The Pharma Innovation Journal 2022; SP-11(10): 45-48

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(10): 45-48

www.thepharmajournal.com
Received: 23-08-2022
Accepted: 27-09-2022

Response of potassic mineral on yield and nutrient uptake by rice in an inceptisol of Chhattisgarh

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Abstract
A field experiment was carried out at Research Farm of College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G) during the *kharif* season of 2021. The trial was conducted in Inceptisol with aim to study the response of potassic mineral on the yield, nutrient uptake and nutrient use efficiency by rice (var. Rajeshwari). The experiment was consisting of ten treatments and three replications in a randomized block design (RBD). The treatments include one RDF (@ N 100, P_2O_5 60 and K_2O 40 kg ha^{-1}) as common practice, one treatment of split dose of recommended potassium, one treatment of no (zero) potassium, one treatment of absolute control and six treatments of different doses of potassic mineral (@ 70-210 kg ha^{-1}) along with the RDF were given with the different schedule of application as per the treatments. In the experiment, combined potassic mineral (Schoenite + Syngenite) was applied. The results showed that application of different doses of potassic mineral (@ 70-210 kg ha^{-1}) along with the RDF non-significantly increased the grain yields of rice up to 0.62-5.76% as compared to treatment of 100% RDF (54.66 q ha^{-1}). In the different treatments, grain yield of rice was recorded 31.33-57.81 q ha^{-1} whereas straw yield was recorded 39.02-74.57 q ha^{-1}. Similarly, the total uptake of nitrogen (50.4-85.7 kg ha^{-1}), phosphorous (10.0-17.9 kg ha^{-1}) and potassium (92.2-168.9 kg ha^{-1}) by rice plant were also not significantly influenced by the potassic mineral when applied with the RDF. Among the all treatments, significantly lowest yield and nutrients uptake were recorded with the treatment of absolute control where no fertilizer and no potassic mineral was applied. Efficiency of applied potassium nutrient was estimated highest with the 100% RDF (219.9%) whereas lowest efficiency 115.8% was recorded with the treatment of RDF + mineral-K @ 210 kg ha^{-1}.

Keywords: Rice, potassic mineral, yield, nutrient uptake, efficiency

Introduction

Despite being one of the major nutrients limiting plant growth and agricultural production, potassium (K) is very abundant in many soils around the world. It is a significant component of several soil minerals, i.e. mica, illite and orthoclase. Potassium (K), along with phosphorus (P) and nitrogen (N), is one of the most essential nutrients for plants. It plays an important role in photosynthesis, enzyme activation, fruit quality, protein synthesis and reduction of disease. Because of intensive agriculture around the world, the available K level in soil has decreased due to crop removal without replenishing the soil through fertilization. Most farmers focused on applying N and P through urea and ammonium phosphate, respectively, for crop production; however, such unbalanced fertilizer management leads to K deficit in soil and impairs crop productivity. Because the crop removes 1.5 times more K than N and P, the soil becomes deficient in K. Farmers use potassic fertilizers in very low amount for the crop production, which promotes rapid soil depletion of available potassium. Thus, there is need to find substitute of potassic fertilizer sources which is therefore necessary to sustain agriculture and reduce reliance on expensive K-fertilizers (Basak *et al.* 2015) [4]. Currently, very little or no potassium (K) fertilizers are given to a huge proportion of India's agricultural land, therefore the majority of the country's potassium needs are met by the soil's potassium reserves. India largely depends on upon the import of potassium fertilizers at the expense of heavy foreign exchange. Fertilizers containing potassium are one commodity on which the country completely depends for import. An indigenously produced double salts of K, namely Potassium Schoenite (($K_2SO_4.MgSO_4$), have been found to be beneficial on acidic and alluvial soils, providing a readily available supply of Potassium, Magnesium, and Sulfur to growing plants in an ideal ratio, despite the fact that very little work has been reported so far (Sharma *et al*. 1998, Rathore *et al*. 2014) [11, 10]. It is a high performance potassic mineral which provides essential nutrients in highly available water-soluble form to achieve all the required best parameters for agricultural & horticultural crops are available in our nation.

With this background, the present work has been investigated to study the response of combined application of potassic mineral (Schoenite and Syngenite) on yield and nutrient uptake by rice in an Inceptisol.

Materials and Methods

The field experiment was conducted during *kharif* season of 2021-22 at Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The experimental soil was clay loam which reaction was neutral (pH 6.91). The status of organic carbon content (0.56%) was moderate. the soil containing available N (175.6 kg ha^{-1}), phosphorus (20.2 kg ha^{-1}), potassium (291 kg ha^{-1}), available sulphur (22.6 mg kg^{-1}), available micronutrients Fe (24.9 mg kg^{-1}), Mn (23.04 mg kg^{-1}), Zn (1.43 mg kg^{-1}), Cu (2.11 mg kg^{-1}). The appropriate methods were used for the soil and plant analysis. The total rainfall received during the period of field experiment was 25.36 mm. The relative humidity during the crop period was in the range of 35 to 94 per cent. The minimum temperature varied from 14.8 °C to 26.5 °C, while maximum temperature was in the range of 29.1 °C to 34.2 °C.

The experiment was laid out in the randomized block design with ten treatments which replicated thrice. The treatments included, T1-RDF + 210 kg ha^{-1} K mineral (@ 70 kg ha^{-1} at transplanting, at 25-30 DAT and at 50-55 DAT), T2-RDF + 150 kg ha^{-1} K mineral (@ 50 kg ha^{-1} at transplanting, at 25-30 DAT and at 50-55 DAT), T3-RDF + 120 kg ha^{-1} K mineral (@ 40 kg ha^{-1} transplanting, at 25-30 DAT and at 50-55 DAT), T4-RDF + 140 kg ha^{-1} K mineral (@ 70 kg ha^{-1} at 25-30 DAT and at 50-55 DAT), T5-RDF +100 kg ha^{-1} K mineral (@ 50 kg ha^{-1} at 25-30 DAT and at 50-55 DAT), T6-RDF + 70 kg ha^{-1} K mineral at 25-30 DAT), T7-100% RDF (@ N 100, P_2O_5 60, and K_2O 40 kg ha^{-1}), T8-100% N, P + K 50% basal at transplanting + K 50% split (25% at 25-30 DAT + 25% at 50-55 DAT), T9-100% N P + K0, T10-Control (N0:P0:K0). Treatments T1-T8 were provided 100% of the recommended dose of fertilizer (RDF), i.e., 100:60:40 kg N, P_2O_5, and K_2O kg ha^{-1}. Treatments T1-T6 were received K-mineral (@ 210, 150, 120, 140, 100, 70 kg ha^{-1}) along with the 100% RDF. Treatment T9 was received only 100% NP fertilizer and T10 was not received any fertilizer. Recommended dose of N and P_2O_5 were applied through Urea and Single super phosphate and potassium was applied through MOP. Combined potassic mineral (Schoenite + Syngenite) was applied as potassic mineral.

Recovery efficiency is calculated based on the formula: {(total uptake in treatments with K application – total uptake in control) divided by kg of nutrient applied} multiplied by 100. (Dobermann, A. 2007) [6]

Results and Discussion

Grain and Straw yield

In the different treatments, grain yield of rice was recorded 31.3-57.8 q ha^{-1} whereas straw yield was recorded 39.0-74.6 q ha^{-1}. The results showed a non-significant increase in the grain yield (0.62-5.76%) due to addition of 70-210 kg ha^{-1} of K-mineral. Highest 5.76% increase over the RDF was observed with the application of 210 kg ha^{-1} of K-mineral. The yields were did not significantly influenced by the application of K mineral in comparison with the 100% RDF. No application of potassium in T9 was also produce at par grain yield. Among all the treatments, controlled plot recorded significant lowest yields. These results were might be due to the sufficient supply of nutrients as RDF (N @ 100, P @ 60 and K @ 40 kg ha^{-1}) in all the treatments (T1-T8) and sufficient availability of potassium in the experimental soil (291 kg ha^{-1}) which were able to fulfilled the nutrient requirement of the crop, resulted at par yields in all the fertilized plots (T1-T9). All the fertilized treatments found significantly superior yields over the control treatment (31.3 q ha^{-1}). The effect of different treatments on the total yield (grain + straw yield) were also showed the same trends as observed in the grain and straw. The findings are in line with Alexander *et al.* (1979) [1], Brohi *et al.* (2000) [5], Alum *et al.* (2009) [2], Swamanna (2015) [14], Khan *et al.* (2007) [9] and Banerjee *et al.* (2018) [3] in rice crop.

Nutrient uptake

The uptake of nitrogen and phosphorous were observed higher in the rice grain and recorded lower in the rice straw whereas, uptake of potassium showed a different trend and observed much higher in the rice straw than the rice grain. Uptake of nitrogen by rice grain was ranged 31.83 to 53.74 kg ha^{-1} and by rice straw it was ranged from 18.53 to 33.87 kg ha^{-1} while uptake of phosphorus in grain was ranged 6.57 to 11.56 kg ha^{-1} and in straw it was ranged from 3.44 to 6.62 kg ha^{-1} and uptake of K by rice grain and rice straw were ranged 8.92 to 15.84 kg ha^{-1} and 83.26 to 155.41 kg ha^{-1}. The uptake of nutrients by grain and straw yield followed the trends of yields of rice as recorded in the different treatments. In the various treatments total uptake of nitrogen, phosphorus and potassium by the rice plant was ranged 50.44-86.4 kg ha^{-1}, 10.14-17.9 kg ha^{-1} and 92.18-171.20 kg ha^{-1}, respectively. The results showed that application of different doses of K-Mineral (@ 70-210 kg ha^{-1}) with RDF were not significantly affect the uptake of nitrogen, phosphorus and potassium. Control where no fertilizer were applied, recorded the significantly lowest yield and significantly lowest uptake of nitrogen, phosphorous and potassium nutrients. Similar results on uptake of nutrients due to application of potassium mineral was also reported by Shete *et al.* (2018) [12].

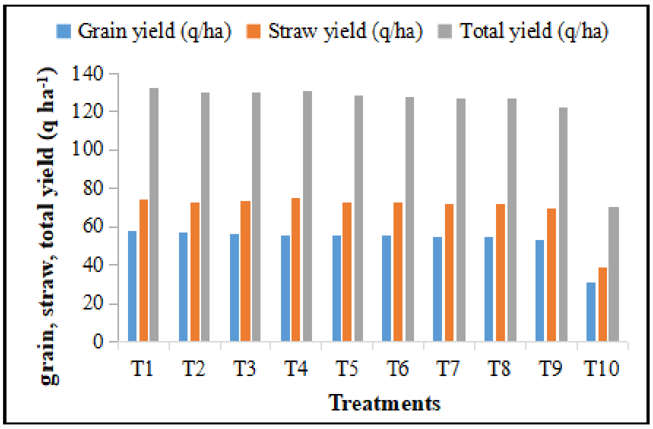

Fig 1: Effect of K mineral on grain and straw yield (q ha^{-1}) of rice.

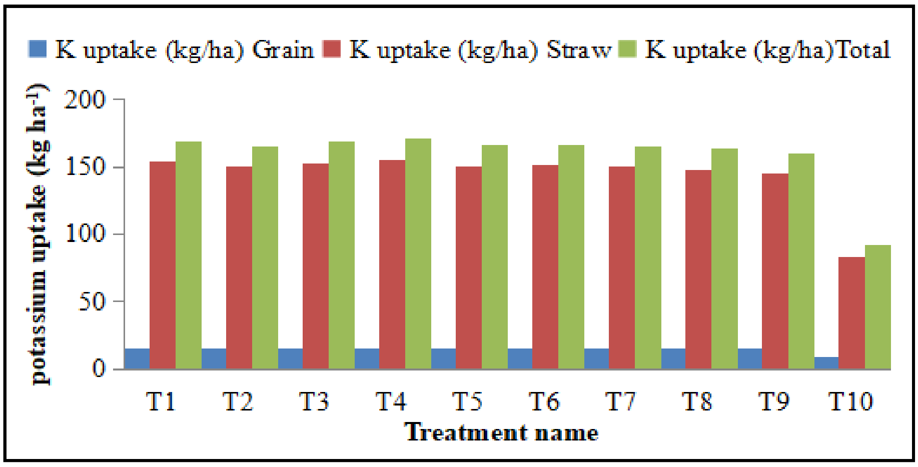

Fig 2: Effect of K mineral on potassium uptake (kg ha^{-1}) by rice.

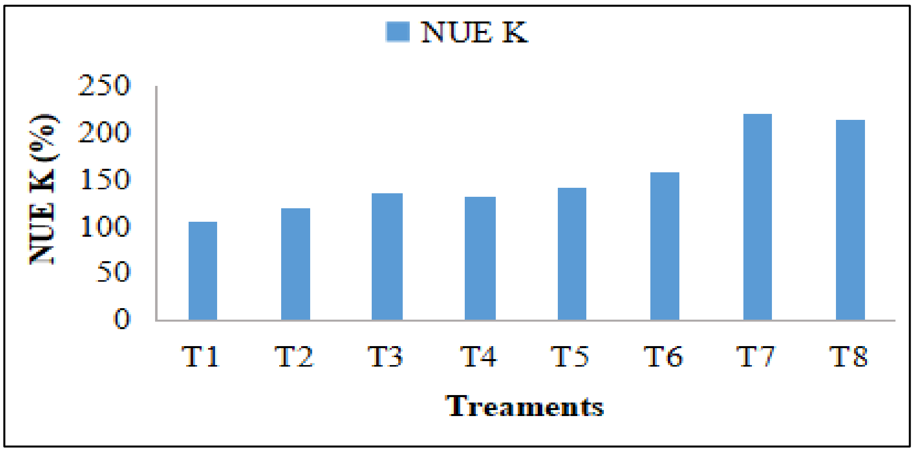

Fig 3: Nutrient use efficiency (%) by rice for applied K

Recovery efficiency of potassium

Among the various treatments, efficiency of applied potassium by rice was estimated between 115.8% to 219.9%. A trend of decreasing in efficiency with increasing dose of applied potassium was observed (figure-03). The maximum efficiency of 219.9% was found with lowest application of 40 kg ha^{-1} potassium as RDF (T7) which was closely followed by 214.8% estimated with application of equal quantity of potassium (40 kg ha^{-1}) in split dose (T8). Among the treatments of addition of different doses of potassium minerals @ 70-210 kg ha^{-1} with RDF, the maximum NUE 166.7% was found with application of lower dose of Mineral-K @ 70 kg ha^{-1} followed by 150.5, 146.6, 143, 129 percent NUE were estimated respectively, with application of Min-K @ 100, 120, 140, and 150 kg ha^{-1} and the minimum nutrient use efficiency of 115% was observed with the application of highest dose of applied potassium as K-Mineral @ 210 kg ha^{-1} potassium + RDF. NUE for the applied potassium observed more than 100%, showed the luxury consumption of potassium by crop from the native source of K (soil). Similar results were also reported by Gajanand *et al.* (2013) [8], Srinivasa *et al.* (2016) [13], Banerjee *et al.* (2018) [3] and Fageria (2015) [7].

Table 1: Effect of potassium mineral on yield, nutrient uptake and nutrient use efficiency by rice

Treat. No.	Grain yield (qha^{-1})	Straw tield (qha^{-1})	Total yield (qha^{-1})	Nitrogen uptake (kg ha^{-1})			Phosphorus uptake (kg ha^{-1})			Potassium uptake (kg ha^{-1})			NUE for K (%)
				Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	
T1	57.81^{a}	74.28^{a}	132.09^{a}	53.25^{a}	32.46^{a}	85.71^{a}	11.33^{a}	6.62^{a}	17.95^{a}	15.59^{a}	153.40^{ab}	168.98^{ab}	115.81
T2	56.95^{ab}	72.58^{ab}	129.53^{ab}	53.03^{a}	32.48^{a}	85.51^{a}	11.21^{a}	6.25^{a}	17.46^{a}	14.76^{a}	150.76^{ab}	165.52^{ab}	129.00
T3	56.36^{ab}	73.36^{ab}	129.72^{ab}	53.74^{a}	31.89^{a}	85.63^{a}	11.56^{a}	5.85^{a}	17.41^{a}	15.50^{a}	153.09^{ab}	168.58^{ab}	146.58
T4	55.69^{ab}	74.57^{a}	130.27^{ab}	52.52^{a}	33.87^{a}	86.39^{a}	10.50^{a}	5.90^{a}	16.40^{a}	15.79^{a}	155.41^{a}	171.20^{a}	142.96
T5	55.35^{ab}	72.60^{ab}	127.95^{ab}	52.71^{a}	31.98^{a}	84.69^{a}	11.48^{a}	5.86^{a}	17.34^{a}	15.21^{a}	150.69^{ab}	165.90^{ab}	150.54
T6	55.00^{ab}	72.55^{ab}	127.55^{ab}	51.55^{a}	32.01^{a}	83.56^{a}	10.92^{a}	5.76^{a}	16.68^{a}	14.87^{a}	151.06^{ab}	165.94^{ab}	166.73
T7	54.66^{ab}	71.97^{ab}	126.64^{ab}	52.48^{a}	32.17^{a}	84.65^{a}	10.62^{a}	6.09^{a}	16.71^{a}	14.90^{a}	150.28^{ab}	165.18^{ab}	219.89
T8	54.80^{ab}	71.71^{ab}	126.51^{ab}	52.50^{a}	30.87^{a}	83.37^{a}	10.72^{a}	6.07^{a}	16.79^{a}	15.84^{a}	147.68^{ab}	163.52^{ab}	214.87
T9	52.98^{b}	69.31^{b}	122.28^{b}	52.62^{a}	32.23^{a}	84.84^{a}	10.55^{a}	5.82^{a}	16.37^{a}	15.28^{a}	145.43^{b}	160.71^{b}	-
T10	31.33^{c}	39.02^{c}	70.35^{c}	31.83^{b}	18.53^{b}	50.36^{b}	6.57^{b}	3.44^{b}	10.01^{b}	8.92^{b}	83.26^{c}	92.18^{c}	-
CD(P=0.5)	1.411	1.634	2.745	2.34	1.92	3.09	0.49	0.50	0.69	0.58	2.67	3.00	-
SEm ±	4.20	4.86	8.16	6.94	5.70	9.17	1.46	1.49	2.06	1.71	7.93	8.91	-

Conclusion

It can be concluded from one year of experiment that RDF alone and application of K-mineral along with RDF resulted almost same effect on the yield and uptake of nutrients by rice crop. Additional application of potassium mineral increased the yield up to 5.76% but observed non-significant over the RDF. For the significant effect of potassic minerals, it can be recommended in potassium deficient soil.

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