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SPLIT APPLICATION OF POTASSIUM AND ITS EFFECT ON BRRI DHAN29 PRODUCTION

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ABSTRACT

A field study was carried out to evaluate the growth and yield of BRRI dhan29 as influenced by different potassium level with recommended NPSZn fertilizer under the regional condition of Mymensingh during the period from February to May 2008. The changes in postharvest soil were also evaluated under the present study. The experiment was laid out in a Randomized Complete Block Design with three replications. The experiment consists of five treatments *viz.* T_1: control, T_2: NPSZn + K_{60}, T_3: NPSZn + $K_{30(FLP)}$ + $K_{30(SA)}$, T_4: NPSZn + $K_{90(FLP)}$, T_5: NPSZn + $K_{45\ (FLP)}$ + $K_{45(SA)}$. Basal application was given with N, P, S, and Zn at the rate of 40, 7, 5, 0.5 Kg ha^{-1} as urea, triple superphosphate, gypsum and zinc oxide, respectively. The split application of K had a significant positive effect on plant height, tillers $hill^{-1}$, effective tiller and unfilled grains $panicle^{-1}$. The grain and straw yields were highly and positively influenced by split application of potassium. The highest grain yield (6.87 t ha^{-1}) and straw (5.89 t ha^{-1}) yields were recorded in T_5 containing NPSZn + $K_{45(FLP)}$ + $K_{45(SA)}$. The uptake of K also increased gradually with K rates and the split application also showed better performance than single application. The concentration of K in soil solution depended on treatment and time of sampling. Split application of K showed lower solution K then single application.

Key words: BRRI dhan29, split application, growth and yield

Introduction

Rice (*Oryza sativa*) is the major food crop of Bangladesh covering about 80% of total cropped area. Agriculture of Bangladesh is characterized by intensive crop production with rice based cropping system. Bangladesh occupies third position in rice area and fourth position in rice production (BRRI, 2000). The expected yield of rice in Bangladesh is not achieved in the farmer's field due to different management practice (BRRI, 2004). Among them, appropriate rate, time and application methods of potassium is one of the most effective factor for enhancing the yield of rice. As evidenced from worldwide research findings, a large percentage of sterile or unfilled spikelets are caused by poor pollen viability and this retards carbohydrate translocation due to potassium deficiency (Dabermann and Fairhurst, 2000). Moreover, potash plays an effective role in root development, spikelet development and ripening. It is also known to play vital role in photosynthesis, translocation of photosynthates and activation of enzymes. In Bangladesh, K is traditionally applied in rice field just before transplanting or at final land preparation. But split application of potassium at appropriate level can increase of filled grain, in other words reduce the sterility and thereby increase the yield of rice. Significantly higher yield of rice have been reported due to split application rather than single application of potassium by many workers (and Singh and Singh, 1978). Potassium also helps to control or reduce the severity of plant diseases and increase the plant's resistance to drought and other stresses. It performs many functions in plant such as promoting growth and increasing yield, increasing resistance to pests, promoting root growth, regulating water utilization by plant, strengthening plant tissues and preventing lodging. Potassium fertilization influenced the uptake of other nutrients like magnesium and calcium depending on the potassium status of the soil (Kansal and Sekhon, 1974). Fertilizer K should be applied in rice crops in such a way that minimum is lost through leaching and maximum is utilized for plant growth and grain production. In order to increase the use efficiency and reduce loss of K, it should be applied in split at various phases of plant growth and development. Sekhon *et al.* (1973) also reported that the two peaks of potassium absorption rate, one at maximum tillering stage and other at flowering stage. Other scientists also reported that split application of potash is superior to its basal application (Ghosh *et al.*, 1995). From the above aspect, the different doses of K fertilizer have been used by split application at the different stages of plant growth to observe the variation in yield and yield attributes of BRRI dhan29 in the present study. Split application of K fertilizer on leaching loss of K and uptake by BRRI dhan29 was also evaluated for obtaining the K balance for Boro rice.

Materials and Methods

An experiment was conducted at the Soil Science field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from January–June 2008 under the regional soil and climatic condition of AEZ–9 (Old Brahmaputra Floodplain). BRRI dhan29, a mordern variety of rice, was used as the test crop in this experiment. Besides, the experiment comprised of five different types and rates of potassium (K) *viz.* T_1 (0 kg K ha^{-1}), T_2 (60 kg K ha^{-1}), T_3 (30+30 kg K ha^{-1}), T_4 (90 kg K ha^{-1}) and T_5 (45+45 kg K ha^{-1}) where T_1, T_2 and T_4 as single application were applied at final land preparation while T_3 and T_5 as split application were applied at final land preparation and 40 days after transplanting i.e. at active vegetative stage. Nitrogen (Urea), phosphorus (TSP), sulphate (Gypsum) and Zinc (ZnO) @ 40, 7, 5 and 0.5 kg ha^{-1}, respectively were applied as basal dose on soil test basis. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each block was subdivided into five unit plots as such there were 15 unit plots for placement of 5 treatments with three replications. The plot size was 2.5 m × 4.0 m with spacing of 20 cm × 20 cm between hills and 1.0 m between block. The soil samples, at a depth of 0–15cm were collected from 10 different spots covering experimental plot by means of a soil sampler before addition of fertilizer. They were mixed thoroughly to make a composite sample. After collecting soil samples, plant roots, leaves etc. were removed, air–dried, and ground to pass though a 20 mesh sieve. The soil samples were mixed properly and kept in a clean plastic container for analysis. Phosphorus was applied at the time of final land preparation while urea was applied in three splits. The first split at 15 DAT, second split at 40 DAT and third at 60 DAT. Thirty five day old seedlings were transplanted on 10 February, 2008 in the prepared experimental plots maintaining 20 cm × 20 cm spacing. The number of rows and hill were equal in all plots. Weeding, irrigation, application of insecticide were done as an intercultural operation. The crop was harvested at maturity on 26 May, 2008. However, soil samples were collected from the experimental field at an interval of 15 days for a period of 105 days to determine the K content. The results were used for calculating the loss of K with percolation water following the formula:

Percolation loss, Q_w= Kw. AT $\frac{{}^{y}h}{\Delta Z}$

Where, Q_w= Quantity of water, Kw= Hydraulic conductivity, A= Area, T= Time, h= difference in hydraulic potential and date to difference between two point taking zoro to downwards as negative.

The hydraulic potential was again calculate by adding the component potential as $\psi_h = \psi_m + \psi_p + \psi_{z;}$ Where, h,ψ_m, ψ_p, ψ_z represent hydraulic, matric, pressure and gravitational potential Negative q was considered as downward movement of water. Source: Hanks *et al.* (1980).

Soil sample of irrigation water applied to the plots from a deep tube well nearby the experimental site was also collected for the determination of K in order to calculate the amount of K added to the soil through irrigation water. Two rain samplers were also installed near by the experimental site by a PhD student of the Department of Soil Science. A sample of rain water was further collected from the installed sampler whenever there was rainfall. The samples of both irrigation water and rain water were analyzed for K with the help of flame photometer as stated above.

The data on yield contributing characters like plant height (cm), total tillers hill^{-1}, effective tillers hill^{-1}, panicle length (cm), panicle length, filled grains panicle^{-1} unfilled grains panicle^{-1}, 1000 grain weight (g) were also recorded. After recording the grain and straw yields per plot it was expressed in t ha^{-1} on sundry basis. Grain and straw samples were preserved for chemical analysis. The statistical analysis of variance of crop characters and nutrient uptake were done following the ANOVA technique and the mean results in case of significant F–value were judged by Duncan’s Multiple Range Test (DMRT).

Results and Discussion

Impact of potassium on morpho–physiological changes of RRRI dhan29 included the changes in nutrients of postharvest soil are presented and discussed below.

Plant height: The plant height of BRRI dhan29 was significantly affected due to the split and application of potassium (Table 1). The plant height was significantly varied from 75.62 cm in T_1 (control, all fertilizers except K) treatment to 80.30 cm in T_5 (split application of K i.e. 45 + 45 Kg K ha^{-1}) treatment. Application of 60 kg K significantly increased the height over control but splitting of 60 kg K ha^{-1} did not show significant effect on plant height over T_2. Application 90 kg K ha^{-1} during land preparation increased the height over 60 kg K ha^{-1} although it was not significant. Splitting of 90 kg K ha^{-1} showed significantly better performance over other treatments (Table 1). Similar observation were also reported by Singh and Singh (2000) who reported that the plant height increased up to 60 kg and 90 kg K_2O ha^{-1}in 1990 and 1991, respectively whereas split application showed better response than single application.

Table 1. Effects of split application of potassium on different yield components

Treatments	Plant height (cm)	Number of total tiller hill^{-1}	Number of effective tiller hill^{-1}	Panicle length (cm)	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1} (no.)	Weight of 1000–grain (g)
T_1 (0 kg K ha^{-1})	70.27c	15.00c	12.33c	24.00	110.00	16.00a	20.18
T_2 (60 kg K ha^{-1})	74.94b	14.00bc	16.33bc	24.14	111.67	14.00ab	22.20
T_3 (30+30 kg K ha^{-1})	75.78b	16.00ab	18.00ab	24.50	113.67	13.00b	22.26
T_4 (90 kg K ha^{-1})	77.20ab	18.67a	16.50ab	25.13	114.00	12.00b	22.39
T_1 (45+45 kg K ha^{-1})	80.30a	17.00ab	17.33a	26.55	116.00	11.00b	22.50
LSD	1.22	1.27	1.41	NS	NS	0.8	NS

Figures in a column with same letter do not differ significantly at 5% level of significance; NS = Non significant

Tiller number hill^{-1}: There was significant effect of potassium on number of tiller hill^{-1} of rice plant (Table 1). The number of tillers due to different treatments varied from 14.0 to 17.0. The highest number of tillers hill^{-1} was found in the treatment T_5 (K_{45+45} kg ha^{-1}) and the minimum number of tillers hill^{-1} was found in the control.

Effective tillers hill^{-1}: Application of K significantly increased the effective tillers hill^{-1}. Different levels of K showed significant difference between them whereas the highest increase was noted due to T_5. Split application of K showed better performance over single application (Table 1). Beltran *et al.* (1986) also reported that the number of effective tillers hill^{-1} increased with increasing K rates.

Panicle length: The application of potassium fertilizer at different levels did not showed any significant variation but it was ranged from 24.00 cm to 26.55 cm (Table 1).

Filled grains panicle^{-1}: However, K application at different rates increased the number of filled grains panicle^{-1} of BRRI dhan29 over control but their variation was not statistically significant (Table 1). The number of filled grains panicle^{-1} was not significantly varied from 110 (control) to 116 (T_5). Thakur and Patel (1997) also reported that the split application of potassium showed that the number of filled grains panicle^{-1} were significantly higher over control while Talukder (1992) also found similar findings with the above and present findings..

Unfilled grains panicle^{-1}: The variations in the number of unfilled grains panicle^{-1} due to different doses of potassium were significant (Table 1). The results indicated that the number of unfilled grains panicle^{-1} varied from 11 to 16. The highest number of unfilled grains panicle^{-1} was produced due to treatment T_1 (control) and the lowest number of unfilled grains panicle^{-1} was produced by the treatment T_5. After T_1, the treatment T_2 produced higher number of unfilled grains panicle^{-1}.

Weight of 1000–grain: The results on 1000–grain weight have been presented in Table 4.1. It appears from the Table that different K levels increased the 1000–grain weight of BRRI dhan29 but this increase was insignificant (Table 1). However, the weight of 1000–grain ranged from 20.18 (control) to 22.50 g (T_5). Thousand–grain weights of 22.20, 22.26, 22.38 and 22.50 were found due to the treatments T_2, T_3, T_4, $T_{5,}$ respectively. Mondal *et al.* (1989) reported that the application of N and K_2O at 60 + 40 Kg ha^{-1} at transplanting and the remaining in 2 equal split dressings increased 1000 grain weight while Talukder (1992) indicated that 5 schedules of K application up to 60 kg K ha^{-1} increased 1000 grain weight.

Grin yield: Grain yield of BRRI dhan29 increased significantly over control due to different levels of potassium and varied from 5.05 to 5.87 t ha^{-1} (Fig. 1). The yield gradually increased with the increasing rates of K which proved that the highest rates (90 kg K ha^{-1}) showed highest significant increased while split application T_5 (K_{45+45} kg ha^{-1}) was always better than single application (K_{90} kg ha^{-1}). As a results, the lowest grain yield was obtained in T_1 (control) treatment. The yield contributing characters like tiller hill^{-1}, filled grains panicle^{-1}, 1000–grain weight were also high in T_5 treatment which probably contributed to obtained highest grain yield in treatment T_5 i.e. split application of 90 kg K ha^{-1} (45+45 Kg). Similarly, Ghosh *et al.* (1995) reported that the grain yield increased by split application compared with 100% as basal application while Sarmah and Baruah (1997) also found that split application of K also increased grain yield compared with a single basal dose and 1000-grain weight were also positively influenced by split application.

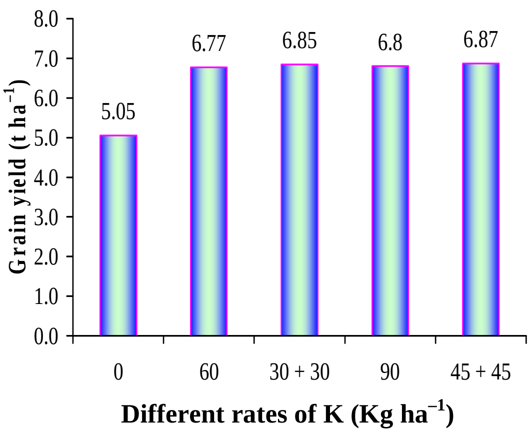

Fig. 1. Effect of K on grain yields of BRRI dhan29

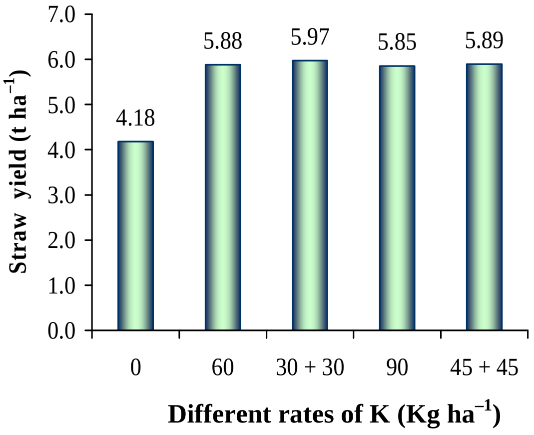

Fig. 2. Effect of K on straw yields of BRRI dhan29

Straw yield: The data on straw yields are shown in Fig. 2. The straw yield ranged from 4.18 to 5.89 K ha^{-1}. The variation in yield due to single and split application of potassium were statistically significant. Like grain yield, the treatment T_5 (splited K_{45+45} Kg ha^{-1}) also produced the highest straw yield (5.89 t ha^{-1}). The maximum yield of T_5 treatment was due to the production of maximum number of effective tillers hill^{-1}. Sarmah and Baruah (1997) also found similar observation with the present findings who reported that the split application of K also increased the straw yield compared with a single basal dose.

Potassium (K) content in grain and straw: The data on potassium content of grain and straw are shown in Table 2. The potassium concentration in grain varied from 0.16 to 0.18% where the highest K concentration in grain was obtained in T_4 and T_5 and the lowest K concentration in grain was obtained in T_1 (control). The grain K concentration of T_2 and T_3 was equal and lower than T_4 and T_5 but higher than control. On the other hand, the K concentration in straw ranged from 1.16 to 1.80% where it was also recorded highest in split application of 90 kg K ha^{-1} (K_{45+45} kg ha^{-1}) and the lowest K concentration was obtained in T_1 (K0 kg ha^{-1}). Similar result was also observed by Thakur *et al.* (1999). The concentration of K in straw gradually increased with the increases rate of K whereas split application K showed better results than single application.

Table 2. Potassium content in grain and straw of BRRI dhan29

Treatments	K concentration (%)		K uptake (Kg ha^{-1})		Total
	Grain	Straw	Grain	Straw	
T_1 (0 kg K ha^{-1})	0.16	1.16	6.48	68.21	74.69
T_2 (60 kg K ha^{-1})	0.17	1.51	9.81	90.15	99.96
T_3 (30+30 kg K ha^{-1})	0.17	1.65	9.95	96.53	106.48
T_4 (90 kg K ha^{-1})	0.18	1.75	10.44	102.24	112.68
T_1 (45+45 kg K ha^{-1})	0.18	1.80	10.57	106.02	116.59

Potassium (K) Uptake: The range of K uptake by grain was significantly varied from 6.48 to 10.57 kg ha^{-1} (Table 2). The highest K uptake by grain was obtained in treatments T_5 and the lowest K uptake by grain was obtained in T_1. Potassium uptake by straw also varied from 68.21 to 106.02 kg ha^{-1} where it was recorded highest in treatment T_5 and the lowest was obtained in T_1 (control). As well as the total uptake of K (grain + straw) varied from 74.69 to 116.59 kg ha^{-1} where the total uptake also showed significant increased with increasing rate of K while split application had highly effective than its single application (Table 2). The influence of basal and split application of potassium were also evaluated by Thakur *et al.* in 1999 reported that K @ 30 or 45 kg ha^{-1} in two equal split showed highest significant increase of K content and uptake.

Potassium (K) Concentration in postharvest soil: Soil solution collected different times from at the experimental plots have been presented in Appendix Fig. 3. In general, the concentration of K in soil solution decreased continuously over the period of time of 105 days from 10.02.08 to 18.05.08. The solution collected from control plot always showed lower concentration of K compared to the solution of K treated plots. The concentration of K in soil solution increased with the increasing rate of application but deceased with time. Single application either at the rate of 60 kg K ha^{-1} or 90 kg K ha^{-1} showed higher values than their split application. Split application at 40 DAT slightly increased the concentration over previous day but it was always lower than single application.

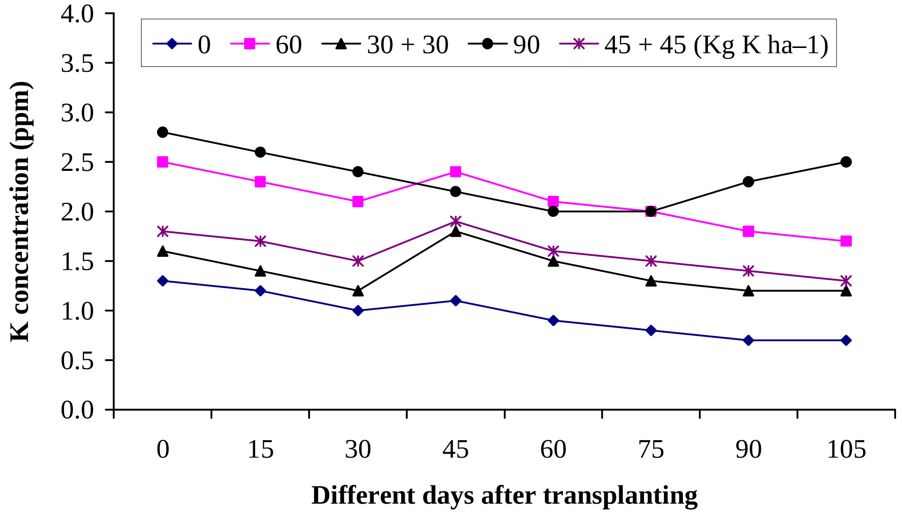

Fig. 3. K content in postharvest soil of BRRI dhan29

Potassium (K) balance: The apparent K balance for boro rice grown at Bangladesh Agricultural University farm has been made by considering input of K from fertilizer, rain water and irrigation water. The output consisted of crop uptake and leaching losses. The balance of K was negative for all treatments ranging from 38.79 to 76.72 kg ha^{-1} where the highest negative balance was noted in control plot. The negative balance decreases as the dose of K fertilizer increases (Table 3). The main source of K in soil was fertilizer followed by irrigation water and then rain water. Irrigation water added 9.6 kg K ha^{-1} where the addition from rain water was 2.0 kg ha^{-1} and the total input varied from 11.0 kg ha^{-1} in control plot to 101 kg ha^{-1} in T_4 and T_5 plots. The output of K was mainly crop uptake which ranged from about 75 to 117 kg ha^{-1}. Leaching loss of K was also considerable. Fertilization increased the loss over control. Split application of K reduced the loss, but increased K uptake by crop through increasing yield (Table 3).

Table 3. Potassium (K) balance (kg ha^{-1})

Treatments	Input				Output			Balance (kg ha^{-1})
	Fertilizer kg ha^{-1}	K from rain water kg ha^{-1}	K from irrigation kg ha^{-1}	Total	Crop uptake	Leaching loss	Total	
T_1 (0 kg K ha^{-1})	0	2.0	9.6	11.60	74.69	13.03	87.72	76.12
T_2 (60 kg K ha^{-1})	60	2.0	9.6	71.66	99.96	30.39	130.35	58.69
T_3 (30+30 kg K ha^{-1})	60	2.0	9.6	71.66	106.48	20.55	127.03	55.37
T_4 (90 kg K ha^{-1})	90	2.0	9.6	101.60	112.68	32.45	145.13	43.53
T_1 (45+45 kg K ha^{-1})	90	2.0	9.6	101.60	116.59	23.79	140.39	38.79

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