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Effect of Sources, Split and Foliar Application of KCl and $KClO_3$ on Availability and Uptake of Phosphorus in Aerobic Rice

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Authors' contributions

This work was carried out in collaboration among all authors. Author PAB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KOH and LA managed the analyses of the study. Author RM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To investigate the effect of KCl and $KClO_3$ as sources of potassium in aerobic rice with four types of split doses and two levels of foliar applications of potassium.
Study Design: The experiment was laid out in Randomized Block Design with three replications.
Place and Duration of Study: Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry.
Methodology : The rice variety PMK 4 was tested with two sources of potassium *viz.,* Potassium chloride (KCl) and Potassium chlorate ($KClO_3$), four types of split application *viz.,* K control (S_1), basal with no split (S_2), two splits (S_3) and three splits (S_4) along with foliar application treatments viz., no foliar (F_1) and foliar spray (F_2).
Results: The results of a field experiment revealed that the two splits of potassium increased the available P at the active tillering stage and harvest stage. Whereas, three splits increased the available P at panicle imitation and flowering stage. The KCl recorded higher available P at panicle

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initiation and harvest stages. The high phosphorus uptake was recorded in panicle initiation and flowering stages by three splits application of potassium. In grain also, especially the three splits through $KClO_3$ recorded higher P uptake.

Conclusion: The split applications tested in this investigation influenced the available phosphorus status in soil and phosphorus uptake. Increase in splits of potassium increased the P uptake. This result is in agreement with the results of Mitra et al. [1] who observed a significant increase in the uptake of N, P, K and S by increased level of K in *Kharif* rice.

Keywords: KCl; KClO3; available phosphorous; phosphorus uptake and aerobic rice.

1. INTRODUCTION

Rice gives life for major populations of the world and it is deeply embedded in the cultural heritage of societies. Rice is the staple food for about 50 % of the world`s populations that live in Asia. Rice is the second most important crop next to wheat in terms of area in the world and about 40% of the world's population consumes rice as a major source of calorie to human kind [2]. The increasing scarcity of water threatens the sustainability of the irrigated rice production system and hence, the security and livelihood of rice producers and consumers are in question. Several strategies for water saving were developed in recent years, to increase water productivity and reduce water losses in the rice system. The concept of aerobic rice was first developed in China during mid-1980. The term "Aerobic rice" was coined by International Rice Research Institute (IRRI). Aerobic rice cultivation will curb methane production and saves water without affecting the productivity. It is the time to save water from the irrigated system of rice cultivation by adapting the aerobic rice cultivation. This technology is a better remedy for future climate change under drought condition with lesser greenhouse gas emission.

2. MATERIALS AND METHODS

The three factor experiment was conducted in Randomized complete Block Design (RCBD) with three replications in the east farm of Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal during the year of 2015.The factor I includes two sources of potassium kcl (k_1) and kclo$_3$ (k_2), factor II includes split doses of potassium like S_1 - K control; S_2 - K as basal (15 DAS) without split; S_3 - K in two splits (Basal (15 days after sowing) & Panicle Initiation); S_4 - K in three splits (Basal, Panicle Initiation & Flowering stages) and factor III includes Foliar spray (2%) - F_1 - Without foliar spray ; F_2 - With foliar spray (2 times at Active tillering & Panicle Initiation). The blanket recommendation of 150:50:50 kg N, P_2O_5 and K_2O ha^{-1}, adopted for aerobic rice was followed in this investigation**.** Nitrogen and phosphorus were applied through urea and super phosphate respectively to meet the blanket recommendation. Potassium was applied through the sources of KCl and $KClO_3$ as per the treatment structure. The available phosphorous was determined by Using 0.5 M $NaHCO_3$ of pH 8.5 method given Olsen et al. [3] and nutrient uptake was calculated by the following formula

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \text{Nutrient content (\%)} \times \text{DMP or } \frac{\text{Grain or straw or root biomass (kg ha}^{-1}\text{)}}{100}$$

3. RESULTS

3.1 Available Phosphorus at Different Stages of Crop Growth

3.1.1 At active tillering stage

The soil available phosphorus was significantly influenced only by the split application of potassium (Table 1). The higher available P was recorded in two splits (60.5 kg ha^{-1}), which was on par with three splits (54.5 kg ha^{-1}) of potassium application. The lower available P (39.7 kg ha^{-1}) was noticed in K control treatment and it was on par with the basal (38.3 kg ha^{-1}) without a split dose of potassium.

3.1.2 At panicle initiation stage

The two sources of potassium significantly influenced the available phosphorus at panicle initiation stage (Table 2). The potassium chloride could express the significance over potassium chlorate by manifesting high level of available phosphorus (56.5 kg ha^{-1}) in soil.

In the case of split application, the available P was recorded more in three splits (56.9 kg ha^{-1}), which was on par with two splits (50.0 kg ha^{-1}) of potassium. The lower available P (42.1 kg ha^{-1}) was recorded in control treatment which was on par with the basal application of potassium.

While seeing the interaction effect of source and split application of potassium, the maximum available P was recorded by potassium chloride with three splits of potassium (67.2 kg ha^{-1}), which was closely followed by two splits (65.8 kg ha^{-1}) of the same source. These two treatment combinations very conspicuously showed their performance over other treatment combinations in keeping the available phosphorus in the soil at this stage.

3.1.3 At flowering stage

The available phosphorus of flowering stage was greatly influenced only by the split application of potassium (Table 3). The higher available P was recorded (38.8 kg ha^{-1}) in three split application of potassium, which was on par with the two split application (37.1 kg ha^{-1}) of potassium. The lower available P was recorded in the basal application of potassium (28.4 kg ha^{-1}), but it was on par with the performance of the control treatment (30.7 kg ha^{-1}). The interaction effects didn't show any significant variations on the availability of phosphorus in soil.

3.1.4 At post-harvest stage

Here again, as revealed in the panicle initiation stage, the main effect of sources and splits and their interactions established their significance in the available phosphorus at post-harvest stage (Table 4). The higher available phosphorus was recorded by the potassium chloride (30.7 kg ha^{-1}) and lower available P (24.8 kg ha^{-1}) was recorded by potassium chlorate, which were independently, expressed their influence in the available P status of the soil after the harvest of the crop. In the case of split application, the two splits registered higher available P (32.7 kg ha^{-1}) which was on par with the three split application (30.9 kg ha^{-1}) of potassium. The remaining treatment viz., K control and basal were inferior to the above split treatments, but showed their individual effect on available P in post-harvest soil.

While seeing the interaction effect of source and split application of potassium, the potassium chloride with two splits showed its superiority in maintaining the available P status (37.7 kg ha^{-1}), but very closely followed by three splits (36.8 kg ha^{-1}) and they established their greatness over other treatment combinations. Among the other interactions, both the sources performed equally in the basal and K control treatment of potassium.

3.2 Phosphorus Uptake at Different Stages of Crop Growth

3.2.1 At active tillering stage

The uptake of phosphorus at active tillering stage (Table 5) was not significantly influenced by sources, split and foliar application of potassium. Even though there were no significance variances, the two splits of potassium showed numerically its superiority over the other split applications of potassium.

3.2.2 At panicle initiation stage

At this stage, the P uptake was significantly influenced only by the split applications of potassium (Table 6). The higher P uptake (8.05 kg ha^{-1}) was recorded by three split application of potassium, followed by two splits (6.85 kg ha^{-1}), basal (5.81 kg ha^{-1}) and control treatment (4.76 kg ha^{-1}) respectively. Even though three splits recorded higher P uptake, it was equivalent with two split application. Likewise, two split was equivalent to the basal (no split) and the basal was with no application of potassium in their performances sequentially. However, three splits established its greater performance than basal and K control.

3.2.3 At flowering stage

Here again the split application of potassium alone significantly influenced the phosphorus uptake of flowering stage (Table 7). All the split applications of potassium showed equal performances one with the other in sequences in the uptake of phosphorus at this stage. However, the higher uptake (9.38 kg ha^{-1}) and lower (5.97 kg ha^{-1}) uptake of phosphorus were recorded in the three splits and control treatment of potassium respectively and the differences between these two treatments were very conspicuous.

3.3 Phosphorus Uptake by Grain

Phosphorus uptake by grain (Table 8) was significantly influenced by split application and the interaction effect of potassium sources with foliar application of potassium. In the case of split applications, the higher phosphorus uptake by grain (14.0 kg ha^{-1}) was recorded in three split application than the other split applications. It was followed by two splits, basal and no application of potassium and these three treatments were equal in their performances in mobilizing phosphorus to grain. The lower uptake of phosphorus (9.55 kg ha^{-1}) by grain was noticed in K control.

In the case of interaction effect between sources and foliar application, more uptake of phosphorus by grain (14.1 kg ha^{-1}) was mainly due to the potassium chloride without foliar application, but it was on par with the performance of potassium chlorate with foliar application (12.3 kg ha^{-1}). At the same time, potassium chloride with foliar application (10.5 kg ha^{-1}) and potassium chlorate with no foliar application (8.2 kg ha^{-1}) performed equally in the uptake of potassium by grain.

3.4 Phosphorus Uptake by Straw

No marked variation could be observed in the uptake of phosphorus by straw (Table 9) due to the main factors viz., sources, split and foliar application of potassium and also due to their interactions. However, numerically the highest uptake (7.65 kg ha^{-1}) was noticed by the three split dose of potassium chlorate with foliar spray.

3.5 Phosphorus Uptake by Root

The phosphorus uptake by root (Table 10) was also not significantly influenced by the sources, split and foliar application of potassium and by their interactions.

Table 1. Available phosphorus (kg ha^{-1}) at active tillering stage (Mean of three replications)

	Control (S_1)	**No split (S_2)**	**Two splits (S_3)**	**Three splits (S_4)**	**KCl (K_1)**	**$KClO_3$ (K_2)**	**Mean**
K_1F_1 - KCl + No foliar spray	30.7	26.9	45.6	49.1	-	-	-
K_1F_2 - KCl + foliar spray	42.0	35.0	66.1	60.8	-	-	-
K_2F_1 - $KClO_3$ + No foliar spray	45.4	43.6	64.9	53.8	-	-	-
K_2F_2 - $KClO_3$ + foliar spray	40.6	47.7	65.6	54.2	-	-	-
K_1 – KCl	36.3	31.0	55.8	55.0	-	-	-
K_2 - $KClO_3$	43.0	45.6	65.3	54.5	-	-	-
F_1 - No foliar spray	38.1	35.2	55.3	51.5	38.1	51.9	45.0
F_2 - Foliar spray	41.3	41.3	65.8	57.5	50.9	52.0	51.5
Mean	39.7	38.3	60.5	54.5	44.5	52.0	-

Sources	**S.Ed.**	**C.D. (p = 0.05)**
K sources (K)	4.098	*NS*
Split application	5.796	9.8
Foliar application	4.098	*NS*
K x S	8.196	*NS*
K x F	5.796	*NS*
S x F	8.196	*NS*
K x S x F	11.591	*NS*

Table 2. Available phosphorus (kg ha-1) at panicle initiation stage (Mean of three replications)

	Control (S_1)	No split (S_2)	Two splits (S_3)	Three splits (S_4)	KCl (K_1)	$KClO_3$ (K_2)	Mean
K_1F_1 - KCl + No foliar spray	40.9	48.8	70.3	65.8	-	-	-
K_1F_2 - KCl + foliar spray	45.7	5.8	61.3	68.7	-	-	-
K_2F_1 - $KClO_3$ + No foliar spray	39.6	37.2	34.3	46.2	-	-	-
K_2F_2 - $KClO_3$ + foliar spray	42.1	34.5	34.0	47.1	-	-	-
K_1 – KCl	43.3	49.8	65.8	67.2	-	-	-
K_2 - $KClO_3$	40.9	35.8	34.1	46.7	-	-	-
F_1 - No foliar spray	40.2	43.0	52.3	56.0	56.4	39.3	47.9
F_2 - Foliar spray	43.9	42.6	47.7	57.9	56.6	39.4	48.0
Mean	42.1	42.8	50.0	56.9	56.5	39.4	-

Sources	**S.Ed.**	**C.D. (p = 0.05)**
K sources (K)	2.956	5.0
Split application	4.180	7.1
Foliar application	2.956	*NS*
K x S	5.911	10.0
K x F	4.180	*NS*
S x F	5.911	*NS*
K x S x F	8.360	*NS*

Table 3. Available phosphorus (kg ha-1) at flowering stage) (Mean of three replications)

	Contro l (S_1)	No split (S_2)	Two splits (S_3)	Three splits (S_4)	KCl (K_1)	$KClO_3$ (K_2)	Mean
K_1F_1 - KCl + No foliar spray	35.0	35.9	28.8	40.2	-	-	-
K_1F_2 - KCl + foliar spray	38.2	28.1	42.3	37.2	-	-	-
K_2F_1 - $KClO_3$ + No foliar spray	27.1	23.3	35.8	34.1	-	-	-
K_2F_2 - $KClO_3$ + foliar spray	22.5	26.3	41.7	43.6	-	-	-
K_1 – KCl	36.6	32.0	35.5	38.7	-	-	-
K_2 - $KClO_3$	24.8	24.8	38.7	38.8	-	-	-
F_1 - No foliar spray	31.1	29.6	32.3	37.1	35.0	30.1	32.5
F_2 - Foliar spray	30.4	27.2	42.0	40.4	36.5	33.5	35.0
Mean	30.7	28.4	37.1	38.8	35.7	31.8	-

Sources	**S.Ed.**	**C.D. (p = 0.05)**
K sources (K)	2.244	*NS*
Split application	3.173	5.4
Foliar application	2.244	*NS*
K x S	4.488	*NS*
K x F	3.173	*NS*
S x F	4.488	*NS*
K x S x F	6.347	*NS*

Table 4. Available phosphorus (kg ha-1) at harvest stage (Mean of three replications)

	Control (S_1)	No split (S_2)	Two splits (S_3)	Three splits (S_4)	KCl (K_1)	$KClO_3$ (K_2)	Mean
K_1F_1 - KCl + No foliar spray	22.6	25.2	37.7	39.0	-	-	-
K_1F_2 - KCl + foliar spray	21.0	27.7	37.7	34.5	-	-	-
K_2F_1 - $KClO_3$ + No foliar spray	19.5	23.8	27.8	28.0	-	-	-
K_2F_2 - $KClO_3$ + foliar spray	23.9	25.8	27.5	22.0	-	-	-
K_1 - KCl	21.8	26.4	37.7	36.8	-	-	-
K_2 - $KClO_3$	21.7	24.8	27.6	25.0	-	-	-
F_1 - No foliar spray	21.0	24.5	32.7	33.5	31.1	24.8	27.9
F_2 - Foliar spray	22.4	26.8	32.6	28.2	30.2	24.8	27.5
Mean	21.7	25.6	32.7	30.9	30.7	24.8	-

Sources	**S.Ed.**	**C.D. (p = 0.05)**
K sources (K)	1.475	2.5
Split application	2.086	3.5
Foliar application	1.475	*NS*
K x S	2.950	5.0
K x F	2.086	*NS*
S x F	2.950	*NS*
K x S x F	4.172	*NS*

Table 5. Phosphorus uptake (kg ha-1) at active tillering stage (Mean of three replications)

	Control (S_1)	No split (S_2)	Two splits (S_3)	Three splits (S_4)	KCl (K_1)	$KClO_3$ (K_2)	Mean
K_1F_1 - KCl + No foliar spray	5.01	5.15	5.52	4.91	-	-	-
K_1F_2 - KCl + foliar spray	3.48	2.70	5.48	3.83	-	-	-
K_2F_1 - $KClO_3$ + No foliar spray	3.58	2.26	7.97	3.43	-	-	-
K_2F_2 - $KClO_3$ + foliar spray	4.58	3.81	4.27	3.32	-	-	-
K_1 - KCl	4.24	3.92	5.50	4.37	-	-	-
K_2 - $KClO_3$	4.08	3.03	4.62	3.37	-	-	-
F_1 - No foliar spray	4.29	3.70	5.24	4.17	5.15	3.56	4.35
F_2 - Foliar spray	4.03	3.25	4.88	3.58	3.87	4.00	3.93
Mean	4.16	3.48	5.06	3.87	4.51	3.78	-

Sources	**S.Ed.**	**CD (p = 0.05)**
K sources (K)	0.608	*NS*
Split application	0.860	*NS*
Foliar application	0.608	*NS*
K x S	1.216	*NS*
K x F	0.860	*NS*
S x F	1.216	*NS*
K x S x F	1.719	*NS*

Table 6. Phosphorus uptake (kg ha-1) at panicle initiation stage (Mean of three replications)

	Control (S_1)	No split (S_2)	Two splits (S_3)	Three splits (S_4)	KCl (K_1)	$KClO_3$ (K_2)	Mean
K_1F_1 - KCl + No foliar spray	5.04	3.68	4.47	8.01	-	-	-
K_1F_2 - KCl + foliar spray	5.37	6.12	8.72	7.16	-	-	-
K_2F_1 - $KClO_3$ + No foliar spray	3.84	6.39	7.07	10.7	-	-	-
K_2F_2 - $KClO_3$ + foliar spray	4.80	7.05	7.16	6.35	-	-	-
K_1 - KCl	5.21	4.90	6.59	7.58	-	-	-
K_2 - $KClO_3$	4.32	6.72	7.11	8.52	-	-	-
F_1 - No foliar spray	4.44	5.03	5.77	9.35	5.30	7.00	6.15
F_2 - Foliar spray	5.09	6.59	7.94	6.75	6.34	6.34	6.59
Mean	4.76	5.81	6.85	8.05	6.07	6.67	-

Sources	S.Ed.	C.D. (p = 0.05)
K sources (K)	0.796	*NS*
Split application	1.125	1.91
Foliar application	0.796	*NS*
K x S	1.591	*NS*
K x F	1.125	*NS*
S x F	1.591	*NS*
K x S x F	2.251	*NS*

Table 7. Phosphorus uptake (kg ha^{-1}) at flowering stage (Mean of three replications)

	Control (S_1)	No split (S_2)	Two splits (S_3)	Three splits (S_4)	KCl (K_1)	$KClO_3$ (K_2)	Mean
K_1F_1 - KCl + No foliar spray	3.53	8.16	7.83	9.29	-	-	-
K_1F_2 - KCl + foliar spray	4.89	6.39	7.15	9.79	-	-	-
K_2F_1 - $KClO_3$ + No foliar spray	8.77	6.08	7.52	11.4	-	-	-
K_2F_2 - $KClO_3$ + foliar spray	6.69	5.73	8.50	7.00	-	-	-
K_1 - KCl	4.21	7.28	7.49	9.54	-	-	-
K_2 - $KClO_3$	7.73	5.90	8.01	9.21	-	-	-
F_1 - No foliar spray	6.15	7.12	7.67	10.3	7.20	8.45	7.82
F_2 - Foliar spray	5.79	6.06	7.83	8.40	7.06	6.98	7.02
Mean	5.97	6.59	7.75	9.38	7.13	7.71	-

Sources	S.Ed.	C.D. (p = 0.05)
K sources (K)	0.732	*NS*
Split application	1.035	1.76
Foliar application	0.732	*NS*
K x S	1.463	*NS*
K x F	1.035	*NS*
S x F	1.463	*NS*
K x S x F	2.070	*NS*

Table 8. Phosphorus uptake (kg ha^{-1}) by grain (Mean of three replications)

	Control (S_1)	No split (S_2)	Two splits (S_3)	Three splits (S_4)	KCl (K_1)	$KClO_3$ (K_2)	Mean
K_1F_1 - KCl + No foliar spray	15.7	13.0	12.7	12.7	-	-	-
K_1F_2 - KCl + foliar spray	6.61	10.8	13.1	11.7	-	-	-
K_2F_1 - $KClO_3$ + No foliar spray	5.16	5.76	8.42	13.6	-	-	-
K_2F_2 - $KClO_3$ + foliar spray	10.7	12.9	10.1	15.6	-	-	-
K_1 - KCl	11.7	11.9	12.9	13.3	-	-	-
K_2 - $KClO_3$	7.94	9.35	9.30	14.6	-	-	-
F_1 - No foliar spray	10.4	9.39	10.5	14.3	14.1	8.24	11.1
F_2 - Foliar spray	8.66	11.8	11.6	13.6	10.5	12.3	11.4
Mean	9.55	10.6	11.1	14.0	12.3	10.3	-

Sources	S.Ed.	C.D. (p = 0.05)
K sources (K)	1.025	*NS*
Split application	1.450	2.46
Foliar application	1.025	*NS*
K x S	2.050	*NS*
K x F	1.450	2.46
S x F	2.050	*NS*
K x S x F	2.899	*NS*

Table 9. Phosphorus uptake (kg ha^{-1}) by straw (Mean of three replications)

	Control (S_1)	No split (S_2)	Two splits (S_3)	Three splits (S_4)	KCl (K_1)	$KClO_3$ (K_2)	Mean
K_1F_1 - KCl + No foliar spray	5.53	4.96	5.20	4.61	-	-	-
K_1F_2 - KCl + foliar spray	5.95	4.93	7.45	5.04	-	-	-
K_2F_1 - $KClO_3$ + No foliar spray	4.25	4.83	3.48	6.71	-	-	-
K_2F_2 - $KClO_3$ + foliar spray	7.45	5.05	6.01	7.65	-	-	-
K_1 - KCl	5.74	4.95	6.33	4.83	-	-	-
K_2 - $KClO_3$	5.85	4.94	4.75	7.18	-	-	-
F_1 - No foliar spray	4.89	4.89	4.34	5.66	5.08	4.82	4.95
F_2 - Foliar spray	6.70	4.99	6.73	6.35	5.84	6.54	6.19
Mean	5.80	4.94	5.54	6.00	5.46	5.68	-

Sources	S.Ed.	C.D. (p = 0.05)
K sources (K)	0.829	*NS*
Split application	1.172	*NS*
Foliar application	0.829	*NS*
K x S	1.657	*NS*
K x F	1.172	*NS*
S x F	1.657	*NS*
K x S x F	2.344	*NS*

Table 10. Phosphorus uptake (kg ha^{-1}) by root (Mean of three replications)

	Control (S_1)	No split (S_2)	Two splits (S_3)	Three splits (S_4)	KCl (K_1)	$KClO_3$ (K_2)	Mean
K_1F_1 - KCl + No foliar spray	4.40	1.28	4.22	2.30	-	-	-
K_1F_2 - KCl + foliar spray	2.68	3.68	4.22	1.86	-	-	-
K_2F_1 - $KClO_3$ + No foliar spray	1.36	1.86	6.80	4.04	-	-	-
K_2F_2 - $KClO_3$ + foliar spray	2.64	2.48	1.40	2.96	-	-	-
K_1 - KCl	3.54	2.48	4.22	2.08	-	-	-
K_2 - $KClO_3$	2.00	2.17	4.10	3.50	-	-	-
F_1 - No foliar spray	2.88	1.57	5.51	3.17	3.05	3.52	3.28
F_2 - Foliar spray	2.66	3.08	2.81	2.41	3.11	2.37	2.74
Mean	2.77	2.33	4.16	2.79	3.08	2.94	-

Sources	S.Ed.	C.D. (p = 0.05)
K sources (K)	0.970	*NS*
Split application	1.372	*NS*
Foliar application	0.970	*NS*
K x S	1.941	*NS*
K x F	1.372	*NS*
S x F	1.941	*NS*
K x S x F	2.745	*NS*

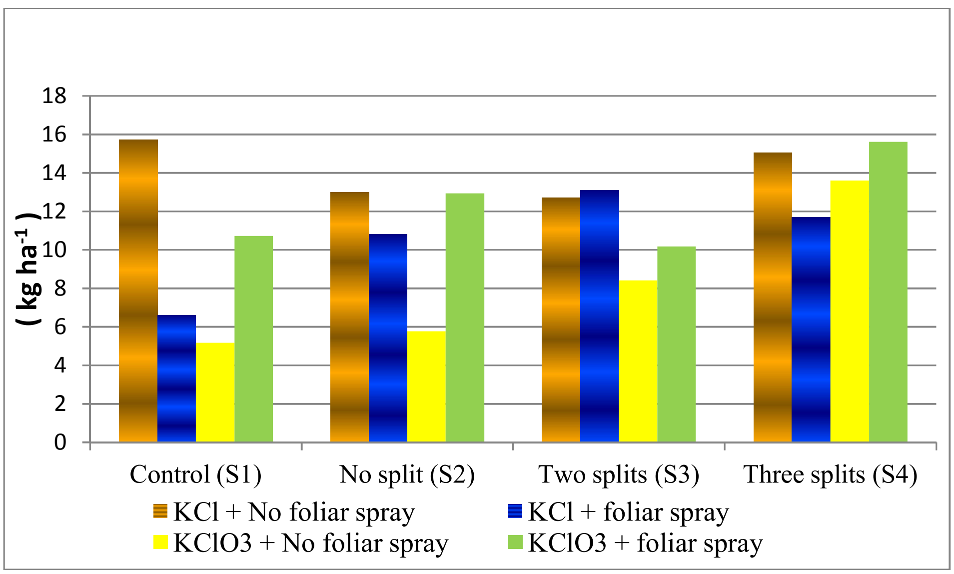

Fig.1. Phosphorus uptake by grain

4. DISCUSSION

4.1 Available Phosphorus at Different Stage of Crop Growth

The influence of source of available phosphorus was observed in panicle initiation and harvest stage. In both the stages, the potassium chloride showed its significant influence to increase the available P status in soil. With regard to split application, in almost all the stages of crop growth, phosphorus availability was increased by split doses of potassium. Among the interaction of sources and split applications, the KCl with two and three splits showed its maximum availability of P in panicle initiation and harvest stages. In this aspect, positive correlation between P and K were reported by Ranjha et al. [4] and Akhtar et al. [5]. Whereas on the contrary, the insignificant and antagonistic effect of K on P were observed by Chapagain and wiesman [6] and walforth et al. [7] respectively.

4.2 Phosphorus Uptake at Different Stage of Crop Growth

Except active tillering stage, the later stages viz., panicle initiation and flowering stages expressed the same results trend in the uptake of P by the plants. Increase in splits of potassium increased the P uptake. This result is in agreement with the results of Mitra et al. [1], Fageria et al. [8] and Singh et al. [9] who observed a significant increase in the uptake of N, P, K and S by increased level of K in *Kharif* rice.

4.3 Phosphorus Uptake by Grain

There was significant variation in P uptake by grain under different split applications of potassium (Fig.1). This means that the split doses of K increases the mobility of P to grain. Increased nutrient uptake, especially N and P resulted in increased photosynthetic rate and increased plant growth. The increased photosynthetic rate improved the translocation of nutrients to sink for more grain yield and uptake. This kind of result finds support from the result of Brohi et al. [10], Ranjha et al. [11], Elliott et al.(2015), Hussian et al. (2015) and Zinugo et al.*(*2019).

4.4 Phosphorus Uptake by Straw

The phosphorus uptake by straw was not influenced by the effect of sources, split and foliar and their interactions of potassium. The non-significant effect of potassium on P uptake was reported by Chapagain and wiesman [6] in tomato plants

4.5 Phosphorus Uptake by Root

Phosphorus uptake by root also followed the similar trend as in the case of straw. The insignificant relationship between phosphorus and potassium was also found by Walforth et al. [7] and by Chapagain and wiesman [6].

5. CONCLUSION

The available P status in soil was influenced by split application in all the stages of crop growth. The two splits of potassium increased the available P at the active tillering stage and harvest stage. Whereas, three splits increased the available P at panicle imitation and flowering stage. The KCl recorded higher available P at panicle initiation and harvest stages.

The phosphorus uptake was not influenced by any factor at tillering stage. Whereas in panicle initiation and flowering stages, the three splits recorded the higher P uptake. In grain also, especially the three splits through $KClO_3$ recorded higher P uptake. The P uptake by straw and root did not show any significant influence by the factors studied.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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