Doi: HTTPS://DOI.ORG/10.23910/IJBSM/2018.9.6.1909 Natural Resource Management

Studies on Integrated Nutrient Management in Hybrid Rice (*Oryza sativa* L.) under Old Alluvial Zone of West Bengal, India

Nakul Mandal[1*], Arun Kumar Barik[1], Ashis Kumar Singha Roy[2], Pritam Ghosh[1] and Biswajit Saha[1]

[1]Dept. of Agronomy, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, Birbhum, W.B. (731 236), India
[2]Dept. of Agronomy, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal (736 165), India

Corresponding Author

Nakul Mandal
e-mail: nakul_mandal2004@rediffmail.com

Article History

Article ID: AR1909
Received in 30th September, 2018
Received in revised form 07th December, 2018
Accepted in final form 08th December, 2018

Abstract

A field experiment was conducted during *kharif* seasons of 2014 and 2015 at Instructional Farm of Dakshin Dinajpur Krishi Vigyan Kendra, Uttar Banga Krishi Viswavidyalaya, Majhian, Patiram, Dakshin Dinajpur, West Bengal, India located at 25^{0}31$^{'}$ N latitude and 88^{0}76$^{'}$ E longitude and at an altitude of 15 m above mean sea level to study the effect of integrated nutrient management on growth attributes, yield attributes, yield and economics of hybrid rice (*Oryza sativa* L.). The experiment, consisted of ten treatments, was laid out in Randomised Block Design where each treatment was replicated thrice. The test crop was grown following recommended package of practices. Standard statistical methods were followed for analysing the experimental data. Integrated nutrient management in hybrid rice significantly influenced growth attributes, yield attributes, yield and economics of hybrid rice. Application of 75% recommended dose of nitrogen (RDN) from urea+25% RDN from *dhaincha* green manure exhibited highest growth attributes, yield attributes, grain yield (5.74 t ha^{-1}), straw yield (6.59 t ha^{-1}), gross return (₹ 95175 ha^{-1}) and net return (₹ 52541 ha^{-1}) from hybrid rice. However, this was at par with the application of 100% RDN from urea followed by 75% RDN from urea+25% RDN from mustard oil cake. The highest return per rupee investment was achieved from 100% RDN from urea (₹ 2.25) though this was similar with 75% RDN from urea+25% RDN from *dhaincha* green manure (₹ 2.23).

Keywords: Hybrid rice, integrated nutrient management, yield, economics

1. Introduction

Rice is one of the most important cereal crops in India. In India by 2025 population level may reach as high as 1500 million in our country and there is an urgent need to increase the food production to meet the growing demand. The country needs about 130 mt of rice by 2025 to feed the ever growing population. India has the largest area (44.14 mha) among rice growing countries and stands second in production (106.65 mt) with a productivity of 2,416 kg ha^{-1} (Anonymous, 2017). In West Bengal, rice is grown in an area of 55.14 lakh ha with a production of 153.71 lakh tonnes and productivity of 2,788 kg ha^{-1} (Anonymous, 2017). Further, there is an urgent need to produce 50% more rice by 2025 to feed ever growing population in India with the existing limited and decreasing resources. It is estimated that rice requirement of India by 2020 will be 118.93 mt. Rice supplies 20% and 31% of the total calories required by world and Indian population, respectively (Sahane et al., 2013). Meeting the targeted demands of rice is a challenging task. Decreasing in the soil fertility and increasing in water scarcity is becoming threat for rice cultivation. Hence, the technology which maintains the soil health and water scarcity and as well as economically beneficial needs to be developed.

Presently indiscriminate use of chemical fertilisers alone has led to environmental pollution and deterioration of soil health, so balanced use of nutrients through inorganic and organic source is prerequisite to sustain soil fertility and to provide maximum crop yield with optimum input level. Beneficial effect of conjunctive use of organic and inorganic nutrients in hybrid rice were also reported by Bhowmik and Nayak (2000) and Pandey et al. (2007). Ghosh et al. (2015) estimated that only 30-50% of applied nitrogen fertilisers and 45% of phosphorus fertilisers are used for crops. However, the efficiency of applied nutrient use may be enhanced by the combined use of organic and inorganic fertilisers.

Rice productivity is now at stagnant situation or declining in areas where N-fertiliser application is very high; it has also raised the concerns about sustainability of monoculture rice. To achieve food security, hybrid rice can be one of the most feasible options to increase 15-20% of food production. The hybrid cultivars are more responsive to higher doses of nutrients and thereby the yield potentiality is all high. New

hybrid varieties have come up with the growers but their package and practices in integrated nutrient management mode was lacking. The present investigation was therefore undertaken to study the effect of integrated nutrient management on growth, yield and economics of transplanted hybrid rice.

2. Materials and Methods

A field experiment was conducted during *kharif* seasons of 2014 and 2015 at Instructional Farm of Dakshin Dinajpur Krishi Vigyan Kendra, Uttar Banga Krishi Viswavidyalaya, Majhian, Patiram, Dakshin Dinajpur, West Bengal, India located at $25^0 31^{'}$ N latitude and $88^0 76^{'}$ E longitude and at an altitude of 15 m above mean sea level to study the effect of integrated nutrient management on hybrid rice (*Oryza sativa* L.). Prior to rice cultivation soil samples were collected at the depth of 30 cm, dried and ground and passed through 40 mm sieve and analysed for physico-chemical properties following the standard methods. The soil of the experimental site was clay loam with pH (5.3) and medium in organic carbon (0.41%). The initial status of available N (Macro Kjeldahl method, Jackson 1973), P_2O_5 (Olsen's method Jackson, 1973) and K_2O (Flame photometric method, Jackson, 1973) of the experimental site was 258.7, 24.4 and 119.3 kg ha^{-1}, respectively measured by using standard methods (Jackson 1973). The experiment, consisted of ten treatments, was laid out in Randomised Block Design where each treatment was replicated thrice. The treatments were 100% RDN (120 kg N ha^{-1}) from chemical fertiliser (urea) (T_1), 75% RDN from chemical fertiliser+25% RDN from Mustard Oilcake (T_2), 75% RDN from chemical fertiliser+25% RDN from Dhaincha (T_3), 75% RDN from chemical fertiliser+25% RDN from FYM (T_4), 50% RDN from chemical fertiliser+50% RDN from Mustard Oilcake (T_5), 50% RDN from chemical fertiliser+50% RDN from Dhaincha (T_6), 50% RDN from chemical fertiliser+50% RDN from FYM (T_7), 25% RDN from chemical fertiliser+75% RDN from Mustard Oilcake (T_8), 25% RDN from chemical fertiliser+75% RDN from Dhaincha (T_9), 25% RDN from chemical fertiliser+75% RDN from FYM (T_{10}). The field was ploughed, levelled and laid out according to experimental scheme. The amount of nitrogen applied through urea. The amount of dhaincha and FYM was calculated as per the treatment on the basis of net plot area and incorporated to the soil 30 days before transplanting. The mustard oil cake was also calculated as per the treatment on the basis of net plot area and incorporated to the soil before final puddling, in which mustard oil cake was powdered before application so that the manure was spread uniformly. Among the chemical fertilisers (NPK) one fourth of total nitrogen, entire P_2O_5 and K_2O was applied after draining out the standing water but before final puddling. Top dressing of the remaining nitrogen was done in two equal splits; one at active tillering stage and the other at panicle initiation stage. Hybrid rice variety 'ARISE 6444' with seedlings of 25 days old were transplanted in a shallow depth (2-3 cm) at a spacing of 20×15 cm^2 @ 1 seedling $hill^{-1}$ on July 22 and July 19 during the year 2014 and 2015, respectively. Observations were recorded for various growth attributes, yield attributes and yield. Standard statistical methods were followed for analysing the experimental data (Gomez and Gomez, 1984).

3. Results and Discussion

3.1. Growth attributes

Different growth attributes viz. plant height, tiller number, leaf area index, dry matter accumulation, crop growth rate and net assimilation rate were recorded, statistically analysed and tabulated (Table 1). Integrated nutrient management in hybrid rice did not show any significant difference of plant height among the treatments. However, taller plant (112.85 cm) of hybrid rice was recorded with application of 25% RDN from chemical fertiliser+75% RDN from mustard oil cake and the lowest value (107.32 cm) was recorded in application of 50% RDN from chemical fertiliser+50% RDN from FYM. Significantly highest number of tillers m^{-2} (457.65) was recorded with the application of 75% RDN from chemical fertiliser+25% RDN from dhaincha green manuring from all other treatments except T_2 (447.70) where 75% RDN from chemical fertiliser+25% RDN from mustard oil cake was applied. Integrated nutrient management played an important role on leaf area index (LAI) of *kharif* hybrid rice. The LAI varied significantly among the nutrient management practices. Pooled data of two years revealed that, the highest leaf area index (LAI) was recorded at 65 DAT (5.29) with application of 50% RDN from chemical fertiliser+50% RDN from dhaincha green manure and lowest LAI (4.81) was recorded in 25% RDN from chemical fertiliser+75% RDN from FYM.

Nutrient management practices exerted positive and significant effect on dry matter accumulation of *kharif* hybrid rice. As per the pooled data the highest dry matter accumulation at 65 DAT (715.83 g m^{-2}) was recorded in treatment with 100% RDN from chemical fertiliser only. However, the result was at par with application of 75% RDN from chemical fertiliser+25% RDN from mustard oil cake (710.85 g m^{-2}) and 75% RDN from chemical fertiliser+25% RDN from dhaincha green manure (712.96 g m^{-2}). Nutrient management practices exerted significant influence on the crop growth rate of hybrid rice at 50 to 65 DAT. Significantly highest crop growth rate (16.03 g m^{-2} day^{-1}) was observed with application of 75% RDN from chemical fertiliser+25% RDN from dhaincha green manure. Although the lowest value of crop growth rate (13.40 g m^{-2} day^{-1}) was recorded with application of 25% RDN chemical fertiliser+75% RDN from dhaincha green manure.

The net assimilation rate of hybrid rice was recorded from each plot at 50 to 65 DAT was analyzed statistically. Nutrient management practices showed significant effect on net assimilation rate of *kharif* hybrid rice. As per the pooled data of both years for the growth period 50 to 65 DAT the highest

Table 1: Effect of Integrated Nutrient Management on growth attributes of hybrid rice during *kharif* season of 2014 and 2015 (pooled data)

Treatments	Plant height at harvest (cm)	No. of tiller m^{-2} area at 65 DAT	LAI at 65 DAT	DMA (g m^{-2}) at 65 DAT	CGR (g m^{-2} day^{-1}) at 50-65 DAT	NAR (g m^{-2} day^{-1}) at 50-65 DAT
T_1	112.20	440.90	5.17	715.83	15.84	3.53
T_2	109.01	447.70	5.17	710.85	15.99	3.34
T_3	111.85	457.65	5.28	712.96	16.03	3.31
T_4	109.85	432.95	4.86	680.36	15.95	3.57
T_5	112.83	436.33	4.97	674.87	14.45	3.28
T_6	111.52	441.40	5.29	683.16	15.07	3.06
T_7	107.32	431.93	4.82	659.16	15.00	3.50
T_8	112.85	426.30	5.03	639.05	14.10	3.25
T_9	111.76	426.48	5.17	644.86	13.40	2.79
T_{10}	108.89	423.18	4.81	639.68	14.24	3.35
SEm±	1.326	4.169	0.101	4.950	0.449	0.146
CD (*p*=0.05)	NS	11.973	0.290	14.216	1.428	0.419

T_1: 100% RDN (120 kg N ha^{-1}) from chemical fertiliser; T_2: 75% RDN from chemical fertiliser+25% RDN from Mustard Oilcake; T_3: 75% RDN from chemical fertiliser+25% RDN from Dhaincha; T_4: 75% RDN from chemical fertiliser+25% RDN from FYM; T_5: 50% RDN from chemical fertiliser+50% RDN from Mustard Oilcake; T_6: 50% RDN from chemical fertiliser+50% RDN from Dhaincha; T_7: 50% RDN from chemical fertiliser+50% RDN from FYM; T_8: 25% RDN from chemical fertiliser+75% RDN from Mustard Oilcake; T_9: 25% RDN from chemical fertiliser+75% RDN from Dhaincha; T_{10}: 25% RDN from chemical fertiliser+75% RDN from FYM; RDN: Recommended dose of nitrogen; DAT: Days after transplanting; LAI: Leaf area index; DMA: Dry matter accumulation; CGR: Crop growth rate; NAR: Net assimilation rate; NS: Not significant

NAR recorded in 75% RDN through chemical fertiliser+25% RDN through FYM application. However, the result was at par with all other treatments except treatment with application of 50% RDN from chemical fertiliser+50% RDN from dhaincha (3.06 g m^{-2} day^{-1}) and 25% RDN from chemical fertiliser+75% RDN from dhaincha green manure (2.79 g m^{-2} day^{-1}).

Increased leaf area index, dry matter accumulation and crop growth rate might be due to increasing the level of chemical fertiliser may be ascribed to the fact that rice plant grew better and accumulated more dry matter as compared to the higher doses of organic manure and the result was similar with the findings of Dass et al. (2009). From the research findings by Singh et al. (2017) it was concluded that growth attributes like plant height, tiller numbers, green leaf numbers, dry matter production and leaf area recorded highest value where 50% RDF+50% N through FYM was applied to rice.

3.2. Yield attributes and yield

The yield attributes like number of panicle m^{-2} area differ significantly due to integrated nutrient management in hybrid rice (Table 2). Number of panicle (437.93 m^{-2} area), grain yield (5.74 t ha^{-1}) and straw yield (6.59 t ha^{-1}) were highest with the application of 75% RDN from chemical fertiliser+25% RDN from dhaincha green manure though this was at par with 100% RDN from chemical fertiliser followed by 75% RDN from chemical fertiliser+25% RDN from mustard oil cake considering the data obtained from both the years. Mohanty et al. (2013) reported that application of chemical fertiliser, FYM and bio-fertiliser produced significantly higher number of tillers and highest number of grains $panicle^{-1}$ as compared to 100% recommended dose of fertiliser and control. The higher straw yield was observed with hybrid was due to more vegetative growth parameters like plant height, $tillers\ hill^{-1}$, dry matter accumulation. These results are in confirmation with Madhu Babu, 2007 and Shashibhushan et al., 2007. The maximum grain yield was obtained by Shah and Kumar 2014 with the integration of NPK 50% RDF+neem cake @ 2.5 t ha^{-1}+FYM @ 5 t ha^{-1}+azotobacter+PSB @ 5 kg ha^{-1}. There was no significant difference in number of filled grain $panicle^{-1}$ was observed in the first year (2014) whereas, significantly highest value was recorded in the second year (2015) and also compiling two years data with the application of 75% RDN from chemical fertiliser+25% RDN from dhaincha and the result was statistically at par with the application 100% chemical fertiliser, 75% RDN from chemical fertiliser+25% RDN from mustard oil cake, 50% RDN from chemical fertiliser+50% RDN from mustard oil cake, 50% RDN from chemical fertiliser+50% RDN from dhaincha, 25% RDN from chemical fertiliser+75% RDN from dhaincha. Singh et al. (2013) also reported that significantly more number of grains per panicle was recorded with the treatment 75% of recommended NPK through inorganic+FYM @ 10 t ha^{-1}+BGA

Table 2: Effect of Integrated Nutrient Management on yield components, yield and economics of hybrid rice during *kharif* season of 2014 and 2015 (pooled data)

Treatments	No. of panicles m^{-2}	No. of filled grains $panicle^{-1}$	Test weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	HI (%)	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	Return per rupee invested (₹)
T_1	421.70	147.87	25.16	5.61	6.39	46.74	41378	92970	51592	2.25
T_2	422.12	150.11	25.22	5.68	6.32	47.29	50464	94071	43607	1.87
T_3	437.93	152.28	25.07	5.74	6.59	46.59	42634	95175	52541	2.23
T_4	408.58	137.26	24.95	5.26	5.95	46.93	43409	87156	43747	2.01
T_5	415.32	146.09	25.01	5.39	6.06	47.08	59550	89298	29748	1.50
T_6	413.95	145.49	24.85	5.43	6.06	47.30	42390	90823	48433	2.14
T_7	406.82	139.96	24.78	5.11	5.65	47.51	45440	84601	39160	1.86
T_8	392.63	139.08	24.81	4.94	5.51	47.26	68637	81819	13182	1.20
T_9	395.13	148.92	24.64	5.03	5.59	47.37	42372	83232	40860	1.97
T_{10}	392.28	139.37	24.30	4.59	5.09	47.39	47472	76002	28530	1.60
SEm±	4.183	3.394	0.084	0.073	0.033	-	-	1164.53	1164.53	0.025
CD (*p*=0.05)	12.013	9.747	0.241	0.210	0.095	-	-	3344.32	3344.32	0.072

Selling price of rice ₹ 15900 t^{-1}, straw ₹ 500 t^{-1} (2014) and rice ₹ 16100 t^{-1}, straw ₹ 500 t^{-1} (2015); Cost of Mustard oil cake ₹ 16 kg^{-1} (2014), ₹ 16.50 kg^{-1} (2015), FYM ₹ 0.50 kg^{-1} (2014 and 2015), Dhaincha ₹ 0.50 kg^{-1}, Urea ₹ 7.20 kg^{-1}, SSP ₹ 8.40 kg^{-1}, MOP ₹ 13.00 kg^{-1}, labour ₹ 220 $manday^{-1}$

@ 15 kg ha^{-1} and the result was closely followed by the treatments 100% of recommended NPK through inorganic. Test weight was recorded significantly highest (25.22) with the application of 75% RDN from chemical fertiliser+25% RDN from mustard oil cake and the result was statistically at with the application of 100% RDN from chemical fertiliser, 75% RDN from chemical fertiliser+25% RDN from dhaincha, 75% RDN from chemical fertiliser+25% RDN from FYM and 50% RDN from chemical fertiliser+50% RDN from mustard oil cake. Yang et al. (2004) recorded that 1000-grain weight was increased by the application of chemical fertiliser along with organic manure. Sri Ranjitha et al. (2013) reported from his study that maximum grain and straw yield was found with the application of 50% RDN (through urea)+50% RDN (organic) through vermicompost and was found to be significantly superior over the rest of the treatments followed by the treatment 100% RDN (through urea).

3.3. Economics

Statistically analysed pooled data of two years field experiment revealed that, the highest cost of cultivation was recorded in treatment T_8 where 25% RDN from chemical fertilizer+75% RDN from mustard oil cake was applied (₹ 68,637 ha^{-1}) followed by application of 50% RDN from chemical fertilizer+50% RDN from mustard oil cake (₹ 59550 ha^{-1}). In the treatment of only chemical nitrogen application it was the lowest (₹ 41,378 ha^{-1}) cost of cultivation of rice. The result indicated that, combination of organic and inorganic nutrients became costlier than that of RDN from sole chemical fertilizer; it might be due to higher cost of organic manures such as mustard oil cake, FYM and Dhaincha.

Integrated nutrient management practices showed significant effect on gross return of *kharif* rice in both the years. As per the pooled data of 2014 and 2015 the highest gross return was recorded in 75% RDN from chemical fertilizer+25% RDN from dhaincha green manuring (₹ 95175 ha^{-1}) which was statistically at par with application of 100% RDN from chemical fertilizer (₹ 92970 ha^{-1}) and 75% RDN from chemical fertilizer+25% RDN mustard oil cake (₹ 94071 ha^{-1}). Similar trend was recorded in net return of *kharif* hybrid rice. Where, significantly highest net return (₹ 52541 ha^{-1}) was estimated with 75% RDN from chemical fertiliser+25% RDN from dhaincha green manure followed by application of 100% RDN from chemical fertiliser (₹ 51592). The lowest gross return and net return ₹ 76002 ha^{-1} and ₹ 13182 ha^{-1}, respectively was observed with application of 25% RDN from chemical fertiliser+75% RDN from FYM.

The highest return per rupee invested (₹ 2.25) was found in 100% RDN from chemical fertiliser. The result was similar with the findings of Borkar et al., 2008. However, this was at par with 75% RDN from chemical fertiliser+25% RDN from dhaincha green manure (₹ 2.23). Similar findings were also reported by Mathew et al. (2008). The lowest return per rupee investment (₹ 1.20) was recorded with 25% RDN from chemical fertiliser+75% RDN from mustard oil cake.

4. Conclusion

Application of 75% RDN from chemical fertiliser+25% RDN from dhaincha green manure in hybrid rice was found best for obtaining profitable crop production.

5. References

Agricultural Statistics at a Glance, 2017. Directorate of Economics and Statistics. Department of Agriculture, Cooperation & Farmers Welfare. Ministry of Agriculture & Farmers Welfare. Government of India. Available at http:// eands.dacnet.nic.in

Bhowmik, N., Nayak, R.L., 2000. Response of hybrid rice varieties to nitrogen, phosphorus and potassium fertilisers during dry season in West Bengal, Indian Journal of Agronomy 45(2), 323–326.

Dass, A., Sudhishri, S., Lenka, N.K., 2009. Integrated nutrient management for upland rice in Eastern Ghats of Orissa. Oryza 46(3), 220–226.

Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. 2013-14. www.indiastat.com.

Ghosh, B.N., Singh, R.J., Mishra, P.K., 2015. Soil and input management options for increasing nutrient use efficiency. In: Nutrient Use Efficiency: from Basics to Advances, (A. Rakshit et al. (Eds.), DOI 10.1007/978-81-322-2169-22, Springer, India.

Gomez, K.A., Gomez, A.A., 1984. Statistical Procedures for Agricultural Research. John Wiley and Sons, Singapore.

Jackson, M.L., 1973. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, India.

Madhu Babu, K., 2007. Performance of SRI over conventional method under ore well irrigation system and perception of farmers in Nalgonda district of Andhra Pradesh. In: SRI India 2007 Second National Symposium on System of Rice Intensification (SRI) in India-Progress and Prospects. Papers and Extended Summaries, 3-5th October, Agartala, Tripura, India, 162–165.

Mathew, J., Kuruvilla, V., Pillai, G.R., 2008. Integrated nutrient management in sandy loam soil on the productivity and economics of rice. Oryza 30, 26–29.

Mohanty, M., Nanda, S.S., Barik, A.K., 2013. Effect of integrated nutrient management on growth, yield and nutrient uptake and economics of wet season rice (*Oryza sativa*) in Odisha. Indian Journal of Agricultural Sciences 83(6), 599–604.

Pandey, N., Verma, A.K., Anurag and Tripathy, R.S., 2007. Integrated nutrient management in transplanted hybrid rice. Indian Journal of Agronomy 52(1), 323–326.

Sahane, A.A., Singh, Y.B., 2013. Cyanobacteria: A green nitrogen for rice. Indian Farming 63(6), 3–6.

Shah, A.R., Kumar, S., 2014. Effect of integrated nutrient management on vegetative growth and yield of transplanted hybrid rice (*Oryza sativa* L.) crop, International Journal of Agriculture and Crop Sciences 7(11), 863–869.

Shashibhushan, V., Satyanarayan, A., Goud, V., 2007. Impact of SRI on Rice Farmers. In: SRI India 2007 Second National Symposium on System of Rice Intensification (SRI) in India-Progress and Prospects. Papers and Extended Summaries, 3–5th October, Agartala, Tripura, India, 180–183.

Singh, R.K., Kumar, J.S.A., Kaleem, M., 2013. Influence of integrated nutrient management practices on yield and economics of hybrid rice (*Oryza sativa* L.). International Journal of Agricultural Science 9(2), 733–735.

Singh, S., Bohra, J.S., Singh, Y.V., Upadhyay, A.K., Verma, S.S., Mishra, P.K., Raghuveer, M., 2017. Effect of integrated nutrient management on growth and development stages of rice under Rice-Wheat Ecosystem. International Journal of Current Microbiology and Applied Science 6(7), 2032–2042.

Sri Ranjitha, P., Mahender Kumar, R., Jayasree, G., 2013. Evaluation of rice (*Oryza sativa* L.) varieties in relation to different nutrient management practices for yield, nutrient uptake and economics in SRI, Annals of Biological Research 4(10), 25–28.

Yang, C.M., Yang, L., Yang, Y., Ouyang, Z., 2004. Rice root growth and nutrient uptake as influenced by organic manure in continuously and alternately flooded paddy soils. Agricultural Water Management 70(1), 67–81.