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Effect of integrated nutrition management on yield and economics of aromatic rice in alluvial soil

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ABSTRACT

The present field experiment was conducted during the wet season of 2012 and 2013 to find out the optimum nutrient management practice for aromatic rice Gobindabhog in an alluvial soil. The experiment was laid out in split plot design with five organic matter levels (O1- Control or no organic manure, O2- FYM @ 2.5 t ha $^{-1}$, O3- FYM @ 5 t ha^{-1}, O4- Mustard cake (MC) @ 0.5 t ha^{-1}, and O5- MC @ 1t ha^{-1}) in main plot and three inorganic fertilizer levels (IN1- $N_{20}P_{10}K_{10}$, IN2 - $N_{30}P_{15}K_{15}$, IN3 - $N_{40}P_{20}K_{20}$) in subplot. Among the treatment combinations, the highest total dry matter production and number of tillers per unit area, straw and grain yield and N, P and K uptake by rice were observed in treatment receiving mustard cake @ 1 t ha^{-1} along with inorganic fertilizer @ $N_{40}P_{20}K_{20}$. Considering the net return (Rs.16, 057 and Rs.28, 767/ha) and benefit: cost ratio (1.53 and 1.92) in both the year, treatment receiving 2.5 t ha^{-1} FYM along with chemical fertilizer @ $N_{30}P_{15}K_{15}$ was the most profitable nutrient management practice.

Key words: *Integrated nutrition, aromatic rice, yield, nutrient uptake, economics*

Gobindabhog is one of the indigenous short grained, low yielding aromatic rice variety grown by the farmers of Gangetic alluvial zone of India following mostly chemical-based agricultural practices, which led to increased productivity but with inferior grain quality, degraded soil health and increased pollution (Banerjee *et al*. 2013). Global energy crisis coupled with environmental pollution and high price of chemical fertilizers compelled the agricultural technologist and farmers for adopting integrated nutrient management practice to supplement chemical fertilizer consumption. The combined use of organic and inorganic sources of plant nutrient not only enhances the production, productivity and quality of crops but also helps in sustaining soil productivity. Integrated nutrient management (INM) envisages the integrated use of nutrients from different potential sources encompassing chemical fertilizer, organic manure, biofertilizer, green manure and other locally available cheap nutrient sources for profitable crop production, sustaining soil health, and protecting environment beyond soil (Mishra *et al*. 2013; Pal 2016). The present field experiment was conducted to find out the economically efficient nutrient management practice for aromatic rice Gobindabhog in an alluvial soil.

MATERIALS AND METHODS

The field experiment was conducted during the wet season of 2012 and 2013 in an Inceptisol at university farm BCKV (22.8^{0}N latitude and 88.30^{0}E longitude), Kalyani to find out the optimum nutrient management practice for aromatic rice Gobindabhog for higher productivity and net return. Experimental soil was well drained and silty clay in texture (38.5% sand, 37.0% silt and 24.5% clay) (Bouyoucos 1962) neutral in reaction (pH 6.8), normal in electrical conductivity (0.26 dS m^{-1}), cation exchange capacity 12.7 cmol (+) kg^{-1} and high in oxidizable organic carbon (7.6 g kg^{-1})

(Jackson, 1973), low in available N (116.3 mg kg^{-1}) (Bremner and Keeney 1966), high in available phosphorus (16.3 mg kg^{-1}) (Olsen *et al*. 1954) and medium in available potassium (56.3 mg kg^{-1}) (Hanway and Heidel 1952).

The experiment was laid out in split plot design with three replications in which main plots received different doses of organic manure from two sources (farm yard manure and mustard cake) and subplots received different doses of chemical fertilizers. The main plot treatments comprised of O1: control (no organic manure), O_2: 2.5 t ha^{-1} FYM, O_3: 5 t ha^{-1} FYM, O_4: 0.5 t ha^{-1} mustard cake (MC) and O_5: 1 t ha^{-1} MC. The sub-plot treatments included three levels of chemical fertilizers viz., IN1: $N_{20}P_{10}K_{10}$, IN2: $N_{30}P_{15}K_{15}$ and IN3: $N_{40}P_{20}K_{20}$. On dry weight basis, the percent nutrient composition (N: P_2O_5: K_2O) of organic manures were 0.6: 0.2: 0.5 and 4.5: 1.5: 1.0, respectively for FYM and mustard cake, respectively. Organic manures and chemical fertilizers were applied before transplanting as per treatment requirement. Twenty days old rice seedlings (cv. Gobindabhog) were transplanted at a spacing of 15 cm x 15 cm in 4 m x 2.5 m plots during second fortnight of July. The total amount of P and K and one half of nitrogen were applied as basal and the remaining one half of N was applied three weeks after transplanting of rice. Standard agronomic practices including pest and disease control were followed and the crop was grown to maturity.

Growth parameters like dry matter yield and number of tiller per m^2 at active tillering, panicle initiation stage and grain and straw yield of rice were recorded following standard methods. For estimation of nutrient uptake by rice only the harvested portion of the crop was taken into account. Total N content in oven dry plant sample was determined by micro-kjeldahl digestion method (Jackson 1973). Total P and K in oven dry plant sample were measured in tri-acid digestion extract (Black 1965).

Main effects of main plot and subplot along with their interaction effects were calculated for each variable. All those means were compared for their significance following split plot design. Pooled split plot analysis technique was further made for each year to compare stage, organic manure and inorganic fertilizer dose means and to test the related main and interaction effects by including stages, organic manure and inorganic fertilizer treatments as an additional source of variation, respectively. Standard error of mean for all main and interaction effects and LSD (0.05) values were calculated only for those effects which were significant.

RESULTS AND DISCUSSION

Dry matter production and number of tiller per m^2 increased consistently with advancement of crop growth (Table 1a). Again, both the sources of organic manures (FYM and mustard cake) had a positive and significant influence on these two yield-attributes of Gobindabhog over control (no organic manure addition). This could be explained by greater and well synchronized release of nutrients from organic sources with plant demand. The highest mean dry matter yield (331.58 g m^{-2}) and number of tillers per m^2 (319.84) were recorded in treatment receiving 1t ha^{-1} of mustard cake. Banerjee et al. (2013) also reported that application of mustard cake (50% recommended dose of N as basal + 50% RDN at 21 DAT) resulted in the highest growth and yield-attributes. The mean dry matter yield and number of tillers per m^2 also increased significantly with increase in the level of chemical fertilizer (Table 1a). The highest mean dry matter accumulation (329.88 g m^{-2}) and number of tillers per m^2 (314.33) were observed with highest fertilizer dose (IN3). The interaction effect showed that the highest mean dry matter yield (341.40 g m^{-2}) was recorded in treatment receiving 1 t ha^{-1} mustard cake along with fertilizer @ $N_{40}P_{20}K_{20}$ (O5IN3) (Table 1b). The highest mean tiller number per m^2 (325.28) was also observed in O5IN3. Application of mustard cake @ 1 t ha^{-1} along with the highest dose of fertilizer resulted to 10 per cent increase in tiller production per m^2 over no organic manure treatment. The result was in the conformity with that of Nwaiwe *et al*. (2010). Ghosh (2007) also reported similar observation when FYM or green manure was applied on rice. He opined that organic manure might have improved root development, thereby higher biomass production and lesser tiller mortality. The greater tiller production in mustard cake applied treatment over FYM treated plots was possibly attributed to faster mineralization of plant nutrients from mustard cake than FYM.

Irrespective of source organic manure had a

Table 1a. Effect of integrated nutrition on dry matter accumulation and number of tillers of rice

Stages	Dry matter accumulation ($g\ m^{-2}$)			Number of tillers per m^2		
	2012	2013	Mean	2012	2013	Mean
AT	183.92	188.00	185.96	293.02	300.21	296.61
PI	273.28	278.64	275.96	305.20	314.65	309.93
Harvest	500.27	506.97	503.62	317.86	319.27	318.57
Mean	319.16	324.54	321.85	305.36	311.38	308.37
LSD(0.05)	4.30	5.02	2.63	2.13	0.97	0.93
Organics						
O1	312.64	320.93	316.79	284.57	289.94	287.25
O2	312.55	318.43	315.49	314.72	312.90	313.81
O3	323.69	323.75	323.72	297.41	312.82	305.12
O4	318.30	325.02	321.66	314.66	317.00	315.83
O5	328.61	334.55	331.58	315.44	324.23	319.84
Mean	319.16	324.54	321.85	305.36	311.38	308.37
LSD(0.05)	5.55	6.48	4.15	2.75	1.25	1.47
Chemical fertilizer						
IN1	311.89	315.83	313.86	301.24	303.54	302.39
IN2	318.92	324.67	321.80	303.13	313.65	308.39
IN3	326.66	333.11	329.88	311.71	316.95	314.33
Mean	319.16	324.54	321.85	305.36	311.38	308.37
LSD(0.05)	1.72	1.48	1.17	1.56	1.19	2.55

Table 1b. Interaction effect of organic and inorganic nutrient on dry matter accumulation and number of tillers of rice

Treatment combinations	Dry matter accumulation ($g\ m^{-2}$)			Number of tillers per m^2		
	2012	2013	Mean	2012	2013	Mean
O1IN1	306.56	310.80	308.68	271.58	280.28	275.93
O1IN2	312.80	321.64	317.22	289.89	291.29	290.59
O1IN3	318.58	330.36	324.47	292.24	298.25	295.25
O2IN1	307.49	309.18	308.33	310.80	303.11	306.96
O2IN2	312.36	318.12	315.24	317.97	321.41	319.69
O2IN3	317.80	328.00	322.90	315.39	314.19	314.79
O3IN1	318.40	313.73	316.07	302.58	301.89	302.23
O3IN2	324.96	324.00	324.48	275.74	316.29	296.02
O3IN3	327.71	333.51	330.61	313.91	320.29	317.10
O4IN1	308.40	319.78	314.09	313.74	312.20	312.97
O4IN2	317.71	324.00	320.86	313.94	316.63	315.29
O4IN3	328.80	331.29	330.04	316.30	322.16	319.23
O5IN1	318.62	325.64	322.13	307.51	320.22	313.87
O5IN2	326.80	335.60	331.20	318.12	322.61	320.37
O5IN3	340.40	342.40	341.40	320.69	329.87	325.28
Mean	319.16	324.54	321.85	305.36	311.38	308.37
LSD(0.05)	6.65	5.75	3.68	6.03	4.59	8.08

significant and positive effect on straw and grain yield of aromatic rice Gobindabhog (Table 2a). Among the two sources of organic manure mustard cake proved its superiority over FYM. The mean effect of application of mustard cake @ 1 t ha^{-1} and FYM @ 5 t ha^{-1} registered 21 and 11 per cent increase in straw yield and 30.6 and 18.3 per cent increase in grain yield of aromatic rice over no organic manure treated plot, respectively. However, inorganic fertilizer addition had no significant response on the yields of rice except in grain yield during 2013. The interaction effect of organic manure and chemical fertilizer revealed that the highest straw yields (4.96 and 5.68 t ha^{-1} in 2012 and 2013, respectively) were recorded with the application of mustard cake @1t ha^{-1} plus chemical fertilizer @ $N_{40}P_{20}K_{20}$ which were 24 and 27.9 per cent higher than the treatment receiving only chemical fertilizer @ $N_{20}P_{10}K_{10}$ (Table 2b). Substitution of 1/4th to 1/3rd of RD of N through organic sources viz. FYM or Azolla or in situ green manuring with Sesbania to rice in conjunction with 75% RD of N, P and K through chemical fertilizer registered the higher grain and straw yield of rice as compared to 100% recommended dose of fertilizer (Mohanty *et al.* 2013; Mondal *et al.* 2014). In year 2012, the highest grain yield (2.70 t ha^{-1}) was recorded with application of mustard cake @ 0.5t ha^{-1} along with chemical fertilizer @ $N_{40}P_{20}K_{20}$ (O4IN3), which was on par with the treatment (O5IN3) receiving mustard cake @ 1t ha^{-1} plus chemical fertilizer @ $N_{40}P_{20}K_{20}$. In 2013, the highest grain yield (3.32 t ha^{-1}) was observed in treatment O5IN3. 21.2 and 37.2 per cent more grain yield of rice were recorded in treatment receiving mustard cake @ 1 t ha^{-1} in conjunction with inorganic fertilizer @ $N_{40}P_{20}K_{20}$ (O5IN3) over the treatment receiving only inorganic fertilizer @ $N_{40}P_{20}K_{20}$ (O1IN3). This was due to additional effect of organic manure applied along with

Table 2a. Effect of Integrated nutrition on straw and grain yield of aromatic rice Gobindabhog

Treatments	Straw yield (t ha^{-1})			Grain yield (t ha^{-1})		
	2012	2013	Mean	2012	2013	Mean
Organics						
O1	4.09	4.56	4.33	2.09	2.28	2.19
O2	4.22	5.12	4.67	2.17	2.78	2.48
O3	4.19	5.42	4.81	2.22	2.95	2.59
O4	4.52	5.45	4.99	2.48	3.17	2.83
O5	4.83	5.65	5.24	2.47	3.25	2.86
Mean	4.37	5.24	4.81	2.29	2.89	2.59
LSD(0.05)	0.39	0.47	0.33	0.17	0.13	0.12
Inorganic fertilizers						
IN1	4.28	5.23	4.76	2.27	2.81	2.54
IN2	4.40	5.22	4.81	2.38	2.88	2.63
IN3	4.43	5.27	4.85	2.29	2.97	2.63
Mean	4.37	5.24	4.81	2.29	2.89	2.59
LSD(0.05)	NS	NS	NS	NS	0.16	NS

Table 2b. Interaction effect of organic and inorganic nutrients on straw and grain yield and economics of aromatic rice Gobindabhog.

Treatment combinations	Straw yield (t ha^{-1})		Grain yield (t ha^{-1})		Cost of cultivation (Rs. ha^{-1})		Net return (Rs.ha^{-1})		B:C ratio	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
O1IN1	4.00	4.44	2.00	2.14	27,217	28,354	13,148	17,385	1.48	1.61
O1IN2	4.05	4.56	2.06	2.28	27,668	28,826	13,877	19,815	1.50	1.69
O1IN3	4.23	4.69	2.22	2.42	28,240	29,423	16,489	22,129	1.58	1.75
O2IN1	4.15	5.08	2.15	2.74	29,802	30,939	14,368	28,179	1.48	1.91
O2IN2	4.45	5.15	2.25	2.79	30,253	31,411	16,057	28,767	1.53	1.92
O2IN3	4.05	5.13	2.10	2.80	30,825	32,008	12,315	28,353	1.40	1.89
O3IN1	4.06	5.43	2.11	2.89	31,552	32,689	11,786	29,727	1.37	1.91
O3IN2	4.42	5.41	2.34	2.90	32,003	33,161	15,993	29,438	1.50	1.89
O3IN3	4.09	5.43	2.20	3.06	32,575	33,758	12,497	32,058	1.38	1.95
O4IN1	4.42	5.53	2.39	3.08	35,552	37,189	13,394	29,112	1.38	1.78
O4IN2	4.32	5.40	2.34	3.19	36,002	37,661	11,913	30,679	1.33	1.81
O4IN3	4.82	5.41	2.70	3.25	36,575	38,258	18,581	31,341	1.51	1.82
O5IN1	4.76	5.69	2.35	3.20	43,052	45,189	5,406	23,648	1.13	1.52
O5IN2	4.76	5.58	2.38	3.22	43,503	45,661	5,525	23,482	1.13	1.51
O5IN3	4.96	5.68	2.69	3.32	44,075	46,258	11,003	24,970	1.25	1.54
Mean	4.37	5.24	2.29	2.89						
LSD(0.05)	0.94	0.20	0.46	0.36						

Cost of rice seed: Rs. 45.00 (2012), 50.00 kg^{-1} (2013); labour wage: 167.00 man day^{-1} (both the years); rate of power tiller: 250.00 (2012), 300 hour^{-1} (2013); cost of FYM: 0.70 kg^{-1} (both the years); cost of mustard cake: 15, 000 (both the years); cost of urea 5.60 (2012) and 5.80 kg^{-1} (2013); cost of SSP: 6.80 kg^{-1} (both the years); cost of MOP: 14.00 (2012), 16.00 kg^{-1} (2013); rate of paddy: 19, 000 (2012), 20,000 t^{-1} (2013); rate of straw: 800 (2012), 850 t^{-1}(2013).

the inorganic fertilizer. Increase in the yield of rice with addition of nutrients through integrated nutrient management improves soil productivity and increases fertilizer use efficiency. The result was well corroborated with the findings of several authors (Ghosh 2007; Wardana *et al.* 2010).

Nutrient (N, P and K) uptake increased consistently from active tillering to harvesting stage keeping in parity with the dry matter production of rice (Table 3a). Among two organic sources nutrient uptake was significantly higher with mustard cake than FYM, which might be due to faster release of nutrients from the former than the latter source. Nutrient uptake also increased significantly with increase in the dose of inorganic fertilizer. The combined effect of organic and inorganic sources of nutrient revealed that at harvest the highest nutrient uptake (53.9 and 63.1 kg N ha^{-1}, 14.4 and 17.7 kg P ha^{-1} and 84.0 and 87.3 kg K ha^{-1}) was recorded in treatment receiving 1 t ha^{-1} mustard cake along with chemical fertilizer @ $N_{40}P_{20}K_{20}$ (O5IN3), while the least (40.6 and 44.3 kg N ha^{-1}, 9.5 and 11.0 kg P ha^{-1} and 65.2 and 68.4 kg K ha^{-1}) in treatment receiving only chemical fertilizer @ $N_{20}P_{10}K_{10}$ (O1IN1) in two consecutive years (Table 3b). Use of organic manure improved soil physical, chemical and biological environment which in turn increased the nutrient absorption efficiency of the plant. Higher nutrient uptake by rice due to combined use of organic manure along with chemical fertilizer by increasing organic carbon, available N, P and K in soil was reported by several authors (Ramkrishna *et al.* 2007; Walia *et al.* 2010; Karmakar *et al.* 2011).

The cost of cultivation varied from Rs.27, 217 and Rs.28, 354/ha in O1IN1 (receiving only chemical fertilizer @ $N_{20}P_{10}K_{10}$) to Rs. 44, 075 and Rs. 46, 258/ha in treatment O5IN3 (receiving 1 t ha^{-1} mustard cake with chemical fertilizer @ $N_{40}P_{20}K_{20}$) during 2012 and 2013, respectively (Table 2b). This variation was primarily due to variation in prices of organic manures and fertilizers. However, the highest net return was received in O_4IN_3 (Rs.18, 581/ha) and in O_3IN_3 (Rs.32, 058/ha) during 2012 and 2013, respectively. Thus, considering net return (Rs.16, 057 and Rs.28, 767/ha) and benefit: cost ratio (1.53 and 1.92) of both the years treatment O_2IN_2 receiving 2.5 t ha^{-1} FYM along with chemical fertilizer @ $N_{30}P_{15}K_{15}$ was the most economically efficient treatment combination. Banerjee

Table 3a. Effect of integrated nutrition on total uptake of nitrogen, phosphorus and potassium (kg ha $^{-1}$) by aromatic rice Gobindabhog.

Organics	N uptake						P uptake						K uptake					
	2012			2013			2012			2013			2012			2013		
	AT*	PI**	Harvest	AT	PI	Harvest	AT	PI	Harvest	AT	PI	Harvest	AT	PI	Harvest	AT	PI	Harvest
O1	17.5	26.5	43.4	18.2	27.5	46.9	3.40	5.24	10.0	3.5	5.4	11.3	24.8	37.7	68.1	25.8	39.1	70.2
O2	17.8	27.3	46.7	18.6	28.0	49.7	3.31	5.48	10.9	3.5	5.6	13.5	25.2	38.2	70.7	26.3	39.2	77.5
O3	19.3	28.2	48.1	18.8	27.9	53.2	4.05	6.12	11.5	3.9	6.1	14.7	27.4	39.5	70.8	26.6	39.0	79.7
O4	18.4	27.6	49.2	18.8	28.3	57.6	3.95	5.98	12.8	4.0	6.1	15.7	26.4	38.9	75.0	26.9	39.8	81.7
O5	19.5	28.9	50.5	20.2	29.7	61.1	4.11	6.05	13.4	4.3	6.2	16.9	27.3	40.0	81.4	28.3	41.1	85.6
Mean	18.5	27.7	47.6	18.9	28.2	53.7	3.76	5.77	11.7	3.8	5.9	14.4	26.2	38.9	73.2	26.8	39.6	79.0
LSD(0.05)	1.36	0.95	0.26	1.40	1.67	2.78	0.35	0.28	0.39	0.35	0.39	0.41	1.96	1.97	0.31	2.00	2.16	1.22
Chemical fertilizer																		
IN1	26.9	45.4	17.9	27.3	51.4	26.9	3.6	5.5	11.0	3.7	5.6	13.9	25.0	38.0	71.2	25.4	38.5	76.9
IN2	27.7	47.2	19.0	28.3	53.7	27.7	3.8	5.7	11.7	3.9	5.8	14.4	26.2	38.6	72.5	26.9	39.3	78.9
IN3	28.5	50.1	19.8	29.2	55.9	28.5	3.9	6.1	12.5	4.0	6.3	14.9	27.4	40.1	75.8	28.1	41.1	81.1
Mean	27.7	47.6	18.9	28.2	53.7	27.7	3.8	5.8	11.7	3.8	5.9	14.4	26.2	38.9	73.2	26.8	39.6	79.0
LSD(0.05)	0.49	0.25	0.32	0.44	1.66	0.49	0.10	0.14	0.16	0.10	0.12	0.36	0.52	0.55	0.41	0.01	0.48	1.13

AT* stands for active tillering stage and PI** for panicle initiation stage

Table 3b. Interaction effect of integrated nutrition on total uptake of nitrogen, phosphorus and potassium (kg ha $^{-1}$) by aromatic rice Gobindabhog.

Treatment combinations	N uptake						P uptake						K uptake					
	2012			2013			2012			2013			2012			2013		
	AT*	PI**	Harvest	AT	PI	Harvest	AT	PI	Harvest	AT	PI	Harvest	AT	PI	Harvest	AT	PI	Harvest
O1IN1	16.9	25.8	40.6	17.3	26.5	44.3	3.2	5.0	9.5	3.3	5.1	11.0	23.5	36.9	65.2	24.2	37.9	68.4
O1IN2	17.8	26.8	43.1	18.4	27.6	47.2	3.6	5.2	9.9	3.7	5.4	11.4	25.1	37.7	68.0	25.9	38.9	70.1
O1IN3	17.8	27.0	46.5	18.7	28.3	49.0	3.4	5.5	10.6	3.6	5.8	11.5	25.9	38.5	71.1	27.3	40.4	72.2
O2IN1	17.1	27.1	44.2	17.3	27.4	47.7	3.2	5.1	10.2	3.2	5.1	12.8	24.4	37.4	68.6	24.7	37.7	75.5
O2IN2	17.8	27.3	47.4	18.8	27.9	49.7	3.3	5.4	11.1	3.5	5.5	13.6	25.0	38.4	69.7	26.4	39.3	76.7
O2IN3	18.5	27.3	48.6	19.7	28.5	51.7	3.4	6.0	11.4	3.7	6.2	13.9	26.1	38.9	73.7	27.8	40.6	80.5
O3IN1	18.8	27.6	46.3	17.9	26.9	50.4	3.9	5.9	10.5	3.7	5.8	14.3	26.7	39.3	68.6	25.3	38.2	76.6
O3IN2	19.4	28.4	48.1	18.7	27.8	53.4	4.1	6.1	11.5	3.9	6.0	14.6	27.4	38.6	69.93	26.3	37.8	80.0
O3IN3	19.8	28.7	49.8	19.8	29.0	55.7	4.1	6.4	12.4	4.1	6.4	15.1	28.0	40.6	73.9	28.0	41.0	82.4
O4IN1	17.4	26.6	47.8	18.1	27.3	54.9	3.8	5.6	12.4	4.0	5.7	15.3	24.7	37.9	73.9	25.8	39.0	79.8
O4IN2	18.5	27.8	48.3	18.6	28.2	57.5	3.9	6.1	12.5	3.9	6.2	15.8	26.8	38.5	74.4	26.9	39.2	82.5
O4IN3	19.3	28.5	51.7	19.6	29.28	60.3	4.2	6.3	13.6	4.2	6.5	16.0	27.6	40.1	76.5	28.1	41.2	82.9
O5IN1	18.2	27.4	48.3	19.0	28.2	59.5	3.9	5.9	12.5	4.1	6.1	16.1	25.8	38.3	79.8	27.0	39.5	84.3
O5IN2	19.1	28.5	49.2	20.3	29.7	60.7	3.9	5.8	13.4	4.2	6.1	16.8	27.0	39.5	80.3	28.7	41.2	85.2
O5IN3	21.1	30.8	53.9	21.2	31.0	63.1	4.5	6.4	14.4	4.6	6.5	17.7	29.2	42.1	84.0	29.4	42.5	87.3
Mean	18.5	27.7	47.6	18.9	28.2	53.7	3.8	5.8	11.7	3.8	5.9	14.4	26.2	38.9	73.2	26.8	39.6	79.0
LSD(0.05)	0.71	1.09	0.56	0.72	0.99	3.71	0.22	0.31	0.36	0.23	0.28	0.81	0.22	0.31	0.36	0.23	0.28	0.81

AT* stands for active tillering stage and PI** for panicle initiation stage

et al. (2013) reported that integrated use of FYM and mustard cake equivalent to 50 kg N ha^{-1} fetched higher net return and B: C ratio in comparison to other organic manures in aromatic Gobindabhog rice.

CONCLUSION

Among the fifteen integrated nutritional package practiced in this study application of 1 t ha^{-1} mustard cake along with chemical fertilizer @ $N_{40}P_{20}K_{20}$ recorded the highest grain and straw yield of aromatic rice Gobindabhog. However, considering net return and benefit: cost ratio the treatment comprising of FYM @ 2.5 t ha^{-1} along with chemical fertilizer @ $N_{30}P_{15}K_{15}$ could be recommended as the most economically efficient nutritional package of aromatic rice Gobindabhog for the soils of this alluvial zone.

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