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TIME OF APPLICATION OF POTASSIUM ON NITROGEN UTILIZATION AND YIELD OF DWARF INDICA RICE VARIETIES

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Opinion regarding potassium nutrition of rice still remains controversial even after the introduction of high yielding varieties of rice with high nutritional requirements. The reason being poor response obtained for potassium in many locations in the country. Nutritional requirements needed for high yield call for not only balanced fertilizer application according to crop requirement but also a well assorted supply of nutrients at a stage when plants require them most. Kimura and Chiba (1943) considered that the time at which nutrients are absorbed influence theyield more than the amount of nutrients absorbed by the rice crop. Potassium and NH_4 ion are found to have almost the same ionic radii and ionic properties and are said to compete with each other on ion exchange sites (Bear, 1964). An experiment was planned to study the effect of combined application of nitrogenous and potassic fertilizers on availability of those nutrients in soil and their uptake by rice as this is the commonly practised system for most of the crops.

Materials and Methods

A pot culture experiment was conducted in CRD with thirteen treatments in soils belonging to the order Entisols of Pattambi and Trivandrum to study the effect of combined application of muriate of potash and urea to submerged rice crop. Two rice varieties Jaya (medium duration, 120-125 days) and Triveni (short duration, 95-105 days) were used for the study. Soil potassium fractions as estimated in the above two soils are presented in Table 1. The following treatments were tried.

Treatments

1	Control (OK)	
2	$\frac{1}{2}$K + $\frac{1}{4}$K + $\frac{1}{4}$K	Full dose
3	$\frac{1}{2}$K + $\frac{1}{2}$K + 0K	Full dose
4	$\frac{1}{4}$K + $\frac{1}{4}$K + $\frac{1}{2}$K	Full dose
5	$\frac{1}{4}$K + $\frac{1}{2}$K + $\frac{1}{4}$K	Full dose
6	OK + $\frac{1}{2}$K + $\frac{1}{2}$K	Full dose
7	OK + $\frac{1}{4}$K = |K	Full dose
8	$\frac{1}{4}$K + 1/8K + 1/8K	Half dose
9	$\frac{1}{4}$K + $\frac{1}{4}$K + 0K	Half dose
10	1/8K + 1/8K + $\frac{1}{4}$K	Half dose
11	1/8K + $\frac{1}{4}$K + 1/8K	Half dose
12	0K + $\frac{1}{4}$K + $\frac{1}{4}$K	Half dose
13	OK + 1/8K + 3/8K	Half dose

The full dose of K is 45 kg K_2O/ha for medium duration variety and 35 kg K_2O/ha for short duration variety. The levels of N and P_2O_5 where 90 and 45 kg/ha respectively for medium duration variety and 70 and 35 kg/ha respectively for short duration variety. The three stages shown in treatments represent basal dressing, active tillering, and panicle initiation stages.

Urea (46% N), superphosphate (16% P_2O_5) and muriate of potash (60% K_2O) were used to supply N, P and K respectively. Half the dose of nitrogen was applied as basal dressing and the other half in two equal splits at maximum tillering and panicle initiation stages and the entire dose of phosphorus as one single basal dose. Potassium was applied as per treatments. The first top dressing of nitrogen was given at 15th and 30th day of planting which coincide with active tillering and maximum tillering stages for the short and medium duration varieties respectively. Second top dressing was given at the panicle initiation stage for both the varieties. Soil samples collected on the 10th day after basal application first and second top dressing, were analysed for exchangeable NH_4 ion and K. As NH_4 ion is the most stable form of nitrogen in submerged rice soils and rice utilizes nitrogen mainly in the form of NH_4 ion, this form of nitrogen is taken as the available form for submerged rice plant. Plant samples were collected from the extra replications kept for collection of plant samples at active tillering, maximum tillering and flowering stages and analysed for nitrogen and potassium content and their uptake computed using dry weight of plant material.

Results and Discussion

Exchangeable ammonium content of soil under different treatments for both the varieties as well as nitrogen uptake at different stages are presented in Table 2 and 3 respectively. At active tillering stage higher exchangeable ammonium was recorded for treatments 1,6,7,12 and 13 which have received no basal dressing of potassic fertilizers. Exchangeable ammonium was found to decrease with increasing rates of potassic fertilizers indicating the influence of applied potassium on exchangeable NH_4 ion or soil nitrogen availability. A similar trend was observed in the case of nitrogen uptake for, treatments receiving no basal dressing of potassic fertilizers recorded higher uptake (Table 2). Ammonium and potassium ions are having almost the same ionic radii and ionic properties and these ions are reported to compete with each other on ion exchange sites. Nielson (1972) observed that when K ion and NH_4 ion were added simultaneously NH_4 ion was preferably adsorbed on soil exchange complex. Lavte and Paliwal (1971) and Stevanovie (1976) made similar observations on N-K interaction affecting their availability.

At maximum tillering stage exchangeable NH_4 was lesser in those treatments which have received larger quantity of potassium for the first time (Treatments 5, 6 and 12) as the first instalment. But treatments which have received maximum K by that stage (Treatments 2, 3, 5, 8 and 11) showed lesser nitrogen uptake. This might probably due to ionic competition between

K ion and NH_4 ion at root exchange sites of rice also, thus reducing uptake of nitrogen Ammonium ions were reported to have larger ionic size when compared to K ion (Nielson, 1972). Exchangeable potassium content of soil and uptake by the rice crop are presented in Table 4 and Table 5 respectively.

At the active tillering stage low exchangeable potassium content and low uptake by rice plant were observed in T_1, T_6, T_7, T_{12} and T_{18} which have not received basal dose of potassic fertilizers. Higher exchangeable K ion was observed in T_2, T, and T_5 which have received $\frac{1}{2}$ to full K by maximum tillering stage but potassium uptake was not found to follow the same pattern at that stage. At the panicle initiation stage also neither soil exchangeable potassium nor potassium uptake of rice followed any regular pattern.

Irrespective of treatments, exchangeable potassium content and crop uptake. of potassium of Pattambi soil were significantly higher than that of Trivandrum soil. Among varieties, Jaya accumulated more potassium from both the rate of supply when compared to Triveni from both the soils at all stages. A close perusal of the data in Tables 4 and 5 indicates clearly that both exchangeable potassium content of soil and potassium uptake by rice plant is decided by the inherent potassium status of soil and rate of potassium supply to crop.

Potassic fertilizers are usually applied simultaneously with ammoniacal fertilizers or ammonia forming fertilizers like urea for the rice crop. Nielson (1972) observed that when K ion and NH_4 ion were added simultaneously NH_4 ion was preferentially adsorbed on soil exchange complex. Raju and Mukopadhya (1974) in their studies on the sequence of potassium and ammonium application for the availability of nitrogen observed that in treatments where K ion was applied simultaneously with NH_4 ion competition for the adsorption sites by NH_4 ion and K ion results in K ions sharing many of the sites with NH_4 ion resulting in less nitrogen availability. Many research workers like Lavte and Paliwal (1971) and Stevanovie (1976) made similar observations on N-K interaction affecting their availability.

Table 1

Fractions of potassium in soil

Fractions of potassium	Method followed	Pattambi (ppm)	Trivandrum (ppm)
Total K in the fusion extract	Jackson (1958)	1800.0	1120.0
HCl soluble K	A. 0. A. C. (1960)	56.3	53.8
Fixed K	Wood and Turk (1941)	150.3	60.0
Exchangeable K	Jackson (1958)	76.0	190
Water soluble K	Jackson (1958)	85.0	375

Table 2

Exchangeable ammonium of soil at different stages of the crop (me/100 g soil)

	Treatments	Active tillering stage		Maximum tillering stage		Panicle initiation stage	
		Jaya	Triveni	Jaya	Triveni	Jaya	Triveni
1	Control (OK)	0.78	0.77	0.55	0.65	0.65	0.60
2	$\frac{1}{2}$K + $\frac{1}{4}$K + $\frac{1}{4}$K	0.62	0.52	045	0.43	0.52	0.39
3	$\frac{1}{2}$K + $\frac{1}{2}$K + OK	0.59	0.68	0.42	0.59	0.65	0.62
4	$\frac{1}{4}$K + $\frac{1}{4}$K + $\frac{1}{2}$K	0.67	0.72	0.46	0.62	0.35	0.36
5	$\frac{1}{4}$K + $\frac{1}{2}$K + $\frac{1}{4}$K	0.67	0.65	0.42	0.62	0.33	0.46
6	OK + $\frac{1}{2}$K + $\frac{1}{2}$K	0.74	0.78	0.42	0.55	0.39	0.26
7	OK + $\frac{1}{4}$K + $\frac{3}{4}$K	0.70	0.83	0.52	0.45	0.33	0.42
8	$\frac{1}{4}$K + 1/8K + 1/8K	0.49	0.55	0.46	0.59	0.52	0.49
9	$\frac{1}{4}$K + $\frac{1}{4}$K + OK	0.55	0.65	0.49	0.49	0.66	0.56
10	1/8K + 1/8K + $\frac{1}{4}$K	0.68	0.68	0.09	0.71	0.72	0.42
11	1/8K + $\frac{1}{4}$K + 1/8K	0.59	0.72	0.52	0.65	0.59	0.39
12	OK + $\frac{1}{4}$K + $\frac{1}{4}$K	0.84	0.65	0.42	0.62	0.85	0.33
13	OK + 1/8K + 3/8K	0.83	0.72	0.59	0.59	0.39	0 36

Table 3

Nitrogen uptake at different stages of the crop (mg/pot)

Treatment No	Active tillering stage		Maximum tillering stage		Flowering stage	
	Jaya	Triveni	Jaya	Triveni	Jaya	Triveni
1	16.72	3.64	70.34	31.28	173.03	81.20
2	9.76	3.09	23.81	14.15	163.10	115.65
3	7.64	1.77	32.45	15.49	173.82	96.47
4	12.24	2.51	50.65	8.39	213.35	106.35
5	14.79	2.24	29.05	10.85	193.54	91.94
6	21.78	3.10	43.86	24.85	157.91	108.79
7	18.06	3.63	38.08	14.73	217.76	40.03
8	10.51	2.72	35.23	26.46	174.00	71.28
9	7.15	2.87	36.09	34.53	149.23	91.06
10	8.62	2.00	41.82	27.39	183.00	136.23
11	11.33	2.41	21.25	19.99	220.67	108.50
12	22.38	2.59	40.76	22.79	213.95	127.89
13	16.19	2.58	37.72	15.41	235.85	96.59
CD (0.05) for varieties	0,7895		4,45		186, .56	
CD (0.05) for treatments	2.0130		4.45		93,99	

Exchangeable NH_4 ion which is the most stable form of nitrogen in submerged soils was estimated to be more in T_6, T_7, T_{12} and T_{13} which have not received basal dose of potassic fertilizers. Such reduction in exchangeable ammonium was also observed in these treatments which have received urea and potassium chloride simultaneously at maximum tillering and panicle initiation stages.

Yield attributes and yield are presented in Tables 6 and 7. At full dose of potassium supply (45 kg/ha K_2O) for medium duration varieties, T_6 $(0+\frac{1}{2}K+\frac{1}{2}K)$ recorded the highest grain yield (25.40 g per pot). Larger number of productive tillers, higher thousand grain weight and higher fertility percentage have contributed for the higher grain yield, T_6 has also recorded higher straw yield. At half the rate of potassium supply (22.5 kg/ha), Jaya has recorded the highest grain yield for T_{10}

Table 4

Effect of time and rate of application of potassium on exchangeable potassium in soil, me/100g

Treatment No.	Active tillering stage		Maximum tillering stage		Panicle initiation stage	
	Jaya	Triveni	Jaya	Triveni	Jaya	Triveni
1	60.0	60.5	87.5	75.0	42.5	22.3
2	96.0	76.0	322.5	185.0	85.0	49.0
3	75.0	88.0	287.5	157.5	77.5	35.0
4	70.0	74.0	170.0	160.0	60.0	28.0
5	79.0	103.0	120.0	200.0	102.5	27.8
6	65.5	67.5	100.0	135.0	100.0	39.0
7	61.0	65.0	112.5	110.0	82.5	54.0
8	71.0	76.5	112.5	135.0	750	54.8
9	75.0	95.0	130.0	145.0	95.0	33.3
10	68.0	103.5	110.0	125.0	87.5	30.3
11	62.0	107.5	117.5	130.0	72,5	28.8
12	55.0	71.0	125.0	117.5	85.0	27.8
13	60.0	64.5	127.5	110.0	112.5	34.9
Mean	68.3	81.7	147.9	137.3	82.9	35.7
CD (0.05) for comparison of treatments	10.918		32.00		16.35	
CD (0.05) for comparison of variety X treatment interaction	15.439		45.26		23.12	

Table 5

Effect of time and rate of application of potassium on the uptake of potassium by Jaya and Triveni

Treatment No	Active tillering stage mg/pot		Maximum tillering stage mg/pot		Floweringstage mg/pot		Harvest stage mg/pot	
1	10.99	3.21	61.07	20.84	127.05	122.55	313.21	231.99
2	29.16	6.31	98.91	61.22	320.10	183.25	491.21	387.71
3	25.20	4.04	97.08	31.71	200.30	176.34	502.49	239.04
4	20.45	5.64	92.18	46.51	327.70	157.30	548.37	309.04
5	20.50	5.11	100.50	50.66	144.55	173.80	413.09	272.92
6	17.41	3.01	73.12	34.03	196.55	232.85	606.75	246.16
7	15.65	2.63	74.18	34.44	296.90	179.70	585.22	374.67
8	24.12	6.85	74.29	44.86	228.05	187.10	419.51	344.03
9	16.83	4.08	84,88	48.03	226.85	200.45	444.37	293.98
10	19.84	4.88	81.20	54.73	201.60	157.40	429.65	241.69
11	24.75	2.59	82.56	31.48	256.05	131.95	411.32	303.09
12	18.20	2.25	56.17	28.57	159.85	186.15	398.17	270.31
13	12.30	2.56	64.83	24.10	196.55	188.80	402.96	282.49
Mean	19.65	4.09	80.07	39.39	233.09	175.20		
CD for comparison (0.05)	5.73		18.10		67.80		64.07	

(1/8K+1/8K+$\frac{1}{4}$K) indicating that at a lower dose of K supply a small initial dose of potassium is required for medium duration varieties. Higher thousand grain weight and fertility percentage might have contributed for the higher yield for this treatmeut (Table 6). Triveni has recorded comparatively higher grain yield at half the rate of potassium supply (17.5 kg/ha) now recommended in Kerala for short duration varieties. Triveni has recorded highest grain yield as well as straw yield for T_{11} (1/8K+$\frac{1}{4}$K+1/8K). Higher thousand grain weight and fertility percentage might have contributed to higher yield for T_{11}. Uptake of potassium was also found to be higher for the same treatment.

Yield attributes and yield are presented in Tables 6 and 7. Highest number of productive tillers was recorded for T_6 (OK+$\frac{1}{2}$K+$\frac{1}{2}$K) and T_4 ($\frac{1}{4}$K+$\frac{1}{4}$K+$\frac{1}{2}$K). Highest thousand grain weight of 28.60 g was also recorded for T_6 in the case of Jaya and T_{11} for Triveni (24.58 g). For the medium duration variety, potassium applied at maximum tillering and panicle initiation stages contributed to higher thousand grain weight.

Table 6
Effect of time and rate of application of potassium on the yield attributes of Jaya and Triveni

Treatment No	Productive tillers		Earhead length (cm)		1000 grain weight (g)		Percentage fertility	
	Jaya	Triveni	Jaya	Triveni	Jaya	Triveni	Jaya	Triveni
1	15.25	14.25	20.43	15.66	23.24	23.77	76.82	7089
2	14.00	16.00	19.83	18.58	27.42	23.36	82.28	75.81
3	15.25	15.50	20.38	19.55	28.53	21.91	83.84	8088
4	16.00	13.75	19.59	18.44	27.86	23.58	83.69	82.36
5	13.25	15.50	20.43	1936	27.26	22.04	78.54	81.60
6	16.00	15.75	20.28	18.30	28.60	2238	88.01	82.75
7	14.50	13.50	20.27	18.90	27.33	22.69	79.50	82.27
8	12.75	16.00	19.99	18.70	23.86	23.74	78.93	84.18
9	14.25	14.75	20.09	18.92	27.36	22.78	81.88	77.51
10	13.25	11.25	19.73	19.21	27.05	24,26	90.46	78.56
11	13·50	12.00	18.93	18.54	27,01	24.58	80.95	81.67
12	13.50	10.50	18.15	19.09	25.90	22.25	85.50	80.30
13	11.25	11.50	20.15	18.18	23.42	23.20	86.30	78.47
Mean	14.05	13.86	19.86	18.57	26.78	23.12	82.50	79.79
CD (0.05)	N.S	N.S	N.S	N.S	*	*	N.S	N.S

* Significant at 5 per cent level
Thousand grain weight CD for comparison of varieties (0.05) = 0.629
Thousand grain weight CD for comparison of treatments (0.05) = 0.889

Table 7

Effect of time and rate of application of potassium on yield of Jaya and Triveni (g/pot)

Treatment No	Grain	Straw	Grain	Straw
	Jaya		Triveni	
1	14.50	19.28	17.50	9.65
2	18.00	22.75	19.25	12.68
3	18.00	22.80	15.75	7.48
4	18.63	2065	18.75	9.35
5	18.00	17.63	18.25	8.80
6	25 40	22 88	15.25	10.25
7	18 25	18.88	17.00	12.43
8	18.20	17.75	20.00	11.75
9	20.00	19.50	20.00	8.75
10	21.80	22.00	16.00	7.43
11	12 75	16.40	24.00	12.60
12	13.50	17.80	15.50	6.23
13	15.25	17.30	17.75	8.65
Mean	17.66	19.86	18.08	9.69

Grain yield CD (0.05) for comparison of treatment = 1.181
,, of varietyx treatment interaction = 1.671
Straw yield CD (0.05) for comparison of treatment = 2.550
,, of variety x treatment interaction = 3.60

Maximum grain yield of 25.40 g/pot was recorded by T_6 for the variety Jaya. Larger number of productive tillers, higher thousand grain weight and higher fertility percentage have contributed for the higher gram yield (Table 6). Higher straw yield was also given by T_6. Higher plant height and larger number of tillers per plant might have contributed to increased straw weight for this variety. At half the rate of potassium supply, Jaya has recorded maximum grain yield for T_{10} (1/8K+1/8K +$\frac{1}{4}$K) indicating that at half the rate of potassium supply, a small basal dose of 1/8K was required to give better results.

Half the recommended dose (35 kg K_2O/ha) of potassium supply was found sufficient for the short duration variety Triveni. Higher thousand grain weight and fertility percentage might have contributed to higher yield _for T_{11}. Uptake of potassium was also found to be higher [for the same treatment.

Summary

A pot culture trial was conducted using the soil belonging to the order Entisols collected from Pattambi and Trivandrum districts of Kerala. Skipping basal application of muriate of potash along with urea and application of potassic fertilizer at maximum tillering and reproductive stages enhanced grain yield for the medium duration variety Jaya by increasing number of earheads, thousand grain weight and increasing the percentage of fertile grains per panicle. Skipping of potassic fertilizers as basal dose increased soil availability of NH_4 ion nitrogen, the most important from of nitrogen utilized by submerged rice. Initial growth stage was considered as one of the most efficient periods of utilization of nitrogen by rice. For a short duration variety like Triveni 1 7.5 kg K_2O/ha was found sufficient for obtaining maximum yield. A small basal dose of potassic fertilizers was found required for short duration varieties for obtaining maximum yield.

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