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YIELD RESPONSE OF RICE TO DYNAMIC USE OF POTASSIUM IN TRADITIONAL RICE GROWING AREA OF PUNJAB

Tahir Hussain Awan, Zaheen Manzoor, M. Ehsan Safdar and Mushtaq Ahmad
Rice Research Institute, Kala Shah Kaku, Lahore, Pakistan

Effect of split application of recommended dose of potash on the yield and yield components of rice was studied at farmer's field in six (6) Districts of traditional rice growing area i.e. Gujranwala, Sialkot, Narowal, Lahore, Hafizabad and Sheikhupura. In this investigation a recommended dose of potash fertilizer (62.5 kg/ha) was tested in two treatments i.e. whole Potash as a basal dose and ½ potash as basal and ½ potash at 25 DAT that were compared with the treatment where no potash was applied. Means of paddy yield and yield components of rice averaged across six districts showed that maximum value of tillers per hill (26.81), grains per panicle (68.81), 1000 grains weight (22.00 g), paddy yield (4.73 t/ha) and minimum percentage of sterile grains (6.39%) were observed in treatment receiving split use of Potash. Whole of potash applied at transplanting and no potash application treatment ranked at second and third position respectively with respect to all these parameters. The increased grain yield of rice with split applying of K was attributed to continuous supply of K during crop growth period.

Keywords: Potash, split application, rice, locations, yield, yield components

INTRODUCTION

Soils in Pakistan have mixed mineralogy with dominance of hydrous mica. Other minerals present in the soils are smectite, kaolinite, vermiculite and chlorite. These soils are generally considered young and rich in K. But some soils may have been subjected to weathering and thus contain secondary minerals. Therefore these secondary minerals may affect the availability of K irreversibly fixed in the interlayer and wedge sites of soil clay and is rendered unavailable to growing plants (Arshad and Akram, 1999). During weathering, physical disintegration of mica into clay-size fractions resulted in replacement and release of interlayer K by more hydrated cations (Ca^{2+}, Mg^{2+}, or Na^{+}). Evidence of particle size reduction has been found in alluvial soils of Gujranwala, Lyallpur, and Burhan series (Akhtar, 1989). The amount of K fixed increases with added K, whereas the present K fixed relative to total added K decreases (Bouabid *et al.,* 1991). Fixation of K fertilizers may affect its recovery by crops. About 23 to 86 present of the applied K can be fixed. Problem of K fixation can be reduced to some extent and efficiency improved by different K application methods. Also sources of K and their time of application may affect the K recovery. Plants meet part of their K requirements from non-exchangeable pool. Also the K release rate may not keep pace with plant uptake (Grimme, 1974, Rahmatullah *et al.,* 1996). Those who tread the tradition falsely believe that our soils are well supplied with available potash. That is not the case. Fauji Fertilizer Company's mobile soil testing labs have extensively scanned the status of available nutrients, including K, and generalize that more than 30 per cent of Pakistan soils are low in available K and require potash application (Akhtar *et al.*, 2003).

One of the reasons for the low efficiency of fertilizer use for increasing crop productivity is its imbalance of nutrients, as indicated by the nutrient ratios, compared with the remaining world, Pakistan is almost at the bottom of the list (Table 1). While phosphate is emphasized for balancing nutrient use, hardly any attention is paid to potash at the policy level or by the extension departments (Akhtar *et al.*, 2003). The ratio of potassium and nitrogen fertilizer used in Pakistan (0.02:1) is far below than that used in other countries of the world i.e. Japan (3.99:1), UK (0.37:1), Netherlands (0.30:1), China (0.15:1) and India (0.14:1) (Akhtar *et al.*, 2003). In Pakistani Punjab, use of potash was recorded 0.9 m. tonnes in 2001-02 which was 0.1 m. tonnes lower than the last year, whereas, in Indian Punjab, its use was 3.6 m. tonnes which was 0.7 m. tonnes higher than last year (FAI, 2002). Assuming the present level of potash use in Indian Punjab, the consumption in Pakistan should be about 80,000 tonnes K_2O.

Rice being one of the richest starchy foods is consumed by about half of the world's population. It is the most important summer cereal crop of traditional rice growing areas of the Punjab (61%), Sindh (31%), Baluchistan (4%) and high altitude valleys in the North (4%). Rice (*Oryza sativa* L.) is the staple food of the people of South-East-Asia and at present more than half of the world population subsists on this crop. Rice is also one of the most important cereals of Pakistan and occupies second position after wheat. It is a very

Table-1. Physical and chemical properties of soil of six districts under study

Sr. No.	Locations	Soil sample of depth 0-15 cm								Soil sample of depth 15-30 cm							
		EC dS/m	pH	O.M %	N ppm	P ppm	K ppm	Satu %ag	Texture	EC dS/m	pH	O.M %	N ppm	P ppm	K ppm	Satu %ag	Texture
1.	Sheikhupura	1.1	8.0	1.56	0.078	21.6	216	46	Clay loam	0.7	8.0	1.03	0.052	16.8	241	42	Clay loam
2.	Lahore	0.6	8.3	1.03	0.052	24.1	212	40	Clay loam	0.6	8.3	0.90	0.045	15.2	126	36	Loam
3.	Hafizabad	0.8	8.0	0.69	0.035	8.6	76	40	Clay loam	0.6	8.0	0.69	0.036	9.7	169	42	Clay loam
4.	Sialkot	0.8	8.0	1.38	0.069	5.5	194	46	Clay loam	0.5	8.1	0.55	0.028	16.3	169	46	Clay loam
5.	Gujranwala	0.5	8.0	0.97	0.049	8.9	79	42	Clay loam	0.4	7.5	0.69	0.035	13.9	140	42	Clay loam
6.	Narowal	0.9	8.4	1.38	0.069	10.0	194	42	Clay loam	1.0	8.4	0.97	0.049	15.2	112	40	Clay loam

important source of foreign exchange earning giving about US $ 933 annually through its export. In Pakistan, rice is grown on an area of 2.5 million hectares, with an annual production of 4.9 million tons giving an average yield of 2044 Kg/ha (Anonymous, 2003-04). Hence Pakistan enjoys a near monopoly status in the export of fine aromatic Basmati-rice which fetches a price 3 to 4 times that of the normal coarse varieties and have more demand in the international markets. Therefore, there is a need to increase its yield to meet the requirements. Many factors are responsible for increasing the yield and quality of the crops. The proper and balanced application of fertilizers is one of the most important factors. Researchers generally agree that with intensive cultivation, the need for K will increase. In the rice cultivation, the farmers are bestowing much attention only to N fertilization and very often P and K application are carried out at minimal level, mostly missing K fertilization. This practice of imbalance and inadequate fertilizer application affects the soil productivity in general, particularly depletes the essential nutrients (Cassman *et al.*, 1996). The imbalance use of fertilizer in favor of nitrogenous fertilizer is quite evident from fertilizer off take data. Nutrient management practices determine the sustainability of the most intensively cropped systems (Flinn and DeDatta, 1984; Flinn *et al.*, 1982). However the practice of correct dose and timely application of fertilizer nutrients plays an important role in efficient use of fertilizers. At times, the indiscriminate and improper application with unfavourable conditions may not provide adequate nutrients supply because of its poor absorption and translocation in plant system. So the present investigation was planned to find out and demonstrate at farmer field the best suited scheme/timing of recommended dose of potassium fertilizer application for different districts of kallar tract (rice zone).

MATERIALS AND METHODS

The experiment was laid out in a Randomised Complete Block Design (RCBD) and replicated three (3) times having a net plot size of 40 m x 30 m. Super Basmati was used as a test variety. In this experiment, a recommended dose of potash fertilizer (62.5 kg/ha) was used in two splits i.e. whole as a basal dose and ½ as a basal and ½ at 25 DAT that were compared with the treatment where no potash was applied. To study this comparison at farmer field this trial was carried out in six (6) districts of traditional rice growing area i.e. Gujranwala, Sialkot, Narowal, Lahore, Hafizabad and Sheikhupura. One week before transplanting, soil samples from 0-15 cm and 15-30 cm depths were collected from the field for physico-chemical analysis (Table 3). Soil samples were analyzed for particle size distribution by hydrometer method (Bouyoucos, 1962). Soil organic matter was determined by oxidation with potassium dichromate in sulfuric acid medium under standardized conditions by Walkley and Black procedure (Nelson and Sommers, 1982). Nitrogen was estimated by multiplying organic matter (%) age with a factor. Soil pH was measured in water (Soil to water ratio 1:1) Electrical conductivity of the soil suspension was measured using conductivity meter. Phosphorus and K were estimated by using AB-DTPA method (Soltanpour and Worker, 1979).

Nursery was sown near transplanting site at farmer field after soaking seed for 24 hours and incubating for 48 hours. The sprouted seed was broadcasted in puddled field. For transplanting,about 30 days old seedlings were uprooted and transplanted manually in the field at 22.5 x 22.5 cm plant to plant spacing. At the time of land preparation 45 Kg N/ha and 84 Kg P_2O_5 / ha were applied in all the treatments but in T1 no potash, in T2 full dose of K_2O (62.5 kg/ha) as basal while in T3 ½ dose of potash as basal (31.5 kg/ha) and ½ potash (31.5 kg/ha) at 25 DAT was applied. Nitrogen, phosphorus and potash were applied in the form of urea, diammonium phosphate and potassium sulfate respectively and land was well prepared during puddling. This study was conducted for two years. Nursery sowing and transplanting dates for six (6) locations during 2003 & 2004 are given in Table-4. Recommended herbicide i.e. Butachlor was applied 3-5 days after transplanting to all treatments for weed control. Other agronomic and cultural practices were kept standard and uniform for all treatments. Every location was visited weekly & fortnightly to check crop growth and applied the required inputs to the crop. Precautionary fungicides were applied to control Bacterial Leaf Blight (BLB) and Brown Leaf Spot (BLS) Plant population and productive tillers / meter^2 were recorded by counting the average of three samples (1x1 m^2) taken randomly from each repeat. Plant height, grains per panicle, sterility % age and 1000-grain weight were recorded by taking three samples (five plants/sample) taken randomly from each repeat. Data on paddy yield were recorded by harvesting three samples each of size 25 m^2 taken randomly from each repeat. Data collected were statistically analyzed using Fisher's analysis of variance technique and treatment means were compared by DMR test at 0.05 probability level (Steel and Torrie, 1984).

RESULTS AND DISCUSSION

Number of tillers per hill of six districts as affected by two potassium fertilizer application timings is shown in Table 2. Lahore, Hafizabad and Sheikhupura sites reflected significant difference in number of tillers per hill whereas the other sites showed non significant difference. Maximum tillers per hill (35.00) were observed at Hafizabad by applying 1/2 dose of K2O at transplanting and 1/2 K2O at 25 DAT whereas minimum (18.00) at Lahore with no potash application. At Lahore site two-split potash application treatment produced significantly higher number of tillers per hill (28.00) than each of the T1 (control) and T2 (whole of K2O applied at transplanting). As regard Sheikhupura and Hafizabad, full dose of potash at transplanting and ½ dose of potash at transplanting + ½ dose at 25 DAT produced a non significant difference in there values of tillers/hill whereas both of these treatments produced significantly higher number of tillers/hill as compared to the treatment receiving no potash.

Data regarding grains per panicle of six districts as affected by different potassium fertilizer application timings are presented in Table 3. The highest number of grains per panicle (77.00) was produced by two-split potash application treatment at Lahore site whereas minimum of that (53.00) were recorded at Narowal site under no potash application treatment. At Lahore, non-significant difference was observed between each of the three treatments. At all the other sites, two-split potash application treatment produced significantly greater number of grains/panicle compared with control whereas treatment where whole of potash was applied basally showed non-significant difference with control as well as treatment receiving potash in two equal splits, ½ basally + ½ at 25 DAT.

Regarding 1000 grains weight, out of six sites, Lahore, Gujranwala and Narowal showed non significant trend where as three remaining sites showed significant difference between the three fertilizers applied treatments (Table 4). A maximum of 23.48 grams 1000 grains weight was produced in T2 (full dose of K2O applied as basal) and T3 (1/2 K2O as basal + ½ K2O at 25 DAT) at Sialkot site as compared with that of minimum of 19.60 g in no potassium application

Table 2. Tillers/hill of Six Districts as Affected by Time of Potash Application (Average of 2 years)

Treatments	Districts					
	Lahore	Sheikhupura	Gujranwala	Hafizabad	Narowal	Sialkot
T1 = No potash	18.00 c	22.33 b	21.20 a	18.50 b	20.50 a	19.00 a
T2= 62.5 K kg/ha as a basal	23.60 b	28.00 a	25.20 a	34.50 a	21.50 a	21.00 a
T3 = 31.25 K kg/ha as a basal + 31.25 K kg/ha at 25 DAT	28.00 a	29.00 a	25.40 a	35.00 a	22.50 a	21.00 a
LSD values	*3.816*	*3.570*	*5.255*	*4.650*	*4.853*	*2.852*

Table 3. Grains/panicle of Six Districts as Affected by Time of Potash Application (Average of 2 years)

Treatments	Districts					
	Lahore	Sheikhupura	Gujranwala	Hafizabad	Narowal	Sialkot
T1 = No potash	72.00 a	69.00 b	64.65 b	54.50 b	53.00 b	55.00 b
T2= 62.5 kg K /ha as a basal	75.000 a	73.00 ab	67.80 ab	58.50 ab	57.50 ab	59.50 ab
T3 = 31.25 kg K /ha as a basal + 31.25 kg k /ha at 25 DAT	77.00 a	76.67 a	70.00 a	63.00 a	61.50 a	63.50 a
LSD values	*6.412*	*4.856*	*3.184*	*4.719*	*7.632*	*4.581*

Table 4. 1000 grain weight (g) of Six Districts as Affected by Time of Potash Application (Average of 2 years)

Treatments	Districts					
	Lahore	Sheikhupura	Gujranwala	Hafizabad	Narowal	Sialkot
T1 = No potash	20.10 a	21.35 b	20.94 a	19.60 b	21.10 a	21.48 b
T2 = 62.5 kg K /ha as a basal	20.70 a	22.04 b	21.64 a	20.52 b	20.60 a	23.48 a
T3 = 31.25 kg K /ha as a basal + 31.25 kg k /ha at 25 DAT	21.87 a	22.57 a	21.78 a	21.53 a	20.73 a	23.48 a
LSD values	*2.166*	*0.8751*	*0.8573*	*0.9510*	*1.097*	*0.5169*

treatment at Hafizabad. At Hafizabad, and Sheikhupura sites T3 (1/2 K2O as basal + ½ K2O at 25 DAT) produced significantly higher 1000 grains weight than T1 (control) and T2 (full dose of K_2O applied as basal) while at Sialkot this treatment produced significantly higher 1000 grain weight than T1 (control) and at par with T2 (full dose of K_2O applied as basal).

Paddy yield was significantly affected by different potash application treatments at all the sites (Table 5). Maximum paddy yield of 4.93 t/ha was obtained at Sheikhupura under the treatment where potash was applied in two equal splits, half at transplanting and half at 25 DAT, while the minimum paddy yield (3.52 t/ha) was observed at Gujranwala under control treatment where no potash was applied. At all sites, maximum paddy yield was observed in treatment receiving potash in two equal splits which was significantly better than control (no potash application) whereas T2 (where full dose of potash was applied at transplanting) showed non significant difference in yield from control at Lahore, Narowal and Sialkot as well as from T3 (two-split potash application) at Lahore, Gujranwala and Sialkot.

Means of paddy yield and yield components of rice averaged across six districts are presented in Table 6. Maximum value of tillers per hill (26.81), grains per panicle (68.61), 1000 grains weight (22.00) and paddy yield (4.73 t/ha) and minimum percentage of sterile grains (6.39%) were observed in treatment receiving half potassium at transplanting and half potassium 25 days after transplanting. Similarly results were reported by Samrathlal Meena *et al.* (2003), Sarkar *et al.* (1995) and Raju et.al. (1999). Whole of potash applied at transplanting and no potash application treatment ranked at second and third position respectively with respect to all these parameters. The positive response of K application on crops has also been reported by Lauchli and Pfluger (1979). Sharma *et al.* (1980) and Romas *et al.* (1999).

The increased grain yield of rice owing to potassium fertilizer application at recommended rate having two equal splits (half at transplanting + half at maximum tillering 25 DAT) was attributed directly to continuous supply of K to the crop during crop growth period which was proved more beneficial and increased total number of tillers per hill, number of grains per panicle and 1000 grain weight while decreased percentage of sterile grain by enhancing grain filling. These findings are in close conformity with those of Thakur *et al.* (1999); Ravi and Rao (1992); Padmavathi (1997); Dwivedi *et al.* (2000) and Ali *et al.* (2005). Sarkar and Malik, (2001) also claimed that increase in paddy and straw yields by K application might also be attributed to more N utilization in the plant system resulting in more chlorophyll synthesis and efficient translocation of assimilates to reproductive parts.Samrathlal *et al.* (2003) also claimed that Grain and straw yields of rice crop were increased significantly owing to potash fertilization to the level of 62.5 Kg K /ha applied in two equal splits (half at transplanting + half at maximum tillering).

Table 5. Paddy yield (t/ha) of S)x Districts as Affected by Time of Potash Application (Average of 2 years)

Treatments	Districts					
	Lahore	Sheikhupura	Gujranwala	Hafizabad	Narowal	Sialkot
T1 = No potash	3.800 b	4.037 c	3.520 b	3.750 c	3.950 b	4.100 b
T2 = 62.5 kg K /ha as basal	4.100 ab	4.503 b	3.760 a	3.950 b	4.150 b	4.300 ab
T3 = 31.25 kg K /ha as basal + 31.25 kg K/ha at 25 DAT	4.410 a	4.930 a	3.850 a	4.300 a	4.500 a	4.650 a
LSD values	*0.3206*	*0.3285*	*0.2028*	*0.1603*	*0.2151*	*0.3793*

Table 6. Average Yield and Yield Components of Rice as Affected by Time of Potash Application (Average of six districts)

Treatments	Yield and yield Components				
	Tillers/hill	Grains per panicle	Sterility %age	1000 grain weight	Paddy yield (t/ha)
T1 = No potash	19.92	60.68	8.65	20.36	3.86
T2= 62.5 kg K /ha as a basal	25.04	64.77	7.77	21.39	4.12
T3 = 31.25 kg K /ha as a basal + 31.25 kg k/ha at 25 DAT	26.81	68.61	6.39	22.00	4.73

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