

VARIETAL RESPONSE OF RICE GENOTYPES TO DIFFERENT LEVELS OF PHOSPHORUS

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ABSTRACT

A field experiment was conducted during *kharif* 2015 at the research farm of the ICAR–Indian Institute of Rice Research, Hyderabad, to evaluate the response of 30 rice genotypes to four phosphorus levels, viz., P0 (control), P20, P40 and P60. The experiment was conducted in a randomized block design with three replications. Significant variation was observed among genotypes and phosphorus levels for plant height, effective tillers, panicle length, test weight, grain yield and straw yield. Mean plant height increased from 59.72 cm under P0 to 76.29 cm under P40 and P60, while effective tillers increased from 4.34 to 9.56. Mean panicle length increased from 17.72 cm under P0 to 21.76 cm under P60, and test weight increased from 24.11 to 30.70 g. Grain yield increased from 1.34 t ha⁻¹ under P0 to 3.52 t ha⁻¹ under P60, while straw yield increased from 1.63 to 4.24 t ha⁻¹. Among the genotypes, INH12013, PA6444 and DRRH3 recorded higher grain yields under P60, with 5.5, 5.0 and 4.7 t ha⁻¹, respectively. INH12013 also recorded the highest straw yield (6.60 t ha⁻¹) under P60. IET24003 and TRIGUNA recorded comparatively longer panicles, whereas INH10001, PR133 and INH12013 showed higher test weight under different P levels. The results demonstrated substantial genotypic variation in response to phosphorus application and indicated the potential for identifying rice genotypes with superior performance under improved phosphorus availability.

KEYWORDS: Rice, phosphorus, genotypic variation, grain yield, nutrient management, rice genotypes

INTRODUCTION

Phosphorus is one of the major nutrients required for optimum plant growth and crop productivity. Phosphorus deficiency is widespread in both acidic and alkaline soils, and low P availability is an important constraint to crop production in many agricultural soils. The availability of P to plants depends largely on soil characteristics and the size of the labile P pool. A considerable proportion of applied P is rapidly converted into less available forms, thereby reducing its availability to crops. Increasing fertilizer costs and concerns regarding inefficient fertilizer use have increased the importance of developing and identifying crop genotypes capable of producing satisfactory yields under low-P conditions. Plants have evolved several mechanisms to adapt to P deficiency. These mechanisms include improved P acquisition through changes in root morphology, root exudation and P uptake processes, as well as improved P utilization within plant tissues. Considerable genetic variation exists among crop genotypes for these mechanisms, making the identification of P-efficient genotypes an important component of sustainable nutrient management.

Rice is moderately sensitive to P deficiency, and substantial variation exists among rice genotypes in their ability to tolerate low-P conditions. Phosphorus application can improve biomass production, tillering and P uptake and can influence several yield-related traits. However, P availability is often low in rice-growing soils because of strong P fixation. In acidic soils, iron and aluminium oxides can immobilize P, whereas in calcareous soils, calcium- and magnesium-containing compounds can reduce P availability. Consequently, improving P acquisition and utilization by rice genotypes is an important strategy for increasing productivity in P-deficient soils. The identification of genotypes capable of maintaining productivity under different P regimes can reduce dependence on high fertilizer inputs and improve the efficiency of P use. Therefore, the present study was undertaken to evaluate the response of different rice genotypes to varying levels of phosphorus and to identify genotypes showing superior performance for growth, yield attributes and grain yield under contrasting P levels.

MATERIALS AND METHODS

Experimental site

The field experiment was conducted during kharif 2015 at the research farm of the ICAR–Indian Institute of Rice Research (IIRR), Rajendranagar, Hyderabad, Telangana, India. The experimental site was located at 17°19' N latitude and 78°23' E longitude. The study was conducted under field conditions to evaluate the response of rice genotypes to different phosphorus levels.

Weather conditions

The climate of the experimental site is subtropical, with rainfall mainly received from the southwest monsoon during June to October. Weather observations during the crop-growing period were obtained from the meteorological observatory at the Agricultural Research Institute, Rajendranagar. During the experimental period, mean maximum temperature ranged from 28.4 to 34.8°C, with an average of 31.8°C, whereas mean minimum temperature ranged from 17.4 to 24.4°C, with an average of 21.7°C. Mean relative humidity ranged from 70.7 to 96.0%, with an average of 87.8%. Total rainfall during the crop-growth period was 393.8 mm over 28.5 rainy days. Mean sunshine duration ranged from 1.7 to 8.9 h day⁻¹, while mean evaporation ranged from 2.5 to 7.3 mm day⁻¹.

Initial soil characteristics

Before establishing the experiment, representative soil samples were collected from the experimental field and analyzed for their physical and chemical properties. The soil was classified as sandy clay loam, with 40% sand, 25% silt and 35% clay. The bulk density was 1.45 Mg m⁻³. The soil was alkaline (pH 8.01) and non-saline, with an electrical conductivity of 0.27 dS m⁻¹. Soil organic carbon was 0.44%. Available nitrogen and phosphorus were 253 and 10.95 kg ha⁻¹, respectively, and were classified as low, whereas available K₂O was 370 kg ha⁻¹ and was classified as high. Available sulphur was also low (6 mg kg⁻¹). Available Ca, Mg, Fe, Zn, Cu and Mn were reported as high in the experimental soil.

Experimental design and treatments

The experiment was conducted using a randomized block design (RBD) with three replications. The plot size was 35 m × 10 m (350 m²), with a 1.4-m fallow strip surrounding the experimental plots. Four phosphorus treatments were evaluated: control (P0), 33% recommended dose of phosphorus (P20), 66% recommended dose of phosphorus (P40), and 100% recommended dose of phosphorus (P60).

Plant material

Thirty rice genotypes were evaluated in the experiment: AKSHAYADHAN, VASUMATHI, SUGANDHAMATI, T. HAMSA, VARDHAN, VIKAS, TULASI, MAHSURI, MTU1010, RPBIO226, IR64, VANDANA, RASI, KASALATHA, SWARNA, BPT5204, KRH2, IET24036, RAVI, IET24003, TRIGUNA, SAMPADHA, DRRH3, ADITHA, PA6444, PR133, RNR15048, INH10001, INH10002 and INH12013.

Observations and statistical analysis

Observations were recorded for plant height, effective tillers, panicle length, test weight and grain yield. Treatment means and genotypic differences were compared using the reported standard error and least significant difference (LSD) at the 1% probability level. Coefficients of variation (CV) were also calculated to assess variability in the experimental observations.

RESULTS AND DISCUSSION

PLANT HEIGHT

Plant height differed considerably among the 30 rice genotypes and across phosphorus treatments. The mean plant height increased from 59.72 cm under P0 to 72.36 cm under P20 and 76.29 cm under P40 and P60. The CV ranged from 7.47 to 13.04%, indicating moderate variability among the genotypes. KASALATHA recorded the maximum plant height of 108 cm under P60, followed by RNR15048 (100 cm) and VARDHAN (99 cm). In contrast, RAVI recorded only 38 cm under P0, while BPT5204 recorded 50 cm. Several genotypes, including SUGANDHAMATI, VARDHAN, KRH2 and DRRH3, showed an increase in plant height with increasing P levels. The LSD values at 1% probability ranged from 14.99 to 20.49 cm, indicating substantial differences among the evaluated genotypes. The increase in plant height with P application suggests that adequate P availability supported vegetative growth. However, the magnitude of response varied among genotypes, indicating a strong genotype × nutrient interaction. Earlier these findings are reported by Brajendra et al. (2012), Gorlapalli et al. (2022), Parmar et al. (2022), Srilatha et al. (2019) and Tuli et al. (2022).

Effective tillers

Effective tiller production varied substantially among genotypes and phosphorus treatments. The mean number of effective tillers increased from 4.34 under P0 to 7.83 under P20 and 9.56 under P40 and P60. The CV ranged from 17.45 to 21.02%, indicating greater variability than that observed for plant height. IR64 and TULASI recorded 17 effective tillers under P40, while KASALATHA recorded 16 tillers under P60. RAVI and TRIGUNA also showed comparatively high tillering under higher P levels. In contrast, VANDANA recorded only four effective tillers under P60. The LSD values at 1% probability ranged from 2.09 to 4.38, indicating significant variation among genotypes. The increase in effective tiller number up to P40 suggests that phosphorus availability promoted tiller production. However, the response was genotype-dependent, with some genotypes showing little

or inconsistent improvement at higher P levels. Earlier these finding are reported by Brajendra et al. (2012), Sahoo et al. (2022), Srilatha et al. (2019) and Tuli et al. (2022).

Panicle length

Panicle length differed significantly among genotypes and treatments. The mean panicle length increased progressively from 17.72 cm under P0 to 20.80 cm under P20, 20.97 cm under P40 and 21.76 cm under P60. The CV declined from 10.93% under P0 to approximately 7.1–7.7% under the higher P treatments. IET24003 produced a panicle length of 26 cm under P0 and 25 cm under P40, while TRIGUNA recorded the maximum panicle length of 29 cm under P60. SUGANDHAMATI and TULASI recorded shorter panicles under some treatments. The LSD values at the 1% level ranged from 3.90 to 5.09 cm. The improvement in panicle length with increasing P availability indicates a positive influence of phosphorus on reproductive development. However, the magnitude of response varied considerably among genotypes, suggesting differences in nutrient-use characteristics. Earlier these finding are reported by Parmar et al. (2022), Rathod et al. (2021) and Sahoo et al. (2022).

Test weight

Test weight showed clear variation among the rice genotypes. According to Table 2, the mean test weight increased from 24.11 g under P0 to 28.22 g under P20, 29.69 g under P40 and 30.70 g under P60. The relatively low CV values (3.08–5.49%) indicated comparatively lower variability for this trait. The highest test weights recorded in the dataset were 36.8 g in INH10001 under P40, 36.6 g in INH12013 under P60 and 36.2 g in PR133 under P40. RNR15048 recorded comparatively low values across treatments, while VARDHAN recorded 20 g under P0. The LSD at 1% probability ranged from 2.38 to 3.48 g. The increase in test weight with increasing P level indicates a positive response of grain development to improved phosphorus availability. The relatively low CV suggests greater stability of this trait compared with several vegetative and yield traits. Earlier these finding are reported by Kale et al. (2020), Kale et al. (2021), Kumar et al. (2014), Vishwakarma et al. (2023) and Parmar et al. (2026).

Grain yield

Grain yield varied substantially among genotypes and phosphorus treatments. The mean grain yield increased from 1.34 t ha⁻¹ under P0 to 2.45 t ha⁻¹ under P20, 2.65 t ha⁻¹ under P40 and 3.52 t ha⁻¹ under P60. The CV decreased from 11.2% under P0 to 9.1% under P60, suggesting relatively greater uniformity among genotypes at the higher P level. INH12013 recorded the highest grain yield of 5.5 t ha⁻¹ under P60, followed by PA6444 (5.0 t ha⁻¹) and DRRH3 (4.7 t ha⁻¹). SAMPADHA and IET24036 each recorded 4.0 t ha⁻¹ under P60. The lowest yield was recorded by RAVI under P0 (0.8 t ha⁻¹), followed by BPT5204 (1.0 t ha⁻¹). The LSD values at the 1% level ranged from 0.40 to 0.84 t ha⁻¹, demonstrating considerable differences in grain yield. The progressive increase in mean grain yield with increasing P availability indicates that phosphorus was an important yield-limiting nutrient at the experimental site, which initially had low available P (10.95 kg P₂O₅ ha⁻¹). The differential response of genotypes demonstrates the importance of genetic variation in P responsiveness. Genotypes such as INH12013, PA6444 and DRRH3 showed strong yield responses under P60, whereas other genotypes exhibited smaller responses. This variation provides an opportunity for identifying genotypes with improved nutrient-use efficiency and for developing genotype-specific nutrient management strategies. Earlier these finding are reported by Brajendra et al. (2012), Caon et al. (2017), Gorlapalli et al. (2022), Kale et al. (2020) and Sawant et al. (2026).

Straw yield

Straw yield varied considerably among rice genotypes and increased generally with increasing phosphorus supply. The mean straw yield increased from 1.63 t ha⁻¹ under P0 to 2.94, 3.20 and 4.24 t ha⁻¹ under P20, P40 and P60, respectively. Thus, straw yield under P60 was approximately 160% higher than that under the control treatment (P0). Among the genotypes, INH12013 recorded the highest straw yield at P60 (6.60 t ha⁻¹), followed by PA6444 (6.00 t ha⁻¹) and DRRH3 (5.60 t ha⁻¹). INH12013 also showed high straw production at P40 (5.90 t ha⁻¹) and P20 (4.80 t ha⁻¹), indicating a strong response to increasing phosphorus supply. INH10002 produced 5.00 t ha⁻¹ at P60, while PA6444 and DRRH3 produced 6.00 and 5.60 t ha⁻¹, respectively. Under P0, straw yield ranged from 0.86 t ha⁻¹ in SUGANDHAMATI to Under P0, straw yield ranged from 0.86 t ha⁻¹ in SUGANDHAMATI to 2.22 t ha⁻¹ in VASUMATHI. The corresponding values under P60 ranged from 3.00 t ha⁻¹ in TRIGUNA to 6.60 t ha⁻¹ in INH12013. The coefficient of variation decreased from 11.0% under P0 to 8.90% under P60, indicating comparatively lower experimental variability at the highest phosphorus level. The increase in straw production with phosphorus application indicates that adequate phosphorus supply promoted vegetative growth and biomass accumulation in rice. However, the magnitude of response differed among genotypes, demonstrating variation in phosphorus responsiveness. The results also indicate that genotypes such as INH12013 and PA6444 combined relatively high grain and straw yields under P60. Earlier these finding are reported by Brajendra et al. (2012), Caon et al. (2017), Gorlapalli et al. (2022), Parmar et al. (2023) and Sawant et al. (2023).

CONCLUSION

The field experiment demonstrated substantial variation among rice genotypes in their response to different phosphorus levels. Increasing phosphorus application generally improved plant height, effective tiller production, panicle length, test weight, grain yield and straw yield. Across genotypes, mean grain yield increased from 1.34 t ha⁻¹ under P0 to 3.52 t ha⁻¹ under P60, while mean straw yield increased from 1.63 to 4.24 t ha⁻¹. Under P60, INH12013, PA6444 and DRRH3 recorded the highest grain yields of 5.5, 5.0 and 4.7 t ha⁻¹, respectively, while INH12013 recorded the highest straw yield of 6.60 t ha⁻¹. TRIGUNA recorded the longest panicle (29 cm) under P60, whereas high test weights were recorded in INH10001, PR133 and INH12013 under the respective phosphorus treatments. Overall, the results indicate considerable genotypic variation in phosphorus responsiveness and highlight the importance of evaluating genotype-specific responses for improving phosphorus-use efficiency and rice productivity. However, further evaluation across locations, seasons and soil conditions is required to confirm the stability of these responses before making broader recommendations.

Table-1. Effect of different phosphorus levels on plant height and effective tillers of rice genotypes under field conditions

Variety	Plant height (cm)				Effective Tillers			
	(P0)	(P20)	(P40)	(P60)	(P0)	(P20)	(P40)	(P60)
AKSHAYADHAN	59	90	88	72	3	9	7	8
VASUMATHI	68	76	70	89	5	10	8	9
SUGANDHAMATI	59	63	81	95	4	10	14	8
T.HAMSA	50	63	81	71	4	8	9	11
VARDHAN	62	68	76	99	4	9	10	12
VIKAS	56	71	67	68	4	8	9	12
TULASI	51	65	52	62	4	9	17	5
MAHSURI	69	77	95	89	4	5	14	7
MTU1010	60	67	74	83	5	10	8	8
RPBIO226	50	65	64	58	5	9	7	8
IR64	59	57	71	74	4	10	17	12
VANDANA	70	84	84	71	5	5	8	4
RASI	51	58	75	74	5	7	9	7
KASALATHA	70	88	88	108	5	13	10	16
SWARNA	56	64	61	65	5	9	15	10
BPT5204	50	59	56	64	6	11	11	9
KRH2	70	84	83	84	5	10	15	11
IET24036	55	74	84	85	4	9	6	6
RAVI	38	56	79	74	3	8	10	15
IET24003	77	87	97	91	4	4	5	12
TRIGUNA	67	67	68	92	7	10	14	10
SAMPADHA	62	72	85	89	5	8	12	7

DRRH3	75	77	90	94	7	10	9	8
ADITHA	60	64	66	66	4	11	6	6
PA6444	72	76	81	80	6	9	5	7
PR133	52	60	59	71	3	7	8	11
RNR15048	73	80	70	100	6	9	7	8
INH10001	56	77	71	83	6	9	9	7
INH10002	58	65	85	83	5	11	9	7
INH12013	67	74	78	88	8	9	9	7
Mean	59.72	72.36	76.29	76.29	4.34	7.83	9.56	9.56
CV (%)	13.04	9.01	7.47	7.47	18.37	21.02	17.45	17.45
SE(d)	7.79	6.52	5.69	5.69	0.8	1.65	1.67	1.67
LSD (1%)	20.49	17.16	14.99	14.99	2.09	4.33	4.38	4.38

Table-2. Effect of different phosphorus levels on panicle length and test weight of rice genotypes under field conditions

	Panicle Length				Test Weight			
Variety	(P0)	(P20)	(P40)	(P60)	(P0)	(P20)	(P40)	(P60)
AKSHAYADHAN	18	25	25	22	30.1	31.9	30.5	32.5
VASUMATHI	18	22	23	24	28.1	33.4	33.6	24.3
SUGANDHAMATI	13	21	23	26	25.8	22.5	29	29.8
T.HAMSA	15	19	20	20	25.9	30.1	31.2	32.5
VARDHAN	19	19	22	23	20	28.3	29.2	32.1
VIKAS	14	21	20	23	30.1	27.5	30.7	30.5
TULASI	18	18	13	16	23.7	30.6	30.6	23.5
MAHSURI	20	18	22	20	22.1	35	30.1	30.6
MTU1010	22	17	21	22	24.4	30.9	32.8	30
RPBIO226	17	17	18	17	28.1	27.2	34.3	25.5
IR64	20	18	21	22	26.1	32.5	32.9	26.5
VANDANA	19	23	23	18	26.8	34	27	32.1
RASI	15	16	20	18	20.5	30.2	28.7	34.5
KASALATHA	22	20	18	24	20.9	27.3	32.3	33.8
SWARNA	15	17	18	19	28.2	31.5	27.8	21

BPT5204	14	18	16	18	22.7	34.3	30.7	30
KRH2	21	23	19	21	31.2	32	35.1	32.1
IET24036	19	22	24	27	20.1	24.5	34.7	22.5
RAVI	14	16	18	21	24	24.8	28.1	32.5
IET24003	26	23	25	22	27.5	30	30.8	25
TRIGUNA	15	19	20	29	21.7	24	31.5	35
SAMPADHA	19	21	19	23	29	23.5	32.5	27.7
DRRH3	22	23	22	24	29.9	28.5	29.1	32.5
ADITHA	16	19	20	16	29.8	24.2	23.8	27
PA6444	22	23	21	22	28.9	28.1	30.9	32.1
PR133	17	20	18	22	21.6	30	36.2	35
RNR15048	22	22	19	24	20.1	20	20	20.8
INH10001	18	21	21	23	21.9	29.6	36.8	31.5
INH10002	16	19	23	23	21.8	30.8	30	32.1
INH12013	16	20	22	18	22	27.2	24.6	36.6
Mean	17.72	20.8	20.97	21.76	24.11	28.22	29.69	30.7
CV (%)	10.93	7.14	7.66	7.58	5.49	3.2	4.38	3.08
SE(d)	1.94	1.49	1.61	1.65	1.32	0.9	1.3	0.95
LSD (1%)	5.09	3.9	4.22	4.34	3.48	2.38	3.42	2.49

Table-3. Effect of different phosphorus levels on grain yield and straw yield of rice genotypes under field conditions

	Grain yield				Straw yield			
Variety	(P0)	(P20)	(P40)	(P60)	(P0)	(P20)	(P40)	(P60)
AKSHAYADHAN	1.3	2.3	3.3	3.7	1.58	2.7	3.9	4.4
VASUMATHI	1.8	2.7	1.6	3.7	2.22	3.2	2.0	4.5
SUGANDHAMATI	1.4	2.2	2.7	3.2	0.86	2.7	3.3	3.8
T.HAMSA	1.4	2.2	1.9	2.9	1.42	2.6	2.3	3.5
VARDHAN	1.0	2.9	3.0	2.9	1.08	3.5	3.6	3.5
VIKAS	1.6	3.0	2.1	4.0	2.2	3.6	2.6	4.8
TULASI	1.4	2.0	1.5	2.9	1.59	2.4	1.8	3.5
MAHSURI	1.7	2.0	3.0	3.8	1.98	2.3	3.6	4.6

MTU1010	1	2.4	2.4	3.7	1.46	2.9	2.9	4.4
RPBIO226	1.6	1.9	2.1	3.5	1.32	2.2	2.5	4.2
IR64	1.6	3.0	2.1	3.2	2.02	3.6	2.5	3.9
VANDANA	1.2	1.8	3.1	4.0	1.58	2.2	3.7	4.8
RASI	1.3	1.5	2.2	2.9	1.47	1.8	2.6	3.5
KASALATHA	1.2	2.3	2.9	3.6	1.58	2.7	3.5	4.3
SWARNA	1.8	2.7	2.5	3.5	1.92	3.3	3.0	4.2
BPT5204	1.0	1.8	2.5	3.3	1.24	2.2	3.0	3.9
KRH2	1.4	3.0	3.4	3.9	1.84	3.6	4.1	4.7
IET24036	1.5	2.5	2.7	4.0	1.85	3.0	3.2	4.8
RAVI	0.8	1.4	2.2	2.9	1.12	1.8	2.6	3.5
IET24003	1.3	2.2	2.6	3.3	1.5	2.7	3.1	3.9
TRIGUNA	1.6	3.1	2.9	2.5	1.8	3.7	3.5	3.0
SAMPADHA	1.2	2.8	3.8	4.0	1.44	3.3	4.6	4.8
DRRH3	1	2.7	2.3	4.7	1.38	3.2	2.8	5.6
ADITHA	1	1.6	1.8	3.3	1.4	1.9	2.1	3.9
PA6444	1.4	2.9	2.0	5.0	1.8	3.5	2.4	6.0
PR133	1.6	2.2	2.3	2.6	2	2.6	2.8	3.1
RNR15048	1.2	1.5	1.8	3.0	1.56	1.8	2.2	3.6
INH10001	1.4	2.7	3.3	3.6	2.06	3.2	3.9	4.3
INH10002	1.3	3.2	3.9	4.1	1.48	3.9	4.7	5.0
INH12013	1.4	4.0	4.9	5.5	1.54	4.8	5.9	6.6
Mean	1.34	2.45	2.65	3.52	1.63	2.94	3.2	4.24
CV (%)	11.2	10.5	9.8	9.1	11	10.2	9.5	8.90
SE(d)	0.15	0.26	0.26	0.32	0.18	0.3	0.3	0.38
LSD (1%)	0.4	0.68	0.68	0.84	0.47	0.79	0.79	1.00

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