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EFFICACY OF DIFFERENT METHODS OF POTASSIUM FERTILIZER APPLICATION ON PADDY YIELD, K UPTAKE AND AGRONOMIC EFFICIENCY

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A study was conducted at farmer's field in Sheikhupura district to investigate the efficiency of different K fertilization methods for rice cv. 385. Various application methods (band placement, broadcast and fertigation) were compared as application before transplanting and 25 and 50 days after transplanting (DAT). Number of fertile tillers, straw and paddy yields were recorded. Plant samples collected at maturity were analyzed for K concentration to determine its uptake. Application of K through band placement in furrows before transplanting, broadcast at 25 DAT and fertigation at 25 DAT produced statistically higher yields. The maximum K uptake in paddy was also recorded with these methods of K application. The K fertigation at 25 DAT and band placement in furrows registered maximum K recovery as well as agronomic efficiency of rice cv. 385.
Key words: Potassium application; methods; rice; Pakistan.

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 is rendered unavailable to growing plants (Huang, 1977; Lauchli and Pfluger 1979; Mengel *et al.*, 1996, 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 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).

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 the Punjab (61%), Sindh (31%), Baluchistan (4%) and high altitude valleys in the North (4%). Rice is among the major export commodities contributing about 6.3 % to the total foreign earnings that occupies a significant position in agricultural economy of the country. Presently, it is grown approximately on 2461 thousand hectares with a total production of 4848 thousand tons (Anonymous, 2003-04). Hence Pakistan enjoy 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 unfavorable conditions may not provide adequate nutrients supply because of its poor absorption and translocation in plant system. Therefore, there is an imperative need to provide the required nutrients through fertilization by appropriate method at appropriate time for which an attempt was made to assess the efficiency of K nutrition by various methods in traditional rice cropped area of Pakistan.

MATERIALS AND METHODS

The field experiment was carried out at a village (Jatri Kohna) of district Sheikhupura on a loam soil to investigate the efficiency of K fertilization methods for rice having the following treatments:

T1 = Control

T2 = Broadcast and Incorporation (BC & Inc) of K before transplanting.

T3 = Band application K in dry furrows before transplanting.

T4 = Broadcast (BC) application of K 25 days after transplanting (DAT)

T5 = Broadcast (BC) application of K 50 DAT

T6 = Fertigation at transplanting

T7 = Fertigation of K 25 DAT

T8 = Fertigation of K 50 DAT

Table 1. Physico-chemical analysis of soil at Jatri Kohna site.

Parameters	**Units**	**Pre sowing value of composite samples**
pH		7.54
EC (1:1)	dS m^{-1}	0.51
$CaCO_3$	(%)	1.23
OM	(%)	0.65
NO_3 -N	mg kg^{-1}	5.45
P	mg kg^{-1}	4.12
K	mg kg^{-1}	68.0
Zn	mg kg^{-1}	0.53
Sand	(%)	41.5
Silt	(%)	35.7
Clay	(%)	22.8
Textural Class		**Loam**

A basal dose of N, P, K and Zn were applied @ 90, 50, 42 and 10 kg ha^{-1} as Urea, SSP, SOP and $ZnSO_4$, respectively. One week before transplanting, soil samples (0-15 cm) were collected from the field for physico-chemical analysis (Table 1). Soil samples were analyzed for particle size distribution by hydrometer method (Bouyoucos, 1962). The $CaCO_3$ was estimated by acid neutralization (FAO, 1980), and soil organic matter by oxidation with potassium dichromate in sulfuric acid medium under standardized conditions by Walkley and Black procedure (Nelson and Sommers, 1982). Soil pH was measured in water (Soil to water ratio 1:1) Electrical conductivity of the soil suspension was measured using conductivity meter. Phosphorus, K and Zn were estimated by using AB-DTPA method (Soltanpour and Workman, 1979). After 30-day of transplanting, numbers of tillers per hill and at maturity of the crop, paddy and straw yields were recorded. For K determination from plant samples (taken at panicle initiation), wet digestion method (nitric acid + perchloric acid in 2:1 ratio) was followed and measured the concentration by flame photometer (Rhoades, 1982). Potassium concentration in rice straw and paddy was also determined from proportion of applied K taken up by rice and expressed in terms of percentage. Potassium Recovery and Agronomic Efficiency were calculated using the experimental data as given by following formulae (Novoa and Loomis, 1981).

$$\text{K Recovery (\%)} = \frac{\text{K uptake } (\textit{fertilized plot}) - \text{K uptake } (\textit{unfertilized plot})}{\text{K } \textit{applied}} \times 100$$

$$\text{Agronomic Efficiency} = \frac{\text{Yield } (\textit{fertilized plot}) - \text{Yield } (\textit{unfertilized plot})}{\text{K } \textit{applied}}$$

The data thus obtained were subjected to statistical analysis and treatment differences determined using LSD (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Yield and yield components

The data in Table 2 revealed that maximum number of productive tillers was observed with fertigation and broadcasting at 25 DAT and band application of K in furrows while rest of the treatments produced less tillers per hill but was statistically superior to that of control treatment. Fertilization with K results in more luxury consumption than with other nutrients causing healthy growth of crop plants. Similar results have also been discussed by Bouabid *et al*, (1991) and Rehman (1992). Different K application methods significantly affected paddy and straw yields of rice (Table 2). Maximum increase in paddy yield was obtained with K broadcasting 25 days after transplanting (DAT), fertigation at 25 DAT and band placement in dry soil furrows followed by broadcasting and fertigation at 50 DAT. This was perhaps due to adequate K supply which increased plant photosynthesis rate because K is required in the activation of starch synthesis and then conversion of soluble sugars into starch is vital step in the grain filling process that ultimately contributed to crop yield (Smid and Peaslee,1976). Malik *et al*, (1988) and Ahmad *et al*, (1994) have documented similar conclusions. This increase in yield might also be attributed to more N utilization in the plant system activated by K uptake, hence more chlorophyll synthesis and efficient translocation of assimilates to reproductive parts (Sarkar and Malik, 2001). A buildup of amide nitrogen and reduction in conversion to protein has been observed in certain grasses grown with inadequate K by Smid and

Table 2. Effect of different placement methods of K application on tillers, straw and paddy yield at Jatri Kohna site.

S. No.	Treatments	Paddy Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	Tillers Av. No. (per hill)
T1	Control	3352 $_e$	4949 $_d$	10.40 $_e$
T2	BC and Inc of K before transplanting	3662 $_d$	5395 $_c$	12.09 $_d$
T3	Band Application of K in furrows	3874 $_a$	5627 $_{ab}$	13.66 $_a$
T4	BC of K at 25 DAT	3904 $_a$	5479 $_{bc}$	13.85 $_a$
T5	BC of K at 50 DAT	3815 $_b$	5550 $_{bc}$	13.29 $_b$
T6	Fertigation at transplanting	3743 $_c$	5371 $_c$	12.84 $_c$
T7	Fertigation of K at 25 DAT	3884 $_a$	5762 $_a$	13.72 $_a$
T8	Fertigation of K at 50 DAT	3795 $_b$	5424 $_{bc}$	13.16 $_b$
	LSD	46	176	0.25

Peaslee, (1976). Fertigation at transplanting and broadcasting and incorporation before transplanting produced comparatively lower but higher grain yield than that of control treatment. Similarly, less straw yield was obtained with fertigation at transplanting broadcasting of K before transplanting. All other treatments showed statistically higher straw yield being maximum with fertigation at 25 DAT.

Potassium contents and uptake

Potassium contents in paddy increased when K was applied by band placement in furrows, broadcast and fertigation at 25 DAT. Comparatively lower K content were found when K was applied either by broadcast and incorporation before transplanting or through fertigation at transplanting and/or at 50 DAT. Delayed application up to 50 DAT either by broadcast or fertigation showed less K content exhibiting less availability of potassium to plants (Table 3). Significantly higher K content in straw was found when K was applied by fertigation at 25 DAT.

Potassium uptake by paddy was significantly affected by different methods of K application (Table 3). The highest uptake was recorded when K was applied at 25 DAT, either by broadcast or fertigation and band placement of K in furrows. The potassium uptake by paddy followed the order: Broadcast of K at 25 DAT > Fertigation at 25 DAT >Band placement in furrows > Broadcast at 50 DAT > Fertigation at 50 DAT >Fertigation at transplanting > Broadcast and incorporation > Control. Rice plant when transplanted experiences a physiological shock and when recovered from this shock can make the use of nutrition available in root medium. The pattern of maximum K uptake by rice plant exhibited this phenomenon when K was applied at 25 DAT. These results are in line with those of reported by Ghosh and Varade (1976), Sharma *et al* (1980) and Rehman (1992). Non-significant differences in K uptake by straw were recorded. All treatments were statistically at par but were significantly different as compared to control treatment.

Agronomic efficiency and K recovery

Agronomic efficiency was significantly affected by K placement methods (Fig.2). The highest agronomic efficiency was calculated when K was applied through

Table 3. Effect of different placement methods of K application on K content, K uptake, K recovery and agronomic efficiency

Sr. No.	Treatments	K Content (5)		K uptake (kg ha^{-1})		K Recovery (%)	Agronomic Efficiency
T1	Control	0.51 $_d$	1.67 $_c$	17.09 $_d$	82.64 $_b$		
T2	BC and Inc of K before transplanting	0.57 $_c$	1.76 $_b$	20.87 $_c$	94.95 $_a$	38.29 d	7.38 $_d$
T3	Band Application of K in furrows	0.64 $_a$	1.81 $_{ab}$	24.79 $_a$	101.9 $_a$	64.04 $_a$	12.42 $_a$
T4	BC of K at 25 DAT	0.64 $_a$	1.78 $_b$	24.98 $_a$	97.52 $_a$	54.21 $_b$	13.15 $_a$
T5	BC of K at 50 DAT	0.62 $_b$	1.69 $_c$	23.65 $_b$	93.79 $_a$	42.15 $_c$	11.03 $_b$
T6	Fertigation at transplanting	0.61 $_{bc}$	1.76 $_{bc}$	22.83 $_{bc}$	94.52 $_a$	41.94 $_c$	9.30 $_c$
T7	Fertigation of K at 25 DAT	0.64 $_a$	1.84 $_a$	24.85 $_a$	106.1 $_a$	74.13 $_a$	12.68 $_a$
T8	Fertigation of K at 50 DAT	0.61 $_{bc}$	1.77 $_b$	23.14 $_b$	96.00 $_a$	46.21 $_{bc}$	10.54 $_b$
	LSD	0.02	0.06	1.33	30.15	9.24	1.39

broadcasted and/or fertigation at 25 DAT and by band application in furrows. Statistically lower agronomic recoveries were recorded due to rest of the treatments (Table 3). The positive response of K application on crops has been reported by Lauchli and Pfluger (1979), Sharma *et al* (1980) and Romas *et al* (1999). Potassium recovery was significantly affected by different K placement methods (Fig.1). Band placement of K in furrows and fertigation at 25 DAT were statistically at par however broadcast of K at 25 DAT was closely followed and was significantly superior to rest of the treatments. Similarly Data in figure 3 indicate a significant positive correlation (r = 0.92) between K uptake by rice crop and paddy yield. It indicates higher accumulation of K in plants resulting in higher paddy yield.

CONCLUSION

Application of K through band application in furrows, broadcasting at 25 DAT and fertigation at 25 DAT gave the promising results. Since band application of K in furrows and fertigation at 25 DAT is more labour intensive operation as compared to K application at 25 DAT, therefore broadcasting of K in rice at 25 DAT is more convenient and efficient method of K application.

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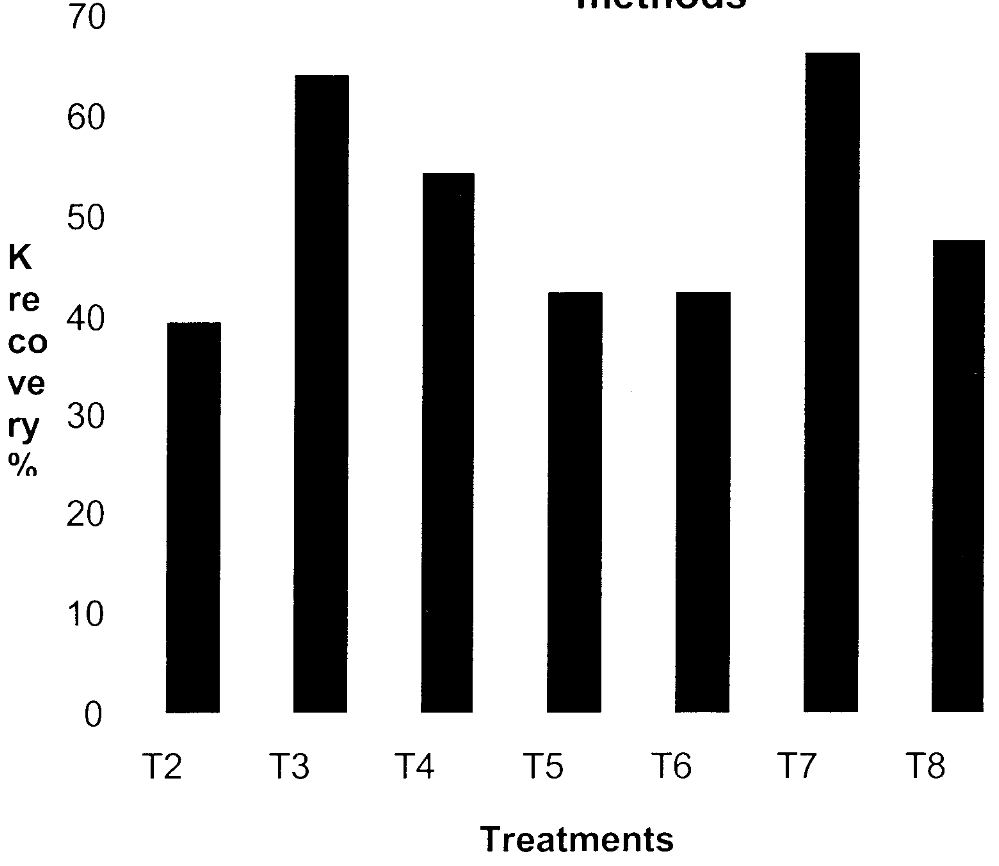
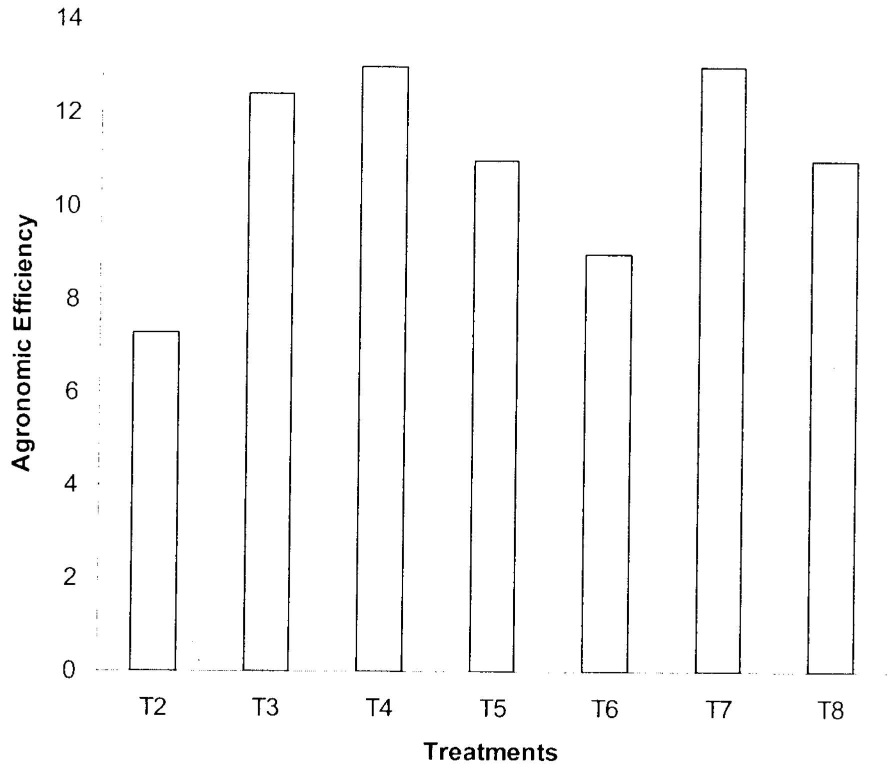
Fig 1: Potassium recovery (%) by Rice crop as affected by different fertilizer application methods



T2 = BC&INC of K at transplanting
T3 = Band application of K in furrows
T4 = Fertigation at transplanting
T5 = BC of K at 25 DAT
T6 = BC of K at 50 DAT
T7 = Fertigation of K at 25 DAT
T8 = Fertigation of K at 50 DAT

Fig 2: Agronomic Efficiency as affected by different K fertilizer application methods in Rice



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Correlation between K uptake and Paddy yield