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Responses of hybrids to N, P and K in different rice soils

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ABSTRACT

Multi-location field experiments under Directorate of Rice Research during wet season 2002-03 and 2003-04 on responses of hybrids and inbreds to applied N, P and K revealed that the differences among hybrids/high yielding cultures and fertilizer treatments were significant at substantial number of locations while the interactions viz., varieties x fertilizer treatments were significant at majority of the centers. The paired t-test revealed that hybrids had a significant yield advantage of 0.82 t ha^{-1} during 2002 and 1.01 t ha^{-1} during 2003 over high yielding cultures indicating superiority of hybrids. With respect to responses of applied N, P and K nutrients, hybrids were found significantly superior to high yielding cultures for N responsiveness while response to P and K responses was not significant between hybrids and high yielding cultures. A significant positive relationship (R=0.51 to 0.57) between P availability in soils and response to applied N could be established irrespective of factors like variety and soil textural conditions and soil pH. Based on data from 9 locations in clay loam soils, no significant relationship between soil pH and response to N could be observed, while a negative relationship between soil pH and response to N could be established in clay soils. However, similar response was observed with hybrids and inbred rice varieties to applied P and K.

Key words: *rice hybrids, N, P, K response, rice soils*

Meeting the food requirements of growing population is a matter of concern in India. To feed this predominantly rice eating population, the rice production should be elevated from the present 131 million tonnes to 200 million tonnes by 2020 (Anonymous, 2000). However, there is either stagnation or at times deceleration in growth of rice production in recent years is creating alarming situation for food security of the country. Shrinking of agriculture land is, further, worsening the situation much graver. Therefore there is thrust to enhance the rice yields by increasing genetic potential of the rice plant and with improved management practices. Of late, hybridization is identified as one of the thrust areas to enhance the genetic potential of rice plant. At present hybrid rice technology for large scale production has a yield advantage of 15 to 20 percent or 1 tonne of grain yield per hectare over the best high yielding inbred cultures. In India, though substantial progress have been made in development of hybrid rice and some hybrids have already been released for farmer's cultivation, matching management technologies are yet to be developed for the best utilization of these hybrids. Multi-location testing may provide an opportunity to test different management practices and evolve strategies for improving the productivity of rice in different agro-climatic conditions. Even with application of recommended doses of NPK (120:60:30 kg ha^{-1}) it was not possible to sustain the productivity of rice-rice system on long term basis (Nambiar and Abrol, 1991). In the present study an attempt was made to evaluate the responses of hybrid rice vis-à-vis inbreds with respect to nitrogen, phosphorus and potassium application and their interaction under different soil conditions.

MATERIALS AND METHODS

Field experiments were conducted under All India Coordinated Rice Improvement Programme in 30 and 27 locations during wet seasons of 2002-03 and 2003-04, respectively. The field experiments were laid out in split plot design with varieties in main plots and 12 combinations of different levels of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) in subplots. As each nutrient had three levels resulting 27 total number of combinations, which is difficult to test under field conditions, only 12 combinations were chosen to represent all the levels for each nutrient. The NPK availability status of soil was low to high and varied across the locations and available soil data including pH was presented in Table 1. The treatment combinations chosen were T_1- $N_0P_0K_0$, T_2- $N_0P_{60}K_{30}$, T_3- $N_{120}P_0K_{30}$, T_4 $N_{120}P_{60}K_0$, T_5- $N_{120}P_{60}K_{30}$, T_6- $N_{120}P_{60}K_{60}$, T_7- $N_{120}P_{80}K_{30}$, T_8- $N_{120}P_{80}K_{60}$, T_9- $N_{150}P_{60}$ K_{30}, T_{10}- $N_{150}P_{60}K_{60}$, T_{11}- $N_{150}P_{80}K_{30}$ and T_{12}- $N_{150}P_{80}K_{60}$. The main objective was to assess the response of hybrids and inbreds to major nutrients for enhancing the productivity. Nitrogen in the form of prilled urea in 3 splits (50% basal, 25% at maximum tillering stage and 25 % at booting stage); P_2O_5 in the form of single super phosphate all in basal and K_2O in the form of muriate of potash in 2 splits (75% at basal and 25% at PI stage) were applied. One of the two hybrids KRH-2 and PHB-71 and two local popular inbred

Table 1. Nutrient response, status, soil type and pH at different locations of India

	Response to nutrient			Nutrient availability in soil (kg ha^{-1})					
Locations	N	P	K	N	P	K		Soil type	pH
Mandya	*	*	*	241	54	182	1	Red sandy loam	7.2
Faizabad	*	ns	ns	200	24	234	2	Sandy loam	7.5
Kanpur	*	*	ns	106	14.4	117	2	Sandy loam	8
Nawagam	*	ns	ns	48	42.2	467.7	2	Sandy loam	7.4
Varanasi	*	ns	ns	181.6	26.7	210	2	Sandy loam	7.3
Kapurthala	*	ns	ns	-	-	-	3	Loam	9
Chiplima	*	ns	ns	247	8.6	255	4	Sandy clay loam	6.5
Gerua	*	ns	ns	-	-	-	4	Silty Clay loam	5.1
Arundhathi Nagar	ns	ns	*	-	16	190	5	Clay loam	5.5
Coimbatore	ns	*	ns	350	18	540	5	Clay loam	7.5
Chakda	*	*	ns	-	22	197.2	5	Clay loam	7
Karimganj	*	ns	ns	289.1	9.2	124.3	5	Clay loam	4.9
Kota	*	ns	*	-	18	-	5	Clay loam	8.2
Kaul	*	ns	ns	180	32	381	5	Clay loam	8.1
Rewa	*	ns	ns	270	9.6	332	5	Clay loam	7.7
Ranchi	*	*	ns	217	36.4	171.6	5	Clay loam	6.4
Rajendranagar	*	ns	ns	257	26	270	5	Clay loam	8.2
Titabar	ns	ns	*	450	12	150	5	Clay loam	5.2
Umiam	ns	ns	ns	-	-	-	5	Clay loam	
Wangbal	ns	ns	*	low	low	low	5	Clay loam	5.5
Raipur	*	*	*	218	22	310	6	Silty Clay	7.1
Aduthurai	*	ns	ns	209.4	30	295.2	7	Clay	7
Annanagar	*	*	ns	246.5	18.5	200.8	7	Clay	6.6
DRR	*	*	*	230	30	380	7	Clay	7.5
Parbani	*	*	ns	-	-	-	7	Clay	8.3
Patna	*	ns	ns	285	32	345	7	Clay	7.2
Chatha	*	*	ns	195	13.4	110		-	7.5
Karjat	*	*	ns	211	22	319		-	6.5
Pusa	*	*	*	256.4	32.4	106.4		-	8
Sabour	*	*	ns	292	26	271		-	-
Siriguppa	*	*	ns	337	25	400		-	8
Umsing	*	ns	ns	-	8.3	105.4		-	5.2
Upper Shillong	*	Ns	ns	-	8.2	116.5		-	5.2

*-statistically significant in most of the times over the years and varieties tested; ns –not significant

varieties (chosen by respective location) were involved in the experiment. The crop was managed as per standard agronomic practices and observations on grain yield plot^{-1} were recorded at harvest leaving two border rows in all sides. The grain yield was converted to kg per hectare before statistical analysis. Grain yield was analyzed by analysis of variance to asses the differences in the effect of treatments and varieties and their interactions. Multiple regression technique was used to study the fertilizer responses (Snedecor and Cochran, 1968). Location wise and variety wise yield response to N, P and K was calculated to draw meaningful conclusions

RESULTS AND DISCUSSION

The analysis of variance revealed that during wet season of 2002-03, out of 30 centers where the experiment was carried out, difference among fertilizer treatments was significant at 29 centres, the differences among hybrids and inbreds at 25 locations and the interaction (varieties x fertilizer treatments) at 16 locations. During *wet season* 2003-04, out of 27 locations, the corresponding figures were 26, 20 and 14 centers, respectively (Table 2). When location wise performance of hybrids was compared, hybrids out yielded the high yielding cultures in almost all the locations. The mean grain yield data of the hybrids as a group and high yielding cultures as another group, based on all the locations and fertilizer treatments by paired t-test revealed that hybrids had a significant yield advantage of 0.82 t ha^{-1} during wet season 2002 and 1.01 t ha^{-1} during *wet season* 2003-04 over inbreds. Similar results of higher grain yields of hybrids reported across the locations (Anonymous, 2002 and 2003). In addition, the comparison of variances of hybrids and high yielding cultivars showed that the yield consistency is same in both indicating suitability of hybrids across the locations.

Multiple regression analysis on the effect of responsiveness of hybrids and inbreds to individual nutrients could work out the intercepts which represent the minimum grain yield that a hybrid or an inbred can produce by utilizing native soil fertility without any addition of fertilizer nutrients. These values for hybrids were 3.36 and 3.49 t ha^{-1} during 2002 and 2003, respectively, while the corresponding values for inbreeds were 2.81 and 3.00 t ha^{-1} respectively, recording significant differences between hybrids and inbred varieties.

The responses of hybrids and inbreds to applied N, when computed as kgs of grain ha^{-1} per each kg of N applied to soil, the hybrids were significantly superior (0.01803 t ha^{-1}) to high yielding

Table 2. Comparison of intercepts, nutrient responses, grain yield in hybrid and inbreds during wet season of 2002 and 2003

	Wet season, 2002		Wet season, 2003	
	Hybrids	Inbreds	Hybrids	Inbreds
Intercepts				
Mean grain yield (t ha^{-1})	3.36	2.81749	3.49	3.00
t Stat	2.72**		2.10*	
Response to N				
Mean (grain yield t ha^{-1} kg N ha^{-1} applied)	0.018	0.014	0.015	0.012
t Stat	3.09**		1.75*	
Response to P				
Mean (grain yield t ha^{-1} kg P ha^{-1} applied)	0.008	0.007	0.009	0.008
t Stat	0.72ns		0.61ns	
Response to K				
Mean (grain yield t ha^{-1} kg K ha^{-1} applied)	0.007	0.006	0.007	0.007
t Stat	0.24ns		0.08ns	
Mean grain yield (t ha^{-1})	5.97	5.15	6.23	5.22
t Stat	20.04**		24.16**	

NB-response means increase in grain yield (t ha^{-1}) kg^{-1} applied nutrient

Table 3. Mean of intercepts, regression coefficients of N, P and K in selected hybrid and inbred varieites

Variety	Intercept	Response to N	Response to P	Response to K	No of locations
2002					
PHB-71	3.46	0.0160	0.0099	0.0075	11
KRH-2	3.15	0.0201	0.0078	0.0072	13
Jaya	3.16	0.0115	0.0071	0.0068	29
2003					
PHB-71	3.28	0.0125	0.0094	0.0133	5
KRH-2	3.23	0.0149	0.0097	0.0117	13
Jaya	2.74	0.0125	0.0089	0.0059	18

NB-response means increase in grain yield (t ha^{-1}) kg^{-1} applied nutrient

cultures (0.01376 t ha^{-1}) during 2002 and 2003 (Table 3). Om Hari *et.al*., (1998) also reported that the higher grain yield under high N level attribute to the fact that nitrogen being the constituent of enzymes and protein, enhanced cell expansion increases metabolic processes. This indicated that hybrids were more efficient than high yielding cultures in utilizing the fertilizer applied to the soil. However the 't' test with respect to the responses of hybrids/high yielding cultures to applied P and K clearly showed that high yielding cultures and hybrids were at par. Application of graded levels of NPK increased the grain yield significantly in hybrids (Singh and Subbaiah, 2007).

Detailed analysis with selected rice hybrids *viz*., PHB-71 and KRH-2 and the selected variety Jaya was made with regard to N, P and K responses at selected centers (Tables 3 and 4). The results indicated that KRH-2 was the best hybrid with regards to response to N (20.1 kg grain kg^{-1} N applied) and was significantly superior to PHB-71 (16 kg grain kg^{-1} of N applied) and Jaya (11.5 kg grain kg^{-1} of N applied) during *wet season* 2002. However, with regard to response to applied K, during *wet season* 2003, both the hybrids (KRH-2 and PHB-71) were significantly superior (11.7 and 13.3 kg grain respectively kg^{-1} K applied) to the variety Jaya (5.9 kg grain kg^{-1} K applied), but both the hybrids were at par (Table 3 and 4). The increased response to nutrient in case of hybrids to added nutrients is associated with better nutrient use efficiencies (Surekha *et al.,* 2001). With respect to varietal response to P, there was no significant difference.

Multiple linear regression equations were fitted on grain yield with applied N, P and K levels for all hybrids/inbreds in all locations in both the years. A generalized responsiveness to N, P and K over all the varieties in both the years in each location and nutrient availability status of soil (N, P and K), along with the textural classification and pH is presented in Table 1. The results showed that response to N was significant at 28 centers while response to P and K was significant at 14 and 8 centers respectively out of a total of 33 centers. Though it is known fact for inbred varieties, this indicates 'N' is the most important nutrient even for hybrids, for obtaining higher productivity at majority

Table 4. Statistical significance of different parameters between selected varieites

Comparison	Intercept	Response to N	Response to P	Response to K
2002				
Jaya vs PHB-71	ns	*	ns	ns
Jaya vs KRH-2	ns	**	ns	ns
PHB-71 vs KRH-2	ns	*	ns	ns
2003				
Jaya vs PHB-71	ns	ns	ns	**
Jaya vs KRH-2	ns	ns	ns	**
PHB-71 vs KRH-2	ns	ns	ns	ns

Ns-not significant;*-significant at 5% level and **-significant at 1% level of the centers followed by P and K. Comparison of response of N in relation to textural classification of soil at different centers (Fig. 1) indicated that red sandy soil with neutral pH (7.2) represented by Mandya resulted in higher response to N, followed by silty clay loam with neutral pH (7.1) represented by Raipur and sandy loam soil (Faizabad, Kanpur, Varnasi and Nawagam). Lowest response to N was observed at Kapurthala due to loamy soil condition with alkaline pH *i.e.* 9.0 (Fig 1).

The relationships between availability of nutrients in soil with response of nutrients over the locations, seasons and hybrids/inbreds indicated a significant positive relationship of P availability and response to N (R=0.5669, 0.5107 in 2002 and 2003, respectively) (Table 5, Fig 2). It is also apparent that at majority of the centers involved in the study, the status of available 'P' in the soil was the most limiting factor for higher level of response to N irrespective of factors like variety, and other soil textural conditions and soil pH.

Based on the results of the present study it may be concluded that hybrids had a significant yield advantage over high yielding varieties and superior N responsiveness, while with respect to response of P and K, there was no significant difference. A significant positive relationship between P availability in soils and response to applied N was established irrespective of factors like variety and soil texture and soil pH. Significant positive relationship of soil available P with response to N proved that P is the limiting factor for yield increase in hybrids as well as inbred varieties.

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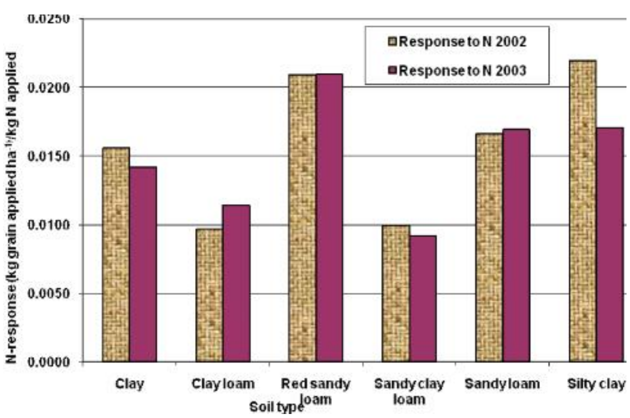

Fig.1. Response to N by soil type, wet season 2002 and 2003

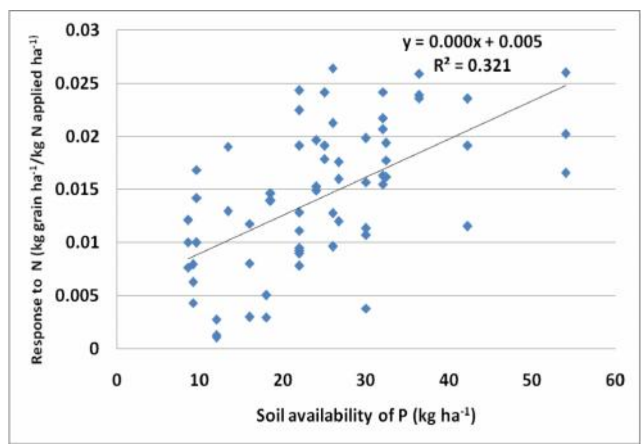

Fig 2. The effect of availability of P in soil on response to N, during wet season 2003

Table 5. Relationship of nutrient availability in soil and responsiveness of rice varieties to NPK

	Available nutrient status in soil					
	2002			2003		
	N	P	K	N	P	K
N-responiveness	-0.4134**	0.5669**	0.0091	-0.1738	0.5107**	-0.0679
P-responsiveness	0.15428	0.0639	0.044541	0.2969**	-0.0961	-0.0192
K-responsiveness	0.1310	-0.0732	-0.17967	0.1217	-0.1104	-0.2955

Responsiveness - grain yield t ha^{-1} kg nutrient ha^{-1} applied

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