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RESEARCH PAPER

Integrated Plant Nutrition System for Mungbean-T. Aus-T. Aman Cropping Pattern in the Ganges Tidal Floodplain

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ABSTRACT

The study was undertaken in farmers' fields of Dumki, Patuakhali and Amtali, Barguna in 2010 and 2011. The objective was to develop suitable integrated plant nutrition system (IPNS) for the Mungbean-T. aus–T. aman cropping pattern in the coastal zone of Bangladesh. The experimental fields belong to Ganges Tidal Floodplain (AEZ 13) having low soil organic matter and N & P contents. There were seven treatments for Mungbean which include T_1: control (no fertilizer or manure), T_2: High yield goal (soil test basis) from chemical fertilizers, T_3: HYG with IPNS (CD 3 t ha^{-1}), T_4: HYG with IPNS (CD 5 t ha^{-1}), T_5: HYG with IPNS (PM 1.5 t ha^{-1}), T_6: HYG with IPNS (PM 3 t ha^{-1}) and T_7: Farmer practice. For T. aus and T. aman rice, the treatments were T_1: control, T_2 : 100% chemical fertilizer (STB) ; T_3 : 75% P, K & Zn of T_2; T_4 : 50% P, K & Zn of T_2; T_5 : 75% P, K & Zn of T_2; T_6 : 50% P, K & Zn of T_2 and T_7 : Farmer practice. All IPNS treatments produced statistically identical seed/grain yield in all crops over the years. Significantly higher yield was observed in the treatments T_6 and T_4 as compared to T_3 (only chemical fertilizer). Farmer practice and control treatments produced statistically similar yield. The IPNS treatments had positive effect on mungbean yield and showed considerable residual effect on the following T. aus rice, but no residual effect on succeeding T. aman rice. Considering the whole cropping system the productivity was higher in IPNS nutrient application. Benefit- cost ratio of the whole cropping system was found to be the highest in the treatment T_5 (IPNS treatment with 1.5 t ha^{-1} poultry manure). Therefore, it can be concluded that farmers of the coastal areas of Bangladesh should follow IPNS fertilizing system using available organic manure like cowdung or poultry manure to increase crop yield as well as to maintain soil fertility.

Key words: Cowdung, poultry manure, NPK, Mungbean, T. aus, T. aman, yield, BCR

Introduction

Declining soil fertility is a major concern of increasing crop production in Bangladesh. Over the last 2-3 decades, enormous pressure has been exerted on the soil resource to produce more food for its huge population (Jahiruddin and Satter, 2010). In Bangladesh, most of the soils have less than 1.5 % and some have even less than 1% organic matter whether a good agricultural soil should have around 2.0 % organic matter (FRG, 2012). But, she has no alternative to maintain soil fertility as demand of agricultural commodities is in increasing trend. Rahman (2003) reported that soil aggregation, structure, permeability, fertility and infiltration are improved with the inclusion of legumes in the cropping system. Integrated use of organic manure and chemical fertilizers could improve crop productivity and sustain soil fertility (Prasad *et al.*, 2002). Integrated plant nutrition system (IPNS) is a modern system of nutrient management, providing ideal nutrition for a specific crop. It is also an important component of sustainable agricultural intensification, as well as crop, pest, soil and water management (Brahmachari *et al.*, 2005). Along with soil nutrient scarcity southern coastal region of Bangladesh is the most vulnerable area in the context of agriculture such as soil salinity, drought and scarcity of suitable irrigation water in the dry season, sometimes also in early *kharif*-1

season, high rainfall in the wet season, cyclone, tidal surge etc. In the coastal area present land use is primarily limited to within growing of T. aman rice (transplanted wet season rice) in the wet season. During dry period (December to mid-April) a vast area of land remains fallow. Farmers hardly follow any regular cropping pattern. In Patuakhali district, Mungbean-T.aus-T. aman is the second highest cropping pattern covering 11.73 % of total cultivable land of (DAE, 2008). The farmers grow *rabi* crops with less care and judicial application of fertilizer is beyond their knowledge. They are not aware of integrated plant nutrition system which is the prime concern for sustenance of soil fertility and soil productivity. Incorporation of brown mungbean biomass and T. aus straw can help increase soil organic matter (Bhuiyan, 2005). There is a good scope of this practice without increasing production cost. Further scope exists to add organic matter to soils in the form of cowdung and poultry manure for restoration of soil health. Hence, the present study was undertaken in order to determine the benefits of integrated plant nutrition system and to suggest the suitable rate of cowdung or poultry manure application combined with fertilizers for Mungbean -T. aus–T. aman cropping pattern in the Ganges Tidal Floodplain.

Materials and Methods

The study was conducted in the farmers' field of southern coastal region of Bangladesh. Field trials were made with Mungbean-T. aus-T. aman cropping pattern at Dumki and Amtaliupazilas of Patuakhali and Barguna districts, respectively under the agro ecological zone (AEZ) 13 (Ganges Tidal Floodplain). The experiment includes fertilizer treatments based on balanced fertilization with or without integrated plant nutrition system (IPNS). The experiments were conducted at farmers' fields for two consecutive cropping calendars (2009-10 and 2010-11).

Cropping seasons and Crops

In Bangladesh there are three major cropping seasons, namely *rabi*, *kharif-I* and *kharif-II* that extends from middle October to middle March, middle March to the end of June and early July to mid-October, respectively. The first crop in the cropping pattern was mungbean (var. BARImung 6) collected from Regional Pulses Research Station, BARI, Madaripur having the potential yield of 1000-1200 $kgha^{-1}$. The second and third cropswere T. aus rice (var. BRRI dhan27) and T. aman rice (var. BR23) having yield potentiality of 4.00 tha^{-1} and 5.00 tha^{-1}, respectively.

Treatments

Eachcrop of the experiment comprised seven treatments including absolute control. The fertilizer treatments used in the experiment were based on FRG-2005. Initial soil nutrient properties are given in tables 1 and 2 and the treatment details used for the Mungbean–T. aus–T. aman cropping pattern are given in Table 3. The source of N, P and K nutrients was urea, TSP and MoP, respectively. Decomposed cowdung @ 5 and 3 tha^{-1} and poultry manure @ 3 $tha^{-1}$and 1.5 tha^{-1} (dry wet basis) were applied to the first crop only and its residual effects were assessed in the succeeding T. aus and T. aman rice in the cropping sequence. Farmer practice of fertilizer use was estimated on the average of 10 farmers' practices in each location. Farmers in the southern region of Bangladesh hardly use manures. They use urea, TSP and MP only in case of modern varieties of T. aus and T. aman rice.

Table 1. Initial soil chemical properties of experimental plots at Lebukhali, Patuakhali

Farmer	EC ($ds\ m^{-1}$)	pH	OM (%)	N (%)	P ($mg\ kg^{-1}$)	K (meq/ 100g soil)	S ($mg\ kg^{-1}$)	Zn ($mg\ kg^{-1}$)
F1	0.59	5.20	1.38	0.119	1.45	0.23	145.7	0.40
F2	0.78	6.20	0.87	0.044	1.25	0.20	134.1	0.23
F3	0.59	5.00	1.67	0.083	1.14	0.21	111.2	0.66
F4	0.72	5.80	1.90	0.095	1.31	0.19	135.2	0.67
F5	0.78	5.40	0.87	0.044	1.07	0.26	163.4	0.68
Avg	0.69	5.52	1.34	0.077	1.24	0.23	137.9	0.53
Interpretation	M	M	L	VL	VL	M	VH	L

VL= Very low, M=Medium, VH= Very high, L = Low

Table 2. Initial soil chemical properties of experimental plots at Amtali, Barguna

Farmer	EC (dsm^{-1})	pH	OM (%)	N (%)	P ($mg\ kg^{-1}$)	K (meq/ 100g soil)	S ($mg\ kg^{-1}$)	Zn ($mg\ kg^{-1}$)
F1	1.77	5.10	1.98	0.099	1.24	0.23	358.7	0.43
F2	0.72	6.00	1.67	0.083	1.25	0.15	95.2	0.47
F3	1.38	5.60	1.90	0.095	1.21	0.24	109.2	0.45
F4	2.37	5.60	1.35	0.067	1.23	0.15	145.2	0.25
F5	1.31	5.20	1.43	0.071	1.19	0.17	115.8	0.19
Avg	1.51	5.50	1.67	0.083	1.22	0.19	164.8	0.36
Interpretation	H	M	L	VL	VL	M	VH	L

VL= Very low, M=Medium, VH= Very high, L = Low

Table 3. Treatments used in the experiment

Treat.	Mungbean (BARImung 6)	T. aus rice (BRRI dhan27)	T. aman rice (BR23)
T_1	Control (no fertilizer or manure)	Control (no fertilizer or manure)	Control (no fertilizer or manure)
T_2	High yield goal (STB) from chemical fertilizer	High yield goal (STB) from chemical fertilizer	High yield goal (STB) from chemical fertilizer
T_3	High yield goal (STB) with IPNS (CD 3 t ha^{-1})	75%, P, K and Zn of T_2	75%, P, K and Zn of T_2
T_4	High yield goal (STB) with IPNS (CD 5 t ha^{-1})	50% P, K and Zn of T_2	50% P, K and Zn of T_2
T_5	High yield goal (STB) with IPNS (PM 1.5 t ha^{-1})	75%, P, K and Zn of T_2	75%, P, K and Zn of T_2
T_6	High yield goal (STB) with IPNS (PM 3 t ha^{-1})	50% P, K and Zn of T_2	50% P, K and Zn of T_2
T_7	Farmer practice	Farmer practice	Farmer practice

Table 4. Fertilizer doses for Mungbean-T. aus-T. aman cropping pattern atLebukhali, Patuakhali

Treat.	Mungbean					T. aus rice				T. aman rice			
	N	P	K	Zn	CD/PM	N	P	K	Zn	N	P	K	Zn
	(kg ha^{-1})				(t ha^{-1})	(kg ha^{-1})							
T_1	0	0	0	0	0	0	0	0	0	0	0	0	0
T_2	19	38	19	2	0	79	15	14	2	94	19	18	2
T_3	6	34	4	2	CD: 3	79	11	11	1.5	94	14	14	1.5
T_4	0	31	0	2	CD: 5	79	8	7	1	94	10	9	1
T_5	2	22	8	2	PM: 1.5	79	11	11	1.5	94	14	14	1.5
T_6	0	7	0	2	PM: 3	79	8	7	1	94	10	9	1
T_7	0	0	0	0	0	70	23	19	0	70	15	0	0

CD = Cowdung, PM = Poultry manure

Table 5. Fertilizer doses for Mungbean-T. aus-T. aman cropping pattern at Amtali, Barguna

Treat.	Mungbean					T. aus rice				T. aman rice			
	N	P	K	Zn	CD/PM	N	P	K	Zn	N	P	K	Zn
	(kg ha^{-1})				(t ha^{-1})	(kg ha^{-1})							
T_1	0	0	0	0	0	0	0	0	0	0	0	0	0
T_2	19	39	23	2	0	77	16	22	2	99	20	26	2
T_3	6	35	8	2	CD: 3	77	12	17	1.5	99	15	20	1.5
T_4	0	32	0	2	CD: 5	77	8	11	1	99	10	13	1
T_5	2	23	13	2	PM: 1.5	77	12	17	1.5	99	15	20	1.5
T_6	0	8	3	2	PM: 3	77	8	11	1	99	10	13	1
T_7	0	0	0	0	0	52	18	27	0	52	12	0	0

CD = Cowdung, PM = Poultry manure

Fertilizer doses and Methods of application

On the basis of soil test value, required nutrients for high yield goal was calculated on IPNS basis. Amounts of different fertilizer doses for Mungbean-T. aus-T. aman rice system for each location showed in Table 4 and 5. The sources of N, P, K and Zn were urea, TSP, MoP and zinc sulphate (monohydrate), receptively. In case of mungbean full amount of cowdung/poultry manure, urea, TSP, MoP and $ZnSO_4.H_2O$ as per treatments were applied at the time of final land preparation. In T. aus rice full amount of TSP, MoP and $ZnSO_4.H_2O$, and one-third of urea were applied during final land preparation according to treatment dose. Rest of the urea was top dressed in two equal installments at tillering stage and panicle initiation stage. Again, in T. aman rice full amount of TSP, MoP and $ZnSO_4.H_2O$, and one-third of urea were applied during final land preparation according to treatment dose. Rest of the urea was top dressed in two equal installments at tillering stage and panicle initiation stage. Manure was applied to the first crop only in each crop cycle and it was applied 5 days before sowing /transplanting. Their residual effects were evaluated on the second and third crops.

Crop cultivation

In the cropping pattern experiment first crop was mungbean. The land was prepared by repeated ploughing and cross-ploughing 4 times by power tiller followed by laddering and weeding. It was sown in 3rd week of January in 30cm X 5cm spacing and harvesting was completed by 1st week of May. After first crop, land preparation was done and 20 days old T. *aus* seedling was transplanted in 1-3 June and harvested on 19-23 August when 80% grain was ripen. Again, the 3rd crop T. *aman* was transplanted on 6-10 September with 30 days old seedling and it was harvested on 21-24 December at 80% ripening.

Experimental design and Data analysis

The experiment was laid out in a randomized complete block design (RCBD) with five replications where each farmer represents a replication. Each replication represented a block, which was divided into seven unit plots. The size of the individual plot was 8m x 5m. Plot to plot distance was maintained 0.5 m. Data on plant population m^{-2}, plant height (cm), pods $plant^{-1}$, seeds pod^{-1}, 1000-seed weight, seed yield (kg ha^{-1})and stover yield (kg ha^{-1})for mungbean and plant height, panicle length (cm), number of effective tillers $hill^{-1}$, number of filled grains $panicle^{-1}$, 1000-grain weight (g), grain yield (t ha^{-1}) and straw yield (t ha^{-1}) for T. aus rice and T. aman rice were collected and recorded. Data were analyzed by computer using MSTAT-C Package while mean separation was done by LSD.

Results and Discussion

The study was done to develop a suitable IPNS taking cowdung or poultry manure as a source for the Mungbean - T. aus rice - T. aman cropping pattern in the coastal zone of Bangladesh with seven treatments, of which four IPNS, one 100% fertilizers, one farmer practice and one absolute control. The results are as follows-

Mungbean

Mungbean (var. BARImung 6), the first crop in the pattern, was used as a legume crop and significant variation was observed among the treatments. The maximum plant height (39 cm), plant population m^{-2} (33) and number of pods $plant^{-1}$ (9) were recorded in the treatment T_6 (IPNS with PM 3 t ha^{-1} + fertilizer, STB) which was statistically similar to all other IPNS treatments but significantly higher over control (T_1) and the farmer practice (T_7). The number of seeds pod^{-1} and 1000-seed weight did not differ significantly. The highest seed yield (1155 kg ha^{-1}) and stover yield (1548 kg ha^{-1}) of mungbean was observed in the treatment T_6 (IPNS with 3 t PM ha^{-1} + fertilizer, STB) which was statistically similar to T_4 treatment. Almost all the observations were found the lowest in control treatment (T_1) which was also very close to that of the farmer practice (T_7) in 2010 (Table 6). Like in 2010, in 2011 the highest plant height (47 cm) was produced in the treatment T_6 which was statistically similar to all other IPNS treatments. The highest plant population m^{-2} (32) and number of pods $plant^{-1}$ (12) were observed in all the IPNS treatments. Treatment T_2 also produced statistically similar pods $plant^{-1}$ with all IPNS treatments. Seed yield (1142 kg ha^{-1}) and stover yield (1184 kg ha^{-1}) were found the highest in in treatment T_6 (IPNS with 3 t PM ha^{-1} + fertilizer, STB) which was stistically similar to all other IPNS treatments (T_3, T_4 and T_5). Farmer practice and control treatment gave statistically lower results than that of other treatments in 2011 at Lebukhali (Table 7).

At Amtali in 2010, the highest plant population m^{-2} was observed in T_3 (IPNS with 3 t CD ha^{-1}+ fertilizer, STB) which was similar to that of all other IPNS treatments (T_6, T_4 and T_5) and chemical fertilizer treatment (T_2). The lowest plant population m^{-2} was observed in T_1 (control) which was identical to the treatment T_7 (farmer practice). The highest plant height of mungbean was observed in the treatment T_6 (IPNS with 3 t PM ha^{-1} + fertilizer, STB) which was statistically similar to that of all IPNS treatments (T_4, T_3 and T_5) and T_2 and followed by the farmer practice (T_7) and control (T_1). The highest number of pods $plant^{-1}$ was observed in treatment T_6 which was statistically similar to the treatments T_4 and T_5. The lowest number of pods $plant^{-1}$ was observed in the control treatment (T_1), which was statistically similar to that of treatments T_2, T_3 and T_7. The highest seed yield of mungbean (1204 kg ha^{-1}) was observed in treatment T_6 which was similar to that of all other IPNS treatments (T_3, T_4 and T_5). The control treatment (T_1) exhibited the lowest seed yield (695kg ha^{-1}) which was statistically similar to that of the farmer practice (T_7). In case of stover yield, the same trend was observed. Ratio of seed and stover (stover : seed) yields were higher in control (T_1) and farmer practice (T_7) treatments.

In 2011 at Amtali, Plant population m^{-2} was the highest in the treatments T_4 and T_6 which were identical to those of treatments T_3 and T_5. Plant population (m^{-2}) in the treatment T_2 was statistically identical to that of the treatments T_3 and T_5, but was significantly lower than those of T_4 and T_6. The lowest plant population m^{-2} was observed in T_1 (control) which was identical to T_7 (farmer practice). The highest plant height was produced by the treatment T_6 which was statistically identical to that of all other IPNS treatments (T_4, T_3 and T_5) and chemical fertilizer treatment (T_2). The highest number of seeds pod^{-1} was observed in the treatment T_4 and T_6 which was statistically similar to all other treatments. The highest seed yield (1240 kg ha^{-1}) was observed in treatment T_6 (IPNS with 3 t PM ha^{-1} + fertilizer , STB) which was statistically similar to other IPNS treatments (T_4, T_5 and T_3). Control treatment (T_1) produced the lowest seed yield (757 t ha^{-1}) of mungbean which was statistically similar to that of the farmer practice (T_7). Stover yield of mungbean followed similar trend as in the case of grain yields over the treatments.

T. aus rice

The second crop in the experiment was T. aus rice (var. BRRI dhan27). The crop was grown in both the locations of Lebukhali and Amtali. At Lebukhali in 2010, the highest plant height (155 cm) was noted in the treatments T_4 and T_5. Treatments T_2 and farmer practice (T_7) also recorded statistically similar plant height. Panicle length of BRRI dhan27 due to different treatments ranged from 19 to 24 cm and the highest value was observed in the treatment T_5, which was statistically similar to that of all other treatments except control (T_1). Panicle length

Table 6. Yield and yield attributes of mungbean (BARI mung 6) as influenced by different treatments at Lebukhali in 2010

Treat.	Plant population(m^{-2})	Plant height (cm)	Pods $plant^{-1}$(no.)	Seeds pod^{-1} (no.)	1000-seed wt. (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1	30c	33c	7c	7	47	712e	954e
T_2	31bc	36b	8b	8	48	907d	1215d
T_3	31bc	38a	9a	8	48	1072c	1436c
T_4	32ab	38a	9a	8	48	1142ab	1530ab
T_5	33a	38a	8b	8	48	1088bc	1458bc
T_6	32ab	39a	9a	8	48	1155a	1548a
T_7	30c	32c	7c	7	47	725e	972e
CV(%)	3.53	3.55	5.94	12.28	3.48	4.72	4.33
Sig. level	**	**	**	NS	NS	**	**
SE (±)	0.42	1.04	0.34	0.18	0.18	72.16	96.65

T_1: control; T_2: chemical fertilizer for mungbean (STB); T_3: IPNS (CD 3 t ha^{-1}+ fertilizer, STB), T_4: IPNS (CD 5 t ha^{-1} + fertilizer, STB); T_5: IPNS (PM 1.5 t ha^{-1}+ fertilizer, STB); T_6: IPNS (PM 3 t ha^{-1} + fertilizer, STB); T_7: Farmer practice

Table 7. Yield and yield attributes of mungbean (BARI mung 6) as influenced by different treatments at Lebukhali in 2011

Treat.	Plant population(m^{-2})	Plant height (cm)	Pods $plant^{-1}$(no.)	Seeds pod^{-1}(no.)	1000-seed wt. (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1	29c	41d	10c	7	45	730d	978e
T_2	31ab	44c	12a	8	46	1031c	1382d
T_3	32a	46ab	12a	8	46	1064bc	1469bc
T_4	32a	46ab	11b	8	46	1118ab	1399cd
T_5	32a	45bc	12a	8	46	1096abc	1498b
T_6	32a	47a	12a	8	46	1142a	1584a
T_7	30bc	41d	9d	7	45	708d	949e
CV(%)	3.46	3.00	5.09	10.88	3.84	4.96	4.30
Sig. level	**	**	**	NS	NS	**	**
SE (±)	0.46	0.92	0.46	0.18	0.18	69.82	96.14

T_1: control; T_2: chemical fertilizer for mungbean (STB); T_3: IPNS (CD 3 t ha^{-1}+ fertilizer, STB), T_4: IPNS (CD 5 t ha^{-1} + fertilizer, STB); T_5: IPNS (PM 1.5 t ha^{-1}+ fertilizer, STB); T_6: IPNS (PM 3 t ha^{-1} + fertilizer, STB); T_7: Farmer practice

Table 8. Yield and yield attributes of mungbean (BARI mung 6) as influenced by different treatments at Amtali in 2010

Treat.	Plant Population (m^{-2})	Plant height(cm)	Pods $plant^{-1}$(no.)	Seeds pod^{-1} (no.)	1000-seed wt. (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1	27c	25e	7d	8	48	695c	931c
T_2	33ab	27d	8c	9	49	1058b	1418b
T_3	34a	30bc	8c	9	49	1148a	1538a
T_4	32b	31ab	9b	9	49	1175a	1575a
T_5	32b	29c	9b	9	49	1156a	1549a
T_6	33ab	32a	10a	9	49	1204a	1613a
T_7	28c	26de	8c	8	48	710c	951c
CV(%)	3.46	4.01	5.18	9.07	2.76	4.31	5.15
Sig. level	**	**	**	NS	NS	**	**
SE (±)	1.02	1.00	0.37	0.18	0.18	83.94	112.53

T_1: control; T_2 : chemical fertilizer for mungbean (STB);T_3 : IPNS (CD 3 t ha^{-1}+ fertilizer, STB),T_4 : IPNS (CD 5 t ha^{-1} + fertilizer, STB); T_5 : IPNS (PM 1.5 t ha^{-1}+ fertilizer, STB) ; T_6 : IPNS (PM 3 t ha^{-1} + fertilizer, STB); T_7 : Farmer practice

Table 9. Yield and yield attributes of mungbean (BARIMung 6) as influenced by different treatments at Amtali in 2011

Treat.	Plant Population (m^{-2})	Plant height (cm)	Pods $plant^{-1}$(no.)	Seeds pod^{-1} (no.)	1000-seed wt. (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1	28c	30d	9b	8c	46b	757c	1014c
T_2	32b	33c	9b	9b	46b	1082b	1450b
T_3	33b	35ab	10a	9b	48a	1156ab	1549ab
T_4	35a	34bc	10a	10a	48a	1212a	1624a
T_5	33b	35ab	10a	9b	48a	1175a	1575a
T_6	35a	36 a	10a	10a	48a	1240a	1662a
T_7	29c	31d	9b	8c	46b	783c	1049c
CV(%)	3.18	3.28	4.90	6.01	2.85	5.94	5.68
Sig. level	**	**	**	**	*	**	**
SE (±)	1.03	0.84	0.20	0.31	0.40	76.68	102.84

T_1: control; T_2 : chemical fertilizer for mungbean (STB);T_3 : IPNS (CD 3 t ha^{-1}+ fertilizer, STB),T_4 : IPNS (CD 5 t ha^{-1} + fertilizer, STB); T_5 : IPNS (PM 1.5 t ha^{-1}+ fertilizer, STB) ; T_6 : IPNS (PM 3 t ha^{-1} + fertilizer, STB); T_7 : Farmer practice

noted in the control (T_1) treatment was 19 cm. The number of effective tillers hill^{-1} of BRRI dhan27 with different treatments ranged from 7 to 8 and varied insignificantly. The IPNS treatments recorded higher number of tillers hill^{-1} compared to other treatments. Filled grains panicle^{-1} varied from 70 to 87 and the highest value was observed in the treatment T_5, which was statistically similar to that of the treatments T_2 and T_3. Treatments T_4 and T_6 produced the identical number of filled grains panicle^{-1} (79) which was statistically lower than that of the treatments T_5 and T_2, but similar to T_3. Farmer practice (T_7) produced significantly lower number of filled grains panicle^{-1} as compared to all other fertilizer application treatments which was followed by control. Control treatment (T_1) produced the lowest number of filled grains panicle^{-1}. The 1000-grain weight of BRRI dhan27 varied from 26 to 28 g and differed insignificantly with different treatments. The highest grain yield (3.58 t ha^{-1}) was observed in treatment T_5 which was statistically similar to that of the treatment T_2 and then treatment T_3. Farmer practice (T_7) produced significantly lower grain yield ha^{-1} as compared to all other fertilizer treatments. Control treatment (T_1) produced the lowest grain yield (2.14 t ha^{-1}) of BRRI dhan27. Similar trend was observed in case of straw yields. The grain and straw yields of BRRI dhan27 at Lebukhali in 2010 due to different treatments may be ranked in the order of T_5> T_2> T_3> T_6> T_4> T_7> T_1 and T_5> T_2> T_3> T_6> T_4> T_7> T_1 respectively.

Again, in 2011 all the treatments noted significantly higher plant height over the control treatment (T_1) at Lebukhali. Plant height due to IPNS treatments was inconsistent. Panicle length of BRRI dhan27 with different treatments varied from 18 to 22 cm and all the treatments except control were statistically similar. The treatments T_2 and T_5 produced the highest panicle length (22cm) while the minimum value (18 cm) was observed in the control (T_1). Effective tillers hill^{-1} of BRRI dhan27 due to different treatments varied insignificantly and ranged from 7 to 9. The highest number of effective tillers hill^{-1} was found in the treatments T_2 and T_6 (9) while T_1 and T_7 recorded the minimum value (7). Filled grain panicle^{-1} with different treatments ranged from 70 to 90 and differed significantly. The highest and lowest values were recorded in the treatments T_5 and T_1, respectively. Control treatment (T_1) noted the lowest number of filled grain panicle^{-1} which was statistically similar to the farmer practice (T_7). The 1000-grain weight of BRRI dhan27 varied from 26 to 28 g and differed insignificantly. The grain and straw yields of BRRI dhan27 varied significantly due to different treatments and ranged from 2.27 to 3.81 and 2.54 to 4.23 t ha^{-1}, respectively. The treatment T_7 recorded higher grain yield than that of the treatments T_4 and T_6 but lower than T_3 and T_5 treatments. Treatment T_5 noted the highest grain yield (3.81) which was followed by the treatment T_2. All the treatments resulted in significantly higher grain yields over control. Rice straw produced by different treatments followed similar trend as in grain yields. The grain and straw yields of BRRI dhan27 at Lebukhali in 2011 due to different treatments may be ranked in the order of T_5> T_2> T_3> T_7> T_4> T_6> T_1 and T_5> T_2> T_3> T_7> T_4> T_6> T_1, respectively.

In 2010 at Amtali, the plant height, panicle length, number of filled grains panicle^{-1} and both grain and straw yields of T. aus rice (var. BRRI dhan27) varied significantly with different treatments (Table 11). The maximum plant height (159 cm) was observed in the treatment T_5 which was statistically similar to that of the treatments T_2 and T_5. Treatments T_2 and T_5 produced the highest panicle length of 23 cm and the value was significantly higher over the control. The treatments T_2 and T_5 recorded the highest number of tillers hill^{-1} and the minimum value was noted in the control (T_1). The treatments T_2, T_3 and T_5 noted higher number of filled grains panicle^{-1}compared to the treatments T_1 (control) and T_7 (farmers practice).The 1000-grain weight of BRRI dhan27 did not vary significantly with different treatments and ranged from 26 to 28 g. The grain yield of BRRI dhan27 at Amtali in 2010 varied significantly with different treatments and ranged from 2.24 to 3.78 t ha^{-1}. The highest and lowest rice yield were recorded with the treatments T_5 and T_1 (control), respectively. All the treatments noted significantly higher grain yields over control. Farmer practice (T_7) produced significantly higher grain yield over the treatments T_1, T_4 and T_6. The grain and straw yields of BRRI dhan27 at Amtali in 2010 due to different treatments may be ranked in the order of T_5> T_2> T_3> T_7> T_4> T_6> T_1 and T_5> T_2> T_7> T_3> T_4> T_6> T_1, respectively.

Again, in 2011 the maximum plant height (158 cm) was noted in the treatment T_2 which was statistically similar to that of the treatment T_5 at Amtali. All the treatments except control recorded statistically similar panicle length of BRRI dhan27. Tillers hill^{-1} of BRRI dhan27 ranged from 8 to 10 and did not vary significantly with different treatments. The treatments T_2, T_3 and T_5 noted higher number of filled grains panicle^{-1}compared to the treatments T_1 (control) and T_7 (farmer practice).The 1000-grain weight of BRRI dhan27 did not vary significantly with different treatments and ranged from 26 to 27 g. The grain yield of BRRI dhan27 at Amtali in 2011 varied significantly due to different treatments and ranged from 2.35 to 3.74 t ha^{-1} (Table 13). The highest and lowest yields of rice were recorded with the treatments T_5 and T_1 (control), respectively. The straw yields of rice also varied significantly with different treatments and ranged from 2.75 to 4.41 t ha^{-1}. Straw yields of BRRI dhan27 due to different treatments followed the same trend as in case of the rice grain yields. The grain and straw yields of BRRI dhan27 at Amtali in 2011 due to different treatments may

Tab. 10. Yield and yield attributes of T. aus rice (BRRI dhan27) as influenced by different treatments at Lebukhali in 2010

Treat.	Plant height (cm)	Panicle length(cm)	Effective tillers hill^{-1}(no.)	Filled grains panicle^{-1} (no.)	1000-grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	132d	19d	7	70e	26	2.140f	2.590f
T_2	150b	23b	7	85a	27	3.370b	4.140b
T_3	154ab	23b	8	82b	27	3.120c	3.760c
T_4	155a	22c	8	79c	27	2.920d	3.500d
T_5	155a	24a	8	87a	27	3.580a	4.370a
T_6	153ab	22c	8	79bc	28	2.960cd	3.550cd
T_7	143c	22c	7	74d	26	2.520e	3.120e
CV(%)	2.14	2.46	12.45	2.84	5.57	4.94	4.55
Sig. level	**	**	NS	**	NS	**	**
SE (±)	3.23	0.59	0.20	2.26	0.26	0.19	0.23

T_1: control, T_2 : 100% chemical fertilizer for T. aus rice (STB) ; T_3 : 75% P, K & Zn of T_2; T_4 : 50% P, K & Zn of T_2; T_5 : 75% P, K & Zn of T_2;T_6 : 50% P, K & Zn of T_2; T_7 : Farmer practice.

Tab. 11. Yield and yield attributes of T. aus (BRRI dhan27) rice as influenced by different treatments at Lebukhali in 2011

Treat.	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1}(no.)	Filled grains panicle^{-1}(no.)	1000-grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	127c	18c	7b	70e	26	2.270d	2.540d
T_2	147a	22a	9a	87ab	28	3.750a	4.120a
T_3	143ab	21ab	8ab	85b	28	3.340b	3.710b
T_4	136b	20b	8ab	80c	28	2.950c	3.270c
T_5	151a	22a	8ab	90a	28	3.810a	4.230a
T_6	137b	20b	9a	79c	28	2.940c	3.240c
T_7	144ab	20b	7b	75d	27	3.080c	3.430c
CV(%)	4.13	4.93	15.76	3.36	4.24	5.44	6.10
Sig. level	**	**	NS	**	NS	**	**
SE (±)	3.03	0.53	0.31	2.65	0.30	0.20	0.22

T_1 : control, T_2 : 100% chemical fertilizer for T. aus rice (STB) ; T_3 : 75% P, K & Zn of T_2; T_4 : 50% P, K & Zn of T_2; T_5 : 75% P, K & Zn of T_2;T_6 : 50% P, K & Zn of T_2; T_7 : Farmer practice.

Table 12. Yield and yield attributes of T. aus (BRRI dhan27) rice as influenced by different treatments at Amtali in 2010

Treat.	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1}(no.)	Filled grains panicle^{-1}(no.)	1000-grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	134d	19 d	8b	72e	26	2.240d	2.670d
T_2	156ab	23a	10a	87a	26	3.640a	4.370a
T_3	151abc	22b	9ab	84b	28	3.230b	3.800b
T_4	144cd	20c	9ab	78d	28	2.700c	3.240c
T_5	159a	23a	10a	89a	28	3.780a	4.584a
T_6	145bc	20c	9ab	78d	28	2.670c	3.210c
T_7	150abc	22b	9ab	81c	26	3.190b	3.810b
CV(%)	5.26	3.30	9.18	2.35	6.42	7.27	7.34
Sig. level	**	**	*	**	NS	**	**
SE (±)	3.15	0.61	0.26	2.22	0.40	0.21	0.25

T_1 : control, T_2 : 100% chemical fertilizer for T. aus rice (STB) ; T_3 : 75% P, K & Zn of T_2; T_4 : 50% P, K & Zn of T_2; T_5 : 75% P, K & Zn of T_2;T_6 : 50% P, K & Zn of T_2; T_7 : Farmer practice.

Table 13. Yield and yield attributes of T. aus (BRRI dhan27) rice as influenced by different treatments at Amtali in 2011

Treat.	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1} (no.)	Filled grains panicle^{-1}(no.)	1000-grain wt.(g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	139c	19e	8c	75d	26	2.35d	2.75d
T_2	158a	23b	10a	89a	27	3.65a	4.30a
T_3	150ab	21c	9b	85b	27	3.27b	3.86b
T_4	147bc	20d	9b	80c	27	2.81 c	3.32c
T_5	156ab	24a	10a	91a	27	3.74a	4.41a
T_6	148abc	20d	8c	81c	27	2.83c	3.33c
T_7	152ab	21c	9b	84b	26	3.24b	3.80b
CV(%)	4.68	3.33	6.76	2.62	4.25	8.91	5.53
Sig. level	**	**	**	**	NS	**	**
SE (±)	2.38	0.67	0.31	2.07	0.18	0.19	0.22

T_1 : control, T_2 : 100% chemical fertilizer for T. aus rice (STB) ; T_3 : 75% P, K & Zn of T_2; T_4 : 50% P, K & Zn of T_2; T_5 : 75% P, K & Zn of T_2;T_6 : 50% P, K & Zn of T_2; T_7 : Farmer practice.

be ranked in the order of T_5> T_2> T_3> T_7> T_6> T_4> T_1 and T_5> T_2> T_3> T_7> T_6> T_4> T_1, respectively.

T. aman rice

The third crop in the pattern of the experiment was T. aman rice (var. BR23). The crop was grown in both the locations of Lebukhali and Amtali.

Plant height, panicle length, effective tillers hill^{-1}, grains panicle^{-1}, and grain and straw yields of T. aman rice varied significantly due to different treatments at Lebukhali in 2010 (Table 14). Plant height ranged from 109 to 117cm and the highest plant height was noted in the treatment T_4 which was statistically similar to that of the treatments T_3, T_5 and T_6. Panicle length of BR23 rice ranged from 20 to 24 cm and the highest value was noted in the treatment T_2. Panicle length noted in the control (T_1) treatment was 20 cm. The number of effective tillers hill^{-1} varied insignificantly. Filled grains panicle^{-1} varied from 73 to 103 and the highest value was observed in the treatment T_2 which was statistically similar to that of the treatments T_3 and T_5. The 1000-grain weight of BR23 rice varied from 27 to 29 g and differed insignificantly with different treatments. The grain and straw yields of BR23 rice at Lebukhali due to different treatments ranged from 2.70 to 4.86 and 3.16 to 5.69 t ha^{-1}, respectively. The highest grain yield (4.86 t ha^{-1}) was observed in treatment T_2 which was statistically superior to all other treatments. The treatments T_2 and T_5 recorded statistically identical grain yields which were significantly higher than that of the treatment T_7 (farmer practice). All the treatments noted significantly higher grain yield of aman rice over the control treatment (T_1). The IPNS treatments recorded higher grain yields over the farmer practice (T_7). The grain yield of BR23 rice at Lebukhali in 2010 due to different treatments may be ranked in the order of T_2> T_5> T_3> T_4> T_6> T_7> T_1 Similar trend was observed in case of straw yields and the treatments may be ranked in the order of T_2> T_5> T_3> T_4> T_6> T_7> T_1 .

In 2011 at Lebukhali, plant height of BR-23 rice ranged from 96 to 118 cm and the highest and lowest value were recorded in the treatments T_2 and T_1, respectively. Plant height due to IPNS treatments was significantly higher compared to control (T_1) and farmer practice (T_7). Panicle length of BR23 rice with different treatments ranged from 21 to 24 cm and the treatments differed insignificantly. The treatments T_2, T_3 and T_5 recorded the highest panicle length while the minimum value was observed in the control (T_1). Effective tillers hill^{-1} of BR23 rice with different treatments varied insignificantly and ranged from 8 to 10. Filled grain panicle^{-1} due to different treatments ranged from 77 to 105 and differed significantly. The highest and lowest values were recorded in the treatments T_2 and T_1, respectively. Control treatment (T_1) noted the lowest number of filled grain panicle^{-1} which was statistically similar to that of the farmer practice (T_7). All the IPNS treatments produced higher number of filled grains panicle^{-1} compared to the control (T_1) and farmer practice (T_7). The 1000-grain weight of BR-23 rice varied from 27 to 29 g and differed insignificantly. The IPNS treatments recorded higher 1000-grain weight over the control (T_1). The grain and straw yields of BR23 rice at Lebukhali in 2011 varied significantly due to different treatments and ranged from 2.28 to 4.77 and 2.57 to 5.25 t ha^{-1}, respectively. The treatment T_2 recorded the highest grain yield (4.77 t ha^{-1}) which was superior to all other treatments. All the treatments resulted in significantly higher grain yields over control. Rice straw yield produced by different treatments followed similar trend as in the grain yields. The grain and straw yields of BR23 rice at Lebukhali in 2011 due to different treatments may be ranked in the order of T_2> T_5> T_3> T_4> T_6> T_7> T_1 and T_2> T_5> T_3> T_4> T_6> T_7> T_1, respectively.

Plant height, panicle length, effective tillers hill^{-1}, grains panicle^{-1}, and grain and straw yields of T. aman rice varied significantly due to different treatments at Amtali in 2010 (Table 15). The highest plant height was noted in the treatments T_2 and T_3 which was statistically similar to that of the treatments T_4, T_5 and T_6. All the IPNS treatments recorded higher plant height over the farmer practice (T_7). Control treatment (T_1) produced the lowest plant height. Panicle length of BR23 rice at Amtali in 2010 ranged from 19 to 25 cm due to different treatments and the highest value was noted in the treatments T_2 and T_3 which was statistically similar to that of all other treatments except for control (T_1). The IPNS treatments recorded higher number of tillers hill^{-1} compared to other treatments except T_2. Filled grains panicle^{-1} varied from 76 to 100 and the highest value was observed in the treatment T_2 which was statistically similar to that of the treatments T_3, T_4, T_5 and T_6. Farmer practice produced lower number of filled grains panicle^{-1} compared to all fertilizer and IPNS treatments. Control treatment (T_1) produced the lowest number of filled grains panicle^{-1}. The 1000-grain weight of BR23 rice varied from 29 to 30 g and differed insignificantly with different treatments. The grain and straw yields of BR23 rice at Amtali in 2010 due to different treatments ranged from 2.72 to 4.80 and 3.13 to 5.38 t ha^{-1}, respectively. The highest grain yield was observed in treatment T_2 which was statistically superior to all other treatments. The treatments T_3 and T_6 recorded statistically similar grain yields which were significantly higher than that of the treatment T_7 (farmer practice). All the treatments noted significantly higher grain yields of aman rice over the control treatment (T_1). The grain yield of BR23 rice at Amtali in 2010 due to different treatments may be ranked in order of T_2> T_3> T_6> T_5/T_7> T_4> T_1 and T_2> T_3> T_6> T_5> T_4> T_7> T_1, respectively.

In 2011 at Amtali, plant height of BR23 rice ranged from 96 to 109 cm and the highest and the lowest value were recorded in treatments T_2 and T_1, respectively. Plant

Table 14. Yield and yield attributes of T. aman (BR23) rice as influenced by different treatments at Lebukhali in 2010

Treat.	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1}(no.)	Filled grains panicle^{-1}(no.)	1000-grain wt.(g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	109d	20c	9b	73d	27	2.70e	3.16d
T_2	111cd	24a	11a	103a	29	4.86a	5.69a
T_3	113abc	23ab	11a	95b	29	4.31b	5.04b
T_4	117a	22b	10ab	87c	29	3.52c	4.12c
T_5	115abc	23ab	11a	97b	29	4.37b	5.11b
T_6	116ab	23ab	10ab	86c	29	3.39cd	3.97c
T_7	110cd	22b	9b	84c	27	3.29d	3.85c
CV(%)	3.32	3.89	8.61	2.57	5.42	4.44	8.14
Sig. level	*	**	**	**	NS	**	**
SE (±)	1.18	0.48	0.34	3.75	0.37	0.29	0.33

T_1: control, T_2: 100% chemical fertilizer for T. aman rice (STB) ; T_3: 75% P, K & Zn of T_2; T_4: 50% P, K & Zn of T_2; T_5 : 75% P, K & Zn of T_2;T_6 : 50% P, K & Zn of T_2; T_7 : Farmer practice.

Table 15. Yield and yield attributes of T. aman (BR23) rice as influenced by different treatments at Lebukhali in 2011

Treat.	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1}(no.)	Filled grains panicle^{-1} (no.)	1000-grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	96c	21d	8c	77d	27	2.28b	2.57d
T_2	118a	24a	10a	105a	28	4.77a	5.25a
T_3	116a	24a	10a	101a	28	4.26ab	4.69b
T_4	115a	23b	10a	96b	28	3.88ab	4.27c
T_5	113a	24a	10a	102a	29	4.32ab	4.75b
T_6	112a	23b	9b	94b	29	3.81ab	4.19c
T_7	103b	22c	9b	83c	28	3.56ab	3.98c
CV(%)	4.17	3.00	6.61	3.15	5.27	7.37	6.57
Sig. level	**	**	**	**	NS	**	**
SE (±)	3.01	0.44	0.30	3.93	0.26	0.30	0.32

T_1: control, T_2 : 100% chemical fertilizer for T. aman rice (STB) ; T_3 : 75% P, K & Zn of T_2; T_4 : 50% P, K & Zn of T_2; T_5 : 75% P, K & Zn of T_2;T_6 : 50% P, K & Zn of T_2; T_7 : Farmer practice.

Table 16. Yield and yield attributes of T. aman (BR23) rice as influenced by different treatments at Amtali in 2010

Treatment	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1}(no.)	Filled grains panicle^{-1}(no.)	1000-grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	98c	19d	9c	76f	29	2.72d	3.13d
T_2	115a	25a	12a	100a	29	4.80a	5.38 a
T_3	115a	25a	11ab	97b	29	4.28b	4.79b
T_4	111ab	24ab	10bc	93cd	30	3.77c	4.22c
T_5	114ab	23b	11ab	95bc	29	3.81c	4.27c
T_6	112ab	23b	11ab	92d	30	4.25b	4.66b
T_7	106b	21c	10bc	88e	29	3.81c	4.21c
CV(%)	5.37	3.70	8.94	2.04	3.36	7.54	5.78
Sig. level	**	**	**	**	NS	**	**
SE (±)	2.34	0.83	0.37	2.97	0.18	0.24	0.26

T_1: control, T_2 : 100% chemical fertilizer for T. aman rice (STB) ; T_3 : 75% P, K & Zn of T_2; T_4 : 50% P, K & Zn of T_2; T_5 : 75% P, K & Zn of T_2;T_6 : 50% P, K & Zn of T_2; T_7 : Farmer practice.

Table 17. Yield and yield attributes of T. aman (BR23) rice as influenced by different treatments at Amtali in 2011

Treat.	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1}(no.)	Filled grains panicle^{-1}(no.)	1000-grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	96c	19d	8c	79e	27	2.68e	2.99e
T_2	109 a	23a	11a	102a	28	4.62a	5.17a
T_3	106ab	23a	11a	99ab	28	4.20b	4.71b
T_4	105ab	21bc	10ab	94c	28	3.73 c	4.18c
T_5	107ab	22ab	11a	98b	28	4.17b	4.67b
T_6	106ab	21bc	10ab	93c	28	3.68c	4.10c
T_7	99bc	20cd	9bc	87d	27	3.22d	3.58d
CV(%)	5.54	4.76	7.74	2.85	3.89	7.29	6.36
Sig. level	*	**	**	**	NS	**	**
SE (±)	1.77	0.57	0.44	2.99	0.18	0.25	0.28

T_1 : control, T_2 : 100% chemical fertilizer for T. aman rice (STB) ; T_3 : 75% P, K & Zn of T_2; T_4 : 50% P, K & Zn of T_2; T_5 : 75% P, K & Zn of T_2;T_6 : 50% P, K & Zn of T_2; T_7 : Farmer practice.

height due to IPNS treatments was significantly higher compared to the control (T_1) and farmer practice (T_7). Panicle length of BR23 rice with different treatments ranged from 19 to 23 cm and differed significantly. The treatments T_2 and T_3 recorded the highest panicle length (23 cm) while the minimum value (19 cm) was observed in the control (T_1). The highest number of effective tillers hill^{-1} was found in the treatments T_2, T_3, and T_5 while T_1 recorded the minimum value (8). IPNS treatments recorded higher effective tillers hill^{-1} over the farmer practice (T_7). The highest and lowest values were recorded in the treatments T_2 and T_1, respectively. The 1000-grain weight of BR23 rice varied from 27 to 28 g and differed insignificantly. The IPNS treatments recorded higher 1000-grain weight over the control (T_1) and farmer practice (T_7). The grain and straw yields of BR23 rice produced at Amtali in 2011 varied significantly due to different treatments and ranged from 2.68 to 4.62 and 2.99 to 5.17 t ha^{-1}, respectively. The treatment T_2 recorded the highest grain yield (4.62 t ha^{-1}) which was superior to all other treatments. Statistically similar grain yield was noted in the treatments T_3 and T_5.The treatments T_4 and T_6 also recorded statistically similar grain yields of BR23 rice. All the IPNS treatments noted higher grain yields over the farmer practice (T_7).All the treatments resulted significantly higher grain yields over control. Rice straw yield produced by different treatments followed similar trend as in grain yields. The grain and straw yields of BR23 rice at Amtali in 2011 due to different treatments may be ranked in the order of T_2> T_3> T_5> T_4> T_6> T_7> T_1 and T_2> T_3> T_5> T_4> T_6> T_7> T_1, respectively.

Conclusion

Maintenance of soil organic matter in Bangladesh is a crucial need. Integrated plant nutrition system (IPNS) can add organic matter along with necessary plant nutrients. Treatments receiving 5 t ha^{-1} cowdung or 3 t ha^{-1} poultry manure performed better than the treatments containing 3 t ha^{-1} cowdung or 1.5 t ha^{-1} poultry manure, next to 100% inorganic fertilizer use. Organic manure application showed residual effect on the following T. aus rice, but no residual effect to succeeding T. aman rice in the Mungbean-T. aus–T. aman cropping pattern. Therefore, it can be concluded that farmers of the coastal areas of Bangladesh should follow IPNS fertilizing system using available organic manure like cowdung or poultry manure to increase crop yield as well as to maintain soil fertility.

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