leaf, flag leaf and whole organ in the treatment without foliar application were significantly lower than other treatments. Twice foliar application of fertilizer using recommended dose significantly increased stem and whole organ DMR(Table 4). These results show that increasing the concentration of foliar application may not necessarily increase the DMR of rice organs. The amount of remaining nitrogen, phosphorous and potassium was measured both in grain and straw of Shiroodi and Hashemi. While nitrogen and phosphorous content of grains was more than straw in both cultivars, potassium was highly accumulated in rice straw. Analysis of the macro element content in grain and straw under various times and dose of foliar application was performed. According to the results, no significant differences were observed among the treatments. Therefore, foliar application at the vegetative and panicle initiation stages may not alter the remaining macro elements in rice grain and straw after harvesting.

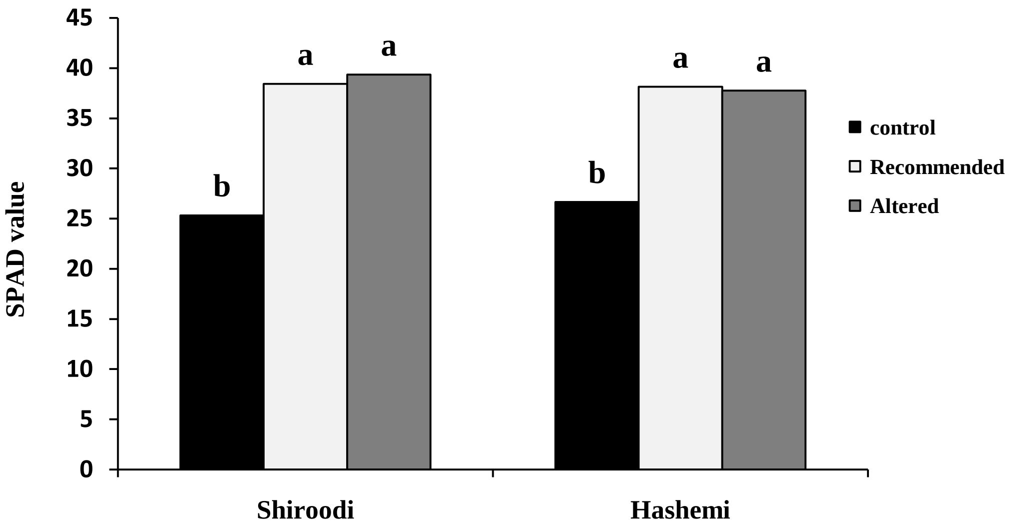

Fig. 1: Chlorophyll content of rice varieties using various doses of foliar application. Two doses of foliar application were compared with control in both rice cultivars, Shiroodi and Hashemi and the chlorophyll was measured using a chlorophyll meter.

Table 1: Analysis of variance for dry matter remobilization.

Source of variance	df	Mean square			
		Stem	Leaf	Flag leaf	Whole organ
Block	2	6.19*	1.29	3.47	2.42*
Cultivar	1	34.87**	4.87	3.11	41**
error A	2	0.35	1.56	0.42	0.07
Times of application	1	0.24	0.36	3.02	0.007
Times of application*cultivar	1	19.49*	46.5**	0.58	36.9**
errorB	4	2.37	2.25	1.38	0.8
Dose	1	2.10	3.50	4	2.64
Cultivar*dose	1	16.75**	17.56*	1.81	21.03**
Times of application*dose	1	52.89**	1.02	4.36	24.4**
Cultivar*Times of application*dose	1	56.94**	2.82	0.77	64.5**
error C	8	1.86	3.06	1	1.59
CV (%)		11.04	36.38	22.87	8.9

*and**: Significant at 5% and 1% probability level, respectively.

Table 2: Mean values of dry matter remobilization (g.m^{-2}) of cultivar*Times of application interaction effect.

Cultivar	Times of application	Stem	Leaf	Flag leaf	Whole organ
Shiroodi	Once	208.3 a	43.2 a	28.1 a	279.6 a
	Twice	181.2 b	18.7 c	18.7 b	218.6 b
Hashemi	Once	104.2 d	10.4 d	19.8 b	134.4 d
	Twice	147.9 c	37.5 b	14.9 c	200.3 c

-In each column, means with similar letter are not significantly different (P<0.01).

Table 3: Mean values of dry matter remobilization (g.m^{-2}) of cultivar*dose interaction effect.

Cultivar	Dose of foliar application	Stem	Leaf	Flag leaf	Whole organ
Shiroodi	Control	74.8 f	28.7 b	13.5 c	117 e
	Recommended	221.9 a	35.4 a	25.3 a	282.6 a
	Altered	167.7b	26.6 b	21.5 b	215.8 b
Hashemi	Control	90.6 e	19.2 c	8.9e	118.7e
	Recommended	114.6d	22.5 c	23.2 b	160.3 d
	Altered	137.5c	35.4 a	11.4 d	184.3 c

-In each column, means with similar letter are not significantly different (P<0.01).

Table 4: Mean values of dry matter remobilization (g.m^{-2})of foliar application time*dose interaction effect.

Times of application	Dose of foliar application	Stem	Leaf	Flag leaf	Whole organ
Without application	-	82.7 e	23.9 c	11.2 c	117.8 e
Once	Recommended	125 c	28.1 b	31.6 a	184.7 c
	Altered	187.5 b	25.5 b	16.3 b	229.3 b
Twice	Recommended	211.4 a	25.8 b	17 b	254.2 a
	Altered	117.7 d	36.4 a	16.7 b	170.8 d

-In each column, means with similar letter are not significantly different (P<0.01).

Conclusion:

Remobilization of dry matter from various organs is varied in rice cultivars and the high-yielding variety had a higher DMR than local landrace. This finding confirms the genetic differences between rice varieties for remobilization from the organs. Study the effects of dose and times of foliar application in DMR clearly showed how supplemental fertilizer can affect the DMR in rice varieties. For instance, while the DMR in Shiroodi was higher with one time application, it was higher in Hashemi with twice foliar applications. Recommended dose including 2% nitrogen and 0.5% potassium gave a better result in Shiroodi for DMR from stem, leaf, flag leaf and whole organ. Therefore, foliar application can enhance remobilization of dry matter in rice cultivars. However, concentration and times of application should be adopted for rice cultivars.

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