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Effect of balanced nutrition on productivity, economics and soil fertility of rice (*Oryza sativa* L.) – greengram [*Vigna radiata* (L.) Wilczek] cropping system under coastal West Bengal

M. RAY, P. HALDAR, S. SAHA, S. CHATTERJEE, [1]S. ADHIKARY AND S.K. MUKHOPADHYAY

AICRP on Integrated Farming Systems, BCKV, Kalyani-741235, Nadia, West Bengal
[1]AERU, Indian Statistical Institute, Kolkata, West Bengal, India

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ABSTRACT

A field experiment was conducted during rainy (kharif) and summer season of 2011-12, 2012-13, 2013-14 and 2014-15 at farmers' field of Mandirbazar and Kakdwip blocks of South 24 Parganas district, West Bengal to study the response of rice (Oryza sativa L.) – greengram cropping sequence to balanced nutrition. The experiment consisted of 7 treatments combinations, viz. absolute control, recommended N alone, recommended N and P, recommended N and K, recommended N, P and K, recommended NPK with ZnSO4 in rice along with NPK in succeeding greengram, and farmers' practice, were replicated in 24 farmers' field. Application of 80 kg ha^{-1} N, 40 kg ha^{-1} P and 40 kg ha^{-1} K along with 25 kg ha^{-1} ZnSO4 to rice recorded significantly higher grain (4.51 t ha^{-1}) as well as straw (6.48 t ha^{-1}) yield and in the same plot in succeeding greengram application of 20 kg ha^{-1} N, 40 kg ha^{-1} P, 40 kg ha^{-1} K also recorded significantly higher seed (0.92 t ha^{-1}) yield. Similarly the maximum system rice equivalent yield (8.81 t ha^{-1}) and productivity (24 kg ha^{-1} day^{-1}) were also achieved under this nutrient combination. Significantly higher cost of cultivation (62,704 ha^{-1}), gross return (1, 90,699 ha^{-1}), net return (46,994 ha^{-1}), B: C ratio (1.76) and sustainable yield index (0.83) for rice-greengram cropping system were also recorded with the same treatment combination. This nutrient combination also responsible for higher fertility build up.

Keywords: Balanced nutrition, economics, rice-greengram cropping system, soil fertility, sustainable yield index

The coastal flood plains of West Bengal spread over an area of 10,158.2 Km^2 and represents lowland agro-ecosystem with heavy textured saline soils. Farmers used to grow high yielding varieties of rice during wet season followed by greengram, khesari and some other low water requiring crops (Ray *et al.*, 2016). Among them rice-greengram is the dominant cropping system and occupying 10,253 ha greatly support the livelihood of the rural people. During the last 30 years as a result of intensified crop management involving improved germplasm, greater use of fertilizer and irrigation, the yield has markedly increased in India in cereal-based system. During the period 1950-51 to 2007-08, the cereal production in the country increased by 5 times, whereas the fertilizer consumption increased by 322 times, implying a very low fertilizer use efficiency (Rajendra Prasad, 2009). A decline in partial factor productivity of nitrogenous fertilizer is the most commonly observed effect of intensive cereal-based systems (Hobbs and Merris, 1996). Decline in soil N supply results in declining factor productivity of chemical nitrogen, because soil N is natural substitute for chemical nitrogen. In addition to nitrogen, phosphorus and potassium are the most important nutrient elements required by the cereal-based systems. In post green revolution era multiple-nutrient deficiency including micronutrients is one of the important problems making system unsustainable (Jat *et al.*, 2016). Moreover, deficiency of Zn is very frequent in rice-based intensive system with no or little application of Zn fertilizer (Saha *et al.*, 2015). Considering this fact, a participatory research was carried out at farmers' field to quantify the productivity potential of rice-greengram cropping system with set of nutrient combination treatments for 4 consecutive years.

MATERIALS AND METHODS

The field experiment was conducted during rainy (kharif) and summer seasons of 2011-12, 2012-13, 2013-14 and 2014-15 on farmers' field of Mandirbazar (Madhabpur, Akhraberia and Ghateswar villages) and Kakdwip (Akshyanagar, Moynapara and Bishalaxmipur villages) blocks of South 24 Parganas district, situated in Coastal Saline Zone of West Bengal. The mean value of physical and chemical characteristics of soils over the sites at the initiation of experiment indicated that, soil is silty clay loam with soil pH 5.45, EC 0.59 dS/m, organic carbon 0.72, available N 140.50 kg ha^{-1}, available P 48.10 kg ha^{-1}, available K 281.5 kg ha^{-1} and available Zn 0.59 ppm.

The experiment comprised of 7 treatments, *viz.* control (no fertilizer), recommended N, NP, NK, NPK, NPK+$ZnSO_4$ and farmers' practice, applied to rice and greengram in sequence. In case of NPK+$ZnSO_4$, $ZnSO_4$ was only applied to rice crop. At each site/village, 4 farmers were selected thus making 24 farmers and all

Email: manabbckv@gmail.com

Table 1: Grain/seed, straw yield and rice equivalent yield (REY) as influenced by nutrient combinations (pooled data of 4 years)

Treatment	Rice grain yield (t ha^{-1})	Rice straw yield (t ha^{-1})	Greengram seed yield (t ha^{-1})	REY (t ha^{-1})	System productivity (kg ha^{-1}day^{-1})
Control	3.04	4.39	0.57	5.69	15.59
N	3.49	5.05	0.65	6.55	17.95
NP	3.90	5.61	0.78	7.54	20.66
NK	4.02	5.80	0.76	7.56	20.72
NPK	4.36	6.29	0.88	8.48	23.23
NPK+$ZnSo_4$	4.51	6.48	0.92	8.81	24.13
Farmers' practice	4.09	5.84	0.80	7.83	21.46
SEm(±)	**0.016**	**0.024**	**0.005**	**0.028**	**0.08**
LSD (0.05)	**0.043**	**0.067**	**0.014**	**0.077**	**0.210**

Table 2: Post-harvest soil-nutrient status as influenced by nutrient combinations in rice-greengram cropping system (pooled data of 4 years)

Treatment	OC (%)	Avail. N (kg ha^{-1})	Avail. P (kg ha^{-1})	Avail. K (kg ha^{-1})	Avail. Zn (ppm)
Control	0.963	172.62	46.63	276.70	0.584
N	0.970	178.32	45.15	275.80	0.530
NP	0.933	176.93	48.94	273.73	0.529
NK	0.929	176.21	44.07	276.93	0.572
NPK	0.848	174.68	48.69	279.74	0.590
NPK+$ZnSO_4$	0.838	176.53	48.06	278.82	0.693
Farmers' practice	0.986	165.13	46.33	271.51	0.580
SEm(±)	**0.01**	**1.30**	**0.47**	**1.79**	**0.01**
LSD (0.05)	**0.03**	**3.61**	**1.32**	**4.97**	**0.03**

Table 3: Economics of rice-greengram cropping system as influenced by nutrient combinations (pooled data of 4 years)

Treatment	Gross returns (x 10^3 ₹ ha^{-1})	Cost of cultivation (x 10^3 ₹ ha^{-1})	Net returns (x 10^3 ₹ ha^{-1})	B : C ratio	SYI
Control	71.33	49.30	22.03	1.44	0.71
N	82.17	53.38	28.80	1.54	0.78
NP	94.25	58.39	35.86	1.62	0.80
NK	94.65	56.49	38.16	1.68	0.81
NPK	105.73	61.21	44.52	1.74	0.83
NPK+$ZnSo_4$	109.70	62.70	46.99	1.76	0.83
Farmers' practice	97.67	58.28	39.40	1.69	0.81
SEm(±)	**0.331**	**0.085**	**0.331**	**0.01**	**0.01**
LSD (0.05)	**0.919**	**0.237**	**0.919**	**0.02**	**0.04**

the 7 treatments were allotted in each of the farmers' field taking a block of 350 m^2 area (net plot) *i.e.* the area of treatment at every farmers' plot was 50 m2. Statistical analysis of the recorded data was done using SPSS software, IBM Inc.2009 and critical difference (CD) was completed at 5 per cent level of probability (P=0.05), whereas, each of the selected farmer's field was treated as 1 replication. Rice cultivar 'ranjit' and chickpea 'local selection' were grown. The recommended dose of $N:P_2O_5$: $K_2O:ZnSO_4$ in rice was 80:40:40:25 kg ha^{-1} respectively, while for greengram it was 20:40:40:0 kg ha^{-1}. In farmers' practice 52:56:24 kg ha^{-1} $N:P_2O_5$: K_2O respectively was applied in rice, whereas in greengram 18:34:10 kg ha^{-1} $N:P_2O_5:K_2O$ respectively were applied. Both the crops were raised with recommended package of practices. The rice crop was grown under rainfed condition, while greengram was given only 1 irrigation. In case of rice, both grain and straw yield were considered as economic yield, whereas, only seed yield of greengram was taken into consideration and the biomass was ploughed down after plucking the pods. The greengram yield was converted into rice-equivalent yield (REY) based on prevailing market price in the respective years. Production efficiency in terms of kg ha^{-1} day^{-1} was calculated by dividing the total REY of rice-greengram system with 365 days and sustainable index of each treatment was calculated as per Devsenapathy *et. al.*, 2008.

RESULTS AND DISCUSSION

Productivity of rice and greengram

Application of recommended dose of NPK along with $ZnSO_4$ resulted significantly higher grain (4.51 t ha-1) and straw (6.48 t ha^{-1}) yield of rice and seed (0.92 t ha^{-1}) yield of greengram (Table 1). The increase in grain yield of rice due to application of recommended doses of NPK along with $ZnSO_4$ was 48, 29, 16, 12, 3 and 10 percent higher over the control, N, NP, NK, NPK and farmers' practice respectively (Table 1). Further in succeeding greengram, the increase in seed yield with NPK along with $ZnSO_4$ (residual effect) were to the tune of 62, 40, 18, 4 and 15 percent over control, N, NP, NK, NPK and farmers' practice respectively. Again with respect to system REY and system productivity NPK along with $ZnSO_4$ recorded significantly higher value (8.81 t ha^{-1} and 24.13 kg ha^{-1} day^{-1} respectively) in comparison with other nutrient treatments (Table 1). Significant improvement in grain/seed yield of rice and greengram may be attributed to improvement of P in better root development and subsequently absorption of N, while K is involved in N metabolism in cereals. Further, soils of the experimental sites are deficient in Zn; the application of this deficit nutrient helped both the crops to record higher yields over NPK treatment alone. The results are in agreement with Ravisankar *et al.* (2014), Hiremath *et al.* (2016) and Shinde *et al.* (2015).

Post-harvest nutrient status of soil

The data on soil fertility status after harvesting of the crops are presented in the table 2. The higher value of organic carbon and available N, P, K and Zn were observed with the application of 80 kg N, 40 kg P_2O_5, 40 kg K_2O, 25 kg $ZnSO_4$ to rice and 20 kg N, 40 kg P_2O_5, 40 kg K_2O to the succeeding greengram in same plot over the other treatment combinations. Further the inclusion of greengram in the cropping system was responsible for nutrient buildup of soil as it is a legume add considerable amount of crop residue to the soil besides symbiotic N fixation. Mohan Kumar and Hiremath (2015) reported significant improvement in post-harvest soil fertility in elevated doses of fertilizer.

Economic analysis of cropping system

Application of 80 kg N, 40 kg P_2O_5, 40 kg K_2O along with $ZnSO_4$ @ 25 kg ha^{-1} in rice and 20 kg N, 40 kg P_2O_5, 40 kg K_2O in greengram in same plot resulted in significantly higher cost of cultivation (62,704 ha^{-1}), gross return (1,09,699 ha^{-1}), net return (46,994 ha^{-1}) and benefit: cost ratio (1.76) of the rice-greengram system over the remaining nutrient combinations (Table 3). Whereas, the control treatment recorded the significantly lower system cost of cultivation (49,299 ha^{-1}), system gross return (71,329 ha^{-1}), system net return (22,031 ha^{-1}) and benefit-cost ratio (1.44). Though recommended NPK along with $ZnSO_4$ recorded the highest cost of cultivation due to highest level of fertilizer application, at the same time this treatment recorded the highest level of yield for both the crops and the marginal gain is higher than any of the treatments. Similarly, in control treatments though, the cost of cultivation is the lowest owing to no fertilizer application, at the same time this treatment recorded the minimum level of yield for both the crops and marginal gain was also the lowest. These findings are in line with those of Sharma *et al.* (2011). Further in terms of sustainable yield index *i.e.* which treatment is more sustainable over the year and also over the location, application of 80 kg N, 40 kg P_2O_5, 40 kg K_2O, 25 kg $ZnSO_4$ to rice and 20 kg N, 40 kg P_2O_5, 40 kg K_2O in succeeding greengram in same plot excelled over all other fertilizer treatment combinations owing to consistent higher yield of rice and greengram over the locations and years.

It may be concluded that the application of 80 kg N, 40 kg P_2O_5, 40 kg K_2O, 25 kg $ZnSO_4$ to rice and 20kg N, 40 kg P_2O_5, 40 kg K_2O in succeeding greengram with the residual effect of $ZnSO_4$ applied in rice are required to harvest optimum crop yield, maintaining soil fertility and economic returns in rice-greengram cropping sequence under coastal saline soils of West Bengal.

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