

Original Research Article

<https://doi.org/10.20546/ijcmas.2019.803.178>

Plant Growth Parameters and Soil Potassium Pool as Influenced by Potassium Fertilization in Kharif Season Rice

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ABSTRACT

Keywords

Soil potassium pool,
Plant parameters,
Potassium
fertilization

Article Info

Accepted:
12 February 2019
Available Online:
10 March 2019

The field experiment was conducted during kharif season of 2016-17 and 2017-18 to find the influence of potassium fertilization on different growth and yield parameters of rice along with soil potassium pool. The experiment was laid out in Randomized Block Design with treatments comprised of different doses of potassium viz. 15, 30, 45, 60, 90, 120 kg/ha and a control plot without any fertilizer and it was replicated thrice. The experiment revealed that the plant growth parameters viz. plant height, number of active tillers per plant, test weight and yield were significantly increased with application of potassium fertilizer. With application of potassium fertilizer, plant parameters such as plant height, no of active tillers, test weight and yield of rice increased significantly. Pooled data of both the years suggested that, water soluble, exchangeable, available and HNO₃ soluble potassium increased at all three stages, as fertilizer dose increased. The exchangeable potassium in control plot showed a decreasing trend with time.

Introduction

Attaining Food Security had been a major challenge for the nation since independence. With ever increasing population it is very crucial for our country to increase food grain production from the current level. United Nations Sustainable Development Goal no. 2 also talks about increasing agro productivity two fold by the end of 2030. The current stagnation in food grain production necessitates special initiatives to meet the increasing demands of food grains. Expansion

of the area has ceased to be a major source of increased output. Most of the targeted increase in production now must result from greater yield per hectare. Appropriate nutrient management in general and potassium management in particular, will play a major role in overcoming stagnation in crop production. The picture of crop responses to potassium (K) in India has been changing with time. Although Indian soils were sufficient in terms of potassium status but intensive cropping without its application has rendered the soils deficient in potassium. There is a

growing evidence of increasing deficiency of K as a result of inadequate use of the nutrient as compared to nitrogen (N) and phosphorus (P). International potash institute found K balance negative in many soils even under the optimum rates of fertilization.

In view of the above considerations, the experiment was conducted to characterize the soil with respect to potassium status and determine different forms of potassium in soil and its dynamics.

Materials and Methods

The field experiment was conducted in the *kharif* season of 2016-17 and repeated the same in the year 2017-18 at the Agricultural Farm of PalliSiksha Bhavana (Institute of Agriculture), Visva- Bharati, Sriniketan which situated at 23°39' N latitude and 87°42' E longitude with an average altitude of 58.9 m above the mean sea level under sub humid semi-arid region of West Bengal.

The experiment was conducted in a randomized block design having three replications in both the years. Seven different treatments were randomly allotted to the plots following random number table (Gomez and Gomez, 1976)

The experiment was laid out in Randomized Block Design with three replications in 6m x 5m plots and spacing of 20cm. × 10cm. The treatment comprised of different doses of potassium viz. 15,30, 45, 60, 90, 120 kg/ha along with a control plot without having any fertilizer applied.

Height of plants and number of tillers per plant was measured by taking measurement of 5 plants from each plot was at 45, 70 and 90 DAT. A sample of 1000 seeds was drawn randomly from each plot. The sample was weighed and analyzed statistically. After

harvesting was done from individual plot, the grain was weighed with balance and yield per hectare was calculated.

Water soluble potassium was determined by following procedure of Black *et al.*, (1965) by taking soil and water in 1:2 ratio, shaking on the mechanical shaker for two hours and allowing it to reach equilibrium for additional sixteen hours. Available potassium of soil samples was determined in soil: neutral normal ammonium acetate extract (1:5) of the soil using flame photometer (Jackson 1973). Exchangeable K was the difference between available and water soluble potassium. Nitric acid soluble potassium was determined by following procedure of Wood and Deturk (1941).

Results and Discussion

Plant parameters in rice

Plant height

The observations on plant height each year, recorded at 45, 70, and 90 days after transplanting (DAT) were analyzed statistically and presented in the table no 1. The plant height of *kharif* rice was highly influenced by the application of potassium fertilizer in every stage i.e. 45, 70, and 90 days after transplanting (DAT).

At 45 DAT the height increased from control (T₁) to T₅ having potassium application rate 60 kg/ha then declined. At 70 DAT and 90 DAT height increased with increase in fertilizer dose. Highest value was recorded in T₇ treatment which was significantly higher than other treatments except T₄, T₅, T₆, with which it was at par. Similar effect of potassium fertilization was reported by Bahmaniar *et al.*, (2007), Biswas *et al.*, (2001) and Mukherjee and Sen (2005).

No. of active tillers/hill

A perusal of pooled data shows that no. of active tillers per hill was highly influenced by potassium fertilization. Highest no. of active tillers were recorded in treatment T₇ followed by T₅ and T₆ and was significantly higher than rest of the treatments (table no 2). Similar results were corroborated by Thakur *et al.*, (1993), Meena *et al.*, (2003) and Tabar *et al.*, (2012).

Test weight

The test weight data from different years were pooled together where it can be noticed that test weight increased with increasing the dose of potassium fertilizer. Highest test weight was recorded in treatment T₇ which was at par with the all treatments except control with which it was significantly higher. The pooled data revealed that the range of test weight was from 11.94 to 15.47 g.(table no 2).

Grain yield

Grain yield was also influenced by fertilization as revealed from table no 2. It ranged from 2.04 to 3.24 t ha⁻¹ and 1.94 to 3.40 t ha⁻¹ for years 2016-17 and 2017-18 respectively. The pooled data revealed that highest yield was recorded from treatment T₅ which was significantly higher than treatment T₁ and T₂. The second highest yield was recorded in treatment T₆ and T₇ followed by treatment T₄. Krishnappa *et al.*, (2006) revealed that potassium application had positive impact on yield of rice. Similar observations were reported by Mathad *et al.*, (2002) and Biswas *et al.*, (2001).

Soil potassium pool

Water soluble potassium

Soil samples from surface soils were analyzed for water soluble potassium at different

intervals of kharif season rice for successive years 2016-17 and 2017-18 and pooled together in table no 3. At 45 DAT highest water soluble potassium was present in treatment of highest dose of fertilizer application, T₇ and was significantly higher than all other treatments. Similar trends were seen during various stages of crop 70 DAT and 90 DAT. The range of water soluble potassium was in the range of 10.04 to 23.20 ppm, 9.64 to 22.97 ppm and 8.86 to 22.36 ppm for 45 DAT, 70 DAT and 90 DAT respectively. The control plot showed a different trend than other treatments where water soluble potassium decreased with passing of time, while for the rest of the treatment this trend was absent due to fertilization. Similar results were revealed from experiments by Padole and Mahajan (2003), Ranganathan and Sathyanarayana (1980) and Pharande and Sonar (1996). The quantity of water soluble K was found lower than other potassium fractions which could be due to the fact that K in solution is present in lower quantities in comparison to other potassium reserves (Bansal *et al.*, 2002).

Exchangeable potassium

Highest exchangeable potassium was found in T₇ treatment at all three stages 45, 70, 90 DAT i.e. 79.95, 80.96, 76.71 ppm respectively and the values were significantly higher than all other treatments except treatment T₅ and T₆ with which it was at par. Lowest value was recorded in control plot having no potassium application (table no 4). Pooled data suggests that, at all three stages exchangeable potassium increased as fertilizer dose increased. The exchangeable potassium in control plot showed decreasing trend with time which was due to the depletion of potassium pool with plant uptake and leaching. Similar trend was observed from the pooled data of all the treatments except treatment T₇ where no such trend was discernible.

Table.1 Effect of potassium fertilizer application on plant height (in cm) in Kharif Rice

Treatments	45 DAT			70 DAT			90 DAT		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁ (N ₆₀ P ₃₀ K ₀)	36.82	35.67	36.25	72.32	71.56	71.94	99.76	101.27	100.52
T ₂ (N ₆₀ P ₃₀ K ₁₅)	40.73	39.28	40.00	76.27	74.73	75.50	108.81	108.21	108.51
T ₃ (N ₆₀ P ₃₀ K ₃₀)	41.21	40.21	40.71	80.94	79.86	80.40	109.53	111.27	110.40
T ₄ (N ₆₀ P ₃₀ K ₄₅)	42.31	41.75	42.03	79.46	77.42	78.44	111.79	111.00	111.40
T ₅ (N ₆₀ P ₃₀ K ₆₀)	45.59	44.19	44.89	79.01	82.07	80.54	112.85	113.71	113.28
T ₆ (N ₆₀ P ₃₀ K ₉₀)	45.72	43.75	44.73	83.37	79.65	81.51	113.60	113.10	113.35
T ₇ (N ₆₀ P ₃₀ K ₁₂₀)	43.23	42.05	42.64	85.55	79.30	82.42	112.52	117.19	114.85
S Em (±)	1.20	1.34	0.90	2.10	2.23	1.55	2.92	3.03	2.17
CD at 5%	3.71	4.12	2.63	6.48	6.88	4.52	9.01	9.33	6.32

Table.2 Effect of potassium fertilizer application on number of active tillers/hill, test weight and grain yield in kharif rice

Treatments	No. of Active Tillers/hill			Test weight (in g)			Grain Yield (in t/ha)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁ (N ₆₀ P ₃₀ K ₀)	8.74	9.97	9.35	13.69	10.18	11.94	2.04	1.94	1.99
T ₂ (N ₆₀ P ₃₀ K ₁₅)	10.93	11.70	11.32	15.23	14.09	14.66	2.59	2.31	2.45
T ₃ (N ₆₀ P ₃₀ K ₃₀)	12.20	13.80	13.00	15.21	14.46	14.84	2.98	3.01	2.99
T ₄ (N ₆₀ P ₃₀ K ₄₅)	12.85	13.47	13.16	15.12	14.22	14.67	3.18	3.33	3.26
T ₅ (N ₆₀ P ₃₀ K ₆₀)	15.05	15.47	15.26	15.56	14.97	15.27	3.24	3.39	3.32
T ₆ (N ₆₀ P ₃₀ K ₉₀)	14.62	15.14	14.88	15.64	14.96	15.30	3.18	3.40	3.29
T ₇ (N ₆₀ P ₃₀ K ₁₂₀)	15.54	15.81	15.68	15.75	15.20	15.47	3.21	3.37	3.29
S Em (±)	0.44	0.47	0.33	0.37	0.61	0.36	0.16	0.16	0.11
CD at 5%	1.36	1.44	0.95	1.15	1.88	1.05	0.48	0.48	0.33

Table.3 Effect of potassium fertilizer application on water soluble potassium (in ppm) in soils of kharif rice

Treatments	45 DAT			70 DAT			90 DAT		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁ (N ₆₀ P ₃₀ K ₀)	10.23	9.85	10.04	9.70	9.57	9.64	9.21	8.52	8.86
T ₂ (N ₆₀ P ₃₀ K ₁₅)	11.60	11.16	11.38	12.55	11.52	12.04	11.70	11.39	11.54
T ₃ (N ₆₀ P ₃₀ K ₃₀)	15.90	15.22	15.56	15.91	14.95	15.43	15.36	14.24	14.80
T ₄ (N ₆₀ P ₃₀ K ₄₅)	14.94	14.48	14.71	14.61	13.65	14.13	15.25	14.64	14.94
T ₅ (N ₆₀ P ₃₀ K ₆₀)	17.98	17.78	17.88	17.69	16.83	17.26	16.96	16.32	16.64
T ₆ (N ₆₀ P ₃₀ K ₉₀)	20.12	19.80	19.96	20.01	18.96	19.48	18.63	18.68	18.65
T ₇ (N ₆₀ P ₃₀ K ₁₂₀)	23.33	23.07	23.20	23.25	22.68	22.97	22.57	22.15	22.36
S Em (±)	0.53	0.84	0.51	1.08	0.92	0.71	1.14	1.07	0.78
CD at 5%	1.64	2.58	1.49	3.34	2.84	2.08	3.51	3.28	2.28

Table.4 Effect of potassium fertilizer application on exchangeable potassium (in ppm) in soils of kharif rice

Treatments	45 DAT			70 DAT			90 DAT		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁ (N ₆₀ P ₃₀ K ₀)	60.85	61.17	61.01	59.39	53.98	56.68	57.12	55.83	56.47
T ₂ (N ₆₀ P ₃₀ K ₁₅)	68.51	69.62	69.07	67.17	65.69	66.43	65.56	65.72	65.64
T ₃ (N ₆₀ P ₃₀ K ₃₀)	74.68	75.23	74.96	73.61	71.15	72.38	71.28	70.10	70.69
T ₄ (N ₆₀ P ₃₀ K ₄₅)	75.19	76.33	75.76	74.09	75.03	74.56	71.38	67.03	69.20
T ₅ (N ₆₀ P ₃₀ K ₆₀)	77.34	79.31	78.33	76.10	78.82	77.46	74.38	74.09	74.23
T ₆ (N ₆₀ P ₃₀ K ₉₀)	78.45	78.03	78.24	76.82	79.11	77.97	75.12	71.30	73.21
T ₇ (N ₆₀ P ₃₀ K ₁₂₀)	80.23	79.68	79.95	79.62	82.30	80.96	77.58	75.84	76.71
S Em (±)	1.80	1.52	1.21	1.82	2.20	1.45	2.19	2.23	1.71
CD at 5%	5.55	4.68	3.52	5.61	6.78	4.24	6.74	6.88	4.99

Table.5 Effect of potassium fertilizer application on available potassium (in ppm) in soils of kharif rice

Treatments	45 DAT			70 DAT			90 DAT		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁ (N ₆₀ P ₃₀ K ₀)	71.07	71.03	71.05	69.09	63.55	66.32	66.33	64.35	65.34
T ₂ (N ₆₀ P ₃₀ K ₁₅)	80.11	80.78	80.45	79.73	77.20	78.47	77.25	77.11	77.18
T ₃ (N ₆₀ P ₃₀ K ₃₀)	90.58	90.45	90.51	89.52	86.11	87.82	86.64	84.33	85.49
T ₄ (N ₆₀ P ₃₀ K ₄₅)	90.13	90.81	90.47	88.71	88.68	88.69	86.63	81.67	84.15
T ₅ (N ₆₀ P ₃₀ K ₆₀)	95.32	97.09	96.20	93.78	95.64	94.71	91.35	90.40	90.87
T ₆ (N ₆₀ P ₃₀ K ₉₀)	98.57	97.82	98.20	96.83	98.07	97.45	93.75	89.98	91.86
T ₇ (N ₆₀ P ₃₀ K ₁₂₀)	103.56	102.75	103.16	102.87	104.98	103.93	100.15	97.99	99.07
S Em (±)	1.69	2.09	1.36	1.96	3.00	1.81	2.61	2.52	1.92
CD at 5%	5.21	6.45	3.98	6.04	9.24	5.29	8.05	7.77	5.62

Table.6 Effect of potassium fertilizer application on HNO₃ soluble Potassium (in ppm) in soils of kharif rice

Treatments	45 DAT			70 DAT			90 DAT		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T ₁ (N ₆₀ P ₃₀ K ₀)	476.18	486.00	481.09	472.01	457.88	464.94	452.81	436.46	444.64
T ₂ (N ₆₀ P ₃₀ K ₁₅)	500.04	495.04	497.54	516.95	525.88	521.42	530.52	541.47	536.00
T ₃ (N ₆₀ P ₃₀ K ₃₀)	516.57	499.99	508.28	528.66	518.31	523.49	542.75	546.78	544.76
T ₄ (N ₆₀ P ₃₀ K ₄₅)	524.95	506.51	515.73	550.48	533.30	541.89	566.28	563.90	565.09
T ₅ (N ₆₀ P ₃₀ K ₆₀)	561.09	559.06	560.08	571.13	559.61	565.37	590.58	578.04	584.31
T ₆ (N ₆₀ P ₃₀ K ₉₀)	571.64	558.08	564.86	579.22	592.01	585.62	594.01	622.52	608.27
T ₇ (N ₆₀ P ₃₀ K ₁₂₀)	563.65	569.72	566.69	586.03	587.33	586.68	603.30	626.18	614.74
S Em (±)	18.04	21.17	13.96	22.33	17.32	14.23	21.17	16.66	13.62
CD at 5%	55.60	65.23	40.75	68.80	53.37	41.54	65.22	51.33	39.75

Similar results were recorded from experiments by Ranganathan and Sathyanarayana (1980), Venkatesh and Sathyanarayana (1994), Hirekurbar *et al.*, (2000) and Padole and Mahajan (2003).

Available potassium

In study of the pooled data of 2016-17 and 2017-18 (table no 5) pertaining to available potassium, it was noticed that available potassium was significantly influenced by application of potassium fertilizer in all the treatments over the control. At 45 DAT highest available potassium was recorded in treatment T₇ with a value of 103.16 ppm which was significantly higher than rest of the treatments except treatment T₆ with which it was at par. At 70 and 90 DAT similar result were obtained from treatment T₇, which was significantly higher than all other treatments. The available potassium in control plot showed decreasing trend with time which was due to the depletion of potassium pool with plant uptake and leaching. Similar trend was observed from the pooled data of all the treatments except treatment T₇ where no such trend was discernible. Similar findings were obtained from Singh and Brar (1977) and Padole and Mahajan (2003)

HNO₃ soluble potassium

HNO₃ soluble Potassium from soil samples during kharif season of each year at 45, 70, and 90days after transplanting (DAT) were analyzed statistically and presented in the table 6. The pooled data suggests that HNO₃ soluble Potassium was highly influenced by the application of potassic fertilizer in every stage i.e. 45, 70, and 90days after transplanting (DAT). At 45 DAT, treatment T₇ found to be highest in terms of HNO₃ soluble potassium and was at par with treatments T₅ and T₆ and significantly higher than all other treatments. Similar trend was

also seen in soil samples of 70 DAT and 90 DAT. The range of HNO₃ soluble potassium was within 481.09 to 566.69 ppm, 464.94 to 586.68 ppm and 444.64 to 614.74 ppm for 45 DAT, 70 DAT and 90 DAT respectively. Chand and Swami (2000) and Kaskar *et al.*, (2001) recorded similar values from their experiments. HNO₃ soluble Potassium found to be increasing in soil with fertilization over time whereas in treatment T₁, HNO₃ soluble potassium decreased with passing of time.

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How to cite this article:

Sai Parasar Das, Goutam Kumar Ghosh, Suchhanda Mondal, Pabitra Kumar Biswas and Manik Chandra Kundu. 2019. Plant Growth Parameters and Soil Potassium Pool as Influenced by Potassium Fertilization in Kharif Season Rice. *Int.J.Curr.Microbiol.App.Sci.* 8(03): 1547-1553. doi: <https://doi.org/10.20546/ijcmas.2019.803.178>