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Influence of integrated Nutrient Management in Summer Rice (*Oryza sativa* L.) under Terai Zone of West Bengal

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ABSTRACT: Use of inorganic fertilizers have increased the production of rice but causes various detrimental effects on physical and chemical properties of soils and ecological pollutions. Therefore, conjunctive use of organic and inorganic sources of nutrients helps in sustaining productivity and biological health of soil and achieves a part of chemical fertilizers of crop. A field experiment was carried out at Uttar Banga Krishi Viswavidyalaya, Cooch Behar, West Bengal during two consecutive summer season of 2018and 2019 to evaluate the effect of judicious use of inorganic fertilizers, organic manures and zinc on summer rice (cv. Gotra Bidhan-1). Out of different nutrient management practices, treatment receiving 75% RDN through fertilizer +25% RDN through vermicompost + 25 kg $ZnSO_4$ha^{-1} registered significantly the highest yield components and grain yield (5.10 t ha^{-1}). The total uptake of N, P, K and Zn nutrients by crop was remarkably increased with the treatment receiving 75% RDN through fertilizer + 25% RDN through vermicompost + 25 kg $ZnSO_4$ ha^{-1}.Integrated nutrient management enhanced the organic carbon and available N, P, K and Zn contents in the soil. Significant variation in N, P, K and Zn content of soil under various treatments could be observed after harvest of summer rice. The maximum soil available N, P, K and Zn were noticed with the 50% RDN through fertilizer + 50% RDN through vermicompost + 25 kg $ZnSO_4$ ha^{-1}. The highest net return (Rs. 40560 ha^{-1}) and benefit: cost (1.80) ratio was achieved under the treatment, where 75% RDN was applied through fertilizer +25% RDN through vermicompost + 25 kg $ZnSO_4$ ha^{-1}.

Keywords: Summer rice, integrated nutrient management, yield, economics.

INRODUCTION

According to Jena and Pattanayak (2021), country like India having expanding population, maximum food production on existing croplands through increased nutrient input and reclaiming is essential. Integrated nutrient management includes maintenance of soil fertility, sustainable crop productivity and enhancement of farmer's profitability. Adoption of integrated nutrient management practices involving organic and inorganic fertilizers is the prime approach to make the production system more sustainable and profitable (Sarkar *et al*., 2020). According to Gogoi (2011), conjunctive use of organic and inorganic sources of nutrients helps in sustaining productivity and biological health of soil in one way and meets a part of chemical fertilizer requirements of crops in other. Application of chemical fertilizers have boosted the production of rice but it has created different problems such as degradation of soil physical and chemical properties, soil fertility, harden the soil, release of green house gases, soil erosion, depletion of organic matter in soil, lower availability of water and environmental degradation. Continuous and extensive use of inorganic fertilizers also mainly attributed to macronutrient imbalance, micro-nutrients deficiency and fertilizer related environmental pollution (Biswas *et al*., 2019; Kumar *et al*., 2018). Under such conditions recycling of soil fertility, enhancement in rice yield and its quality could be achieved through integrated use of organic manures in combination with chemical fertilizers (Chowdhury *et al*., 2015). Application of organic manures such as vermicompost, farm yard manure, bio-fertilizers and recycling of crop biomass plays a vital role in nutrient cycling, improving soil physical, chemical and biological properties (Patel *et al*., 2015). Zinc is one of the most important micronutrient essential for plant growth especially for rice under submerged condition. After nitrogen, phosphorus and potassium, wide spread of zinc deficiency has been found responsible for yield reduction in rice. Therefore, appropriate nutrient management practice is required for obtaining higher yield of summer rice. Keeping these in view an experiment was conducted to study the effect of chemical fertilizers, organic manures and zinc on summer rice in terai zone of West Bengal.

METERIALS AND METHODS

A field experiment was conducted at Uttar Banga Krishi Viswavidyalaya, Cooch Behar, West Bengal during summer season of 2018 and 2019. The soil of the experimental field was sandy loam in texture (55.98% sand, 26.23% silt and 17.87% clay) with pH 5.60, organic carbon 15.59 g kg^{-1}, available N 160.56 kg ha^{-1}, available P 38.15 kg ha^{-1}, available K 117.64 kg ha^{-1} and available zinc 1.82 kg ha^{-1}. The experiment was laid out in randomized block design with 3 replications, comprising of ten treatments- 100% RDN through fertilizer (T_1), 100% RDN through fertilizer + 25 kg $ZnSO_4ha^{-1}$(T_2), 75% RDN through fertilizer + 25% RDN through vermicompost (T_3), 75% RDN through fertilizer + 25% RDN through FYM (T_4), 50% RDN through fertilizer + 50% RDN through vermicompost (T_5), 50% RDN through fertilizer + 50% RDN through FYM (T_6), 75% RDN through fertilizer + 25% RDN through vermicompost + 25 kg $ZnSO_4ha^{-1}$(T_7), 75% RDN through fertilizer + 25% RDN through FYM + 25 kg $ZnSO_4$ ha^{-1}, (T_8), 50% RDN through fertilizer + 50% RDN through vermicompost + 25 kg $ZnSO_4$ ha^{-1}, (T_9) and 50% RDN through fertilizer + 50% RDN through FYM + 25 kg $ZnSO_4$ ha^{-1}(T_{10}). A uniform dose of 80 kg N, 40 kg P_2O_5 and 40 kg K_2O ha^{-1} were applied to all the plots. One fourth of N and three fourth of K_2O along with full doses of P_2O_5 was applied as basal dose during final land preparation, remaining dose of N was given in two split doses, first at active tillering (½) and second at panicle initiation stage (¼) and remaining dose of K_2O (¼) at panicle initiation stage. The quantity of organic manures *viz.* vermicompost and FYM was estimated based on recommended fertilizer dose of 80 kg N, 40 kg P_2O_5 and 40 kg K_2O ha^{-1}. The laboratory analyses of different manures samples before application in field revealed 1.65 and 1.68% N in vermicompost and 0.58 and 0.61% during first and second year of experimentation, respectively.

Thirty days old rice seedlings cv. Gotra Bidhan-1 were transplanted at a spacing of 20 cm × 15 cm in 4 m × 3 m plots during first week of March in both the years of investigation. Growth parameters (plant height, tiller production), yield components, grain and straw yield were recorded following standard methods. The soil available nutrient after harvest of summer rice was analysed for different treatments also following standard methods. The economic parameters like total cost of cultivation, net returns and benefit: cost (B:C) ratio were worked out based on prevailing market prices of inputs, outputs and labour wage.

RESULTS AND DISCUSSION

Yield and yield attributes. Different nutrient management had a significant effect on yield attributes, *viz.* Tillers m^{-2}, panicle length, number of panicles m^{-2}, number of filled grains $panicle^{-1}$. Yield is the manifestation of various yield components. Among the nutrient management treatments (Table 1), it showed positive and significantly higher yield attributes and yield (grain and straw) under 75% RDN through fertilizer + 25% RDN through vermicompost + 25 kg $ZnSO_4$ ha^{-1} than the rest of the treatments. The beneficial effect of organic manure on yield and attributes could be attributed to the fact that after proper decomposition and mineralization, the manures supplied available nutrients directly to the plant and also had solubilizing effect on fixed forms of nutrients in soil (Singh, 2006). The findings clearly showed that vermicompost use in conjunction with inorganic fertilizer increased rice growth and yield parameters. Vermicompost was known to improve soil physical, chemical and biological qualities. It also improved the soil ability to cycle nutrients and increased the content of exchangeable Ca, Na, Mg and P as well as available N, P and Mo in soil. (Palaniappan and Annadurai 1999). According to Robinson *et al*. (1992) the nutrients in vermicompost were easily accessible to crop plants, resulting in improved plant growth and grain yield. Several workers (Banik and Bejbaruah 2004; Adhikari and Mishra 2002) also reported that vermicompost increased the grain yield of rice.

Due to balanced nutrition of the rice crop with special attention to micronutrients, the application of 25 kg $ZnSO_4$ ha^{-1} increased rice growth and yield qualities over other treatments without $ZnSO_4$. Numerous scientists (Raoand Shukla,1997; Darade and Banker, 2009; Mustafa *et al*., 2011; Karmakar *et al*., 2009; Muamba *et al*., 2013) also noted comparable outcomes.Among the nutrient management treatments (Table 1), the highestgrain yield was noted with the application of $ZnSO_4$@ 25 kg ha^{-1} in combination with 75% RDN through fertilizer + 25% RDN through vermicompost. Many Scientists (Salam and Subramanian, 1993; Sakal *et al*., 1993; Patnaik and Raj 2001; Wijebandara *et al*., 2009 and Dwivedi and Prakash 2014) also noted that application of zinc sulphate to the soil increased grain production for rice.

Soil chemical properties. Changes in soil pH, electrical conductivity (EC), soil organic carbon (SOC) during 2018 and 2019 as affected by different inorganic and integrated use of nutrient sources in summer rice in acidic soil of West Bengal (Table 2) indicates that soil pH (5.72), EC (0.182) was highest when 50% RDN through fertilizer + 50% RDN through vermicompost + 25 kg $ZnSO_4$ were applied. Increase in pH with integrated treatments may be defined as the deactivation of Al^{3+} and concomitant release of basic cations due to addition of organic matter (Gogoi *et al*., 2015). Over time, the use of inorganic fertilizer had negative effects and decreased soil organic content. With the treatment, which received 50 % RDN through organic manure and then 25 % RDN through organic manure, a higher soil organic content was observed (Nath *et al*., 2011; Singh and Dhar 2011).

Nutrient status of soil. Application of integrated nutrient management increased the soil available Nover the treatments (T_1 and T_2), where 100% nitrogen was supplied through inorganic fertilizer (Table 2). This could be as a result of the mineralization of organic sources or the solubilization of nutrient from the native source during the breakdown of organic sources (Yadav and Kumar 2009). According to Bouldin *et al*. (1984), organic manures continuously released N fraction, which may account for the higher post harvest soil nitrogen.

The available P content was minimum in 100% RDN through fertilizer (T_1) and 100% RDN through fertilizer + 25 kg $ZnSO_4$ kg ha^{-1} (T_2). The available phosphorus content of soil (Table 2) increased remarkably with the application of 50% organic manure along with 50% inorganic fertilizer. This may be due to CO_2 released and organic acid produced during decomposition, it aids in native P solubilization. The organic (humus) may also lessen the fixation of phosphate by offering protective cover on sesquioxide and chelating cations, which in turns increased the availability of P (Singh *et al*., 2008).

Table 1: Yield attributes, yield (grain and straw) as influence by integrated nutrient management practices of summer rice (Pooled data of two years).

Treatments	Tillers m^{-2}	Panicle length (cm)	Number of panicles m^{-2}	Number of filled grains $panicle^{-1}$	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
100% RDN through fertilizer	338.00	23.64	317.14	123.61	22.80	4.32	6.28
100% RDN through fertilizer + 25 kg $ZnSO_4$ ha^{-1}	366.37	24.18	337.90	132.65	22.96	4.63	6.55
75% RDN through fertilizer + 25% RDN through vermicompost	347.92	23.82	322.48	127.92	22.88	4.42	6.40
75% RDN through fertilizer + 25% RDN through FYM	342.85	23.75	319.87	126.03	22.83	4.37	6.34
50% RDN through fertilizer + 50% RDN through vermicompost	333.21	23.57	312.00	121.90	22.78	4.26	6.22
50% RDN through fertilizer + 50% RDN through FYM	328.73	23.53	307.54	120.93	22.74	4.22	6.19
75% RDN through fertilizer + 25% RDN through vermicompost + 25 kg $ZnSO_4$ ha^{-1}	377.83	24.38	348.72	142.54	23.10	5.10	6.93
75% RDN through fertilizer + 25% RDN through FYM + 25 kg $ZnSO_4$ ha^{-1}	372.95	24.32	343.32	137.02	23.00	4.86	6.72
50% RDN through fertilizer + 50% RDN through vermicompost + 25 kg $ZnSO_4$ ha^{-1}	361.49	23.99	333.23	134.71	22.94	4.56	6.51
50% RDN through fertilizer + 50% RDN through FYM + 25 kg $ZnSO_4$ ha^{-1}	354.39	23.87	327.45	130.86	22.90	4.50	6.43
$S.E_m$ (±)	4.729	0.111	4.978	2.613	0.335	0.107	0.093
C.D. (P=0.05)	13.56	0.32	14.28	7.50	NS	0.31	0.27

Due to the combined application of organic manures and inorganic fertilizers, the soil available potassium level increased significantly. The highest value was obtained in 50% RDN through fertilizer + 50% RDN through vermicompost + 25 kg $ZnSO_4$ ha^{-1} and the lowest value was found in 100% RDN through fertilizer. This might be due to release of K due to the interaction of organic matter with clay, decrease in K-fixation, solubilization, besides the direct potassium addition to the potassium pool of the soil (Singh *et al.*, 2008).

Nutrient uptake. Among nitrogen management practices, it was apparent that the maximum N, P and K content in grain and straw were recorded at T_7 (75% RDN through fertilizer + 25% RDN through vermicompost + 25 kg $ZnSO_4$ ha^{-1}), which was closely followed by T_8 *i.e.* 75% RDN through fertilizer + 25% RDN through FYM + 25 kg $ZnSO_4$ ha^{-1} and T_2 *i.e* 100% RDN + 25 kg $ZnSO_4$ ha^{-1} (Table 3). Increase in N, P and Kuptake with application of organic manures was also reported by many workers (Bhandari *et al*. 1992; Rathore *et al*; 1995; Virdia and Mehta 2009; Sathish *et al*., 2011). Soil application of $ZnSO_4$@ 25 kg ha^{-1} showed remarkably highest concentration in rice grain over no application of $ZnSO_4$ treatments. According to Anzer and Monoj (2015), the highest zinc content in grain and straw may be the result of an increased amount of zinc being present in the soil solution as a result of the application of zinc, which permitted greater absorption. Similar results were reported earlier by Mollah *et al.* (2009); Fageria *et al.* (2011). Zinc sulphate application @ 25 kg ha^{-1} also enhanced grain uptake of N, P, K and Zn.

Table 2: Soil physical properties and nutrient availability after harvest of summer rice as influenced by integrated nutrient management practices (Pooled data of two years).

Treatments	Soil pH	Soil organic C ($g\ kg^{-1}$)	Soil EC (dSm^{-1})	Nitrogen ($kg\ ha^{-1}$)	P_2O_5 ($kg\ ha^{-1}$)	K_2O ($kg\ ha^{-1}$)	Zinc ($kg\ ha^{-1}$)
100% RDN through fertilizer	5.58	15.75	0.159	154.07	38.31	112.20	1.66
100% RDN through fertilizer + 25 kg $ZnSO_4$ ha^{-1}	5.59	15.83	0.162	156.60	39.00	115.44	2.04
75% RDN through fertilizer + 25% RDN through vermicompost	5.65	17.10	0.170	157.92	40.50	117.26	1.71
75% RDN through fertilizer + 25% RDN through FYM	5.60	17.44	0.165	157.05	39.79	115.87	1.69
50% RDN through fertilizer + 50% RDN through vermicompost	5.70	17.94	0.179	160.84	41.99	119.65	1.80
50% RDN through fertilizer + 50% RDN through FYM	5.67	18.40	0.175	158.38	41.49	118.10	1.75
75% RDN through fertilizer + 25% RDN through vermicompost + 25 kg $ZnSO_4$ ha^{-1}	5.66	17.12	0.173	168.23	41.17	122.13	2.11
75% RDN through fertilizer + 25% RDN through FYM + 25 kg $ZnSO_4$ ha^{-1}	5.63	17.21	0.167	164.07	41.04	121.17	2.08
50% RDN through fertilizer + 50% RDN through vermicompost + 25 kg $ZnSO_4$ ha^{-1}	5.72	18.18	0.182	172.10	42.86	125.91	2.20
50% RDN through fertilizer + 50% RDN through FYM + 25 kg $ZnSO_4$ ha^{-1}	5.69	18.87	0.178	168.54	42.65	124.38	2.15
$S.E_m$ (±)	0.029	0.195	0.003	2.70	1.20	2.706	0.052
C.D. (P=0.05)	0.08	0.560	0.001	7.74	3.45	7.76	0.15

Table 3: Nutrient uptake of summer rice as influenced by integrated nutrient management practices (Pooled data of two years).

Treatments	N content (%)			P content (%)			K content (%)			Zn content (%)		
	Grain	Straw	Total N uptake ($kg\ ha^{-1}$)	Grain	Straw	Total K uptake ($kg\ ha^{-1}$)	Grain	Straw	Total K uptake ($kg\ ha^{-1}$)	Grain	Straw	Total Zn uptake ($g\ ha^{-1}$)
100% RDN through fertilizer	1.755	1.058	141.94	0.184	0.118	15.37	0.266	1.178	85.42	24.467	34.300	325.47
100% RDN through fertilizer + 25 kg $ZnSO_4$ ha^{-1}	1.985	1.147	167.07	0.214	0.126	18.17	0.305	1.297	99.03	26.733	36.494	361.52
75% RDN through fertilizer + 25% RDN through vermicompost	1.890	1.075	152.03	0.196	0.122	16.49	0.278	1.236	91.42	25.383	35.133	336.26
75% RDN through fertilizer + 25% RDN through FYM	1.843	1.061	147.79	0.195	0.121	15.81	0.275	1.208	88.63	24.983	34.694	330.68
50% RDN through fertilizer + 50% RDN through vermicompost	1.719	1.048	138.49	0.176	0.116	14.68	0.270	1.163	83.85	24.433	34.017	315.95
50% RDN through fertilizer + 50% RDN through FYM	1.667	1.029	134.22	0.174	0.114	14.48	0.251	1.138	81.08	23.567	33.667	310.43
75% RDN through fertilizer + 25% RDN through vermicompost + 25 kg $ZnSO_4$ ha^{-1}	2.019	1.163	183.60	0.224	0.132	20.11	0.320	1.317	107.51	27.150	37.528	403.30
75% RDN through fertilizer + 25% RDN through FYM+ 25 kg $ZnSO_4$ ha^{-1}	2.006	1.151	174.42	0.218	0.128	19.20	0.314	1.301	102.61	26.967	37.178	383.46
50% RDN through fertilizer + 50% RDN through vermicompost + 25 kg $ZnSO_4$ ha^{-1}	1.957	1.126	162.64	0.210	0.124	17.66	0.299	1.280	96.92	26.700	35.822	353.50
50% RDN through fertilizer + 50% RDN through FYM + 25 kg $ZnSO_4$ ha^{-1}	1.917	1.099	156.92	0.204	0.123	17.10	0.285	1.260	93.76	25.283	35.589	344.89
$S.E_m$ (±)	0.036	0.020	2.943	0.007	0.002	0.812	0.010	0.026	1.757	0.510	0.553	3.426
C.D. (P=0.05)	0.103	0.057	8.449	0.022	0.005	2.329	0.028	0.076	5.045	1.46	1.59	9.83

Table 4: Production economics of summer rice as influenced by integrated nutrient management practices (Pooled data of two years).

Treatments	Common cost (Rs. ha^{-1})	Total cost of production (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit: Cost
100% RDN through fertilizer	40828	44767	78321	33553	1.75
100% RDN through fertilizer + 25 kg $ZnSO_4$ ha^{-1}	40828	46517	83468	36950	1.79
75% RDN through fertilizer + 25% RDN through vermicompost	40828	49034	80080	31045	1.63
75% RDN through fertilizer + 25% RDN through FYM	40828	55265	79145	23880	1.43
50% RDN through fertilizer + 50% RDN through vermicompost	40828	53302	77360	24057	1.45
50% RDN through fertilizer + 50% RDN through FYM	40828	65762	76681	10919	1.17
75% RDN through fertilizer + 25% RDN through vermicompost + 25 kg $ZnSO_4$ ha^{-1}	40828	50784	91345	40560	1.80
75% RDN through fertilizer + 25% RDN through FYM+ 25 kg $ZnSO_4$ ha^{-1}	40828	57015	87214	30199	1.53
50% RDN through fertilizer + 50% RDN through vermicompost + 25 kg $ZnSO_4$ ha^{-1}	40828	55052	82381	27329	1.50
50% RDN through fertilizer + 50% RDN through FYM + 25 kg $ZnSO_4$ ha^{-1}	40828	67512	81291	13778	1.20

Economics. Cost of cultivation of rice ranged from Rs. 44767 ha^{-1} for 100% RDN through inorganic fertilizer to Rs. 67512 ha^{-1}. The highest gross and net returns and benefit: cost ratio was recorded with the application of 75% RDN through inorganic fertilizer + 25% RDN through vermicompost along with 25 kg $ZnSO_4$ ha^{-1} (Table 4). The lowest cost of cultivation was recorded under the treatment, where 100% recommended dose of nitrogen was applied through inorganic fertilizer. Thus, rice cultivation proved more profitable when grown with integrated nutrient management (inorganic and organic).

CONCLUSION

From the above study, it can be concluded that significantly higher grain yield and nutrient uptake could be obtained with the application of 75% RDN through fertilizer + 25% RDN through vermicompost along with 25 kg $ZnSO_4$ ha^{-1} which was closely followed by 75% RDN through fertilizer + 25% RDN through FYM along with 25 kg $ZnSO_4$ ha^{-1}. Application of 75% RDN through fertilizer + 25% RDN through vermicompost along with 25 kg $ZnSO_4$ ha^{-1} in summer rice also showed higher net return and B:C ratio interai region of West Bengal.

FUTURE SCOPE

The author wants to conclude that summer rice could be successfully cultivated in terai region of West Bengal by using combine application of plant nutrient trough organic and inorganic sources, which increased the total productivity and profitability of summer rice and improved residual soil nutritional status.

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Conflict of Interest. None.

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