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RESEARCH PAPER

Nutrient management in rice-lentil (*paira*)-sesame cropping system under coastal saline zone of West Bengal

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Abstract : A field experiment was undertaken at Regional Research Station, Bidhan Chandra Krishi Viswavidyalaya during 2005-2006 and 2006-2007 under coastal saline soil of West Bengal. The experiment was laid out in Randomized Block Design (RBD) with nine different nutritional treatments each replicated four times, to evaluate the growth, productivity and economics in rice-lentil (*paira*)-sesame sequence. The growth parameters, yield components and seed yield of all the crops in sequence were the maximum when organic manure was applied along with inorganic fertilizer at 75 per cent of the recommended dose (RD). The effect of well decomposed fishmeal (WDFM) was as good as farm yard manure (FYM) vis-à-vis vermicompost and sometimes it showed better result over FYM and vermicompost. The maximum rice equivalent yield, net returns and net production value in rice-lentil (*paira*)-sesame sequence were obtained from the crops treated with 75 per cent RD of NPK+2 t WDFM ha-1 only to rice.

Key Words : *Paira* cropping, Nutrient management, Fishmeal, Coastal saline zone

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INTRODUCTION

Presently fertilizer application is based on the nutrient requirement of individual crop and the carry-over effect of the manures or fertilizers applied to preceding crop are generally ignored. Further, application of inorganic fertilizers even in balanced amount can not sustain the soil fertility and crop productivity under diversified continuous cropping or mono-cropping and as a result of these things agriculture is now facing a lot of stresses. Integrated nutrient management involving conjunctive use of organic and inorganic sources of nutrients may improve the soil productivity (Patra *et al.*, 2000), and system productivity becomes sustainable (Raju and Reddy, 2000), rather to say, the soil-water-plant-animal-human continuum is maintained *i.e.* the agriculture is thus conserved to a large extent. It is fact that in the village cowdung is becoming scarce day-by-day. A large part of the available amount of it is used for preparing cowdung cakes for fuel purpose. So, emphasis should be given to use alternative sources (specifically different for different areas) for organic manures. In the coastal saline zone of West Bengal, farmers are habituated in applying raw fishmeal in the vegetables and some other crops, but it causes problems of disease and insect occurrence. Preparation of well-decomposed fishmeal (WDFM) from dried fish, easily and amply available at low cost in this zone and application it increases the yield of crops without causing any pest problem and improves soil fertility simultaneously. In this context, with a broader objective of utilizing the organic resources for substituting the chemical fertilizer partly, augmenting the soil health for sustainability in agricultural production and increasing the cropping intensity of the coastal saline zone in an eco-friendly manner. Inclusion of low water requiring crop like oilseed and pulse in the cropping sequence after *Kharif* rice not only increases the cropping intensity but also promote optimal utilization of land-water-nutrient resources. Moreover, a deficit in demand

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position of oilseed and pulses in West Bengal (50% and 80%, respectively) will also be mitigated. Again, inclusion of grain legumes in rice based cropping system improves the soil health as a whole. Keeping this view in the background, a field experiment was conducted at Regional Research Station (Coastal Saline zone), Bidhan Chandra Krishi Viswavidyalaya, Kakdwip, 24 Parganas (South), West Bengal during 2005-2006 and 2006-2007.

MATERIALS AND METHODS

The experiment was carried out at Regional Research Station, Bidhan Chandra Krishi Viswavidyalaya during rainy season (*Kharif*), winter season (*Rabi*) and summer season (pre-*Kharif*) of 2005-06 and 2006-07 under coastal saline soil of Kakdwip (Latitude-21090/N, longitude-88010/E and altitude-5.5m), 24 Parganas (South), West Bengal. The experimental soil was silty clay loam in texture having pH 7.6, BD 1.41 gm^{-3}, EC 2.85 dsm^{-1}, organic carbon 0.53 per cent, total nitrogen 1140.00 kg ha^{-1}, available phosphorus 28.20 kg ha^{-1} and available potassium 515.00 kg ha^{-1}. The experimental site was subtropical humid climate with an average rainfall ranging between 1377 mm and 2284 mm and means maximum, minimum temperature of 15 to 36^0C, respectively. The experiment was laid out in Randomized Block Design (RBD) with 9 different nutritional treatments each replicated four times. The different nutritional treatments of rice were T_1-100 per cent recommended dose (RD) of NPK; T_2-75 per cent RD of NPK; T_3-50 per cent RD of NPK; T_4-75 per cent RD of NPK+10 t farm yard manure (FYM) ha^{-1}; T_5-50 per cent RD of NPK+10 t FYM ha^{-1}; T_6-75 per cent RD of NPK+2 t well decomposed fishmeal (WDFM) ha^{-1}; T_7-50 per cent RD of NPK+2 t WDFM ha^{-1}; T_8-75 per cent RD of NPK+4 t vermicompost ha^{-1}; and T_9-50 per cent RD of NPK+4 t vermicompost ha^{-1}.

The experiment was conducted for six consecutive seasons in the same piece of land without change in the layout. Starting with *Kharif* rice (cv. KHITISH *i.e.* IET-4094) in 2005, the staple cereal grain of West Bengal, was transplanted in the end of July in every year with recommended dose of fertilizers (60,30,30 kg NPK ha^{-1}), one popular grain legume lentil (cv. ASHA *i.e.* B-77), widely cultivated as a *Rabi* pulse in the coastal saline zone of West Bengal, was grown as a *paira* crop at end of October with residual nutrient and it was followed by a short duration and low water requiring oilseed crop, sesame (cv. TILOTTAMA *i.e.* B-67*)* was sown at 1st part of March in every year with residual nutrient. The sources of NPK were urea, SSP and MOP. Organic manure like FYM, WDFM (Dried fish, amply available in this zone, but erratically used in raw condition causing various insect and diseases problems in crops, was decomposed properly in "heap method") and vermicompost were incorporated into the soil at the time of final land preparation. The well decomposed fishmeal containing 6.92 per cent N, 5.11 per cent P_2O_5 and 1.45 per cent K_2O whereas FYM containing 0.62 per cent N, 0.32 per cent P_2O_5 and 0.76 per cent K_2O and vermicompost containing 1.42 per cent N, 0.56 per cent P_2O_5 and 1.06 per cent K_2O. Total nitrogen, available phosphorus and available potassium were estimated by modified Macro- Kjeldahl's method, Olsen's method and flame photometric method (Jackson, 1967).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Rice:

The growth parameter of rice *i.e.*, LAI, drymatter accumulation (DMA), crop growth rate (CGR), plant height and number of tillers m^{-2} were differed significantly with the different nutritional management treatments at different stages (Table 1). The maximum LAI (5.27 and 1.14 at 60 and 90 days after transplanting, respectively) were recorded when the rice crop was fertilized with 75 per cent RD of NPK along with 2 t WDFM ha^{-1} (T_6). The lowest value of LAI (3.47 and 0.57 at 60 and 90 DAT, respectively) was obtained under the treatment where the rice crop was fertilized with only 50 per cent RD of NPK (T_3). At both the stages, the highest value of dry matter accumulation (DMA) were observed in the treatment T_6 (75% RD of NPK+2 t WDFM ha^{-1}) and the lowest DMA was recorded in the treatment T_3 (50% RD of NPK). In case of CGR the maximum value (6.61 g m^{-2} day^{-1}) was found in the treatment T_6 and it was statistically at par with the treatment T_8 (75% RD of NPK+4 t vermicompost ha^{-1}). The maximum plant height (89.4cm) was recorded in treatment T_1 (100% RD of NPK). The significantly height number of tillers m^{-2} (326.9 m^{-2}) was obtained in the crop receiving 75 per cent RD of NPK along with 2 t WDFM ha^{-1} (T_6).

The yield components of rice *i.e.*, number of panicle m^{-2}, number of filled grains $panicle^{-1}$ and percentage of filled grain varied significantly with the variation in nutritional management treatments. The maximum number of panicles m^{-2} (316.4 m^{-2}) was recorded in the T_6 and it was statistically at par with treatment T_8. Conjunctive use of chemical fertilizer along with organic manure in general showed higher number of panicles m^{-2} as compared to use of inorganic fertilizer alone to the crop. The highest value of number of filled grains $panicle^{-1}$ (81.8) was obtained from T_6 and this treatment was statistically at par with the treatment T_8. The maximum percentage of grain filling (76.9%) was obtained under the treatment T_6 and it was statistically at par with T_8 and T_4. The 1000 grain weight of rice did not differ significantly with different nutritional management treatment. The maximum grain yield (3435 kg ha^{-1}) was recorded in the treatment T_6 where rice crop was fertilized with 75 per cent RD of NPK along with 2 t WDFM ha^{-1} and it was statistically at par with treatment T_8. The significantly lowest grain yield of rice (2399 kg ha^{-1}) was found from the treatment T_3 (50% RD of NPK)

Table 1 : Effect of different nutritional management treatments on growth parameters, yield components, yield and harvest index of rice (pooled data of two years)

Treatments	LAI		DMA		CGR	Plant height (cm)	No. of tillers m^{-2}	Yield components				Yield (kg ha^{-1})		Harvest index (%)
	60 DAT	90 DAT	60 DAT	90 DAT	60-90 DAT			No. of panicles m^{-2}	No. of filled grains $panicle^{-1}$	% filled grain	1000 grain weight (g)	Grain yield	Straw yield	
T_1	5.08	1.08	506.8	675.0	5.61	89.4	301.0	298.4	78.0	73.1	21.26	3087	4243	42.14
T_2	4.18	0.68	452.9	599.1	4.87	80.4	286.3	271.6	72.0	68.6	20.45	2826	4179	40.35
T_3	3.47	0.57	395.5	523.8	4.28	77.6	261.9	249.6	66.0	65.0	19.34	2399	3417	41.25
T_4	4.58	0.97	529.0	717.8	6.29	85.5	309.4	301.9	79.6	74.7	20.21	3295	4504	42.25
T_5	4.06	0.83	468.0	633.6	5.52	81.9	291.8	285.2	73.8	69.6	20.72	3035	4354	41.08
T_6	5.27	1.14	584.9	783.2	6.61	85.7	326.9	316.4	81.8	76.9	21.34	3435	4455	43.54
T_7	4.78	0.92	512.1	696.1	6.13	82.3	301.2	296.0	75.2	70.5	21.30	3126	4329	41.93
T_8	5.06	1.03	570.6	764.4	6.46	86.6	312.4	307.2	80.8	73.5	20.72	3388	4446	43.25
T_9	4.47	0.88	498.8	678.3	5.98	82.7	298.7	289.3	74.5	69.9	20.87	3078	4224	42.15
S.E.(±)	0.061	0.029	12.96	15.99	0.064	1.068	4.507	4.425	0.740	1.284	0.629	30.993	34.18	---
C.D. (P=0.05)	0.179	0.084	37.85	46.70	0.188	3.12	13.16	12.92	2.16	3.75	NS	90.5	99.8	---

*LAI- Leaf area index (%), DMA- Dry matter accumulation (g m^{-2}), CGR- Crop growth rate (g m^{-2} day^{-1})
**DAT- Days after transplanting ***NS- Non-significant

among all the treatments. The maximum straw yield (4504 kg ha^{-1}) was obtained when the crop was fertilized with 75 per cent RD of NPK along with 10 t FYM ha^{-1} (T_4) and this treatment was closely followed by the treatment T_6 and T_8. Harvest index of rice was maximum (43.54%) where crop received with 75 per cent RD of NPK along with 2 t WDFM ha^{-1} (T_6) and it was closely followed by the treatment T_8 and T_4. This result is in agreement with the findings of Talashilkar *et al*. (1999) and Patil *et al.* (2000). They opined that application of 1, 2 and 3 t fishmeal ha^{-1} increased the grain yield of rice by 0.75, 1.86 and 2.93 t ha^{-1}, respectively over no application of fishmeal.

Lentil:

Lentil crop was grown as a *paira* crop with residual nutrient, the growth parameters like LAI, DMA and CGR were differed significantly with the different nutritional management treatments at different stages (Table 2). In case of LAI of lentil, at 60 days after sowing (DAS) the maximum value (3.15) was observed in the treatment T_6 where the previous crop, rice received 75 per cent RD of NPK along with 2 t WDFM ha^{-1}, but at 90 DAS changes in nutritional treatment had no significant effect in changing the LAI of lentil. The highest DMA (197.9 and 256.5 g m^{-2} at 60 and 90 DAS, respectively)

Table 2 : Effect of different nutritional management treatments on growth parameters, yield components, yield and harvest index of lentil (pooled data of two years)

Treatments	LAI		DMA		CGR	Plant height (cm)	No. of branches $plant^{-1}$	Yield components			Yield (kg ha^{-1})		Harvest index (%)
	60 DAS	90 DAS	60 DAS	90 DAS	60-90 DAS			No. of pod $plant^{-1}$	No. of seed pod^{-1}	1000 seed weight (g)	Seed yield	Stover yield	
T_1	2.94	1.80	181.0	233.0	1.73	33.6	6.61	57.2	1.93	18.45	567	1477	27.74
T_2	2.63	1.71	153.2	202.0	1.63	30.7	5.89	48.3	1.84	18.50	508	1344	27.43
T_3	2.19	1.52	141.4	181.3	1.33	28.7	5.13	38.3	1.57	17.21	423	1142	27.03
T_4	3.10	1.85	194.2	245.9	1.72	35.7	7.21	62.3	2.02	19.01	667	1604	29.37
T_5	2.75	1.76	167.6	211.6	1.47	34.9	6.42	54.2	1.83	18.85	560	1291	30.25
T_6	3.15	1.84	197.9	256.5	1.95	35.2	7.43	64.5	1.98	18.36	731	1539	32.20
T_7	2.78	1.78	172.0	223.2	1.71	34.5	6.81	56.7	1.87	18.47	595	1319	31.09
T_8	2.95	1.75	188.0	243.2	1.84	34.9	6.39	61.2	1.90	17.86	707	1448	32.81
T_9	2.66	1.68	163.6	207.5	1.46	32.6	5.87	52.4	1.80	18.72	576	1231	31.88
S.E.(±)	0.185	0.11	10.59	14.70	0.098	1.79	0.781	3.664	0.207	1.765	30.49	95.86	---
C.D. (P=0.05)	0.539	NS	30.91	42.93	0.285	NS	NS	10.70	NS	NS	89.03	279.9	---

*LAI- Leaf area index (%), DMA- Dry matter accumulation (g m^{-2}), CGR- Crop growth rate (g m^{-2} day^{-1})
**DAS- Days after sowing ***NS- Non-significant

were observed where the previous crop, rice received 75 per cent RD of NPK along with 2 t WDFM ha^{-1} (T_6). The crop growth rate (CGR) varied significantly with the variation in nutritional management treatments. It ranged from 1.95 g m^{-2} day^{-1} (T_6) to 1.33 g m^{-2} day^{-1} (T_3). Plant height and number of branches plant^{-1} of lentil did not differ significantly with the variation of nutritional management treatments.

Yield component of lentil like, number of pods plant^{-1} was maximum (64.5 plant^{-1}) in the treatment T_6 (Table 2). Though, the number of seeds pod^{-1} and 1000 seed weight did not significantly differ with the difference in nutritional treatments. The highest seed yield of lentil (731 kg ha^{-1}) was obtained in the treatment T_6 where the previous crop, rice was fertilized with 75 per cent RD of NPK along with 2 t WDFM ha^{-1} and it was statistically at par with the treatments T_8 and T_4. The lowest seed yield (423 kg ha^{-1}) of lentil was recorded from the treatment T_3 among all the treatments. The treatment T_4 (75% RD of NPK along with 10 t FYM ha^{-1}) showed the maximum stover yield (1604 kg ha^{-1}). In case of harvest index treatment T_8 (75% RD of NPK along with 4 t vermicompost ha^{-1}) produced the highest value (32.81%) and this treatment was closely followed by the treatment T_6. The similar finding reported by Singh *et al*. (2001) that integrated use of FYM and NPK gave significant maximum average rice yield of 3.34 t ha^{-1} and lentil yield of 1.02 t ha^{-1} in rice-lentil cropping system.

Sesame:

The growth parameter of sesame differed significantly with the different nutritional management treatments at different stages (Table 3). At both the stages, LAI varied significantly, the highest value of LAI (2.25 and 0.94 at 60 and 90 DAS, respectively) was observed in treatment T_6 where rice was fertilized with 75 per cent RD of NPK along with 2 t WDFM ha^{-1}. The maximum DMA (226.7 and 328.3 g m^{-2} at 60 and 90 DAS, respectively) were observed under the treatment T_6 and it was statistically at par with the treatment T_4 and T_8. The CGR of sesame did not differ significantly with the difference in nutritional management treatments. The maximum plant height (90.45 cm) of sesame was recorded in the treatment T_6 where rice crop was fertilized with 75 per cent RD of NPK along with 2 t WDFM ha^{-1}. The number of branches plant^{-1} of sesame did not vary significantly with the variation of nutritional management treatments.

The maximum number of capsules plant^{-1} (53.16) was noticed in the treatment T_6 and it was statistically at par with treatment T_8 and T_4 (Table 3). The maximum number of seeds capsule^{-1} (54.25) recorded in the treatment T_6 where rice crop received 75 per cent RD of NPK along with 2 t WDFM ha^{-1}. The 1000-seed weight of sesame did not vary significantly with different nutritional management treatments. The maximum seed yield (796 kg ha^{-1}) and stover yield (2113 kg ha^{-1}) were recorded under the treatment T_6 and it was closely followed by the treatments T_8 and T_4, whereas the treatment T_3 (50% RD of NPK) produced the lowest seed yield (513 kg ha^{-1}) of seasame among all the treatments. In case of harvest index, the treatment T_8 (75% RD of NPK along with 4 t vermicompost ha^{-1}) showed the highest value (28.50%) and it was closely followed by the treatment T_9, T_6 and T_4. Pal *et al.* (2003) reported that application of fishmeal @ 2 t ha^{-1} along with mineral fertilizer performed the best in rice-rapeseed-blackgram sequence and this treatment was as good as FYM applied plots and sometimes better.

Rice equivalent yield:

Table 4 clearly showed that the maximum rice equivalent yield (7958.7 kg ha^{-1}) was found where the rice crop received

Table 3 : Effect of different nutritional management treatments on growth parameters, yield components, yield and harvest index of sesame (pooled data of two years)

Treatments	LAI		DMA		CGR	Plant height (cm)	No. of branches plant^{-1}	Yield components			Yield (kg ha^{-1})		Harvest index (%)
	60 DAS	90 DAS	60 DAS	90 DAS	60-90 DAS			No. of capsules plant^{-1}	No. of seed capsule^{-1}	1000 seed weight (g)	Seed yield	Stover yield	
T_1	2.07	0.75	191.7	285.5	3.13	87.25	2.98	46.76	46.60	3.06	598	1711	25.90
T_2	2.02	0.68	187.3	278.4	3.04	86.45	2.94	46.15	45.25	2.98	572	1778	24.34
T_3	1.97	0.61	171.3	264.3	3.10	82.16	2.75	44.21	42.01	2.85	513	1598	24.30
T_4	2.18	0.85	210.4	314.3	3.46	89.26	3.09	52.21	52.62	2.95	731	1950	27.27
T_5	2.09	0.71	182.3	275.8	3.12	87.07	2.89	45.81	47.23	3.16	626	1715	26.74
T_6	2.25	0.94	226.7	328.3	3.39	90.45	3.10	53.16	54.25	2.89	796	2113	27.36
T_7	2.14	0.80	192.3	291.4	3.30	88.42	2.91	46.23	47.17	3.09	678	1839	26.94
T_8	2.21	0.87	210.9	312.3	3.38	89.25	3.04	51.86	51.27	3.01	759	1904	28.50
T_9	2.10	0.77	184.3	280.3	3.20	85.27	2.82	45.19	46.35	2.72	651	1675	27.99
S.E.(±)	0.051	0.029	9.332	13.18	0.185	1.694	0.169	2.025	1.293	0.186	29.35	82.74	---
C.D. (P=0.05)	0.149	0.084	27.25	38.47	NS	4.947	NS	5.912	3.775	NS	85.7	241.6	---

*LAI- Leaf area index (%), DMA- Dry matter accumulation (g m^{-2}), CGR- Crop growth rate (g m^{-2} day^{-1})
**DAS- Days after sowing ***NS- Non-significant

75 per cent RD of NPK along with 2 t WDFM ha^{-1} (T_6) and this treatment was closely followed by the treatment T_8 (7604.7 kg ha^{-1}) where the rice crop was fertilized with 75 per cent RD of NPK along with 4 t vermicompost ha^{-1}. The treatment T_3 (50% RD of NPK) recorded the lowest value of rice equivalent yield (5191.9 kg ha^{-1}) among all the treatments. This is corroborated with the findings of several workers (Pal *et al.,* 2003 and Pal *et al.,* 2010).

Net production values (NPV) per unit investment:

From Table 4 it may be concluded that the maximum net production value (1.38) was obtained where the rice crop received 75 per cent RD of NPK along with 2 t WDFM ha^{-1} (T_6) and it was closely followed by that (1.36) recorded in the treatment T_8 (75% RD of NPK along with 4 t vermicompost ha^{-1}). Among all the treatments, T_3 (50% RD of NPK) showed the minimum value of net production value (0.84). This result corroborates with the findings of Mondal and Mondal (1996), Mondal and Chettri (1998). Application of fishmeal at 2 t ha^{-1} along with 75 per cent RD of NPK showed the best result (Pal *et al.,* 2010).

Table 4 : Effect of different nutritional management treatments on rice equivalent yield and net production value in rice-lentil (*paira*)–sesame crop sequence (pooled data of two years)

Treatments	Rice equivalent yield (kg ha^{-1})	Net returns (Rs. ha^{-1})	Net production value (NPV)
T_1	6692.3	24049.98	1.12
T_2	6218.2	21316.73	1.02
T_3	5191.9	16413.16	0.84
T_4	7478.3	29064.28	1.30
T_5	6761.9	23499.81	1.14
T_6	7958.7	32356.58	1.38
T_7	7008.4	26076.91	1.21
T_8	7604.7	30176.58	1.36
T_9	6930.7	24376.07	1.18

Treatment Details: T_1-100% recommended dose (RD) of NPK; T_2-75% RD of NPK; T_3-50% RD of NPK; T_4-75% RD of NPK+10 t farm yard manure (FYM) ha^{-1}; T_5-50% RD of NPK+10 t FYM ha^{-1}; T_6-75% RD of NPK+2 t well decomposed fishmeal (WDFM) ha^{-1}; T_7-50% RD of NPK+2 t WDFM ha^{-1}; T_8-75% RD of NPK+4 t vermicompost ha^{-1}; and T_9-50% RD of NPK+4 t vermicompost ha^{-1}.

Conclusion:

Thus, it may be concluded that utilization of different organic resources of the coastal saline zone for partial substitution of chemical fertilizers not only offers higher crop yields but also augments the soil fertility as a whole for sustainability in agricultural production *vis-à-vis* eco-friendly recycling of different organic matter or waste. Inclusion of different *Rabi* and pre-*Kharif* crop after *Kharif* rice may increase the cropping intensity of the conventional mono-cropped coastal areas properly. The growth parameters, yield components and yield of all the crops in sequence were the maximum when organic manure was applied along with inorganic fertilizer at 75 per cent of the recommended dose. The effect of well decomposed fishmeal was as good as farm yard manure (FYM) *vis-à-vis* vermicompost and sometimes it showed better result over FYM and vermicompost. The maximum rice equivalent yield and net returns in rice-lentil (*paira*)-sesame sequence were obtained from the crop treated with well decomposed fishmeal.

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