Response of Rice (*Oryza sativa* L.) Hybrids under Different Nutrient Management Practices during *Boro* Season

Biplab Show[1], Megha Sana[1*] and Sukanta Pal[1]

[1]*Department of Agronomy, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur-741252, Nadia, West Bengal, India.*

Authors' contributions

This work was carried out in collaboration among all authors. Author BS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MS and SP managed the analyses of the study. Author MS managed the literature searches. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Aim: To study the effect of rice hybrids to different nutrient management practices to find out the most suitable nutrient management and variety for hybrid rice in new alluvial zone of west Bengal.
Study Design: The experiment was laid out in Factorial Randomized Block Design (FRBD) with 20 treatment combinations with three replicates.
Place and Duration of Study: *Rabi* seasons of 2011-12 and 2012-13 at Regional-Research Sub-Station (RRSS) Chakdaha of BCKV under new alluvial zone of West Bengal.
Methods: Combinations having with five hybrid rice varieties viz., V_1 (Winner), V_2 (Champion) V_3 (Raja), V_4 (Karishma) V_5 (KRH-2), and four nitrogen levels viz. N_1 (150:75:75 N: P_2O_5: K_2O Kg/ha), N_2 (75%N of N_1+ full dose of P_2O_5 & K_2O as recommended in N_1+ 25% N through FYM), N_3 (50%N of N_1+ full dose of P_2O_5 & K_2O as recommended in N_1+ 50% N through FYM), N_4 (120:60:60 N: P_2O_5: K_2O Kg/ha) Generally yield contributing characters were studied at maturity of the crop. For yield analysis samples were taken from each plot and yield attributes were calculated.
Results: Experimental results revealed that almost all the growth parameters and yield attributes gave significantly superior performance in the variety Champion with N_1 level of

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*Corresponding author: E-mail: meghasana31@gmail.com;

fertilization. The maximum grain yield (7.49 t ha^{-1}) was recorded in the variety V_2 in combination with N_1 level of nitrogen. Highest harvest index (52.23%) was noticed in same treatment combination.

Conclusion: It may be concluded that Champion can be recommended for South Bengal locations with N_1 (i.e.150:75:75 N: P_2O_5: K_2O Kg ha^{-1}) nutrient level for maximum grain yield.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereal crops of India and is used as a staple food for more than 60% of the total population of the country [1] and contributes about 42% of countries food grain production. In India, the state of West Bengal ranks first with acreage of 5.80 million ha with the largest production of 15.5 million tonnes [2], still the demand for rice is increasing day by day due to enormous population growth. On the other hand, due to yield plateau in high yielding rice in our country, yield growth has slowed down like other south-east Asian countries due to lack of expansion in acreage. Hybrid rice technology has been proved to be one of the most feasible and readily adoptable approaches to meet the domestic demand. The rice hybrids, recently introduced in cultivation, on an average, give 20-30% higher yield over the high yielding varieties [3].

Agricultural sustainability depends to a extent upon improvements in soil properties – mineral nutrition one of them. But use of sole chemical fertizers to supply needed plant nutrients had adverse effect on fertility and productivity status of soil. So use of organic and inorganic sources of nutrients help in sustaining productivity and biological health of soil and also meet chemical fertilizer requirements of crops as no single source of nutrients is capable of supplying plant nutrients in adequate and balanced proportion. More integrated efforts of researchers, extension workers and farmers would be desirable to make hybrid rice cultivation a successful endeavor in India. Hence an experiment has been made to integrate organic and inorganic sources of nutrients in hybrid rice for higher yield and to evolve sustainable management.

2. MATERIALS AND METHODS

A field experiment was conducted in 2011-12 and 2012-13 during *boro* season at Regional Research Sub-Station, Chakdaha under Bidhan Chandar Krishi Viswavidyalaya West Bengal. The climate of the experimental site is humid subtropical with hot humid, long summer and mild short winter. The experiment was conducted under irrigated shallow medium land situation, having medium fertility status with good drainage facility. The soil of the experimental field was sandy clay loam in texture (Entisol) with pH 7.0, EC 0.61 ds m^{-1}, organic carbon 0.68%, available N 184 kg ha^{-1}, available P 16.00 kg ha^{-1} and available K 126.10 kg ha^{-1}. The experiment was laid out in Factorial Randomized Block Design (FRBD) with 3 (three) replicates. The 4 m × 3 m experimental plots were made with 0.5 m bunds leaving 1 m irrigation channel in between. Hybrid rice varieties used in the experiment were Winner, Champion, Raja, Karishma and KRH-2. Four levels of nitrogen [N_1 (150:75:75 N: P_2O_5: K_2O Kg/ha), N_2 (75%N of N_1+full dose of P_2O_5& K_2O as recommended in N_1+ 25% N through FYM), N_3 (50%N of N_1+full dose of P_2O_5& K_2O as recommended in N_1+ 50% N through FYM), N_4 (120:60:60 N: P_2O_5: K_2O Kg/ha)] were applied to prescheduled experimental plots. One fourth of total N, entire amount of P and three fourths of K were applied as basal after draining out the standing water but before final puddling. Remaining N was top dressed in three equal splits, each at three weeks after transplanting, panicle initiation and panicle emergence stages. Remaining one fourth of K was also applied at panicle initiation stage. FYM were applied at the time of land preparation as per recommendation of the plots. Well germinated seeds of hybrid rice (var. Winner, Champion, Raja, Karishma and KRH-2) @ 15 g m^{-2} were sown on 9th December and 12th December of 2011 and 2012 respectively. 35 days old seedlings were transplanted. The seedlings were uprooted and transplanted at the spacing of 20 cm x 15 cm. Single seedling were planted $hill^{-1}$ at a depth of 2-3 cm as per all treatments. Nitrogen, phosphorus and potash in the form of urea, single super phosphate and muriate of potash were applied as per treatment. Gap filling was done seven days after transplanting to keep same plant population density for every plot. All other cultural and plant-protection measures were also adopted as recommended for the

region [4]. The crop was harvested on 24th April and 27th April of 2012 and 2013 respectively. The plant height was measured from the base of the plant at ground surface to the tip of the tallest leaf panicle^{-1}. Heights of five plants were taken from each replication and the mean values were computed and expressed in cm and also count the total number of tillers from each plant and the mean value were computed. For dry matter accumulation plants cut from middle row close to ground from each plot at 30, 45 and 60 DAT and then samples were oven dried at 65±5°C till constant weight was obtained. The dry weight was expressed in g m^{-2}. LAI of the samples were calculated through the area-weight relationships. LAI was expressed as the ratio of leaf area (one side only) to the ground area occupied by the plant. Finally, at maturity plot wise crop was harvested and sun-dried for three days in the field and after threshing and cleaning grain yield was recorded in t ha^{-1} and reported at 15% moisture content. Data on different yield components were recorded at harvest. Statistical analysis was done for determining the standard error of mean (S.Em±) and the value of CD (Critical difference) at 5% level of significance using standard methodology.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

There was a significant influence of interaction effects of different hybrid rice varieties (winner, champion, raja, karishma and KRH 2) and nitrogen level in case of all growth parameters namely plant height, number of tillers m^{-2}, LAI, DMA and CGR (Table 1). Maximum plant height at 90 DAT was observed in the variety Champion (V_2) with the application of higher doses of nutrient (N_1 - 150: 75: 75 N:P_2O_5:K_2O Kg/ha) level of fertilization to the tune of 101.5 cm. Higher nitrogen level encourages the carbohydrate synthesis that resulted taller plant [5]. At 90 DAT the highest number of effective tiller hill^{-1} was 15 with V_5N_1 treatment combination which was statistically at par with V_2N_1 treatment combination. In case of dry matter production the highest value was found with V_2N_1 treatment combination (790.81 g m^{-2}) which was statistically at par with V_5N_1 (781.20 g m^{-2}) & V_2N_4 (782.19 g m^{-2}) combinations. Highest dry matter accumulation was recorded during the higher doses of nutrient levels [6]. Champion along with maximum level of nutrient gave highest LAI (3.90) and LAI on flag leaf (5.99) at 90 DAT [7]. Variety KRH-2 performed (17.29 g

m^{-2} day^{-1}) best crop growth rate during 60-90 DAT along with N_1 level.

3.2 Yield Attributes

There was a significant influence of all yield attributing characters like number of panicle m^2, panicle length, panicle weight, total grains/panicle except filled grains panicle^{-1} and test weight. Among interaction effects of varieties and nutrient levels, V_5N_1 treatment combination gave highest number of panicle m^{-2} followed by the treatment V_2N_1 combination (Table2). The difference of this parameter i.e. panicle m^{-2} were mainly due to their genetic build up [8]. Panicle m^{-2} has one of the yield component for better yield in hybrid rice [9]. V_3N_4 treatment combination gave highest panicle length (28.10 cm) which was statistically at par with V_1N_1 (26.13 cm) and V_2N_1. In case of panicle weight and filled grains per panicle V_5N_1 combination gave highest result (4.10 g and 268 respectively) [10]. However best test weight (23.15 g) was obtained from V_2N_1 treatment combination.

3.3 Yield and Harvest Index

The grain yield and harvest index of paddy hybrid significantly varied among the varieties and different levels of nitrogen. However, among varieties highest grain yield (6.87 t ha^{-1}) was observed with variety V_2 i.e. Champion (NPH-207) & least with V_4 i.e. Karishma (NPH-8899). The yield differences among the hybrids were mainly due to the differences in their yield components. Sharing of total dry matter from source to the sink is also one of the major factors for enhancing the yield of hybrid rice [11]. Regarding nutrient levels highest grain yield (6.83 t ha^{-1}) showed with N_1 (i.e.150:75:75 N: P_2O_5: K_2O Kg ha^{-1}) nutrient level & least (6.04 t ha^{-1}) with N_2 (i.e.75%N of N_1 + full dose of P_2O_5& K_2O of N_1+ 25% N through FYM Kg ha^{-1}) nutrient level. Generally hybrid rice showed better grain yield then any low performing inbred varieties. This is probably due to some efficient photosynthesis, higher production in dry matter, extensive root system. Increasing trend of nitrogen level increased yield [12]. The record yield in hybrid rice production gave 7.49 t ha^{-1} with V_2N_1 treatment combination and least production gave 5.35 t ha^{-1} with V_4N_3 treatment combination.

Harvest index varied from 49.10 to 50.83% in Champion and Karishma respectively. Among the hybrid varieties, highest harvest index

Table. 1 Effect of nutrient management and varieties on growth attributes of hybrid rice (mean data of 2 years)

Treatments	Plant height (cm) at 90 DAT					No. of effective tillers hill⁻¹ at 90 DAT					Dry matter production (g m⁻²) at 90 DAT				
	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean
V_1	89.4	87.3	88.0	88.5	88.3	14.0	13.2	12.0	13.9	13.2	760.2	695.8	680.3	750.4	721.6
V_2	101.5	100.0	97.3	99.5	99.5	14.8	13.6	12.0	14.0	13.6	790.8	70.7	712.	782.1	756.4
V_3	87.3	88.0	87.2	86.6	87.2	14.1	12.5	12.0	14.0	13.1	695.3	505.8	480.1	640.2	580.3
V_4	83.6	82.1	83.0	84.0	83.1	13.9	12.5	11.7	14.0	13.0	695.1	500.2	480.7	510.7	546.6
V_5	98.6	98.0	97.6	100.0	98.5	15.0	13.2	12.0	14.1	13.5	781.2	700.2	680.2	750.2	727.9
Mean	92.0	91.0	90.6	91.7		14.3	13.0	11.9	14.0		744.5	628.5	606.6	686.7	
	V	**N**	**V x N**			**V**	**N**	**V x N**			**V**	**N**	**V x N**		
S.Em ±	0.34	0.31	0.69			0.08	0.07	0.16			3.92	3.50	7.84		
CD (0.0.5%)	1.02	0.91	2.04			0.24	0.21	0.48			11.47	10.26	22.95		

Treatments	LAI at 90 DAT					Leaf area index (LAI) of flag leaf					CGR 60-90 DAT(g m⁻²day⁻¹)				
	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean
V_1	3.20	2.99	2.86	3.00	0.029	5.00	4.84	4.31	4.92	4.76	16.37	11.24	10.29	11.21	12.27
V_2	3.90	3.21	2.86	3.00	0.084	5.99	5.67	5.40	5.20	5.56	16.84	13.11	12.90	14.21	14.26
V_3	3.61	3.25	2.97	3.21	0.029	5.49	5.21	5.00	5.31	5.25	16.40	12.00	9.90	12.00	12.57
V_4	3.24	2.99	2.86	3.00	0.084	5.68	4.92	4.89	5.00	5.12	15.28	11.00	9.95	13.12	12.33
V_5	3.68	3.00	2.98	3.10	0.029	5.90	5.46	5.32	5.90	5.64	17.29	13.29	13.00	14.11	14.42
Mean	3.52	3.08	2.90	3.06		5.61	5.22	4.98	5.26		16.43	12.12	11.20	12.93	
	V	**N**	**V x N**			**V**	**N**	**V x N**			**V**	**N**	**V x N**		
S.Em ±	0.029	0.026	0.058			0.044	0.039	0.087			0.162	0.145	0.324		
CD (0.0.5%)	0.084	0.076	0.169			0.128	0.114	0.254			0.474	0.724	1.62		

V_1- Winner, V_2-Champion, V_3-Raja, V_4-Karishma, V_5- KRH-2; N_1-150:75:75 N: P_2O_5:K_2O Kg/ha, N_2- i.e. 75% N of N_1 + 25% N through FYM, N_3- i.e. 50% N of N_1 + 50% N through FYM, N_4- 120:60:60 N: P2O5:K2O Kg/ha;
DAT- days after transplanting; LAI- leaf area index; CGR- crop growth rate;

Table. 2 Effect of nutrient management and varieties on yield components of hybrid rice(mean data of 2 years)

Treatments	Number of Panicle m^{-2}					Panicle length (cm)					Panicle weight (g)				
	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean
V_1	344	300	297	323	316	26.1	24.3	25.8	25.0	25.3	3.12	3.00	2.95	2.98	3.01
V_2	367	312	300	342	330	26.2	24.4	24.9	25.4	25.2.	3.46	2.98	3.00	3.14	3.14
V_3	307	300	300	298	301	24.8	22.5	22.4	28.1	24.4	4.04	3.31	3.42	3.98	3.68
V_4	320	297	281	300	300	24.6	21.4	22.0	23.0	22.7	3.95	3.05	3.30	3.60	3.47
V_5	381	325	322	334	340	26.1	23.1	24.4	25.1	24.7	4.10	3.33	3.42	3.95	3.70
Mean	344	307	300	319		25.6	23.1	23.9	25.3		3.73	3.13	3.21	3.53	
	V	N	V x N			V	N	V x N			V	N	V x N		
S.Em ±	0.81	3.41	7.63			0.35	0.31	0.71			0.048	0.043	0.096		
CD (0.0.5%)	2.38	9.98	22.34			1.04	0.93	2.08			0.140	0.125	0.280		
Treatments	Filled grains panicle^{-1}					Test weight (g)									
	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean					
V_1	245	200	209	230	221	22.9	22.00	21.8	22.4	22.2					
V_2	220	260	220	245	236	23.1	22.10	21.9	22.4	22.4					
V_3	247	205	220	223	224	23.0	21.00	20.9	22.1	21.7					
V_4	266	210	228	238	235	22.8	21.00	20.8	22.0	21.6					
V_5	268	209	222	230	232	23.0	22.00	21.9	22.4	22.3					
Mean	249	217	220	233		22.9	21.6	21.4	22.2						
	V	N	V x N			V	N	V x N							
S.Em ±	3.37	3.01	6.74			0.084	0.075	0.168							
CD (0.0.5%)	9.875	8.833	19.751			0.240	0.215	0.481							

V_1- Winner, V_2-Champion, V_3-Raja, V_4-Karishma, V_5- KRH-2; N_1-150:75:75 N: P_2O_5:K_2O Kg/ha, N_2- i.e. 75% N of N_1 + 25% N through FYM, N_3- i.e. 50% N of N_1 + 50% N through FYM, N_4- 120:60:60 N: P2O5:K2O Kg/ha

Table. 3. Effect of different nutrient management and varieties on Yield and harvest index of hybrid rice(mean data of 2 years)

Treatments	Grain yield (t ha^{-1})					Harvest index (%)				
	N_1	N_2	N_3	N_4	Mean	N_1	N_2	N_3	N_4	Mean
V_1	7.34	6.40	6.50	6.95	6.79	51.54	45.71	47.10	52.06	49.10
V_2	7.49	6.40	6.60	7.00	6.87	52.23	49.23	50.38	51.69	50.88
V_3	6.27	5.60	5.75	6.00	5.90	50.28	49.12	50.66	50.84	50.22
V_4	5.98	5.40	5.35	5.50	5.55	50.76	50.94	50.71	50.92	50.83
V_5	7.10	6.42	6.60	6.80	6.73	51.63	48.93	50.19	51.12	50.46
Mean	6.83	6.04	6.16	6.45		51.18	48.78	49.80	51.43	
	V	N	V x N			V	N	V x N		
S.Em ±	0.025	0.022	0.049			0.345	0.309	0.690		
CD (0.0.5%)	0.073	0.064	0.143			0.988	0.885	1.975		

V_1- Winner, V_2-Champion, V_3-Raja, V_4-Karishma, V_5- KRH-2; N_1-150:75:75 N: P_2O_5:K_2O Kg/ha, N_2- i.e. 75% N of N_1 + 25% N through FYM, N_3- i.e. 50% N of N_1 + 50% N through FYM, N_4- 120:60:60 N: P2O5:K2O Kg/ha

(50.88%) was recorded in V_2 i.e. Champion (NPH-207). Regarding nutrient levels highest harvest index (51.43%) was recorded with N_1 nutrient level i.e. 150:75:75N:P_2O_5:K_2O Kg ha^{-1} which was statistically at par (51.18) with N_4 nutrient level i.e.120:60:60N:P_2O_5:K_2OKg ha^{-1}. However among interaction effect V_2N_1 treatment combination gave highest harvest index (52.23%) which was statistically at par with most of the interaction effects.

4. CONCLUSION

From this experiment, it can be concluded that the interaction of N_1 (150:75:75 N:P_2O_5:K_2O Kg ha^{-1}) nutrient level of Nitrogen with the varietie V_2 i.e. Champion (NPH-207) has more yield potential (7.49 t ha^{-1}), could be recommended for cultivation in new alluvial zone of West Bengal.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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