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Effect of fishmeal application on rice-based cropping sequence in coastal saline belts of West Bengal

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ABSTRACT

The effects of partial substitution of chemical fertilizers with different organic sources on rice-rapeseed-blackgram cropping sequence were evaluated in coastal saline belts of West Bengal during 2005-06 and 2006-07. The growth parameters, yield components and productivity of all the crops in sequence were the maximum when organic manure was applied along with inorganic fertilizer at 75% of the recommended dose. The effect of well decomposed fishmeal on rice and its residual effect on succeeding crops of rapeseed and blackgram were as good as farm yard manure. The highest rice equivalent yield (9.62 t ha^{-1}), net returns (Rs 43728 ha^{-1}) and net production value (1.86) were recorded when 75% recommended dose of NPK + 2 t well decomposed fishmeal ha^{-1} was applied to rice.

Key words: *residual effect, fishmeal, FYM, rice-rapeseed-blackgram, coastal saline soil*

The climatic condition of the coastal zone of West Bengal favours intensive/multiple cropping except in the extremely saline islands. It is feasible to take two crops under rainfed and three crops per year under irrigated condition in rice-based cropping sequence. Inclusion of low water requiring crops like oilseeds and pulses in the cropping sequence not only improves the cropping intensity but also promotes optimal utilization of land, water and nutrient resources. Moreover, it may bring down the deficit in the demand of oilseeds and pulses in West Bengal. It can also augment the soil health as a whole (Reddy, 2009). Integrated use of organic and inorganic sources of plant nutrients helps in maintaining stability in crop production under intensive cropping by improving the physico-chemical properties of soil. Organic maters like farmyard manure (FYM), compost, crop residues, vermin-compost as well as animal manures like fish manure/fishmeal, green manures etc. are eco-friendly, besides supplying nutrients to the current crop, it often leaves substantial residual effect to the succeeding crops. In the coastal zone of West Bengal, farmers usually apply raw fishmeal, amply available in this area, in the vegetables and some other crops, but it causes problems of diseases and insect occurrence. However, application of well decomposed fishmeal increases the yield of crops without causing any pest problem (Brahmachari *et al.,* 2009). Thus the low cost local resources may be used in a proper manner. In this context, the present study was undertaken with the objective of utilizing the locally available organic resources for substituting the chemical fertilizer partly and augmenting the soil health for sustaining crop productivity and increasing the cropping intensity of the coastal saline zone (CSZ) of West Bengal.

MATERIALS AND METHODS

A field experiment was conducted at the Regional Research Station, Bidhan Chandra Krishi Viswavidyalaya, West Bengal during 2005-06 and 2006-07 taking three crops in rotation viz., rice-rapeseed-blackgram with treatments consisting of 100% recommended dose (RD) of NPK to all the crops in sequence, 75% RD of NPK to all the crops in sequence, 50% RD of NPK to all the crops in sequence, 75% RD of NPK to all the crops in sequence + 10 t farm yard manure (FYM) ha^{-1} only to rice, 50% RD of NPK to all the crops in sequence + 10 t FYM ha^{-1} only to rice, 75% RD of NPK to all the crops in sequence + 2 t well decomposed fish meal (WDFM) ha^{-1} only to rice, 50% RD of NPK to all the crops in sequence + 2 t WDFM ha^{-1} only to rice , 75% RD of NPK to all the

crops in sequence + 5 t paddy straw ha^{-1} only to rice, 50% RD of NPK to all the crops in sequence + 5 t paddy straw ha^{-1} only to rice in Randomized Complete Block Design (RBD) with three replications. The experimental soil was silty clay loam in texture having pH 7.6, bulk density 1.41 gm^{-3}, EC 2.85 dsm^{-1}, organic carbon 0.53%, total nitrogen 1140.0 kg ha^{-1}, available phosphorus 15.2 kg ha^{-1}, available potassium 315.0 kg ha^{-1}. The experiment was conducted for six consecutive seasons in the same piece of land without changing the experimental layout. Starting with wet season rice (cv. *Khitish* i.e. IET-4094), transplanted at the end of July with RD of fertilizer of 60:30:30 kg NPK ha^{-1}, the second crop, rapeseed (cv. *Binoy* i.e. B-9) as a winter crop, was sown in mid November with RD of fertilizers of 80:40:40 kg NPK ha^{-1} and the third crop blackgram (cv. *Sarada* i.e. WBU-108) sown in mid March with RD of fertilizers of 20:40:20 kg NPK ha^{-1}. Organic manure viz., FYM, WDFM (Dried fish was decomposed properly in "heap method" with little amount of chopped rice straw, fresh cowdung, dry soil and FYM in the ratio of 8:1:0.5:0.5) and paddy straw were incorporated into the soil at the time of final land preparation. It was prepared by mixing dried fish along with a little amount of chopped rice straw. The other components like fresh cowdung, dry soil and farmyard manure were mixed separately. At first, a layer of straw (whole straw) was made. Above this layer the mixture of dried fish and chopped straw was spreaded and 2% urea solution was sprayed on the layer. Then the mixture of fresh cowdung, dry soil and farmyard manure was evenly distributed on the above layer. Same process was repeated chronologically as long as the entire materials were utilized for preparing the well decomposed fishmeal (WDFM) in 'heap method'. The entire heap was then covered with a polythene sheet and along the periphery of the base of the heap bricks, stones or small wooden logs were placed over the polysheet for protecting the organic materials within the heaps from rats and rodent. It takes about two and a half months for proper decomposition of the aforesaid organic matter. The well decomposed fishmeal containing 7.91% N, 6.22% P_2O_5 and 1.25% K_2O, whereas FYM containing 0.65% N, 0.41% P_2O_5 and 0.68% K_2O and paddy straw containing 0.47% N, 0.32% P_2O_5 and 2.22% K_2O. Total nitrogen, available phosphorus and available potassium of soil were estimated by modified Macro- Kjeldahl's method, Olsen's method and flame photometric method (Jackson, 1967). Net production value was calculated by dividing net profit with total cost of cultivation.

RESULTS AND DISCUSSION

The growth parametres of rice i.e., dry matter accumulation (DMA), crop growth rate (CGR) and plant height differed significantly with different treatments at different stages (Table 1). The maximum DMA (604.9 and 798.6 g m^{-2} at 60 and 90 days after transplanting, respectively) were obtained in the treatment 75% RD of NPK along with 2 t WDFM ha^{-1} only to rice but it was at par with 75% RD of NPK to all the crops in sequence + 10 t FYM ha^{-1} only to rice. The maximum value of CGR (6.46 g m^{-2} day^{-1}) at 60-90 days after transplanting was recorded with 75% RD of NPK along with 2 t WDFM ha^{-1} only to rice. At harvest, the maximum plant height (98.6 cm) was recorded in treatment with 100% RD of NPK to all the crops in sequence. The yield components of rice i.e., number of panicles m^{-2}, number of filled grains panicle^{-1} and percentage of filled grain varied significantly with different treatments (Table 1). The highest number of panicles m^{-2} (337.5 m^{-2}) was recorded with 75% RD of NPK along with 2 t WDFM ha^{-1} only to rice and it was at par with 75% RD of NPK + 10 t FYM ha^{-1} only to rice. The maximum number of filled grains panicle^{-1} (87.2) and maximum grain filling percentage (82.3%) were also obtained in the same treatment. However, the 1000 grain weight of rice did not differ significantly with different treatments. The highest grain yield of rice (3.60 t ha^{-1}) was recorded in 75% RD of NPK along with 2 t WDFM ha^{-1} and it was at par with 75% RD of NPK + 10 t FYM ha^{-1} only to rice. However, the highest straw yield (4.67 t ha^{-1}) was obtained with 75% RD of NPK along with 5 t paddy straw ha^{-1}. The harvest index of rice was maximum in the plots where crop received 75% RD of NPK along with 2 t WDFM ha^{-1}. However, Patil *et al.* (2000) reported 50% RD of NPK along with it WDFM ha^{-1}. Bandopadhyay and Puste (2002) reported higher yield and yield attributes when 25% of chemical fertilizer replaced either with FYM or rice straw.

The growth parameters of rapeseed viz., dry matter accumulation (DMA), crop growth rate (CGR) and number of branches plant^{-1} differed significantly

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

Treatments	DMA		CGR 60-90 DAT	Plant height (cm)	Yield components				Yield		Harvest index (%)
	60 DAT	90 DAT			No. of panicles m^{-2}	No. of filled grains $panicle^{-1}$	% filled grain	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	
T_1	526.8	690.0	5.44	98.61	307.4	81.2	75.3	21.45	3.36	4.51	42.69
T_2	472.9	613.2	4.68	90.34	287.6	73.2	72.4	20.49	2.97	4.07	42.18
T_3	415.5	533.3	3.93	87.31	261.4	70.4	69.4	20.12	2.56	3.90	39.63
T_4	590.6	780.5	6.33	97.42	328.3	85.6	80.1	20.56	3.55	4.58	43.67
T_5	523.8	692.1	5.61	94.31	309.4	83.4	75.6	21.79	3.31	4.36	43.16
T_6	604.9	798.6	6.46	97.85	337.5	87.2	82.3	21.54	3.60	4.53	44.28
T_7	532.1	704.9	5.76	96.21	315.4	83.2	76.3	19.83	3.39	4.29	44.14
T_8	549.0	727.5	5.95	95.34	311.2	83.4	78.2	20.32	3.37	4.67	41.92
T_9	488.0	643.4	5.18	93.26	297.5	78.3	73.5	20.42	3.15	4.42	41.61
SEm(±)	13.31	15.58	0.066	1.04	4.31	0.72	1.25	0.629	0.03	0.033	-
CD (P=0.05)	37.85	44.31	0.188	3.12	12.92	2.16	3.75	NS	0.091	0.099	-

* DMA- Dry Matter Accumulation (g m^{-2}), CGR- Crop Growth Rate (g m^{-2} day^{-1})
**DAT- Days After Transplanting ***NS- Non Significant
$T_1$100% recommended dose (RD) of NPK to all the crops in sequence, $T_2$75% RD of NPK to all the crops in sequence, T_3 50% RD of NPK to all the crops in sequence, $T_4$75% RD of NPK to all the crops in sequence + 10 t farm yard manure (FYM) ha^{-1} only to rice, $T_5$50% RD of NPK to all the crops in sequence + 10 t FYM ha^{-1} only to rice, $T_6$75% RD of NPK to all the crops in sequence + 2 t well decomposed fish meal (WDFM) ha^{-1} only to rice, $T_7$50% RD of NPK to all the crops in sequence + 2 t WDFM ha^{-1} only to rice , $T_8$75% RD of NPK to all the crops in sequence + 5 t paddy straw ha^{-1} only to rice, T_9 50% RD of NPK to all the crops in sequence + 5 t paddy straw ha^{-1} only to rice in Randomized Complete Block Design (RBD)

with different treatments (Table 2). The maximum DMA (328.0 and 656.8 g m^{-2} at 60 and 90 days after sowing respectively) was recorded in the plots treated with 75% RD of NPK along with 2 t WDFM ha^{-1} to rice only. The CGR at 60-90 DAS in rapeseed crop showed the similar trend. The treatments did not show any significant influence on the plant height at harvest, however it was highest (133.4 cm) in 100% RD of NPK. The number of branches $plant^{-1}$ was highest (5.42) in 75% RD of NPK along with 2 t WDFM ha^{-1} to rice only. The number of siliquae $plant^{-1}$ ranged from 135.6 - 181.2 and the treatment differences were significant (Table 2). However, the number of seeds $siliqua^{-1}$ and 1000 seed weight of rapeseed crop did not differ with the treatments. The highest seed yield (1281kg ha^{-1}) and stover yield (5412 Kg ha^{-1}) was obtained due to application of 75% RD of NPK along with 2 t WDFM ha^{-1} only to rice. However, the harvest index was highest (19.26%) in 75% RD of NPK to all the crops in sequence + 10 t FYM ha^{-1} only to rice. Pramanik *et al.* (2000) also recorded higher economic yield upto 33.3% in rice-mustard cropping system when treated with chemical fertilizer + FYM compared with the chemical fertilizer alone.

Significant variations were also observed in case of dry matter accumulation (DMA), plant height and number of branches $plant^{-1}$ of blackgram (Table 3). The highest DMA (268.8 and 381.7 g m^{-2} at 60 and 90 DAS, respectively) was recorded with 100% RD of NPK. But the CGR at 60-90 DAS did not vary with the nutritional management treatments. Plant height of blackgram at harvest significantly differed and the maximum plant height (34.2 cm) was observed in the crop fertilized with 100% RD of NPK. The number of branches $plant^{-1}$ varied significantly from 2.10 in the treatment 50% RD of NPK to all the crops in sequence to 2.97 in the treatment where 100% RD of NPK applied to all the crops in sequence. The yield components of blackgram i.e. number of pods $plant^{-1}$ and number of seeds pod^{-1} also varied significantly with the different treatments (Table 3). The highest number of pods $plant^{-1}$ (12.98) was observed in the crop fertilized with 100% RD of NPK. The maximum number of seeds pod^{-1} (6.35) was observed in 75% RD of NPK + 2 t WDFM ha^{-1} only to rice. However,

Table 2. Effect of different nutritional management treatments on growth parameters, yield components, yield and harvest index of rapeseed (Mean of 2005-07)

Treatments	DMA		CGR	Plant height (cm)	No. of branches plant^{-1}	Yield components			Yield		Harvest index (%)
	60 DAS	90 DAS	60-90 DAS			No. of siliquae plant^{-1}	No. of seeds siliqua $^{-1}$	1000 seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	
T_1	305.0	599.6	9.82	133.4	5.31	173.2	16.75	4.05	1245	5352	18.87
T_2	256.4	541.9	9.52	125.7	4.72	158.8	14.86	3.92	1094	4881	18.31
T_3	192.1	462.7	9.02	118.4	3.44	135.6	12.95	3.45	885	4187	17.45
T_4	315.7	642.4	10.89	132.6	5.35	176.4	16.77	3.85	1267	5311	19.26
T_5	266.6	562.4	9.86	127.5	4.80	160.2	14.89	3.96	1105	4757	18.85
T_6	328.0	656.8	10.96	132.9	5.42	181.2	16.74	3.78	1281	5412	19.14
T_7	276.2	575.6	9.98	128.3	4.87	164.3	14.84	4.02	1139	4909	18.83
T_8	283.1	592.4	10.31	130.5	5.21	165.3	15.86	3.68	1172	5211	18.36
T_9	242.4	533.4	9.70	126.7	4.70	147.4	14.02	3.79	1059	4743	18.25
SEm(±)	18.41	30.46	0.228	5.73	0.271	8.21	1.71	0.85	38.2	129.3	-
CD (P=0.05)	55.19	91.32	0.684	NS	0.812	24.61	NS	NS	114.5	387.5	-

* DMA- Dry Matter Accumulation (g m^{-2}), CGR- Crop Growth Rate (g m^{-2} day^{-1})
**DAS- Days After Sowing ***NS- Non Significant
$T_1$100% recommended dose (RD) of NPK to all the crops in sequence, $T_2$75% RD of NPK to all the crops in sequence, T_3 50% RD of NPK to all the crops in sequence, $T_4$75% RD of NPK to all the crops in sequence + 10 t farm yard manure (FYM) ha^{-1} only to rice, $T_5$50% RD of NPK to all the crops in sequence + 10 t FYM ha^{-1} only to rice, $T_6$75% RD of NPK to all the crops in sequence + 2 t well decomposed fish meal (WDFM) ha^{-1} only to rice, $T_7$50% RD of NPK to all the crops in sequence + 2 t WDFM ha^{-1} only to rice , $T_8$75% RD of NPK to all the crops in sequence + 5 t paddy straw ha^{-1} only to rice, T_9 50% RD of NPK to all the crops in sequence + 5 t paddy straw ha^{-1} only to rice in Randomized Complete Block Design (RBD)

Table 3. Effect of different nutritional management treatments on growth parameters, yield components, yield and harvest index of blackgram (Mean of 2005-07)

Treatments	DMA		CGR	Plant height (cm)	No. of branches plant^{-1}	Yield components			Yield		Harvest index (%)
	60 DAS	90 DAS	60-90 DAS			No. of pods plant^{-1}	No. of seeds pod^{-1}	1000 seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	
T_1	268.8	381.7	3.76	34.23	2.97	12.98	6.02	40.21	885	3092	22.25
T_2	232.2	349.4	3.91	29.16	2.54	11.02	5.42	41.39	798	2653	23.12
T_3	197.2	315.2	3.93	26.45	2.10	9.25	4.79	41.12	680	2487	21.47
T_4	245.3	352.3	3.57	32.25	2.74	12.71	5.98	40.95	852	2764	23.56
T_5	212.3	331.7	3.98	28.12	2.32	10.74	5.45	41.16	749	2603	22.35
T_6	255.4	369.4	3.80	33.47	2.86	12.86	6.35	41.45	878	2802	23.86
T_7	218.9	339.7	4.03	29.32	2.49	10.98	5.87	39.97	781	2620	22.96
T_8	240.3	341.7	3.38	32.80	2.59	12.12	5.86	40.72	820	2906	22.01
T_9	204.3	321.4	3.90	28.21	2.21	10.29	5.74	41.11	721	2686	21.16
SEm(±)	8.78	9.76	0.205	1.409	0.178	0.725	0.247	0.908	37.4	101.6	-
CD (P=0.05)	26.32	29.26	NS	4.224	0.539	2.254	0.741	NS	112.1	302.8	-

* DMA- Dry Matter Accumulation (g m^{-2}), CGR- Crop Growth Rate (g m^{-2} day^{-1})
**DAS- Days After Sowing ***NS- Non Significant
$T_1$100% recommended dose (RD) of NPK to all the crops in sequence, $T_2$75% RD of NPK to all the crops in sequence, T_3 50% RD of NPK to all the crops in sequence, $T_4$75% RD of NPK to all the crops in sequence + 10 t farm yard manure (FYM) ha^{-1} only to rice, $T_5$50% RD of NPK to all the crops in sequence + 10 t FYM ha^{-1} only to rice, $T_6$75% RD of NPK to all the crops in sequence + 2 t well decomposed fish meal (WDFM) ha^{-1} only to rice, $T_7$50% RD of NPK to all the crops in sequence + 2 t WDFM ha^{-1} only to rice , $T_8$75% RD of NPK to all the crops in sequence + 5 t paddy straw ha^{-1} only to rice, T_9 50% RD of NPK to all the crops in sequence + 5 t paddy straw ha^{-1} only to rice in Randomized Complete Block Design (RBD)

there was no significant effect on the 1000 seed weight of blackgram. The highest seed (885 Kg ha^{-1}) and stover yield (3092 Kg ha^{-1}) of blackgram was recorded with 100% RD of NPK. In case of harvest index, the highest value (23.86%) was obtained with 75% RD of NPK to all the crops in sequence + 2 t WDFM ha^{-1} only to rice. Similar results were also reported by Brahmachari *et al.* (2009) that application of fishmeal at 2 t ha^{-1} in the rice- based cropping sequence produced higher grain and straw yield of rice. Thus there is a positive residual effect of well decomposed fishmeal on the subsequent crops in terms of increasing yield component & yield.

The highest rice equivalent yield (9.62 t ha^{-1}) was obtained in treatments where the rice crop received 75% RD of NPK along with 2 t WDFM ha^{-1} only to rice followed by the treatment 75% RD of NPK along with 10 t FYM ha^{-1} only to rice (9.46 t ha^{-1}). This result is corroborated with the findings of several workers (Sharma *et al*., 2001 and Pal *et al*., 2005). It is apparent that application of organic manure only to wet season rice could substitute NPK dose of the crops in the sequence to the tune of 25% of recommended dose (RD) as it was observed that rice equivalent yield obtained from 75% RD of NPK to all the crops in sequence along with organic manure (WDFM and FYM) was more than that obtained with 100% RD of NPK to all the crops in sequence (Table 4). The maximum net production value (1.86) was obtained in the treatments of 75% RD of NPK along with 2 t WDFM ha^{-1} only to rice and it was followed by the treatment 75% RD of NPK + 10 t FYM ha^{-1} only to rice (1.84). Mondal and Chettri (1998), observed that the net production value was highest when 75% RD of NPK along with 2 t WDFM ha^{-1} applied to rice crop in rice-based cropping sequence. Application of fishmeal at 2 t ha^{-1} was along with 75% RD of NPK in rice showed the best result under coastal saline zone of West Bengel (Brahmachari *et al*., 2009).

Table 4. Effect of different nutritional management treatments on rice equivalent yield and net production value in rice-rapeseed–blackgram crop sequence (Mean of two years)

Treatments	Rice equivalent yield (t ha^{-1})	Net Returns (Rs. ha^{-1})	Net Production Value (NPV)
T_1	9.289	39428	1.70
T_2	8.21	34941	1.59
T_3	6.86	27105	1.30
T_4	9.46	42499	1.84
T_5	8.48	37015	1.69
T_6	9.62	43728	1.86
T_7	8.69	37908	1.70
T_8	8.97	40006	1.72
T_9	8.07	34092	1.54

$T_1$100% recommended dose (RD) of NPK to all the crops in sequence, $T_2$75% RD of NPK to all the crops in sequence, T_3 50% RD of NPK to all the crops in sequence, $T_4$75% RD of NPK to all the crops in sequence + 10 t farm yard manure (FYM) ha^{-1} only to rice, $T_5$50% RD of NPK to all the crops in sequence + 10 t FYM ha^{-1} only to rice, $T_6$75% RD of NPK to all the crops in sequence + 2 t well decomposed fish meal (WDFM) ha^{-1} only to rice, $T_7$50% RD of NPK to all the crops in sequence + 2 t WDFM ha^{-1} only to rice , $T_8$75% RD of NPK to all the crops in sequence + 5 t paddy straw ha^{-1} only to rice, T_9 50% RD of NPK to all the crops in sequence + 5 t paddy straw ha^{-1} only to rice in Randomized Complete Block Design (RBD)

Thus, it may be concluded that the direct effect of well decomposed fishmeal (WDFM) on rice and residual effect on succeeding rapeseed and blackgram crops were as good as farm yard manure. The maximum rice equivalent yield and net returns in rice-rapeseed-blackgram sequence was obtained from the crop treated with well decomposed fishmeal @ 2 t ha^{-1} only to rice along with 75% RD of NPK. Thus application of well decomposed fishmeal to rice and its residual effect on succeeding crops under coastal saline soil of West Bengal may be a low cost, locally suited technology for the poor farming community.

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