RESPONSE OF RICE TO SOIL AND FOLIAR APPLICATION OF K_2SO_4 FERTILIZER

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ABSTRACT

A field experiment was conducted at village Jatri Kohna, district Sheikhupura during the growing season of 2003 to compare foliar application of K_2SO_4 at various concentrations (0.5, 1.0, 2.0, 4.0 and 6.0 %) with soil application of K_2SO_4 at the rate of 50 kg K_2O ha^{-1} on yield of rice crop. The experiment was arranged in a Randomized Complete Block Design with three replications. Number of fertile tillers, straw and paddy yields of fine grain rice (Basmati-385) were recorded. Foliar application of K_2SO_4 at different concentrations significantly influenced the yield components. Among all the foliar application treatments, foliar application with 6.0% K_2SO_4 significantly out yielded than rest of the treatments that was statistically at par with soil application of K_2SO_4 @ 50 kg K_2O ha^{-1}. Maximum paddy yield (3837 kg ha^{-1}) was obtained with this treatment. Paddy yield in different treatments followed the order: 50 kg ha^{-1} K_2O soil application = 6.0% > 4.0% > 2.0% > 1.0% > 0.5% K_2SO_4 > control. Plant samples analyzed for K concentration showed significant increase in K uptake by rice paddy and straw with foliar application of different K_2SO_4 concentrations. Interestingly, foliar application at 6.0 % K_2SO_4 (24.12 kg ha^{-1} K uptake) showed statistically equal performance as that of K_2SO_4 soil application at the rate of 50 kg K_2O ha^{-1} (24.70 kg ha-1 K uptake). However, in case of K uptake by straw, foliar application of K_2SO_4 at 2.0, 4.0 and 6.0 % concentration showed similar results but were statistically comparable to soil application of K_2O @ 50 kg ha^{-1}. Our results suggested that foliar application of K_2SO_4 at 6.0 % concentration was safe and appropriate and could produce yield of rice equal to the yield obtained with soil application of K_2O at the rate of 50 kg ha^{-1}.

Keywords: Foliar application, K_2SO_4, Physiochemical analysis, Rice, Soil

INTRODUCTION

Rice being one of the richest starchy foods is consumed by about half the world's population. It is the most important summer cereal crop of traditional rice growing areas of Pakistan and is among the major export commodities. It accounts for 5.7 % of the total value added in agriculture and 1.3 % to GDP. Rice is cultivated on an area of 2503 thousand hectares with a total production of approximately 4991 thousand tons during this year (GOP, 2005).

Soils in Pakistan are generally considered young and rich in K (Ali *et al*. 2005a). But some soils may have been subjected to weathering and thus contain secondary minerals. Therefore, these minerals may affect the availability of K. It may be fixed in the interlayer and on wedge sites of soil clay and is rendered unavailable to growing plants (Huang, 1977; Arshad and Akram, 1999). 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. Problem of K fixation can be reduced to some extent and efficiency improved by different K application techniques. Plants meet part of their K requirements from non-exchangeable pool as the K release rate may not keep pace with plant uptake (Grimme, 1974; Mengel *et al.* 1996). Majority of Pakistani soils are calcareous in nature with pH greater than 8.5 that affects K availability. The major fraction of potash fertilizer directly applied to soil gets fixed with clay fraction and becomes unavailable to crop plants (Ali *et al.* 2005b). Further, the price of K fertilizers is getting higher day by day and becoming unaffordable to farmers (NFDC, 2005).

Many factors are responsible for increasing the yield and quality of 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 increases. In the rice cultivation, the farmers are bestowing much attention only to N fertilization and very often P and K application are partially or completely ignored. This practice of imbalance and inadequate fertilizer application affects the soil productivity in general (Cassman *et al.* 1996). The practice of correct dose and timely application of fertilizers nutrients plays an important role in efficient use of fertilizers as well. Nutrient management practices determine the sustainability of the most intensively cropped system (Flin and DeDatta, 1984: Flin et al., 1982), K utilization by plants through foliar application is well recognized and is being practiced in agricultural advanced countries. Hence, there is a need to provide the required K through foliar application as well. Therefore, this study was planned to compare different concentration of K_2SO_4 for foliar application to obtain optimum paddy yield.

MATERIALS AND METHODS

A field experiment was carried out at village Jatri Kohna, district Sheikhupura during the growing season 2003 to investigate the efficiency of foliar application of graded K concentrations on rice crop. The following treatments were selected and arranged in a Randomized Complete Block design with three replications to assess appropriate concentration for foliar application of K_2SO_4 and compare with soil application of K_2SO_4 on rice.

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Control (no K), soil application of K (50 kg K_2O ha^{-1}) and foliar applications with various concentrations of K_2SO_4 (0.5 %, 1.0 %, 2.0 %, 4.0 % and 6.0 % equivalent to 4, 8, 16, 32 and 48 kg K_2SO_4 ha^{-1} respectively) were used for spray.

Basal doses of N, P and Zn were applied to all treatment plots including control @ 100, 50 and 10 kg ha^{-1} as urea, SSP and $ZnSO_4$, respectively. One month old seedlings of rice genotype Basmati-385 were transplanted on 15th July with plant to plant and line to line distance of 20 cm in each treatment plot measuring 8 m X 6 m. The foliar application of K_2SO_4 was carried out at 30 and 45 DAT whereas the soil application as broadcast carried out at the time of transplanting. Before transplanting, soil samples (0-15 cm depth) were collected from the field for physico-chemical analysis (Table I). Data on number of tillers per plant was recorded at panicle initiation stage. At the same time, flag leaf samples for chemical analysis were also collected. At maturity paddy and straw yields were recorded. Paddy and straw samples were analyzed for K concentration.

Soil samples were analyzed for particle size distribution by hydrometer method (Gee and Bauder, 1986), for $CaCO_3$ by acid neutralization method (FAO, 1980), and for soil organic matter by Walkley and Black procedure (Nelson and Sommers, 1982). Soil pH was measured in soil: water suspension (1:1 ratio). Electrical conductivity of the soil suspension was measured using conductivity meter. Extractable P, K and Zn were determined using AB-DTPA extractant (Soltanpour and Workman, 1979). Total K in plant samples was determined using wet digestion (nitric acid + perchloric acid in 2:1 ratio) (Rhoades, 1982). Data were analyzed statistically and treatment differences determined using LSD (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Paddy yield was significantly increased by all fertilizer treatments compared with the control. The maximum paddy yield (3874 kg ha^{-1}) was obtained with soil application of K_2SO_4 @ 50 kg ha^{-1} K_2O. This treatment was at par with 6.0 % K_2SO_4 spray treatment where 3837 kg ha^{-1} paddy yield was obtained. Paddy yield in different treatments followed the order: 50 kg ha^{-1} K_2O soil application = 6.0 % K_2SO_4 > 4.0 % K_2SO_4 (1328 kg) > 2.0 % K_2SO_4 (3519 kg) > 1.0 % K_2SO_4 (3464 kg) > 0.5 % K_2SO_4 (3157 kg) > control (2959 kg ha^{-1}). Foliar application at 4.0 % K_2SO_4 solution significantly produced lower yield than 6.0 % K_2SO_4 application and was at par with the treatment receiving 2.0 % K_2SO_4 solution. However, significantly higher paddy yield was recorded with 6.0 % K_2SO_4 as compared to 1.0, 0.5 % K_2SO_4 and control (Table II). This might be due to quite appropriate concentration of K_2SO_4 for foliar application which caused maximum yield. Ali *et al*. (2005) reported that foliar application of 1.5 % K_2SO_4 produced better paddy and straw yields as compared to KNO_3 and KCl. Similar results had also been obtained by Glass and Siddiqi (1984), Rehman (1992) and Ramos *et al.* (1999).

Straw yield was also significantly affected by foliar application of different K_2SO_4 concentration. The treatments receiving 6.0 % (5443), 4.0 % (5207), and 2.0 % K_2SO_4 foliar application (5191 kg ha^{-1}) produced statistically similar straw yields, but were significantly higher as compared to lower concentrations i.e., 1.0 % (4993), 0.5 % K_2SO_4 foliar spray (4549) and control (4368 kg ha^{-1}). Poor yields in the case of 1.0 and 0.5 % K_2SO_4 treatments indicate sub-optimal K supply at these low levels of K application (Table II). The maximum average number of tillers $hill^{-1}$ (15.18) was recorded with 6.0 % K_2SO_4 foliar application. The treatment followed the order: 6.0 % > 4.0 % (13.98) > 50 kg ha^{-1} K_2O (13.66) > 2.0 % (13.43) > 1.0 % (13.13) > 0.5 % K_2SO_4 foliar application (11.42) > control (10.33). It is well known fact that K serves a vital role in photosynthesis by directly increasing growth and leaf area index and hence CO_2 assimilation enhance outward translocation of more ATP essential for vigorous growth of plants. Many researchers have reported the positive response of K_2SO_4 foliar application to rice and wheat crops as well as higher plants (see Page *et al.* 1963; Kisana and Khan, 1975; Malik *et al.* 1988; Hussain and Jilani, 1991 and Ramos *et al.* 1999; Ali *et al*. 2005a, b).

Potassium concentration in paddy was significantly affected by foliar application at various concentrations of K_2SO_4. The highest concentration (0.63 %) was recorded when 6 % K_2SO_4 solution was sprayed which was statistically equal to soil application of K (0.64 %). Rest of the treatments showed comparatively less K concentration in plant tissues being minimum (0.41%) in case of control and 0.5 % K_2SO_4 foliar application. The K concentration in straw was also significantly affected by different K_2SO_4 application treatments which were non-significantly different with the foliar application of 2.0, 4.0, 6.0 % K_2SO_4 concentrations and soil application of K_2O @ 50 kg ha^{-1}. Control and 0.5 % K_2SO_4 spray again exhibited the lowest K concentration in straw (Table III).

The K uptake by paddy was also significantly affected by foliar application at different K_2SO_4 concentrations (Table III). A consistent increase in K uptake by paddy was observed due to increased concentration of K_2SO_4 foliar application. Maximum uptake (24.12 kg ha^{-1}) was recorded with 6.0 % K_2SO_4 foliar application which was statistically equal to soil application of K_2O at the rate of 50 kg ha^{-1}. The K uptake by straw was also significantly affected with different concentrations of K_2SO_4 foliar application and soil application as well. However, uptake pattern was not similar as noticed in K uptake by paddy. The K uptake by straw was at par when foliar application of 2.0, 4.0 and 6.0 % K_2SO_4 were applied. These were again comparable to soil application of K_2O at the rate of 50 kg ha^{-1}. Among various treatments, again the lowest K uptake was observed in the case of 0.5 % K_2SO_4 which was statistically equal to K uptake under control treatment (Table III). Similar findings regarding significant effect of K application have also been obtained by various researchers (see Howard *et al*. 1998; Arabi *et al.* 2002; Ali *et al.* 2005a & b).

CONCLUSION

It could be concluded from this study that foliar application of K2SO4 at 6.0 % concentration (equivalent to 48 kg K2SO4 ha-1) and soil application of K2SO4 @ 50 kg K2O ha-1 to rice crop produce almost equal yields.

Table I. ***Physico-chemical analysis of soil at experimental site Jatri Kohna, Dist. Sheikhupura***

Parameters	Value
pH	7.54
EC (1:1)	0.51 dS m^{-1}
$CaCO_3$	1.23 %
OM	0.65 %
NO_3 –N	5.45 mg kg^{-1}
P (AB-DTPA)	4.12 mg kg^{-1}
K (AB-DTPA)	68.0 mg kg^{-1}
Zn (AB-DTPA)	0.53 mg kg^{-1}
Sand	41.5 %
Silt	35.7 %
Clay	22.8 %
Textural Class	Loam

Table II: ***Effect of Soil and application of K_2SO_4 at different concentrations on fertile tillers, paddy and straw yields of rice.***

Treatments	Crop Yield (kg ha^{-1})		No. of Tillers ($hill^{-1}$)
	Paddy	Straw	
Control	2959 $_e$	4368 $_c$	10.33 $_g$
Foliar application of K_2SO_4 at 0.5%	3157 $_d$	4549 $_c$	11.42 $_f$
Foliar application of K_2SO_4 at 1 %	3464 $_c$	4993 $_b$	13.13 $_e$
Foliar application of K_2SO_4 at 2 %	3519 $_{bc}$	5191 $_{ab}$	13.43 $_d$
Foliar application of K_2SO_4 at 4 %	3618 $_b$	5207 $_{ab}$	13.98 $_b$
Foliar application of K_2SO_4 at 6 %	3837 $_a$	5443 $_a$	15.18 $_a$
Soil application of K_2SO_4 at 50 kg ha^{-1} K_2O	3874 $_a$	5627 $_a$	13.66 $_c$

Means followed by different letter (s) within the columns differ significantly at 5% level of significance.

Table III: ***Effect of Soil applied K and foliar applied different concentrations of K_2SO_4 on Potassium content (%) and Potassium uptake (kg ha^{-1})***

Treatments	K Contents (%)		K Uptake (kg ha^{-1})	
	Paddy	Straw	Paddy	Straw
Control	0.41 $_c$	1.55 $_c$	12.02 $_f$	67.82 $_c$
Foliar application of K_2SO_4 at 0.5%	0.46 $_c$	1.59 $_c$	14.41 $_e$	72.29 $_c$
Foliar application of K_2SO_4 at 1 %	0.53 $_b$	1.68 $_b$	18.51 $_d$	83.98 $_b$
Foliar application of K_2SO_4 at 2 %	0.54 $_b$	1.72 $_{ab}$	19.29 $_c$	89.43 $_{ab}$
Foliar application of K_2SO_4 at 4 %	0.57 $_b$	1.72 $_{ab}$	20.74 $_b$	89.96 $_{ab}$
Foliar application of K_2SO_4 at 6 %	0.63 $_a$	1.77 $_a$	24.12 $_a$	96.64 $_a$
Soil application of K_2SO_4 at 50 kg ha^{-1} K_2O	0.64 $_a$	1.81 $_a$	24.70 $_a$	102.0 $_a$

Means followed by different letter (s) within the columns differ significantly at 5% level of significance.

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