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EFFECT OF INTEGRATED APPROACH OF PLANT NUTRIENTS ON YIELD AND YIELD ATTRIBUTES OF DIFFERENT CROPS IN WHEAT-SESAME-T. AMAN CROPPING PATTERN

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Abstract

The experiment was carried out at FSRD site, Pushpopara, Pabna, during November, 2010 to December, 2011 to observe the comparative performance of integrated plant nutrients management (IPNS) system through the use of organic (cowdung, cowdung slurry) manure and inorganic fertilizer on wheat, sesame and T. Aman crops under wheat-sesame-T. Aman cropping pattern. The experiment was consisted with four treatments viz. T_1: Soil test based inorganic fertilizer dose for high yield goal, T_2: Cowdung @ 5 t ha^{-1} + IPNS basis inorganic fertilizer dose for high yield goal, T_3: Cowdung slurry @ 5 t ha^{-1} + IPNS basis inorganic fertilizer dose for high yield goal and T_4: Fertilizer dose usually practiced by the farmers. In case of wheat, the highest grain yield (3.80 t ha^{-1}) was obtained from bio-slurry treated plot that means T_3 treatment followed by T_2 and the lowest (3.31 t ha^{-1}) from T_4. Higher seed yield (1.31 t ha^{-1}) of sesame was obtained from T_3 that was statistically identical to T_2 and T_1 and the lower (1.01 t ha^{-1}) from T_4. For T. Aman rice, the highest grain yield (4.89 t ha^{-1}) was obtained from T_3 which was statistically indistinguishable from T_1 where as the lowest grain yield (4.1 t ha^{-1}) was recorded from T_4. Considering the whole pattern, it is observed that the highest gross return (271100 Tk ha^{-1}) was obtained from T_3 followed by T_2 and the lowest (225650 Tk ha^{-1}) from T_1 treatment. Total variable cost was recorded as the highest (100368 Tk ha^{-1}) in T_2 followed by T_3 and the lowest (86775 Tk ha^{-1}) in T_4 treatment. The highest marginal value of product (45450 Tk ha^{-1}) was recorded in T_3 followed by T_2 where as the minimum (28710 Tk ha^{-1}) was found in T_1 over the T_4 treatment. Marginal variable cost was observed as the highest (13593 Tk ha^{-1}) in T_2 treatment followed by T_3 and the minimum (8899 Tk ha^{-1}) was recorded in T_1 treatment. The highest MBCR (4.15) was recorded from T_3 followed by T_2 and the minimum (2.31) from T_2 treatment.

Keywords: IPNS System, Organic Manure, Rice Equivalent Yield, Cropping Pattern

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Introduction

The basic concept of Integrated Plant Nutrition System (IPNS) is the management of all available plant nutrient sources, organic and inorganic, to provide optimum and sustainable crop production conditions within the prevailing farming system. Therefore, in IPNS an appropriate combination of mineral fertilizers, organic manures, crop residues, compost, N-fixing crops and bio fertilizer is used according to the local ecological conditions, land use systems and the individual farmer's social and economic conditions.

The main aim of integrated plant nutrition system is to increase and sustain soil fertility to provide a sound basis for flexible food production systems that, within the constraints of soil and climate, can grow a wide range of crops to meet changing needs (FAO, 2001). Therefore, it is necessary to use inorganic and organic fertilizers in an integrated way so as to obtain economically profitable crop yield, without incurring loss to soil fertility (Haque *et al*., 2001). IPNS can produce comparable or higher crop yield compared to sole fertilizer use (BARC, 2005).

Soil fertility deterioration is a major constraint for higher crop production in Bangladesh. The increasing land use intensity without adequate and balanced use of chemical fertilizers and with little or no use of organic manure have caused severe fertility deterioration of our soils resulting in stagnating or even declining of crop productivity. The farmers of this country use on an average, 215 kg nutrients/ha annually (149 kg N + 37 kg P2O5 + 22 kg K2O + 7 kg S, Zn, B and others), while the crop removal is about 280-350 kg ha^{-1} (Islam, 2008). Since fertile soil is the fundamental resource for higher crop production, its maintenance is a prerequisite for long- term sustainable crop productivity. Soil organic matter is a key factor for sustainable soil fertility and crop productivity. Organic matter undergoes mineralization with the release of substantial quantities of N, P, and S and smaller amount of micronutrients. In Bangladesh, most of the cultivated soils have less than 1.5% organic matter and some soils even less than 1%, while a good agricultural soil should contain at least 2.5% organic matter (BARC, 2005). Moreover, this important component of soils is declining with time due to intensive cropping and use of higher doses of nitrogenous fertilizers with little or no addition of organic manure.

In Bangladesh, major food crops remove about 2.98 million tons of nutrients annually against a total addition of 0.72 million ton (Rahman *et al.,* 2008). According to an appraisal report of Bangladesh soil resources, soils of about 6.10 m ha contain very low (less than 1%) organic matter, 2.15 m ha contain low (1-2%) organic matter and the remaining 0.90 ha contain more than 2 % organic matter. Ali (1997) reported that during the years 1967-1995, the highest depletion of organic matter occurred in soils of Meghna River Floodplain (35%) followed by Madhupur Tract (29%), Brahmaputra Floodplain (21%), Old Himalayan Piedmont Plains (18%) and Gangetic Floodplain (15%).

The average organic matter content of top soils has decline by 20-46% over past 20 years due to intensive cropping without inclusion of legume crops, imbalance use of fertilizer, use of modern varieties and scanty use of organic manure. It is agreed that decrease in soil fertility is a major constraint for higher crop production in Bangladesh. The beneficial effect of organic manure in crops production has been demonstrated by many workers (Joshi *et al.,* 1994; Batsai *et al.,* 1979; Singh *et al.*, 1970; Subhan, 1991).

A suitable combination of organic and inorganic source of nutrients is necessary for sustainable agriculture that can ensure food production with high quality (Reganold *et al.,* 1990). Nambiar (1991) viewed that integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility. The long-term research of BRRI revealed that the application of cowdung 5 t/ha/yr improved rice productivity as well as prevented the soil resources from degradation (Bhuiyan, 1991). Thus, it is necessary to use fertilizer and manure in an integrated way in order to obtain sustainable crop yield without affecting soil fertility. Based on the soil fertility problem as discussed above, the present study was undertaken to investigate the effect of combined use of chemical fertilizers and organic manures in wheat-sesame-T. Aman rice cropping pattern regarding yield and economic return.

Material and Methods

The experiment was carried out at FSRD site, Pushpopara, Pabna, during November, 2010 to December, 2011 to observe the comparative performance of integrated plant nutrients management (IPNS) system through the use of organic (cowdung, cowdung slurry) and inorganic fertilizer on wheat, sesame and T. Aman crops under wheat-sesame-T. Aman cropping pattern. The trial was conducted in 6 different locations at the farmer's field. Before conducting the experiment, initial composite soil samples (0-15 cm depth) were collected from the experimental plots and were analyzed. Nutrient packages was calculated on the basis of soil test value according to the instructions outlined by BARC fertilizer recommendation guide 2005.

$$F_r = U_f - X \frac{Ci}{Cs} (S_t - L_s)$$

Where

F_r = Fertilizer nutrient required for given soil test value

U_f = Upper limit of the recommended fertilizer nutrient for the respective STVI class

C_i = Units of class intervals used for fertilizer nutrient recommendation

C_s = Units of class intervals used for STVI class

S_t = Soil test value

L_s = Lower limit of the soil test value within STVI class

The experiment was laid out in Randomized Complete Block Design with a unit plot size of 5m×6m. Four fertilizer treatments viz. T_1: Soil test based inorganic basis fertilizer dose for high yield goal, T_2: Cowdung @ 5 t ha^{-1} + IPNS basis inorganic fertilizer dose for high yield goal, T_3: Cowdung slurry @ 5 t ha^{-1} + IPNS basis inorganic fertilizer dose for high yield goal and T_4: Farmers practice. Variety BARI Gom 24, BARI Til 4 and Swarna was selected for wheat, sesame and T. Aman respectively by the cooperator farmers and used in the trial. Wheat seeds were sown in the field on December 15-25, 2010 maintaining spacing of 20 cm × 5 cm. Fifty percent urea and entire amount of TSP, MoP, Gypsum, Zinc sulphate , Boric acid and organic manure were applied as basal as per treatment specification. Rest 50% urea was applied at 18-21 days after sowing (DAS). The seeds of sesame were broadcasted @ 7 kg ha^{-1} on April 6, 2011. All fertilizers with full amount except urea were applied during final land preparation. Fifty percent urea was applied as basal and the rest amount was applied as top dress during first irrigation. In case of T. Aman rice, thirty day's old seedling was transplanted on 16 and 17

August, 2011. Entire amount of all fertilizers including cowdung manure and cowdung slurry except urea were applied as basal. Urea was applied in two equal splits at 15 and 55 DAT as top dress. Intercultural operations viz. weeding, thinning, irrigation and spraying of pesticides were done as and when required in order to support normal plant growth and development. The crops were harvested after full maturity. Wheat, sesame and T. Aman were harvested on March 12-17, July 7 and 25-29 November, 2011 respectively.

The recorded data were statistically analyzed following Gomez and Gomez (1984). All types of variable production cost are recorded to find out the marginal benefit cost ratio (MBCR). Economic analysis with respect to net return was carried out to evaluate the profitability of different treatments.

Table 1. Soil test value (Nutrient status) of the initial soil of the experimental field at FSRD site, Pushpopara, Pabna

pH	OM (%)	Total N (%)	P	S	B	K (me/100g soil)
			(µg/g soil)			
8.23	1.91	0.11	17	21	0.39	0.23
Alkaline	M	L	M	M	M	O

Table 2. Analytical value of N, P and K nutrient from different manure (Cowdung and bioslurry)

Kind of Manure	Nutrient supply (kg) from 1 ton material		
	N	P	K
Cowdung	3	1	3
Cowdung slurry	4.6	1.6	5

Table 3. Calculated amount of different nutrients as per treatment specification applied for different crops under wheat – sesame – T. Aman cropping pattern (Soil test based)

Treatment	Manure	Wheat						Sesame						T. aman					
		N	P	K	S	B	Zn	N	P	K	S	B	Zn	N	P	K	S	B	Zn
T_1	-	112	18	47	6	1	1.5	73	16	25	9	1	1.5	84	9	27	5	1	1
T_2	CD @ 5 t ha^{-1}	97	13	32	6	1	1.5	58	11	10	9	1	1.5	69	4.0	12	5	1	1
T_3	CDS @ 5 t ha^{-1}	89	10.5	22	6	1	1.5	50	8.5	-	9	1	1.5	61	1.5	2	5	1	1
T_4	-	69	22	19	-	-	-	35	12	18	-	-	-	69	20	37	10	-	-

Results and Discussion

Yield and yield attributes of wheat

Significantly higher plant height (98.84 cm) was obtained from T_3 that was statistically similar to T_2 and lower from T_4 treatment. The spike m^{-2} (333.55) and grain $spike^{-1}$ (44.05) were observed as the highest from T_3 followed by T_2 and the lowest from T_4 treatment. Significantly the highest1000 grain weight (42.61 g) was obtained from T_3 and the lowest (3.31 g) from T_4. The highest grain yield (3.80 t ha^{-1}) was obtained from bio-slurry treated plot that means T_3 treatment followed by T_2 and the lowest (3.31 t ha^{-1}) from T_4 treatment. The highest straw yield (5.92 t ha^{-1}) was also obtained from bio-slurry treated plot i.e. from T_3 and the lowest (5.38 t ha^{-1}) from T_4. Significant variation of grain yield indicated that nutrient management packages had significant influence on wheat production. It was observed that IPNS systems with organic manure (cowdung, bio-slurry) based nutrient packages showed better performance over T_1 and T_4 packages as those dealt with chemical fertilizers only. This might be due to the positive effect of organic manure (bio-slurry, cowdung) on yield and yield contributing characters of wheat. The result of yield increment of wheat was supported by the findings of Bodruzzaman *et al.* (2002), Karki *et al.* (1996), Kologi *et al.* (1993), Maskey (1978).

Table 4. Yield and yield contributing characters of wheat at FSRD site pushpapara, Pabna

Treatment	Plant height (cm)	Spikem^{-2}	Filled grain$spike^{-1}$	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	95.63 b	312.27 c	38.58 c	42.21 b	3.51 c	5.50 c
T_2	98.38 a	320.05 b	39.75 b	42.28 b	3.60 b	5.80 b
T_3	98.84 a	333.55 a	44.05 a	42.61 a	3.80 a	5.92 a
T_4	95.91 b	308.00 c	38.00 c	42.10 c	3.31 d	5.38 d
CV (%)	8.49	11.77	5.90	2.24	6.22	4.77

Within column values followed by same letter(s) did not differ significantly by DMRT

Yield and yield attributes of sesame

Data presented in the Table 5 revealed that plant height, plant population, nos. of siliqua plant^{-1} and nos. of seeds siliqua^{-1} of sesame were statistically non significant but varied numerically among the treatments. The higher plant height (136.8 cm) was recorded from T_3 followed by T_2 and the lower (130.1 cm) from T_4 treatment. Similar trend was found in case of plant populations. The maximum nos. of siliqua plant^{-1} (36.16) was obtained from T_3 followed by T_2 and the minimum (33.42) from T_4 treatment. Numerically higher nos. of seeds siliqua^{-1} (47.00) was found in T_3 followed by T_2 and the lower (44.47) from T_4 treatment. Higher seed yield (1.31 t ha^{-1}) of sesame was obtained from T_3 that was statistically identical to T_2 and T_1 and the lower (1.01 t ha^{-1}) from T_4. The cumulative positive effect of nos. of siliqua plant^{-1}, nos. of seeds siliqua^{-1} and weight of 1000 seeds might be contributed to higher seed yield in T_3. Lower seed yield was attained from farmers practice treatment probably the poor performance of yield contributing characters. Maximum stover yield (3.53 t ha^{-1}) was also recorded in T_3 was statistically indistinguishable from T_2 and T_1 and the minimum (3.32 t ha^{-1}) from T_4. The availability of nutrients and balanced uptake of nutrient might be enhanced optimum plant growth and finally maximized grain yield in T_3 treatment as compared to other treatments. Haruna and Abimiku, (2011) reported about higher yield of sesame from application of organic manure.

Table 5. Yield and yield contributing characters of sesame at FSRD site, Pushpapara, Pabna

Treatment	Plant height (cm)	Plant population	Nos. of siliqua plant^{-1}	Nos. of seeds siliqua^{-1}	1000 seeds weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	134.0	34.00	34.45	44.52	2.62 b	1.21 ab	3.41 ab
T_2	135.9	35.16	35.42	45.00	2.64 ab	1.25 ab	3.44 ab
T_3	136.8	35.42	36.16	47.00	2.68 a	1.31 a	3.53 a
T_4	130.1	33.42	33.42	44.47	2.62 b	1.01 b	3.32 b
CV (%)	8.04	14.71	11.49	8.52	4.32	12.07	12.42

Within column values followed by same letter(s) did not differ significantly by DMRT.

Yield and yield attributes of T. Aman rice

The yield and yield contributing characters were statistically significant except panicle length (Table 6). Yield attributes like filled grain panicle^{-1}, 1000 grain weight were found as the highest in T_3 and the minimum in T_4. The results revealed that the yield contributing characters exhibited better performance due to IPNS with CDS based fertilizer management. The highest grain yield (5.05 t ha^{-1}) was obtained from T_3 which was statistically indistinguishable from T_2 where as the lowest grain yield (4.26 t ha^{-1}) was recorded from T_4 treatment. The maximum yield in T_3 treatment might be due to the cumulative positive effect of yield contributing parameters. Probably integrated fertilizer management using both inorganic and organic sources improved the availability of nutrients and their balanced uptake facilitated optimum growth and development of the crop which ultimately increased grain yield. The poor performance of yield attributes might be attributed to lower grain yield in T_4. The highest straw yield (7.90 t ha^{-1}) was obtained from T_3 followed by T_2 and the lowest (6.6 t ha^{-1}) from T_4 treatment. Similar trend of yield increment in rice with the application of bioslurry was also found by Bodruzzaman *et al.* (2002), Kanthaswamy (1993), Tripathi (1993), Gupta (1991), Singh *et al.* (1995), Maskey (1978).

Table 6. Yield and yield contributing characters of T. aman rice at FSRD site, Pushpopara, Pabna

Treatment	Plant height (cm)	Nos. of tiller hill^{-1}	Nos. of panicle m^{-2}	Nos. of filled grain panicle^{-1}	1000 grain wt (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	108.4 b	8.96 b	276.1 b	117.8 c	20.28ab	4.81 b	7.06 c
T_2	103.1 d	8.57 c	285.7 ab	123.4 b	20.17bc	4.91 ab	7.35 b
T_3	105.8 c	9.38 a	293.7 a	128.7 a	20.35a	5.05 a	7.90 a
T_4	111.0 a	9.31 a	297.3 a	108.4 d	20.14c	4.26 c	6.6 d
CV (%)	6.54	8.07	10.17	7.35	4.66	5.59	6.06

Within column values followed by same letter(s) did not differ significantly by DMRT

Economics

Gross return and total variable cost for wheat, sesame and T. Aman are presented against different treatments in the Table 7. It is observed that the highest gross return (276130 Tk ha^{-1}) was obtained from T_3 followed by T_2 and the lowest (230080 Tk ha^{-1}) from T_1 treatment. Many research work related to integrated use of fertilizer have found profitable (Haque *et al*., 2001; Gupta, 1991). Total variable cost for purchasing different inputs i.e. fertilizers, pesticides and carrying out various intercultural operations recorded as the highest (97674 Tk ha^{-1}) in T_1 followed by T_2 and the lowest (86775 Tk ha^{-1}) in T_4 treatment. Comparatively high variable cost in T_2 than T_3 treatment might be due to higher labour cost for intercultural operations i.e. weed management. Fresh cowdung contains viable weed seeds that compete with the crops and requires farmers to put extra labours for weeding where as bioslurry is also reported to be free from weed seeds (Tripathi, 1993; Van Brake, 1980). The lowest variable cost found in T_4 treatment due to less input cost for purchasing fertilizers as farmers do not use optimum dose of fertilizers for crop production. This statement agrees to the findings reported by Jahiruddin *et al*. (2009). This has created unbalanced use of fertilizers which produces negative impact on soil fertility and crop yield and there by ultimately on economic return. The highest marginal value of product (46050 Tk ha^{-1}) was recorded in T_3 followed by T_2 where as the minimum (27440 Tk ha^{-1}) was found in T_1 over the T_4 treatment. The highest marginal value of product in T_4 treatment is mainly of higher yield and economic return facilitated by IPNS with cowdung slurry. Marginal variable cost was observed as the highest (10899 Tk ha^{-1}) in T_2 treatment followed by T_3 and the minimum (7949 Tk ha^{-1}) was recorded in T_1 treatment. Comparatively low marginal variable cost in T_2 and T_3 over T_1 treatment probably due to less input cost for purchasing chemical fertilizers. The highest MBCR (5.79) was recorded from T_3 followed by T_2 and the minimum (2.52) from T_1 treatment.

Table 7. Profitability of the IPNS system of fertilizer application over the farmers' practice obtained from wheat-sesame-T. Aman rice cropping pattern

Treatment	Rice equivalent yield (t ha^{-1})	Gross return from Wheat- Sesame-T. Aman Pattern (Tk ha^{-1})	Total variable cost for Wheat-Sesame-T. Aman Pattern (Tk ha^{-1})	Marginal value of product (Tk ha^{-1})	Marginal variable cost (Tk ha^{-1})	MBCR
T_1	12.88	257520	97674	27440	10899	2.52
T_2	13.22	264365	95425	34285	8650	3.96
T_3	13.81	276130	94724	46050	7949	5.79
T_4	11.50	230080	86775	-	-	-

Item of Input	Unit price (Tk kg^{-1})	Item of Output	Unit price (Tk kg^{-1})
Cowdung / Cowdung slurry	1.0	Wheat grain	20.0
Urea	20.0	Wheat straw	1.00
TSP	24.0	Rice grain	20
MoP	15.0	Rice straw	2.5
Gypsum	10.0	Sesame seed	55
$ZnSO_4$	130.0	Sesame stover	1.0
Boric acid	130.0		

Conclusion

Considering yield and return it can be concluded that treatment T_3 that means IPNS with cowdung slurry is the most profitable as compared to other treatments. Many researchers claim that IPNS based fertilizer management systems have been found promising for maintaining soil health. In order to maintain sustainable agriculture we should give priority for creating awareness and using IPNS based fertilizer package for successful crop production keeping sustenance of soil health.

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