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Influence of Phosphorus and Potassium on Growth and Yield of Black Aromatic Rice (Chak-hao)

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A B S T R A C T

An experiment was conducted at experimental research farm of College of Agriculture, Central Agricultural University, Imphal, Iroisemba to investigate the influence of phosphorus and potassium on yield attributes and yields of black aromatic rice (Chak-hao) during the kharif season 2017. The experiment was laid out under factorial randomized block design with three replication consisting of two factors via, phosphorus levels (0, 20, 40 and 60 kg P_2O_5/ha) and potassium levels (0, 30 and 60 kg K_2O/ha). Maximum plant height, number of effective tillers per hill, panicle length and dry matter production were recorded with 60 kg each of P_2O_5 and K_2O/ha which remain at par with 40 kg P_2O_5/ha and 30 kg K_2O/ha respectively. The result obtained during the investigation concluded that effective tillers/hill (7.69), panicle length (23.44 cm), filled grain/panicle (77.75) and test weight (27.81g) were maximum with the application of 60 kg P_2O_5/ha but statistically identical with 40 kg P_2O_5/ha. Among the different levels of potassium application of 60 kg K_2O/ha recorded maximum effective tillers (7.15), panicle length (23.07 cm), filled grans/panicle (74.59) and test weight (27.74 g).Similar it was recorded for grain (1971.56 kg/ha and 1879.67 kg/ha) and straw yield (3705.56 kg/ha and 3615 kg/ha) with 60 kg P_2O_5/ha and 60 kg K_2O/ha respectively which was statistically at par with 40 kg P_2O_5/ha and 30 kg K_2O/ha respectively. This can be concluded that application of 40 kg P_2O_5/ha and 30 kg K_2O/ha improved plant growth and yield of black aromatic rice.

Introduction

Globally, rice is an important food crop, occupying the second position in production and area under food crop, next to wheat. It occupies 23.3 per cent of gross cropped area of the country. It contributes 43 per cent of total food grain production and 46 per cent of total cereals production. It is grown in almost all the state of India. It occupies an area of 44.1 m ha with a production of 105.5 million tonne and productivity of 2391 kg/ha. In Manipur rice cover an area of 224.50 ha with a production of 255.10 tonnes and productivity of 1488 kg/ha (Anon., 2014-15). There is a wide scope for increasing the productivity and production of rice in the state to meet the food requirement of the burgeoning population. Fine rice occupies a pivotal position in India because of its high quality. Due to its excellent quality characters, it is also popular in the international market. The area under scented rice varieties is also increasing day by day with the opening of world market as well as domestic consumption (Singh *et al.*, 2008)

Black aromatic rice (Chak-hao) is high in nutritional value and is a source of iron, vitamin E and antioxidants. The bran hull of black aromatic rice contains one of the highest levels of anthocyanin found in food. Its grain has similar amount of fibre to brown rice. Cultivation of aromatic rice is very remunerative as it fetches higher price compared to other coarse rice indicating better income of the cultivators. The future of the Indian foreign exchange earnings may largely be secured through export of scented rice (Dwivedi, 1997). In Manipur, black aromatic rice is consumed in various ways like puddings, bread, pulao etc. in different festivals and during important ceremonies by different ethnic people. There is high demand of black aromatic rice not only in the state but in other parts of the country which cannot be met from the low productivity of the crop. Hence, to improve the productivity of this crop suitable nutrients and agronomic practices has to be developed.

Phosphorus and potassium are one of the most important major nutrients required for rice production. Proper fertilization is an important management practices which can increase yield of black aromatic rice. Deficiencies of both the nutrients reduce effective tiller, panicle length, and grain filling and eventually lead to reduction of yield of black aromatic rice (Aide and Picker, 1996).

Materials and Methods

The experiment was conducted at Agronomy research farm, College of Agriculture, CAU, Imphal during the kharif season 2017 to study the influence of phosphorus and potassium on yield attributes and yield of black aromatic rice (chak-hao). The experiment was laid out in Factorial randomized block design with three replication having two factors viz. four phosphorus levels (0, 20, 40 and 60 kg P_2O_5/ha) and three potassium levels (0. 30 and 60 kg K_2O/ha). The soil of the experimental field was clay in texture, acidic in reaction, high in organic carbon (1.3%), 310.1 kg/ha available nitrogen, 16.5 kg/ha available phosphorus and 220.15 kg/ha available potassium. Meanwhile same dose of nitrogenous fertilizer was applied to all the treatment combination (60 kg/ha). Half of the nitrogen with full dose of phosphorus and potassium were applied according to the treatment. And remaining half of the nitrogen was top dressed in two equal split at active tillering and panicle initiation stages. Thirty days old seedling was transplanted maintaining the spacing of 10cm×10cm on the well puddled plots. Gap filling was done after 7 days of transplanting wherever necessary to maintain the spacing.

Results and Discussion

Effect of phosphorus and potassium on the growth of black aromatic rice

The growth of black aromatic rice was significantly influenced by application of phosphorus and potassium and is presented in Table 1. Among the different phosphorus levels, the maximum plant height was recorded with 60 kg P_2O_5/ha (P_3) which remained at par with 40 kg P_2O_5/ha (P_2) at all the stages. Again P_2 did not differ significantly with P_1. The beneficial effect of P application might be attributed to the greater meristematic activity of the apical tissues and its effect on cell division thereby increasing shoots length. These results are in conformity with the findings of Imrul *et al.*, (2016). The increased in the phosphorus levels upto 40 kg P_2O_5/ha increases number of tillers per hill except at 50 DAT. These might be due to increase in more nutrient availability for producing more tillers per hill. This result is in accordance with Alam *et al.,* (2009) and Moridani and Ebrahim (2014). Maximum leaf area index was obtained with the application of 60 kg P_2O_5/ha. This might be due to application of phosphorus increase leaf number and leas expansion of the plant and is supported by Gharib *et al.,* (2011). Plant dry matter production was significantly influenced by phosphorus and potassium. Maximum plant dry matter production was recorded with 60 kg P_2O_5/ha. This is in conformity with the findings of Gharib *et al.,* (2011) and Murthy *et al.,* (2015).

Potassium fertilization significantly influenced growth of black aromatic rice. Maximum plant height at all the stages was obtained with 60 kg K_2O/ha (K_2) which remained at par with 30 kg K_2O/ha (K_1). Increased in plant height may be due to increasing uptake of nutrients like N and P which leads to greater cell division and increase in shoot elongation with increasing supply of potassium. This is in accordance with Islam *et al.,* (2015). Among the different potassium levels, application of 60 kg K_2O/ha (K_2) obtained maximum number of tillers per hill at all the stages which was statistically identical with 30 kg K_2O/ha and significantly superior to control. The increased in number of tillers per hill might be attributed to greater translocation of photosynthates to the reproductive part of the plant. This result is in conformity with Islam *et al.,* (2015). The highest leaf area index was recorded with the application of 60 kg K_2O/ha which was statistically at par with 30 kg K_2O/ha but superior to control. Potassium application helps in greater translocation of nutrients like N&P further increased number of leaves and leaf expansion. This result is supported with the findings given by Murthy *et al.,* (2015). Plant fresh and dry weight of black aromatic rice was significantly increased with increasing potassium levels. Maximum plant fresh and dry weight was recorded with application of 60 kg K_2O/ha which remained at par with 30 kg K_2O/ha. This is supported by Gharib *et al.,* (2011) and Murthy *et al.,* (2015).

The interaction between phosphorus and potassium had significant influenced on the growth parameters like plant height, number of tillers per hill, leaf area index and plant fresh and dry weight. The highest order was recorded with P_3K_2 and lowest with P_0K_0 at all the factors.

Effect of phosphorus and potassium on number of effective tillers/hill, panicle length, number of filled grain/panicle, spikelet sterility and test weight of black aromatic rice

Phosphorus application had a significant effect on the yield attributing factors that was presented in Table 2. The maximum number of effective tiller/hill was recorded with 60 kg P_2O_5/ha (7.69) which was statistically at par with 40 kg P_2O_5/ha (7.48). Application of phosphorus increased P availability to plant for producing more effective tiller/hill. This result was in conformity with the findings of Hasanuzzaman *et al.,* (2012). The maximum panicle length was found with the application of 60 kg P_2O_5/ha which was identical with 40 kg P_2O_5/ha but superior to 20 and 0 (control) kg P_2O_5/ha. Gharib *et al.,* (2011) agreed to this result.

Number of filled grain/panicle was significantly influenced by application of phosphorus. Maximum (77.75) filled grain was recorded with the application of 60 kg P_2O_5/ha which was statistically at par (71.51) with 40 kg P_2O_5/ha but superior to 20 and 0 (control) kg P_2O_5/ha. This result is similar with the findings given by Imrul *et al.,* (2016). The spikelet sterility was lowest with the application of 60 kg P_2O_5/ha which was statistically at par with 40 kg P_2O_5/ha.

Table.1 Effect of phosphorus and potassium on growth of black aromatic rice

Treatment	Plant height (cm)				Number of tillers/hill				LAI				Dry matter production (g/plant)			
	25 DAT	50 DAT	75 DAT	100 DAT	25 DAT	50 DAT	75 DAT	100 DAT	25 DAT	50 DAT	75 DAT	100 DAT	25 DAT	50 DAT	75 DAT	100 DAT
Phosphorus																
P_0	55.88	98.49	140.66	146.97	4.13	5.82	7.86	8.68	0.86	2.00	2.88	1.94	16.82	19.45	19.76	23.21
P_1	62.50	107.98	155.30	160.79	4.99	6.17	8.64	9.76	0.88	2.15	3.35	2.17	18.04	20.57	22.17	24.91
P_2	63.27	110.23	160.05	164.28	5.55	6.76	9.92	10.49	0.91	2.30	3.58	2.30	18.54	21.42	24.36	32.54
P_3	64.64	113.01	162.55	165.02	5.75	7.41	10.53	11.06	0.91	2.34	3.64	2.36	18.48	23.12	25.37	33.62
S.Ed(±)	**0.65**	**1.66**	**1.89**	**1.24**	**0.09**	**0.29**	**0.21**	**0.20**	**0.02**	**0.08**	**0.06**	**0.06**	**0.79**	**0.55**	**0.66**	**0.67**
CD(P=0.05)	**1.91**	**4.86**	**5.53**	**3.63**	**0.28**	**0.84**	**0.62**	**0.58**	**0.04**	**0.23**	**0.19**	**0.18**	**2.31**	**1.62**	**1.94**	**1.96**
Potassium																
K_0	58.69	99.29	141.22	147.25	4.54	6.11	8.58	9.47	0.88	2.03	3.11	2.01	17.35	19.77	21.47	26.76
K_1	62.68	111.35	159.91	164.51	5.30	6.41	9.30	10.08	0.89	2.24	3.47	2.26	18.10	21.38	23.14	28.99
K_2	63.35	111.64	162.79	166.03	5.48	7.10	9.84	10.44	0.91	2.33	3.51	2.31	18.46	22.28	24.13	29.97
S.Ed(±)	**0.56**	**1.44**	**1.63**	**1.07**	**0.08**	**0.25**	**0.18**	**0.17**	**0.01**	**0.07**	**0.05**	**0.05**	**0.68**	**0.48**	**0.57**	**0.58**
CD (P=0.05)	**1.65**	**4.21**	**4.79**	**3.14**	**0.24**	**0.73**	**0.54**	**0.51**	**0.04**	**0.20**	**0.16**	**0.15**	**2.00**	**1.41**	**1.68**	**1.70**

Table.2 Effect of phosphorus and potassium on yield contributing factors of black aromatic rice

Treatment	Effective tillers/hill	Panicle length (cm)	no. of filled grain/panicle	Spikelet sterility	1000 grain weight (g)
Phosphorus					
P_0	5.46	19.98	37.68	71.58	27.27
P_1	6.70	21.40	58.97	54.55	27.58
P_2	7.48	22.23	71.62	52.42	27.60
P_3	7.69	23.44	77.75	51.69	27.81
S.Ed(±)	**0.27**	**0.63**	**4.43**	**0.91**	**0.58**
CD(P=0.05)	**0.55**	**1.30**	**9.19**	**1.88**	**1.19**
Potassium					
K_0	6.33	19.91	40.19	70.10	27.29
K_1	7.01	22.32	69.74	53.30	27.66
K_2	7.15	23.07	74.59	49.29	27.74
S.Ed(±)	**0.23**	**0.54**	**3.84**	**0.79**	**0.50**
CD(P=0.05)	**0.48**	**1.13**	**7.96**	**1.63**	**1.03**

Table.3 Effect of phosphorus and potassium on grain, straw yield and harvest index of black aromatic rice

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index
Phosphorus			
P_0	1508.00	3263.56	33.13
P_1	1703.00	3421.11	33.13
P_2	1909.56	3580.33	34.40
P_3	1971.56	3705.56	34.30
S.Ed(±)	**64.75**	**94.89**	**1.07**
CD(P=0.05)	**189.91**	**278.31**	**3.15**
Potassium			
K_0	1600.00	3314.33	33.28
K_1	1839.42	3548.58	33.99
K_2	1879.67	3615.00	33.95
S.Ed(±)	**56.08**	**82.18**	**0.93**
CD(P=0.05)	**164.47**	**241.02**	**2.73**

Table.4 Effect of phosphorus and potassium on gross income, net income and benefit: cost ratio of black aromatic rice

Treatment	Gross income (Rs/ha)	Net income (RS/ha)	B: C ratio
Phosphorus			
P_0	97007.11	56582.11	2.39
P_1	109000.00	66700.00	2.58
P_2	121778.44	77603.44	2.75
P_3	125704.44	79654.44	2.73
S.Ed(±)	**3914.04**	**3914.04**	**0.09**
CD (P=0.05)	**11479.50**	**11479.50**	**0.26**
Potassium			
K_0	102628.67	60541.17	2.43
K_1	117462.17	74224.67	2.71
K_2	120026.67	75639.17	2.70
S.Ed(±)	**3389.66**	**3389.66**	**0.08**
CD (P=0.05)	**9941.54**	**9941.54**	**0.23**

However test weight was found to be significantly not affected by application of different phosphorus levels. This is due to the fact that grain weight is genetic trait and this is similar with the finding given by Sharma *et al.*, (2012).

Factors contributing yield were significantly affected by application potassium. Maximum (7.15) effective tillers/hill was recorded with the application of 60 kg K_2O/ha which was statistically identical (7.01) with 30 kg K_2O/ha but significantly superior to control. Application of potassium helps in greater translocation of photosynthates to the reproductive part and increased the effective tillers.

Maximum (23.07cm) panicle length was obtained with 60 kg K_2O/ha which was identically produced with 30 kg K_2O/ha but significantly superior to control. Potassium application significantly increased number of filled grain/panicle as potassium helps in pollen germination in the floret which leads to more filled grain. Maximum filled grain was recorded with the application of 60 kg K_2O/ha but statistically at par with 30 kg K_2O/ha. 1000 grain weight was significantly not affected by application of different levels of potassium.

These results are in accordance with the findings given by Islam *et al.*, (2015) and Moridani and Ebrahim (2014). As potassium helps in improving germination of pollen in the floret which leads to more grain filling, spikelet fertility will also increase with increasing potassium application. Maximum spikelet fertility was recorded with 60 kg K_2O/ha which was significantly superior to 30 kg K_2O/ha and control. Murthy *et al.*, (2015) reported the same findings.

The interaction between phosphorus and potassium had significant effect on yield contributing factors like effective tillers, panicle length, no.of filled grain per panicle, spikelet sterility and 1000 grain weight. Combination of P_3K_2 (60kg P_2O_5/ha and 60 kg K_2O/ha) produced maximum effective tillers (8.63), panicle length (25.53cm), no. of filled grain/panicle (94.19), spikelet sterility (38.23%) and 1000 grain weight (28.20g).

Effect of phosphorus and potassium on the grain yield, straw yield and harvest index of black aromatic rice

The grain and straw yield was significantly influenced by phosphorus and potassium and are presented in Table 3. The maximum grain yield was recorded with the application of 60 kg P_2O_5/ha (1971.56 kg/ha) which remained at par with 40 kg P_2O_5/ha (1909.56 kg/ha). This might be due to the effect of P on root development, energy transformation and metabolic processes of the rice plant, which in turn resulted in greater translocation of photosynthates toward the productive part i.e. grain. This result is in conformity with findings given by Gharib *et al.,* (2011), Hasanuzzaman *et al.,* (2012), and Archana *et al.,* (2015). Among the phosphorus levels, application of 60 kg P_2O_5/ha recorded the maximum (3705.56 kg/ha) straw yield which was statistically at par with 40 kg P_2O_5/ha (3580.33 kg/ha).

Applications of phosphorus accelerate the P absorption for increased in number of tiller which increases the straw yield. This result is supported by the findings of Hasanuzzaman *et al.,* (2012) and Archana *et al.,* (2015).

Among the different levels of potassium levels, maximum (1879.67 kg/ha) grain yield was recorded with the application of 60 kg K_2O/ha but statistically identical with 30 kg K_2O/ha (1839.42 kg/ha). This result is in accordance with Hasanuzzaman *et al.,* (2012), and Archana *et al.,* (2015). Application of 60 kg K_2O/ha recorded the maximum (3615.00kg/ha) straw yield which was statistically superior from both 30 and 0 kg K_2O/ha. This result is in conformity with the findings of Islam *et al.,* (2015). Harvest index was significantly not affected by phosphorus and potassium application. This is supported by Hasanuzzaman *et al.,* (2012).The interaction between phosphorus and potassium had no significant effect on grain and straw yield.

Effect of phosphorus and potassium on gross income, net income and benefit: cost ratio of black aromatic rice

Gross income was significantly influenced by application of different levels of phosphorus and potassium. Maximum gross income was recorded with the application of 60 kg P_2O_5/ha (Rs.1,25,704.44) which was statistically identical with 40 kg P_2O_5/ha (Rs.1,21,778.44) but found superior to 20 kg P_2O_5/ha and control. Maximum gross income was recorded with the application of 60 kg K_2O/ha (Rs.1,20,026.67) which did not differ significantly with 30 kg K_2O/ha (Rs.1,17,462.17) and control (K_0). This result is supported by the findings of Sharma *et al.,* (2012). Net benefit ratio was significantly affected by application phosphorus and potassium (Table 4). The highest net income was obtained with the application of 60 kg P_2O_5/ha (Rs.79,654.44) and 60 kg K_2O/ha (Rs.75,639.17) respectively. However, its difference between 40 and 60 kg P_2O_5/ha and 30 and 60 kg K_2O/ha were found to be non-significant. This might be owing to higher productivity as well as efficient use of fertilizers. These results are in close conformity with the findings of Paramasivan and Senthil Kumar (2018). From the data obtained on the benefit: cost ratio revealed that application of 40 kg P_2O_5/ha (2.75) recorded the highest benefit: cost ratio. The interaction between phosphorus and potassium significantly increased net income and gross income except for benefit: cost ratio.

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