Journal of Crop and Weed, 16(1): 172-179 (2020)

ISSN- O : 2349 9400 ; P : 0974 6315

http://cwssbckv.org
www.cropandweed.com

Effect of different nutrient management practices on growth, grain yield, production economics, soil nutrient availability of transplanted *kharif* rice (*Oryza sativa* L.) and correlation studies

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Received : 20.09.2019 ; Revised : 26.03.2020 ; Accepted : 05.04.2020

DOI : 10.22271/09746315.2020.v16.i1.1290

ABSTRACT

A field experiment was conducted to study the "Effect of different nutrient management practices on growth, grain yield, production economics and soil nutrient availability in transplanted rice (Oryza sativa L.) and correlation" during kharif -2016 and 2017 at Regional Research Station, Gayeshpur of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. The treatments of different nutrient management practices were T_1- Control, T_2-N_{60}, T_3-$N_{60}P_{30}$, T_4-$N_{60}P_{30}K_{30}$(RDF: Recommended dose of fertilizer), T_5-$N_{80}P_{40}K_{40}$, T_6-$N_{60}P_{30}K_{30}$ + $ZnSO_4$ @ 25 kg ha^{-1}, T_7-75% RDF+25%MC and T_8-50%MC+50%VC, and laid out in Randomized Block Design (RBD) replicated three times. The results revealed that rice plot fertilized with the higher dose of NPK @ 80, 40, 40 recorded highest plant height, LAI, dry matter accumulation and available nutrient status of the soil but the combination of NPK @ 60:30:30 (kg ha^{-1}) + $ZnSO_4$ @ 25 kg ha^{-1} recorded the highest tiller number and seed yield of 3.96 t ha^{-1} which was 6.73 per cent more yield (3.71 t ha^{-1}) than the treatment T_5 ($N_{80}P_{40}K_{40}$).The result can be more specifically ascertained by the correlation analysis where linear association between dry matter harvest and seed yield (0.836) and other yield attributing characters are distinct. On the other hand, effective tillers (0.958), panicle length (0.861) and weight (0.827), no. of filled grains (0.884) panicle^{-1}, test weight (0.969) registered highly significant positive phenotypic correlation with seed yield as because seed yield is a complex character and it is the end product of association and interaction among all the traits.

Keywords: Available soil nutrient status, correlation studies, growth characters, grain yield and rice

Rice (*Oryza sativa* L.) plays a vital role in food and livelihood security for almost every household, it is a principal source of food for more than half of the world's population and also is an important cereal crop next to wheat which accounts for the major dietary energy requirement of Asian rural people as more than 90% of rice is grown and consumed in Asia. In India rice is the staple food for around 60 per cent of the population and also governs country's food security. It contributes about 40 per cent to the total food grain production of the country and accounts for 29.1 per cent of calories and 22.4 per cent of protein intake daily by Indian population (GRiSP, 2013). India ranks first in the world rice area but stand second position in relation to world production next to China, occupying an area of 43.39 m ha with an average production of 104.32 mt with productivity 2.40 t ha^{-1} of the country. The demand for rice continues to increase owing to continued growth of population. It is predicted that a 50 - 60 per cent increase in rice production will be required to meet demand from population growth by 2025. Among the rice producing states, West Bengal ranks first position with the acreage of 5.80 m ha with the largest production to the tune of 15.5 mt among the states in country achieving the productivity of 2.79 t ha^{-1}. Only traditional fertilizer management does not enough to meet the demand of food for huge population of the world. It is high time to search for innovative practices, which can guarantee higher yields with minimal deterioration of natural resources. Yield of rice per hectare is continuously decreasing due to lack of management practices and nutrient imbalances. Balanced fertilization of a crop needs supply of major, minor and micronutrients. So better matching of nutrient supply with crop demand is often considered a basis for improving and stabilizing yield, in irrigated as well as rain-fed systems (Lafitte, 1998). The nutrients, their sources, method and time of application form an important component of fertilizer management strategies. Besides major nutrients, Zn is the most important micro-nutrient particularly in our country because most of Indian soils are deficient. Zinc is directly or indirectly required by the several enzymic systems and closely involved in the nitrogen metabolism of plant. As well documented by plant physiologists, zinc exerts a great influence on basic plant life processes, such as (i) nitrogen metabolism-uptake of nitrogen and protein quality; (ii) photosynthesis – chlorophyll synthesis, carbon anhydrase activity; (iii) resistance to abiotic and biotic stresses – protection against oxidative damage (Alloway, 2004; Cakmak, 2008). In India, its deficiency is more prevalent in rice–wheat belt of northern India. The general recommendation for rice–

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wheat system in India is soil application of 10–25 kg Zn through $ZnSO_4.7H_2O$. Several Zn products are available in the market but these are beyond the reach of farmers, resulting in reduced crop productivity. Zinc application through soil or foliar sprays and dipping of rice seedlings in ZnO (Jat *et al*., 2011) has been found to ameliorate Zn deficiency. Studies on Zn fertilizer proved that the application of Zn greatly influences growth, yield and quality of rice (Patnaik *et al.*, 2011). In contrast to nutrients in organic fertilizers, this required microbial metabolism to make most of them available to plants. So, inorganic fertilizers can directly affect crop growth and yields. Organic and inorganic fertilizer amendments are used primarily to increase nutrient availability to plants, but they can also affect soil microorganisms.

MATERIALS AND METHODS

A field experiment was conducted at the Central Research Farm, Gayeshpur, Bidhan Chandra Krishi Viswavidyalaya, Nadia, situated at 22º052′ N latitude and 88º322′ E longitude with an altitude of 9.75 m above mean sea level to study the 'Effect of different nutrient management practices on growth, grain yield, production economics, soil nutrient availability of transplanted *kharif* rice (*Oryza sativa.* L) and correlation studies' during *kharif* 2016 and 2017. The experimental site falls under sub-tropical sub-humid climate. The texture of the experimental soil was sandy clay loam and belongs to the order inceptisol with medium fertility and almost neutral in soil reaction. The experiment was laid in Randomized Block Design replicated three times comprising of eight levels of nutrient (kg ha^{-1}) *viz*. T_1-Control ($N_0P_0K_0$), T_2-N_{60}, T_3-$N_{60}P_{30}$, T_4-$N_{60}P_{30}K_{30}$ (RDF), T_5-$N_{80}P_{40}K_{40}$, T_6-$N_{60}P_{30}K_{30}$ + $ZnSO_4$@25 kg ha^{-1}, T_7-75% RDF+25% MC (Mustard cake) and T_8-50%MC+50%VC (vermicompost), respectively. The size of individual plot was 6 x 5 m. The rice seedlings were uprooted from the nursery bed and transplanted in main field with a spacing of 20 x 20 cm with two seedlings per hill without damaging the seedlings. Depth of transplanting was 2-3 cm with 16.5 cm puddling depth and 33 per cent puddling index. The treatment wise fertilizers were applied in two equal splits half at land preparation and rest half of the total nitrogen and full dose of phosphorus and potassium were applied at twenty days after transplanting through Urea, SSP and MOP and for treatments of T_7 and T_8, 25% and 100% nitrogen applied through organic sources like mustard cake and vermicompost. 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 then after threshing and cleaning grain yield was recorded in t ha^{-1} and reported at 15 per cent moisture content. Post harvest soil available nutrients were determined in soil testing laboratory. Statistical analysis was done using standard methodology.

RESULTS AND DISCUSSION

Plant Height

The crop growth in terms of plant height of *kharif* rice cultivated with different nutrient management practices was found significant (Table 1). Among different nutrient management practices (schedules), NPK @ 80:40:40 kg ha^{-1} recorded significantly higher plant height at 30, 60 and 90 DAT (63.19, 88.39 and 111.82cm, respectively) over the others. The increase in plant height with increasing nitrogen might be attributed to the effect of nitrogen fertilizer which encourage and improve plant growth and accelerate cell division which reflected the increase in plant height (Mohadesi *et al*., 2011). Sarawgi *et al*.(2004) also found that higher level of nutrients (*i.e*. NPK @ 50:50:40 kg ha^{-1} + nitrogen blended with FYM) recorded significantly higher plant height, tillers $plant^{-1}$ of tall and short slender scented rice varieties compared to lower level of nutrients (*i.e.* NPK @ 25:40:30 kg ha^{-1}) with or without blending with FYM.

Root Length

The root length of *kharif* rice at 30 and 60 DAT varied significantly with different nutrient management practices (Table 1). Significantly, highest root length at 30 and 60 DAT (23.6 and 28.4 cm, respectively) were found with NPK @ 80:40:40 kg ha^{-1} over the remaining treatments. At 60 DAT combination of lower fertilizer dose of NPK @ 60:30:30 kg ha^{-1} + Zn @ 25 kg ha^{-1} which was statistically at per with the higher fertilizer dose *i.e.* NPK @ 80:40:40 kg ha^{-1}. Enhanced root traits like length and surface area could have contributed to the high uptake of P (Wang *et al*., 2016).

Number of tillers $hill^{-1}$

Data pertaining to tiller numbers in *kharif* rice (Table 2) indicated that at 30, 45 and 60 DAT the rice plant showed significant variation in tiller number under different nutrient management practices. However,

Table 1: Plant height and root length of *kharif* rice as influenced by different nutrient management practices. (Pooled)

Treatments	Plant height (cm)			Root Length (cm)	
	30 DAT	**60 DAT**	**90DAT**	**30 DAT**	**60 DAT**
T_1- Control	41.19	66.35	96.73	14.8	19.6
T_2-$N_{(60)}$	42.24	69.02	97.08	17.6	23.7
T_3-$N_{(60)}P_{(30)}$	58.36	87.53	101.24	21.1	25.2
T_4-$N_{(60)}P_{(30)}K_{(30)}$	59.97	86.19	106.67	21.4	25.8
T_5-$N_{(80)}P_{(40)}K_{(40)}$	63.19	88.39	111.82	23.6	28.4
T_6-$N_{(60)}P_{(30)}K_{(30)}$+$Zn_{(25)}$	61.54	87.69	109.38	21.7	25.5
T_7-75% RDF+25%(MC)	54.47	78.25	103.37	18.9	23.1
T_8-50%(MC)+50%(VC)	50.09	71.37	105.45	18.7	22.6
SEm (±)	**0.53**	**0.58**	**0.69**	**0.71**	**0.93**
LSD(0.05)	**1.61**	**1.79**	**2.11**	**2.18**	**2.89**

Table 2: Number of tillers hill^{-1} of rice as influenced by nutrient management practices during *kharif* season (Pooled)

Treatments	Number of tillers hill^{-1}		
	30 DAT	**45 DAT**	**60 DAT**
T_1- Control	4.27	5.83	6.90
T_2-$N_{(60)}$	4.47	7.07	9.50
T_3-$N_{(60)}P_{(30)}$	7.20	9.17	9.80
T_4-$N_{(60)}P_{(30)}K_{(30)}$	7.70	9.87	10.73
T_5-$N_{(80)}P_{(40)}K_{(40)}$	7.60	10.13	10.97
T_6-$N_{(60)}P_{(30)}K_{(30)}$+$Zn_{(25)}$	7.83	10.43	11.33
T_7-75% RDF+25%(MC)	6.40	8.87	10.10
T_8-50%(MC)+50%(VC)	6.43	8.67	8.90
SEm (±)	**0.09**	**0.30**	**0.27**
LSD(0.05)	**0.28**	**0.92**	**0.84**

Table 3: Dry matter accumulation and leaf area index of *kharif* rice as influenced by different nutrient management practices. (Pooled values of 2 years)

Treatments	Dry matter accumulation (g m^{-2})			LAI	
	30 DAT	60 DAT	90 DAT	30DAT	60 DAT
T_1- Control	101.1	291.87	374.65	1.11	2.78
T_2-$N_{(60)}$	115.9	319.93	430.22	1.36	3.01
T_3-$N_{(60)}P_{(30)}$	122.5	372.30	583.73	1.42	3.24
T_4-$N_{(60)}P_{(30)}K_{(30)}$	133.7	397.70	641.53	1.51	3.33
T_5-$N_{(80)}P_{(40)}K_{(40)}$	167.4	445.60	720.81	1.87	3.96
T_6-$N_{(60)}P_{(30)}K_{(30)}$+$Zn_{(25)}$	154.9	431.60	661.23	1.72	3.75
T_7-75% RDF+25%(MC)	112.6	415.87	571.86	1.31	2.99
T_8-50%(MC)+50%(VC)	108.8	417.33	573.98	1.23	2.83
SEm (±)	**2.38**	**7.34**	**4.88**	**0.06**	**0.07**
LSD(0.05)	**7.30**	**22.47**	**14.95**	**0.18**	**0.21**

application of NPK @ 60:30:30kg ha^{-1}+ $ZnSO_4$ @ 25kg ha^{-1} recorded significantly higher number of tillers per hill (7.83,10.43 and 11.33 at 30,45 and 60 DAT, respectively) over the others though it was at par with NPK @ 60:30:30 and 80:40:40 kg ha^{-1}, respectively. Ghasal *et al*. (2015) also reported significant effect of zinc application on number of tiller hill^{-1} of rice. Effect of different levels of nutrient management on tiller production of rice was also verified by the works of Mirza *et al*. (2005) and they reported that productive

Table 4: Days to flowering and flowering span of *kharif* rice as influenced by nutrient management practices (Pooled)

Treatments	Days to flowering (DAT)		Flowering span	Flowering to
	FL initiation	FL50%	(days)	maturity (days)
T_1- Control	51	56	10	39
T_2-$N_{(60)}$	50	55	10	40
T_3-$N_{(60)}P_{(30)}$	48	53	10	42
T_4-$N_{(60)}P_{(30)}K_{(30)}$	46	50	8	44
T_5-$N(_{80)}P_{(40)}K_{(40)}$	44	50	10	46
T_6-$N_{(60)}P_{(30)}K_{(30)}+Zn_{(25)}$	44	49	9	46
T_7-75% RDF+25%(MC)	45	52	11	45
T_8-50%(MC)+50%(VC)	50	54	9	40
SEm (±)	**0.34**	**0.31**	**0.51**	**-**
LSD(0.05)	**1.03**	**1.03**	**1.57**	**-**

Table 5: Effect of different nutrient management practices on post harvest availability of N, P and K in *kharif* rice (Pooled)

Treatments	N(kg ha^{-1})	P(kg ha^{-1})	K(kg ha^{-1})
T_1- Control	160.76	24.15	157.03
T_2-$N_{(60)}$	227.23	26.16	166.15
T_3-$N(_{60)}P_{(30)}$	231.09	35.07	161.25
T_4-$N_{(60)}P_{(30)}K_{(30)}$	222.01	34.09	207.19
T_5-$N(_{80)}P_{(40)}K_{(40)}$	261.01	36.03	224.28
T_6-$N_{(60)}P_{(30)}K_{(30)}+Zn_{(25)}$	212.26	33.20	203.01
T_7-75% RDF+25%(MC)	228.14	30.15	196.05
T_8-50%(MC)+50%(VC)	242.33	29.23	192.06
SEm (±)	**2.31**	**0.68**	**0.79**
LSD(0.05)	**7.08**	**2.07**	**2.42**

tillers per hill were increased by the application of FYM along with different macro and micro nutrients application.

Dry matter accumulation

Dry matter accumulation increased with increasing duration of crop from 30 to 90 DAT (Table 3). However, significantly highest dry matter accumulation (167.4, 445.6 and 720.81 g m^{-2} at 30, 60 and 90 DAT, respectively) was recorded with application NPK @ 80:40:40 kg ha^{-1} but at par with application of NPK @ 60:30:30 kg ha^{-1}+ $ZnSO_4$ @ 25 kg ha^{-1} and the lowest value was recorded in control plot where no fertilizer were added.

Leaf area index

In general LAI increased with the advancement of crop growth stages. However, at 30 and 60 DAT, the rice plant showed significantly higher LAI 1.87 and 3.96, respectively with application of NPK @ 80:40:40 kg ha^{-1} over the others though at par with application of NPK @ 60:30:30 + $ZnSO_4$ @ 25kg ha^{-1} (Table 3). Somasundaram *et al*. (2002) observed significant increase in plant height and leaf area index with each successive increase in N level from 0 to 150 kg ha^{-1}.

Days to flowering

Number of days taken for flowering in rice varied significantly with variation of different nutrient management practices (Table 4). The requirement of days after transplanting to 1st flowering and 50% flowering of rice with different nutrient management varied from 44 to 51 days with the variation of 15.90 per cent and 49 to 56 days with the variation of 14.28 per cent respectively. Earliest 1st flowering and 50% flowering was observed in the plot fertilized with the combination of NPK @ 60:30:30 kg ha^{-1} + Zn @ 25 kg ha^{-1} *i.e.* 44 and 49 DAT respectively and in the control plot took more

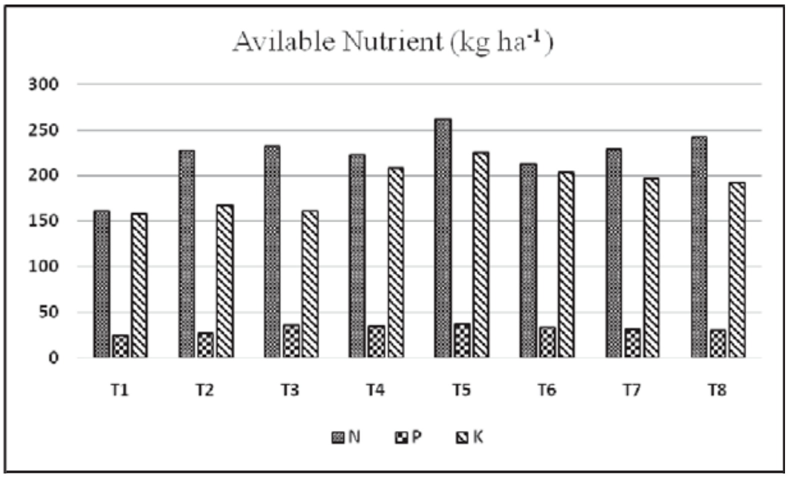

Fig. 1: Effect of different nutrient management practices on post harvest availability of N, P and K in *kharif* rice

number of days to reach 1st flowering stage *i.e.* 51 days followed by the nutrient dose of N @ 60 kg ha^{-1} and RDF (50% Mustard Cake + 50% Vermicompost) respectively. In case of 50% flowering control treatment where no fertilizer was added took the highest numbers of day *i.e.* 56 days. With regards to 1st flowering treatment NPK @ 60:30:30 kg ha^{-1} + Zn @ 25 kg ha^{-1}, NPK @ 80:40:40 kg ha^{-1},75% RDF +25% Vermicompost and NPK @ 60:30:30kg ha^{-1}, were recorded at par with the plot fertilized with NP @ 60:30 kg ha^{-1}. For 50% flowering NPK @ 60:30:30 kg ha^{-1}higher dose of NPK @ 80:40:40 kg ha^{-1} and NPK @ 60.30:30 + Zn @ 20 kg ha^{-1} were observed at par. Findings of Diwakar (2009)reported that differential response to applied nutrients/nutrient management practice leading tovariation in growth parameters in current study.

Flowering span

Number of days taken for 1st flowering to 100% flowering *i.e.* flowering span of rice was found significant under different nutrient management practices (Table 4). However, requirement of days from 1st flowering to 100% flowering for different nutrient management practices ranged from 8 to 10 days with a variation of 25%. Treatment fertilized with NPK @ 60:30:30 kg ha^{-1} took the lowest number of days to reach 100% flowering from 1st flowering date *i.e.* 8 days followed by the treatment fertilized with the combination of NPK @ 60:30:30 + Zn @ 25 kg ha^{-1} and 50% Mustard cake+50% Vermicompost. On the other hand treatment 75% RDF +25% Vermicompost took the maximum number of days to reach 100% *i.e.* (11days). Treatment T_1, T_2, T_3 and T_5 take same number of days to reach 100% flowering from flower initiation and recorded at par value.

Flowering to maturity

Number of days taken for 1st flowering to maturity *i.e.* reproductive time span of rice was different with different nutrient management (Table 4). However, requirement of days from 1st flowering to maturity in different nutrient management practices ranged from 39 to 46 days with a variation of 17.94 per cent. Control plot took the lowest number of days to reach maturity from 1st flowering date *i.e.* 39 days followed by the treatment where only N @ 60 kg ha^{-1}and 50% Mustard cake+50% vermicompost. On the other hand, treatment NPK @ 60:30:30 + Zn @ 25 kg ha^{-1}and higher dose of fertilizer NPK @ 80:40:40 kg ha^{-1} took the maximum number of days to reach maturity *i.e.*46 days.

Available soil nutrient status

After harvest of *kharif* rice, available soil nitrogen, phosphorus and potassium varied significantly with different nutrient management practices (Table 5) (Fig 1). However, significantly higher available nitrogen, phosphorus and potassium of 261.01, 36.03 and 224.28 kg ha^{-1}, respectively were recorded with application of NPK @ 80:40:40 kg ha^{-1} over other treatments. This can be confirmed by Sharma and Sharma (2002), who observed that the increase in organic carbon content in treatments with combination of both organic and inorganic sources of nutrients may be attributed to higher biomass addition to soil through crop residues. Tolanur and Badanur (2003) reported that FYM and green manure addition with inorganic fertilizers had the beneficial effect on increasing the available P status of soil.

The statistical association or correlation analysis is congruous in this experiment because they can indicate a predictive relationship between several variables that

Table 6: Correlation coefficient analysis of yield and yield attributes in *kharif* rice

	Days to 50% Flowering	Dry Matter ($g\ m^{-2}$)	Harvest Effective tillers m^{-2}	Panicle length (cm)	Panicle weight (g)	Filled grains $panicle^{-1}$	Chaffs (%)	1000-seed weight (g)	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)
Days to 50% Flowering	1	-0.911**	-0.969**	-0.922**	-0.824*	-0.947**	0.944**	-0.971**	-0.911**	-0.606^{NS}
Dry Matter ($g\ m^{-2}$) at Harvest	-0.911**	1	0.918**	0.932**	0.829*	0.978**	-0.945**	0.867**	0.836**	0.691^{NS}
Effective tillers m^{-2}	-0.969**	0.918**	1	0.959**	0.905**	0.951**	-0.964**	0.975**	0.958**	0.646^{NS}
Panicle length (cm)	-0.922**	0.932**	0.959**	1	0.953**	0.959**	-0.921**	0.912**	0.861**	0.586^{NS}
Panicle weight (g)	-0.824*	0.829*	0.905**	0.953**	1	0.886**	-0.862**	0.846**	0.827*	0.417^{NS}
Filled grains $panicle^{-1}$	-0.947**	0.978**	0.951**	0.959**	0.886**	1	-0.978**	0.924**	0.884**	0.628^{NS}
Chaffs (%)	0.944**	-0.945**	-0.964**	-0.921**	-0.862**	-0.978**	1	-0.950**	-0.949**	-0.665^{NS}
1000-seed weight (g)	-0.971**	0.867**	0.975**	0.912**	0.846**	0.924**	-0.950**	1	0.969**	0.671^{NS}
Seed yield($t\ ha^{-1}$)	-0.911**	0.836**	0.958**	0.861**	0.827*	0.884**	-0.949**	0.969**	1	0.707*
Straw yield($t\ ha^{-1}$)	-0.606^{NS}	0.691^{NS}	0.646^{NS}	0.586^{NS}	0.417^{NS}	0.628^{NS}	-0.665^{NS}	0.671^{NS}	0.707*	1

Note : (and ** indicates correlation is significant at 5.0 and 1.0% level of significance, respectively*

can be exploited in practice. To evaluate the strength of relationship between growth, yield and nutrient availability of rice under different nutrient management practices, this bivariate exploration is necessary. Correlation between yield and yield components were computed and the results are presented in (Table 6). The days to 50 per cent flowering recorded negative phenotypic correlation with grain yield (- 0.911), dry matter accumulation (-0.911), effective tiller m^{-2} (-0.969), panicle length (-0.922), panicle weight (-0.824), filled grains per panicle (-0.947) and 1000-grain weight (-0.971) and positive and significant correlation with chaffy percentage (0.944) and also non-significant negative phenotypic correlation with straw yield (-0.606). Dry matter accumulation significant positive phenotypic correlation with seed yield (0.836), effective tiller m^{-2} (0.918), panicle length (0.932), panicle weight (0.829), filled grains per panicle (0.978) and 1000-grain weight (0.867). The chaffy percentage (-0.945) play negative correlation with dry matter accumulation and straw yield (0.691) showed non significant correlation. Effective tiller exhibited significant positive phenotypic correlation with seed yield (0.958), panicle length (0.959), panicle weight (0.905), filled grain per panicle (0.951) and 1000 grain weight (0.975) and straw yield (0.646) showed non significant correlation. Number of productive tillers per plant and number of filled spikelet's per panicle were positively associated with grain yield which is in agreement with earlier reports of Biswajit *et al.* (2017), Akinwale *et al.* (2011) and Ravindrababu *et al.*, (2012). Panicle length registered significant positive phenotypic correlation with seed yield (0.861), panicle weight (0.953), filled grains per panicle (0.959) and 1000 grain weight (0.912).The chaffy percentage (-0.921) play negative correlation with panicle length and straw yield (0.586) showed non significant correlation. Panicle weight exhibited significant positive phenotypic correlation with seed yield (0.827), filled grain per panicle (0.886), 1000 grain weight (0.846) and the chaffy percentage (-0.862) play negative correlation with panicle weight and straw yield (0.417) showed non significant correlation. The positive correlation of panicle length with grain yield is in agreement with earlier reports of Kishore *et al.* (2018). The positive association of panicle weight with grain yield is in accordance with earlier findings of Sathisha *et al.* (2015). Number of filled grains per panicle exhibited a significant positive phenotypic correlation with seed yield (0.884), 1000 grain weight (0.924) whereas negative and significant correlation with chaff percentage (-0.978) and non-significant correlation with straw yield (0.628).1000 grain weight showed a significant positive phenotypic correlation with seed yield per plant (0.969). Similar results were reported by Satish Chandra *et al.*, (2009),

Table 7: Grain yield and Benefit cost ratio of *kharif* rice as influenced by different nutrient management practices. (Pooled)

Treatment	Grain yield ($t\ ha^{-1}$)	Cost ($Rs.\ ha^{-1}$)	Gross return ($Rs.\ ha^{-1}$)	Net return ($Rs.\ ha^{-1}$)	B:C
T_1- Control	2.04	41335	66110	24775	1.60
T_2-$N_{(60)}$	2.58	42310	82830	40520	1.96
T_3-$N(_{60)}P_{(30)}$	3.08	44185	98180	53995	2.22
T_4-$N_{(60)}P_{(30)}K_{(30)}$	3.22	44985	102130	57145	2.27
T_5-$N(_{80)}P_{(40)}K_{(40)}$	3.71	46196	117240	71045	2.54
T_6-$N_{(60)}P_{(30)}K_{(30)}+Zn_{(25)}$	3.96	47805	124210	76405	2.60
T_7-75% RDF+25%(MC)	2.64	52472	84710	32238	1.61
T_8-50%(MC)+50%(VC)	2.30	73135	74060	925	1.01
SEm (±)	**0.26**	-	-	-	-
LSD(0.05)	**0.79**	-	-	-	-

Basavaraja *et al*. (2011), Patel *et al*. (2014), Rao *et al*., (2014) for grain yield plant^{-1}. Phenotypic correlations revealed that seed yield plant^{-1} had significant positive association with dry matter accumulation (0.836), effective tiller m^2 (0.958), panicle weight (0.827), filled grain panicle^{-1} (0.884) and also straw yield (0.707). Seed yield is a complex character and it is the end product of action and interaction among number of traits; hence it is important to understand the association of different characters with grain yield. Seed yield plant^{-1}showed positive significant association with dry matter, number of productive tillers plant^{-1}, number of filled grains panicle^{-1}, test weight and also straw yield. This indicated that all these characters were important for yield improvement Similar kind of association was revealed by Patel *et al*. (2014) and Rao *et al*. (2014) number of productive tillers per plant Reddy *et al*.,(2013) and Patel *et al*. (2014) for number of filled grains per panicle.

Grain yield and production economics

The land productivity in terms of seed yield of *kharif* rice was significantly influenced by the different nutrient management practices in the new alluvial soils of lower Indo-Gangetic plains of West Bengal. However, application of NPK @ 60:30:30 kg ha^{-1}+ $ZnSO_4$ @ 25 kg ha^{-1} recorded significantly higher seed yield (3.96 t ha^{-1}) over the others though it is at par with NPK @80:40:40 kg ha^{-1} (3.71 t ha^{-1}) and NPK @ 60:30:30 kg ha^{-1}(3.22 t ha^{-1}) (Table 7). More acceptability of any research finding among small and marginal farmers depends on its economic viability. In the present study the gross returns (1,24,210), net returns (76,405) and B:C ratio(2.60) were found highest with application of NPK @ 60:30:30 kg ha^{-1}+ $ZnSO_4$ @ 25 kg ha^{-1} this might be due to higher grain (3.96 t ha^{-1}) and straw yield realized followed by (gross return, net return and B:C ratio) NPK @ 80:40:40 kg ha^{-1}.

From the experimental results it may be concluded that rice variety Satabdi (IET 4786) may be fertilized with higher dose of N, P, K (80, 40, 40 kg ha^{-1}) gave higher growth parameters like plant height, LAI, dry matter production, root length but combination of N, P, K and Zn (60, 30, 30 kg ha^{-1} along with $ZnSO_4$ @ 25 kg ha^{-1}) gave higher tiller number per hill, grain yield and greater B:C ratio. Character association studies revealed that the characters grain yield plant^{-1} showed significant positive association with number of effective tillers per m^2, panicle weight, number of filled grains panicle^{-1} and 1000 grain weight. This indicated that simultaneous selections of all these characters were important for yield improvement. The results obtained from the field, terminated that growth parameters like plant height, dry matter accumulation, no. of tillers per plant, root length as well as the physiological parameters like leaf area index, days to flowering, flowering span, flowering to maturity and productivity and net return were significantly higher under judicial and balanced inorganic fertilizer and combination application of nutrient resources respectively. Good growth and development of plants reflect the final production and productivity of crop. Therefore, integrated utilisation of N, P, K and Zn (60, 30, 30 kg ha^{-1} along with $ZnSO_4$ @ 25 kg ha^{-1}) could be recommended for more effective in augmenting yield and B:C ratio of transplanted *kharif* rice in the Gangetic plains of West Bengal.

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