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Optimization of phosphorus and potassium levels for productivity enhancement of fine rice in irrigated sub tropics of Jammu

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Abstract
Field experiment was conducted at Research Farm, Division of Agronomy during *kharif* season 2016 to find out the optimum dose of phosphorus and potassium for the productivity enhancement of fine rice in irrigated sub-tropics of Jammu. The experiment was laid out in factorial randomized block design with three replications. 30 day old seedlings of cultivar *SJR-129* were planted at a spacing of 20 cm X 10 cm. The treatments consisted of four phosphorus levels (control, 20, 40 and 60 kg P_2O_5 ha^{-1}), and four potassium levels (control, 10, 20 and 30 kg K_2O ha^{-1}). Rice crop was fertilized with 60 kg N ha^{-1}. The experimental results revealed that among the levels of phosphorous, 60kg P_2O_5 ha^{-1} recorded significantly highest plant height, number of tillers m^{-2}, dry matter accumulation, yield attributes and grain yield (4.31 t ha^{-1}) which was statistically at par with 40 and 20kg P_2O_5 ha^{-1}. Amongst the potassium levels, application of 30 kg K_2O ha^{-1} though being at par with 20 and 10 kg K_2O ha^{-1} recorded significantly highest plant height, number of tillers m^{-2}, dry matter accumulation, yield attributes and grain yield (4.33 t ha^{-1}). Economically optimum level can be realized with 28 kg P_2O_5 ha^{-1} and 18 kg K_2O ha^{-1} for yield optimization of fine rice.

Keywords: Levels of phosphorus and potassium, *Kharif*, yield, optimum dose

Introduction
Fine rice (*Oryza sativa* L.) enjoys a special place both in domestic as well as international market (Gupta and Kumar, 2008) [1]. The area under fine rice varieties is increasing day by day with opening of world market as well as domestic consumption (Singh *et al*. 2008)[9]. The productivity and quality of fine rice depends on the environmental conditions and the agronomic practices especially the proper and balanced application of fertilizers which plays significant role in achieving higher productivity. In rice cultivation, much attention is giving only to nitrogen fertilization and very often phosphorus and potassium are carried out at minimal level. As about 40 percent of yield increase is accounted against fertilizer use, the fertilizer recommendations should be matched to the basic soil fertility, season, target yield, climate etc. With the advent of modern production technology, the usage of higher doses of fertilizers in balanced manner is inevitable to exploit their full potential particularly under irrigated conditions. Modern high yielding varieties producing around 5 t ha^{-1} of grain can remove about 110 kg N, 15 kg P, 129 kg K, 5 kg S, 2 kg Fe, 2 kg Mn, 200 g Zn and 150 g B per hectare from the soil. Emergence of widespread multi-nutrient deficiencies, depletion of native nutrient reserves, imbalanced fertilization are of utmost concern, causing serious stagnation in yields and declining productivity of various rice ecosystems (Mangala Rai,2006) [4]. Excess use of fertilizer nutrients implies increase of cost and decrease of returns and risk of environmental pollution. On the other hand, under use of nutrients depress the scope for increasing the present level of nutrients to the economically optimum level to exploit production potential to a larger extent (Singh *et al.* 2001) [8]. Application of inadequate and unbalanced fertilization to crops not only results in low crop yields but also deteriorate the soil health (Sharma *et al.* 2003) [7]. Hence keeping in view of the above facts, the study entitled "Optimization of phosphorus and potassium levels for productivity enhancement of fine rice in irrigated sub tropics of Jammu" was initiated with the objective to determine the optimum dose of phosphorus and potassium in rice under irrigated conditions of Jammu.

Material and Methods
The experiment was conducted at the Research farm, Division of Agronomy, SKUAST-J during *Kharif* season of 2016. The experimental soil was sandy clay loam in texture, low in available nitrogen, medium in available phosphorus and potassium. The experiment was laid

out in factorial randomized block design with three replications. The experiment consisted of four levels of phosphorus as one factor *viz*. 0 kg P_2O_5 ha^{-1}, 20 kg P_2O_5 ha^{-1}, 40 kg P_2O_5 ha^{-1}, 60 kg $P_2O_5$$ha^{-1}$ and four levels of potassium as another factor *viz.* 0 kg K_2O ha^{-1}, 10 kg $K_2O$$ha^{-1}$, 20 kg K_2O ha^{-1} and 30 kg K_20 ha^{-1}. 30 day old seedlings of cultivar *SJR-129* were planted at a spacing of 20 cm X 10 cm with 2-3 seedlings per hill. Rice crop was fertilized with 60 kg N ha^{-1}. Fertilizers were applied as per the treatment through Urea, single super phosphate (SSP), muriate of potash (MOP). Entire dose of phosphorus & potassium and 1/3rd recommended nitrogen was applied as basal, remaining nitrogen was applied in two equal splits- at active tillering and panicle initiation stage. Weed control measure were taken up with the application of post emergence herbicide bispyribac @ 30 g per hectare. Water level in the crop was maintained at a depth of 2 cm up to panicle initiation and 5 cm thereafter up to one week before harvest. The field was drained before application of fertilizers and one week before harvest. Data on growth, yield attributes and yield were collected following standard procedures from five randomly marked hills. The surface soil samples up to 0-15 cm depth before sowing were collected and analyzed for soil organic carbon, available nitrogen, phosphorus and potassium by following standard procedures. The optimum phosphorus and potassium dose for the fine rice was determined by regression the grain yield with the phosphorus and potassium rates:

$$Y = a + bP + cP^2 \quad (1)$$

Where, *Y* is rice yield (kg/ha), *P* is phosphorus dose (kg/ha), a is intercept (estimated yield without phosphorus application), *b* and *c* are coefficients, respectively (Saleque *et al.*, 2004) [6].

$$Y = a + bK + cK^2 \quad (2)$$

Where, *Y* is rice yield (kg/ha), *K* is potassium dose (kg/ha), a is intercept (estimated yield without potassium application), *b* and *c* are coefficients, respectively (Saleque *et al.*, 2004) [6]. Differentiating *Y* with respect to phosphorus and potassium of the Equation (1) and (2) gives the optimum dose for the maximum yield.

Results and Discussion

Effect of different levels of phosphorus and potassium on growth of fine rice

Growth of rice in terms of plant height, number of tillers m^{-2}, dry matter accumulation (Table 1) revealed that the growth characteristics of fine rice showed pronounced improvement at 60 and at harvest with graded levels of phosphorus and potassium. Among the phosphorus levels, significantly highest plant height, number of tillers m^{-2}, dry matter accumulation were recorded with 60 kg P_2O_5 ha^{-1} which was statistically at par with 40 and 20 kg P_2O_5 ha^{-1} respectively. This might have happened due to better development of root system and nutrient absorption by the crop plants. These results were in conformity with the findings of Masood *et al.* (2011) [5]. Whereas, significantly highest plant height, number of tillers/m^2, dry matter accumulation were recorded with 30 kg K_2O ha^{-1} which was statistically at par with 20 and 10 kg K_2O ha^{-1} respectively. This might have happened probably due to the fact that highest level of potassium triggers the activation of enzyme which enhanced the photosynthetic efficiency leading to more number of leaves and higher dry matter production. A similar view of better performance was reported by Zayed *et al.* (2007) [11].

Table 1: Effect of different levels of phosphorus and potassium on growth parameters of rice

Treatments	Plant height (cm)		No. of tillers m^{-2}		Dry matter accumulation (g m^{-2})	
	60 DAT	At harvest	60DAT	At harvest	60DAT	At harvest
Phosphorus levels (kg ha^{-1})						
P_0	88.42	95.43	244.36	244.83	283.75	807.50
P_{20}	94.33	101.83	254.41	252.16	315.59	962.08
P_{40}	96.42	104.77	256.50	252.86	321.58	973.00
P_{60}	96.58	104.91	258.07	254.62	329.73	987.43
SEd	2.91	3.13	4.61	3.41	8.51	14.50
CD (5%)	5.83	6.27	9.20	6.82	17.02	29.01
Potassium levels (kg ha^{-1})						
K_0	88.50	94.41	245.11	245.30	296.03	833.83
K_{10}	94.67	102.03	254.72	250.91	312.50	954.74
K_{20}	95.67	104.95	256.20	253.39	318.43	966.53
K_{30}	96.92	105.54	257.32	254.87	323.69	974.92
SEd	2.91	3.13	4.61	3.41	8.51	14.50
CD (5%)	5.83	6.27	9.20	6.82	17.02	29.01

Effect of different levels of phosphorus and potassium on yield attributes and yield of fine rice

Yield attributes of rice *viz.* number of panicles m^{-2}, number of grains $panicle^{-1}$, number of filled grains $panicle^{-1}$ were significantly higher with the increased levels of phosphorous and potassium except for 1000-grain weight as compared to control (Table 2). Among levels of phosphorus significantly highest number of panicles m^{-2} (239.51), number of grains $panicle^{-1}$ (96.49), number of filled grains $panicle^{-1}$ (85.93) were recorded with application of 60 kg P_2O_5 ha^{-1} which led to significant enhancement in grain yield of rice. Increased grain yield associated with highest level of phosphorous (60 kg P_2O_5 ha^{-1}) might be due to the cumulative effect of increased translocation of photosynthates which further had a supplemental effect on the yield attributing characteristics leading to higher crop yield. These results were in conformity with the findings of Ya-jie *et al.* (2012) [10] and Kumar and Malarvizhi (2014) [2]. Among potassium levels, application of 30 kg K_2O ha^{-1} recorded significantly higher panicles m^{-2}, number of grains $panicle^{-1}$ and number of filled grain $panicle^{-1}$ which was statistically at par with 20 and 10 kg K_2O ha^{-1}. These treatments registered 26.97, 24.92 and 21.70 per cent higher grain yield of rice as compared to control. This could be because of potassium helps in improving growth, promoting photosynthetic rate and increase in assimilates translocation to grains contributed to improvement in yield attributes and yield. Similar findings were reported by Mahajan *et al.* (2012) [3].

Table 2: Effect of different levels of phosphorus and potassium on growth parameters of rice

Treatments	No. of panicles m^{-2}	No. of grains $panicle^{-1}$	No. of filled grains $panicle^{-1}$	1000-grain weight (g)	Grain yield (t ha^{-1})
Phosphorus levels (kg ha^{-1})					
P_0	226.67	89.39	74.43	23.43	3.41
P_{20}	236.14	94.98	83.59	23.77	4.17
P_{40}	238.55	95.70	85.67	24.15	4.26
P_{60}	239.51	96.49	85.93	24.18	4.31
SEd	3.43	1.38	1.43	0.42	0.14
CD (5%)	9.92	3.97	4.12	NS	0.41
Potassium levels (kg ha^{-1})					
K_0	225.40	89.95	73.64	23.18	3.41
K_{10}	236.12	94.28	84.04	23.93	4.15
K_{20}	239.10	95.89	85.54	24.19	4.26
K_{30}	240.24	96.44	86.39	24.22	4.33
SEm (+)	3.43	1.38	1.43	0.42	0.14
CD (5%)	9.92	3.97	4.12	NS	0.41

Optimization of phosphorus and potassium in rice

Grain and straw yield of rice increased with graded levels of phosphorous and potassium and showed significant quadratic response in rice over control. The model variables that made significant contributuion to the regression and the respective coefficients presented in Table 3 and 4.

Quadratic equation of phosphorus for grain yield

$Y=3.44+0.042p-0.0005p^2$ (1)

Quadratic equation of potassium for grain yield

$Y=3.422+0.0839k-0.018k^2$ (2)

Table 3: Grain yield phosphorous response function parameters and coefficients

Parameter	Coefficient	R^2
a	3.44	0.9992
b	0.042	
c	-0.0005	

Table 4: Grain yield potassium response function parameters and coefficients

Parameter	Coefficient	R^2
a	3.42	0.999
b	0.0839	
c	-0.0018	

By differentiating the equation 1 and 2 optimum phosphorus and potassium dose was worked out. The optimum phosphorus and potassium dose for rice appeared as 28 kg P_2O_5 and 18 kg K_2O ha^{-1}. Grain yield response to phosphorus and potassium perfectly fitted with a quadratic equation with 99.92 and 99.90 per cent of the variance in the grain yield of rice was presented in Figure 1 and 2. This clearly indicated that nutrient cost applied through inorganic sources can be reduced and profit can be increased by decreasing the nutrient dose from maximum yield to economically optimum level.

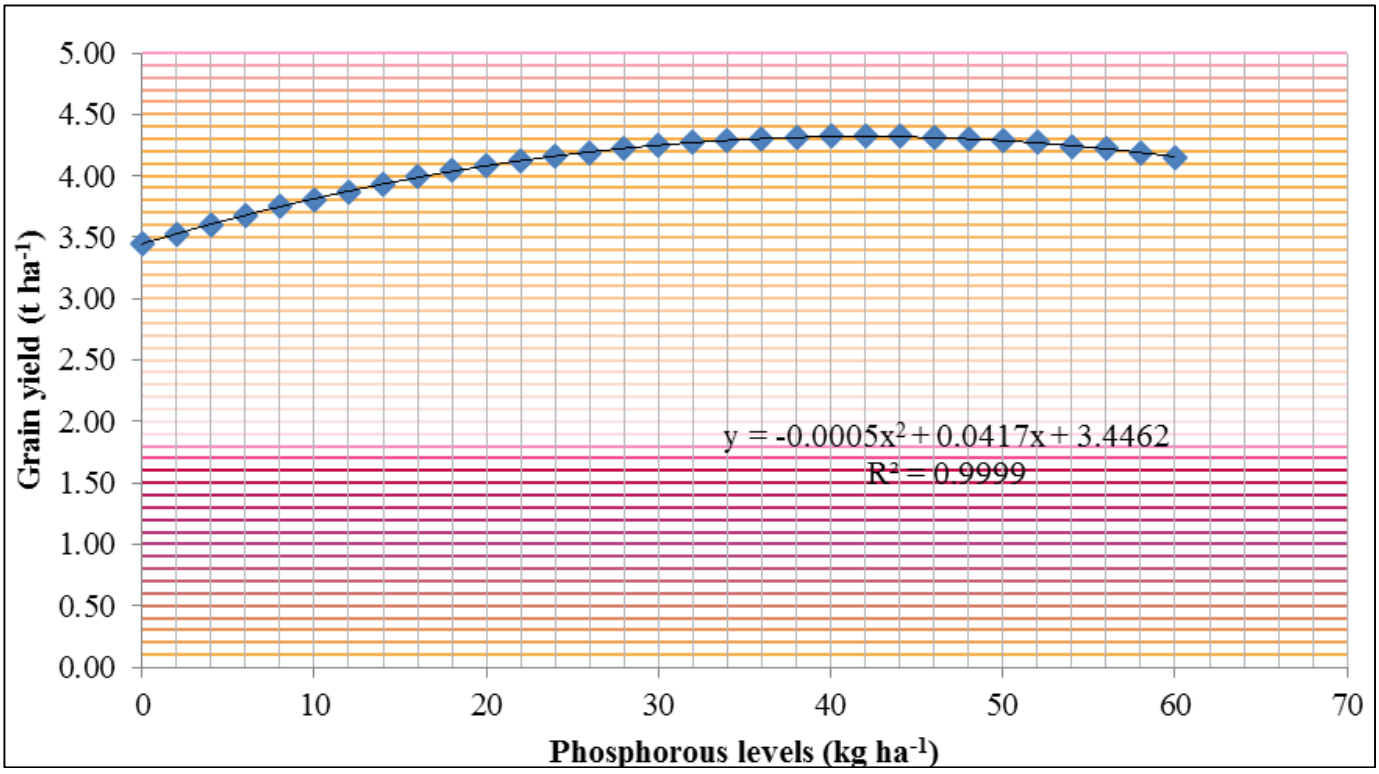

Fig 1: Effect of phosphorous levels on rice grain yield (t ha^{-1})

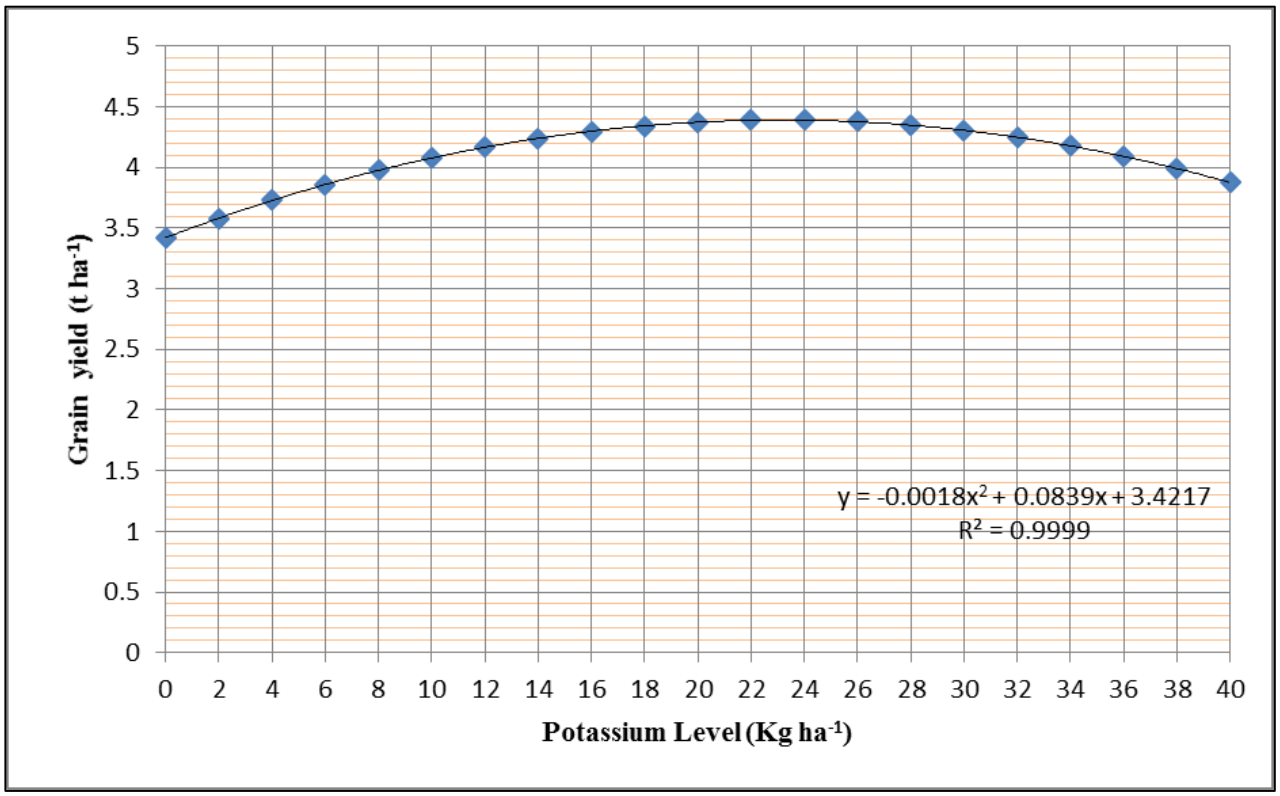

Fig 2: Effect of potassium levels on rice grain yield (t ha^{-1})

Conclusion

Thus from the present study, it can be concluded that application of 60 kg P_2O_5 ha^{-1} and 30 kg K_2O ha^{-1} were found the suitable dose of phosphorus and potassium for yield maximization. Economically optimum level can be realized with 28 kg P_2O_5 ha^{-1} and 18 kg K_2O ha^{-1} for yield optimization of rice in irrigated sub tropics of Jammu region.

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