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Statistical evaluation and optimization of fertilizer requirement of upland rice (*Oryza sativa*) genotypes at varying levels of crop seasonal rainfall under moist sub-humid alfisols

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ABSTRACT

A study was conducted during rainy season (*kharif* 2003–05) at Phulbani using experimental data on the response of rice (*Oryza sativa* L.) varieties to varying fertilizer levels under moist sub-humid Alfisols. Statistical models were developed for yield prediction and fertilizer optimization at varying crop seasonal rainfall. Eight genotypes, viz 'Vandana', 'ZHU-11-26', 'RR-361-1', 'Jaldi-6', 'RR-166-645', 'RR-348-6', 'Heera' and 'Saria' genotypes were tested with an application of 60–30–30, 40–20–20, 20–10–10 kg N–P_2O_5–K_2O/ha and a control. The genotypes attained a mean yield of 1 651 kg/ha with 13% variation in 3 seasons. 'Vandana' was superior in control and 20-10-10 kg/ha, compared with the 'RR-348-6' in 40–20–20 kg/ha and 'RR-166-645' in 60–30–30 NPK kg/ha. Rank correlation between ranks assigned to mean and variation of genotypes shows that the performance of a genotype was significantly correlated with its variation with a maximum correlation of 0.79 in control and a minimum of 0.43 in 60–30–30 kg/ha. Regression models of yield through rainfall, applied fertilizer and their interaction indicated a significant predictability ranging from 0.92 for 'Vandana', 'ZHU-11-26' and 'Jaldi-6' to 0.97 for 'RR-361-1', 'RR-166-645' and 'Saria'. Rainfall had a significant positive influence on yield of all genotypes while quadratic variables of N, P and K had a significant negative influence on 'Vandana' and 'Saria'. Optimum NPK doses for attaining maximum yield were minimum for 'Saria' and maximum for 'ZHU-11-26'. For economic yield they were minimum for 'Saria' while N was maximum for 'Vandana' and K was maximum for 'ZHU-11-26'. P was maximum for 'RR-166-645' at 750 and 1000 mm and 'ZHU-11-26' at 1 250 mm of rainfall. Optimum N ranged from 35 to 77 kg/ha while, P and K ranged from 16 to 67 kg/ha for maximum yield at a crop seasonal rainfall of 750 to 1250 mm. The optimum doses for economic yield ranged from 32 to 69 kg/ha for N, 15 to 56 kg/ha for P and 16 to 62 kg/ha for K in the study.

Key words : Upland, Genotype, Fertilizer, Regression, Sustainability, Prediction, Optimization

Rice (*Oryza sativa* L.) is an important cereal grown as a purely rainfed upland crop in West Bengal, Bihar, Uttar Pradesh, Orissa, Madhya Pradesh, Jharkhand, Maharashtra, Chhattisgarh etc during rainy season (June to September). Rainfed rice in India constitutes 55% of total rice area. Rice is grown as a sole crop and also intercropped with pigeonpea, vegetables and other crops in most of the states. Although productivity under irrigated conditions has crossed 1 tonne barrier in states, like Bihar, Orissa and Madhya Pradesh, the productivity under rainfed conditions continues to be below one tonne in these states. Rainfed rice is grown in 346 districts in 16 states in India under arid, semi-arid to humid climatic conditions. The districts covering 85% of rainfed rice area are recognized as a rainfed rice production region. This region covers an area of 13.22 m ha in 55 districts in 16 states. Out of a total rice area of 45.01 lakh ha in Orissa, 42.48 lakh ha is used for cropping in *kharif* and 2.53 lakh ha is used for cropping in *rabi*. Out of 42.48 lakh ha used in *kharif*, only 15.16 lakh ha area (36%) is under irrigation. Thus about 64% of rice area in *kharif* is rainfed while in *rabi* the entire 2.53 lakh ha of rice area is under irrigation. Unlike in irrigated experiments, upland rice genotypes respond to application of fertilizers differently under rainfed conditions. There is an immediate need to identify a suitable upland rice genotype which is stable and sustainable under rainfed conditions. Further there is also a need to optimize N, P and K fertilizer requirement of upland rice under varying crop seasonal rainfall situations in Orissa.

Riazuddin *et al.* (2001) discussed about soil test based optimal fertilizer doses for attaining different yield targets of rainfed castor under semi-arid alfisols. The regression methodology would be useful for developing suitable models

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for selection of a superior genotype of a crop, its yield prediction and optimum fertilizer requirement for attaining maximum and economic yield under rainfed conditions. Vittal *et al.* (2002) and Maruthi Sankar and Raghuram Reddy (2005) reported that genotypes could be statistically evaluated and ranked for sustainability over a period of time. An attempt is made in this paper to develop the efficient yield prediction models of upland rice genotypes and optimize fertilizer requirement at varying amounts of crop seasonal rainfall based on genotype × fertilizer experiments conducted in a moist sub-humid Alfisol at Phulbani.

MATERIALS AND METHODS

Field experiments were conducted on upland rice (*Oryza sativa*) with 8 short duration genotypes and 4 levels of fertilizer at Phulbani under moist sub-humid Alfisols during rainy season (June to September) in 2003, 2004 and 2005 under rainfed conditions. The study was conducted to select a superior genotype and optimize fertilizer N, P and K for attaining a maximum and sustainable productivity of rice. The 8 genotypes tested were 'Vandana', 'ZHU-11-26', 'RR-361-1', 'Jaldi-6', 'RR-166-645', 'RR-348-6', 'Heera' and 'Saria' with 4 levels of NPK, i e 60–30–30, 40–20–20, 20–10–10 kg/ha and a control. Farmyard manure @ 5 tonnes/ha was uniformly applied in all the 4 fertilizer treatments. Phulbani receives a normal annual rainfall of 1 396 mm from 66 rainy days. The date of onset of monsoon is 10 June and date of withdrawal of monsoon is 6 October. It received a crop seasonal rainfall of 900 mm during 2003, 756 mm during 2004 and 1211 mm during 2005. The crop was sown on 28 June in 2003, 22 June in 2004 and 5 July in 2005. It was harvested between 22 September and 4 October in 2003, 19 and 30 September in 2004 and 29 September and 8 October in 2005. The study was conducted in a split-plot design with 3 replications in a net plot size of 1 m × 3 m. The field under each replication was divided into 4 main plots for randomly allocating fertilizer treatments. Each main plot was further divided into 8 sub-plots for randomly superimposing genotypes. A recommended seed rate of 100 kg/ha and a row spacing of 20 cm were adopted in the study.

RESULTS AND DISCUSSION

Varietal response to fertilizer application

The mean yield attained by genotypes along with coefficient of variation at different levels of NPK fertilizer (Table 1) revealed that the genotypes attained a mean yield of 594 kg/ha with 37% variation in control, 1 117 kg/ha with 23% variation in 20–10–10 kg/ha, 1 317 kg/ha with 21% variation in 40–20–20 kg/ha and 1 618 kg/ha with 27% variation in 60–30–30 kg/ha application in *kharif* 2003. A lower mean yield of 448, 851, 1 061 and 1 164 kg/ha with lower variation of 23, 25, 23 and 25% were observed under 4 treatments, respectively, in *kharif* 2004. Compared to this, a significantly higher mean yield of 2 250, 2 829, 3 377 and 3 181 kg/ha with 11, 10, 12 and 18% variation were observed

Table 1 Yield performance (kg/ha) of rice genotypes at different fertilizer levels at Phulbani

Genotype	Control	20–10 –10	40–20 –20	60–30 –30	Mean	CV (%)
Kharif 2003						
'Vandana'	933	1 345	1 372	1 400	1 263	17
'ZHU-11-26'	300	650	1 167	1 406	881	57
'RR-361-1'	600	1 261	1 406	2 100	1 342	46
'Jaldi-6'	400	1 011	1 078	1 350	960	42
'RR-166-645'	795	1 333	1 728	2 228	1 521	40
'RR-348-6'	611	1 355	1 683	2 022	1 418	43
'Heera'	389	861	1 133	1 389	943	45
'Saria'	722	1 122	972	1 050	967	18
Mean	594	1 117	1 317	1 618	1 162	
CV (%)	37	23	21	27	22	
Kharif 2004						
'Vandana'	622	1 139	1 383	1 295	1 110	31
'ZHU-11-26'	350	711	1 056	1 305	856	49
'RR-361-1'	372	683	900	1 139	774	42
'Jaldi-6'	422	739	922	1 006	772	34
'RR-166-645'	583	1 161	1 356	1 517	1 154	35
'RR-348-6'	445	1 006	1 278	1 433	1 041	42
'Heera'	339	622	800	1 017	695	41
'Saria'	450	744	794	600	647	24
Mean	448	851	1061	1164	881	
CV (%)	23	25	23	25	22	
Kharif 2005						
'Vandana'	2 500	2 939	3 600	2 750	2 947	16
'ZHU-11-26'	2 400	3 000	3 333	3 994	3 182	21
'RR-361-1'	2 344	3 261	3 767	3 433	3 201	19
'Jaldi-6'	2 050	2 395	3 367	2 756	2 642	21
'RR-166-645'	2 478	2 678	3 356	3 589	3 025	18
'RR-348-6'	2 361	2 889	3 900	3 567	3 179	22
'Heera'	1 878	2 911	2 967	3 044	2 700	20
'Saria'	1 989	2 561	2 728	2 311	2 397	13
Mean	2 250	2 829	3 377	3 181	2 909	
CV (%)	11	10	12	18	10	
Pooled over seasons						
'Vandana'	1 352	1 808	2 118	1 815	1 773	21
'ZHU-11-26'	1 017	1 454	1 852	2 235	1 639	42
'RR-361-1'	1 105	1 735	2 024	2 224	1 772	36
'Jaldi-6'	957	1 382	1 789	1 704	1 458	32
'RR-166-645'	1 285	1 724	2 147	2 445	1 900	31
'RR-348-6'	1 139	1 750	2 287	2 341	1 879	36
'Heera'	869	1 465	1 633	1 817	1 446	35
'Saria'	1 054	1 476	1 498	1 320	1 337	18
Mean	1 097	1 599	1 919	1 988	1 651	
CV (%)	15	11	14	19	13	

Critical difference (0.05) (kg/ha) : Fertilizers : 214 (2003), 77 (2004), 415 (2005) and 269 (pooled)

Genotypes: 129 (2003), 121 (2004), 285 (2005) and 171 (pooled)

Between genotypes at a fertilizer level : 257 (2003), 243 (2004), 569 (2005) and 342 (pooled)

Between fertilizer levels for a genotype : 323 (2003), 239 (2004), 677 (2005) and 388 (pooled)

Table 2 Ranking of performance of rice genotypes at different levels of fertilizer at Phulbani

Genotype	Control		20–10–10		40–20–20		60–30–30		Rank sum		λ_g
	g_a	g_b	g_a	g_b	g_a	g_b	g_a	g_b	g_a	g_b	
'Vandana'	1	1	1	2	3	2	6	2	11	7	–0.8
'ZHU-11-26'	6	8	7	8	5	4	3	8	21	28	–2.1
'RR-361-1'	4	5	3	6	4	7	4	4	15	22	–0.9
'Jaldi-6'	7	6	8	4	6	8	7	5	28	23	–1.5
'RR-166-645'	2	3	4	1	2	1	1	1	9	6	–0.1
'RR-348-6'	3	4	2	3	1	3	2	3	8	13	0.3
'Heera'	8	7	6	7	7	5	5	6	26	25	0.3
'Saria	5'	2	5	5	8	6	8	7	26	20	–0.4
λ_f	0.79		0.55		0.67		0.43				

g_a, Rank of mean yield; γ_b : Rank of variation; λ_f, fertilizer treatment-wise rank correlation over genotypes and λ_g, genotype-wise rank correlation over fertilizer levels

under 4 fertilizer treatments respectively in *kharif* 2005.

'ZHU-11-26' attained a minimum mean yield of 881 kg/ha with a variation of 57% while 'RR-166-645' attained a maximum mean yield of 1 521 kg/ha with a variation of 40% over the 4 fertilizer treatments during *kharif* 2003. 'Saria' attained a minimum mean yield of 647 kg/ha with a variation of 24%, while 'RR-166-645' attained a maximum mean yield of 1 154 kg/ha with a variation of 35% over 4 fertilizer treatments during *kharif* 2004. Similarly 'Saria' attained a minimum mean yield of 2 397 kg/ha with a variation of 13% while 'RR-361-1' attained a maximum mean yield of 3 201 kg/ha with a variation of 19% over the 4 fertilizer treatments during *kharif* 2005. The genotypes attained a mean yield of 1 651 kg/ha with a variation of 13% over different fertilizer treatments tested during 3 seasons.

Based on F-test, the differences between genotypes, fertilizer treatments, genotypes at a given level of fertilizer and fertilizer treatments for a given genotype were significantly different from each other in all the 3 seasons and also pooled over seasons. The response curve of genotypes was linear up to 40–20–20 kg/ha and was a plateau beyond that level. However, it significantly increased beyond 40–20–20 kg/ha in 'ZHU-11-26' and 'RR-166-645'. The genotypes attained a higher mean yield at higher fertilizer doses with a lower variation.

Estimates of correlation between different variables

Estimates of Spearman rank correlation were derived between the ranks attained by genotypes for mean and variation under each fertilizer treatment. Rank analysis was carried out for the ranks assigned to mean and variation attained by a genotype at each level of fertilizer application over 3 seasons. Based on the ranks assigned to mean yield attained by genotypes at 4 levels of NPK fertilizer(Table 2), 'Vandana' was superior in both control and 20–10–10 kg/ha treatment while 'RR-348-6' was superior in 40–20–20 kg/ha and 'RR–166–645' was superior in 60–30–30 kg/ha application. It was observed that from the ranks assigned to the coefficient of variation of yield attained by a genotype at 4 fertilizer treatments, 'Vandana' was superior in control while 'RR–166–645' was superior under 20–10–10, 40–20–20 and 60–30–30 kg/ha application. The over-all rank sums indicated that 'RR-348-6' was superior with a minimum rank sum of 8 for mean yield while 'RR-166-645' was superior with a minimum rank sum of 6 based on variation over 4 fertilizer treatments. 'RR-166-645' was the second best with a rank sum of 9 based on mean yield while 'Vandana' was the second best with a rank sum of 7 based on variation and the third best based on mean yield with a rank sum of 11. 'RR-348-6' ranked the first based on mean yield was the third best based on variation with a rank sum of 13. The rank correlation (l_f) between ranks assigned to the mean and variation of genotypes under each fertilizer treatment indicated that the ranks of genotypes were significantly correlated in control with a maximum rank correlation of 0.79 followed by 0.67 under 40–20–20 kg/ha, 0.55 under 20–10–10 kg/ha and 0.43 under 60–30–30 kg/ha of application. However, the rank correlation (l_g) of genotypes over 4 fertilizer levels indicated that performance of a genotype was negatively correlated with its variation in different seasons for all genotypes except 'RR-348-6' and 'Heera'.

Multivariate regression models for prediction of grain yield of rice genotypes

Multivariate regression models (Draper and Smith 1995 and Maruthi Sankar and Vanaja 2003) were calibrated to assess the contribution of crop seasonal rainfall, rainy days and fertilizer N, P and K variables for prediction of yield in different seasons. The performance of upland rice genotypes was assessed (Table 3) based on the estimates of coefficient of determination (R^2), prediction error (F) and sustainability yield index (h) over 3 seasons as discussed by Maruthi Sankar *et al.* (2001) and Vittal *et al.* (2002 and 2003). Multivariate regression models of each genotype were calibrated for predicting grain yield through rainfall during crop growing period (CRF), linear and quadratic variables of fertilizer nitrogen (FN), phosphorus (FP) and potassium (FK) nutrients, and interactions of fertilizer and rainfall variables

Table 3 Multivariate regression models of upland rice genotypes at Phulbani

Genotype	Multivariate regression model	R^2	Φ	η
'Vandana'	$Y = -2969^{**} + 4.50^{**}\,CRF + 44.54\,(FN) - 0.48^{*}\,(FN^2) +)\; 89.07\,(FP) - 1.90^{*}\,(FP^2) + 89.07\,(FK) - 1.90^{*}\,(FK^2) - 0.02\,(FN)\,(CRF) - 0.02\,(FP)\,(CRF) - 0.02\,(FK)\,(CRF$	0.92**	327	0.40
'ZHU-11-26'	$Y = -3619^{**} + 4.85^{**}\,(CRF) + 3.54\,(FN) - 0.03\,(FN^2) + 4.76\,(FP) - 0.14\,(FP^2) + 4.68\,(FK) - 0.14\,(FK^2) + 0.002\,(FN)\,(CRF) + 0.011\,(FP)\,(CRF) + 0.04\,(FK)\,(CRF)$	0.92**	435	0.36
'RR-361-1'	$Y = -3812^{**} + 5.16^{**}\,(CRF) + 25.43\,(FN) - 0.27\,(FN^2) + 50.85\,(FP) - 1.08\,(FP^2) + 50.85\,(FK) - 1.08\,(FK^2) + 0.01\,(FN)\,(CRF) + 0.02\,(FP)\,(CRF) + 0.02\,(FK)\,(CRF)$	0.97**	272	0.40
'Jaldi-6'	$Y = -2874^{**} + 3.98^{**}\,(CRF) + 21.72\,(FN) - 0.32\,(FN^2) + 43.45\,(FP) - 1.27\,(FP^2) + 43.45\,(FK) - 1.27\,(FK^2) + 0.01\,(FN)\,(CRF) + 0.02\,(FP)\,(CRF) + 0.02\,(FK)\,(CRF)$	0.92**	333	0.32
'RR-166-645'	$Y = -2543^{**} + 4.0^{**}\,(CRF) + 6.66\,(FN) - 0.09\,(FN^2) + 14.0\,(FP) - 0.35\,(FP^2) + 35.03\,(FK) - 0.35\,(FK^2) + 0.004\,(FN)\,(CRF) + 0.02\,(FP)\,(CRF) + 0.02\,(FK)\,(CRF)$	0.97**	197	0.43
'RR-348-6'	$Y = -31.47^{**} + 4.46^{**}\,(CRF) + 29.16\,(FN) - 0.35\,(FN^2) + 58.31\,(FP) - 1.39\,(FP^2) + 58.31\,(FK) - 1.39\,(FK^2) + 0.01\,(FN)\,(CRF) + 0.03\,(FP)\,(CRF) + 0.03\,(FK)\,(CRF)$	0.96**	258	0.42
'Heera'	$Y = -3135^{**} + 4.21^{**}\,(CRF) + 18.01\,(FN) - 0.26\,(FN^2) + 36.01\,(FP) - 1.03\,(FP^2) + 36.01\,(FK) - 1.03\,(FK^2) + 0.01\,(FN)\,(CRF) + 0.03\,(FP)\,(CRF) + 0.03\,(FK)\,(CRF)$	0.95**	283	0.32
'Saria'	$Y = -2538^{**} + 3.77^{**}\,(CRF) + 20.28\,(FN) - 0.38^{*}\,(FN^2) + 40.56\,(FP) - 1.50^{*}\,(FP^2) + 40.56\,(FK) - 1.50^{*}\,(FK^2) + 0.01\,(FN)\,(CRF) + 0.01\,(FP)\,(CRF) + 0.01\,(FK)\,(CRF)$	0.97**	182	0.29

*P=0.05; **P=0.01; CRF, crop season rainfall (mm); FN, fertilizer N (kg/ha); FP, fertilizer P (kg/ha); FK, fertilizer K (kg/ha); R^2, coefficient of determination; Φ, prediction error (kg/ha); η, sustainability yield index

under different fertilizer treatments tested during 2003, 2004 and 2005 seasons. The regression models were found to have a high and significant predictability of yield ranging from a minimum of 0.92 for 'Vandana', 'ZHU-11-26' and 'Jaldi-6' genotypes to a maximum of 0.97 for 'RR-361-1', 'RR-166-645' and 'Saria' genotypes in the study. However, there was a wide range in the prediction error of yield of genotypes based on regression models calibrated. It ranged from a minimum of 182 kg/ha for 'Saria' to a maximum of 435 kg/ha for 'ZHU-11-26'. Among different variables, crop seasonal rainfall had a significant influence on grain yield attained by all genotypes. Apart from rainfall, the quadratic variables of fertilizer N, P and K had a negative and significant influence on grain yield attained by 'Vandana' and 'Saria' genotypes.

An estimate of sustainability yield index of each genotype was derived by considering its mean yield over fertilizer treatments and seasons, minimum prediction error from regression models of genotypes and maximum yield potential of rice from yields of genotypes attained at different fertilizer levels in 3 seasons. The indices were derived by considering a minimum prediction error of 182 kg/ha based on the model calibrated for 'Saria' and maximum yield potential of 3 994 kg/ha attained by 'ZHU-11-26' with an application of 60-30-30 kg/ha during *kharif* 2005. Among different genotypes evaluated, 'RR-166-645' was superior with a maximum sustainability yield index of 0.43, followed by 'RR-348-6' with 0.42. 'Vandana' and 'RR-361-1' were the next best genotypes with an index of 0.40. 'Saria' attained a minimum index of 0.29.

Optimization of fertilizer requirement of genotypes for maximum productivity

Based on multivariate regression models of genotypes, fertilizer adjustment equations of N, P and K were derived for attaining maximum and economic yield of rice under rainfed conditions (Table 4). The fertilizer adjustment equations for maximum yield were derived as a function of crop seasonal rainfall received from sowing to harvest of the crop. Similarly, equations were derived as a function of crop seasonal rainfall and ratio of cost of fertilizer and value of the crop for economic yield. Since fertilizer K applied was same as that of P, the fertilizer adjustment equations of K would be same as those of P. Accordingly the optimum P and K would be same for maximum yield, while they differ for economic yield because of differences in P and K fertilizer prices.

The optimum fertilizer N, P and K doses of each of the 8 rice genotypes at 750, 1 000 and 1 250 mm of crop seasonal

Table 4 Optimum fertilizer doses for maximum and economic yield of rice at Phulbani

Genotype	Fertilizer adjustment equation	Optimum fertilizer (kg/ha) doses at a crop seasonal rainfall of								
		750 mm			1000 mm			1250 mm		
		N	P	K	N	P	K	N	P	K
Maximum yield										
'Vandana'	N = 46 + 0.02 CRF P = 23 + 0.01 CRF	61	31	31	66	33	33	71	36	36
'ZHU-11-26'	N = 59 + 0.03 CRF P = 17 + 0.04 CRF	62	47	47	69	57	57	77	67	67
'RR-361-1'	N = 47 + 0.02 CRF P = 24 + 0.01 CRF	62	32	32	67	34	34	72	37	37
'Jaldi-6'	N = 34 + 0.02 CRF P = 17 + 0.01 CRF	49	25	25	54	27	27	59	30	30
'RR-166-645'	N = 37 + 0.02 CRF P = 20 + 0.03 CRF	52	43	43	57	50	50	62	58	58
'RR-348-6'	N = 42 + 0.01 CRF P = 21 + 0.01 CRF	50	29	29	52	31	31	55	34	34
'Heera'	N = 35 + 0.02 CRF P = 18 + 0.01 CRF	50	26	26	55	28	28	60	31	31
'Saria'	N = 27 + 0.01 CRF P = 14 + 0.003 CRF	35	16	16	37	17	17	40	18	18
Economic yield										
'Vandana'	N = 46 + 0.02 CRF – 1.04 R P = 23 + 0.01 CRF – 0.26 R	59	30	30	64	32	33	69	35	35
'ZHU-11-26'	N = 59 + 0.03 CRF – 16.67 R P = 17 + 0.04 CRF – 3.57 R	50	36	42	57	46	52	65	56	62
'RR-361-1'	N = 47 + 0.02 CRF – 1.85 R P = 24 + 0.01 CRF – 0.46 R	58	30	31	63	33	33	68	35	36
'Jaldi-6'	N = 34 + 0.02 CRF – 1.56 R P = 17 + 0.01 CRF – 0.39 R	46	23	24	51	26	26	56	28	29
'RR-166-645'	N = 37 + 0.02 CRF – 5.56 R P = 20 + 0.03 CRF – 1.43 R	41	38	41	46	46	48	51	53	56
'RR-348-6'	N = 42 + 0.01 CRF – 1.43 R P = 21 + 0.01 CRF – 0.36 R	47	27	28	49	30	31	52	32	33
'Heera'	N = 35 + 0.02 CRF – 1.92 R P = 18 + 0.01 CRF – 0.49 R	46	24	25	51	27	27	56	29	30
'Saria'	N = 27 + 0.01 CRF – 1.32 R P = 14 + 0.003 CRF – 0.33 R	32	15	16	34	16	17	37	17	17

CRF, Crop seasonal rainfall (mm); R, cost of fertilizer (per kg)/value of crop (per kg)

rainfall for attaining maximum and economic yield revealed that the doses for attaining maximum yield were minimum for 'Saria' and maximum for 'ZHU-11-26' genotype. The optimum N ranged from 35 to 62 kg/ha at 750 mm, 37 to 69 kg/ha at 1 000 mm and 40 to 77 kg/ha at 1 250 mm of crop seasonal rainfall. The optimum P and K doses for maximum yield ranged from 16 to 47 kg/ha at 750 mm, 17 to 57 kg/ha at 1 000 mm and 18 to 67 kg/ha at 1 250 mm of crop seasonal rainfall.

The optimum N, P and K doses for attaining economic yield were minimum for 'Saria', while optimum N was maximum for 'Vandana' and optimum K was maximum for 'ZHU-11-26' at 750, 1 000 and 1 250 mm rainfall. However, optimum P dose was maximum for 'RR-166-645' at 750 and 1 000 mm and 'ZHU-11-26' at 1 250 mm of crop seasonal rainfall based on the study. The optimum N dose was found to range from 32 to 59 kg/ha at 750 mm, 34 to 64 kg/ha at 1 000 mm and 37 to 69 kg/ha at 1 250 mm of crop seasonal rainfall. The optimum P ranged from 15 to 38 kg/ha at 750 mm, 16 to 46 kg/ha at 1 000 mm and 17 to 56 kg/ha at 1 250 mm of crop seasonal rainfall. The optimum K ranged from 15 to 38 kg/ha at 750 mm, 16 to 46 kg/ha at 1 000 mm and 17 to 56 kg/ha at 1 250 mm of crop seasonal rainfall in the study. The optimum N, P and K doses were found meaningful and closer to the levels used in the field experiments conducted. Among genotypes, 'RR-166-645' was found superior with a maximum yield predictability of 0.97 and sustainability of 0.43. Thus the study has given scope for optimizing fertilizer doses of N, P and K nutrients for 8 different short duration genotypes of rice at varying levels of crop seasonal rainfall for attaining maximum and economic yield under moist sub-humid Alfisols at Phulbani.

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