EFFECTS OF INTEGRATED NUTRIENT MANAGEMENT ON SOIL FERTILITY AND CROP YIELD UNDER MAIZE-MUNGBEAN-T. AMAN CROPPING PATTERN

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Abstract

A field experiment on maize-mungbean-T. aman cropping pattern was conducted in the Tista Meander Floodplain Soil (AEZ 3) at Sherpur, Bogura during 2014-2015 and 2015-2016 with an objective to evaluate the effect of integrated use of manure and fertilizers on soil fertility and crop yield. There were eight treatments viz., T_1: Control, T_2: 75% soil test-based (STB) fertilizer dose, T_3: 100% STB, T_4: 75% STB + 3 t ha^{-1} poultry manure (PM), T_5: 3 t ha^{-1} PM + IPNS, T_6: 75% STB + 5 t ha^{-1} cowdung (CD), T_7: 5 t ha^{-1} CD + IPNS and T_8: 125% STB. The experiment was laid out in a randomized complete block design with three replications. Data revealed that the T_5 (3 t PM + IPNS) treatment produced the highest grain yield of maize (8.11 t ha^{-1} in 2014-2015 & 9.67 t ha^{-1} in 2015-2016) and the highest grain yield of mungbean (1.04 & 1.06 t ha^{-1} in two years, respectively). For T. aman rice, T_5 (3 t PM + IPNS) treatment produced the highest yield which was 4.81 t ha^{-1} in 2014-2015 and 5.40 t ha^{-1} in 2015-2016. Most of the chemical properties of post-harvest soil were improved due to application of organic manure through integrated nutrient management (INM) approach.

Keywords: Cowdung, Crop yield, IPNS, Poultry manure, Soil health

1. Introduction

Integrated lant nutrition system (IPNS) enhances soil productivity through a balanced use of local and external sources of plant nutrients in a way that maintains or improves soil fertility and supports sustained crop productivity. INM techniques minimize nutrient losses and maximize efficiency while enhancing soil properties to boost agricultural production (Zhang *et. al.,* 2012). We need to understand more about the extent and rate of nutrient depletion and soil physical degradation in these intensifying maize-rice systems and formulate amelioration strategies. Research work to sustain the cropping system by addressing soil mineral and organic fertility and maintenance of soil structure is required (Ali *et al.,* 2009). Maize-T. aman rice is a major cropping system and now it becomes widespread in Bangladesh. Maize is a high nutrient demanding crop. An emerging issue is how to sustain the productivity of maize-rice cropping systems through integrated nutrient management (INM) strategies. Nutrient depletion-replenishment studies have shown negative balances for

N and K in this cropping system (Saleque *et al.,* 2006; Timsina *et al.,* 2006a, 2006b). Over-exploitation and poor replenishment deplete soil nutrients, which artificial fertilization can't fully restore, leading to an imbalance in the nutrient pool (Paramesh *et. al.,* 2014, 2020).

Maize is now becoming diversified with many other crops including legume, potato etc. Leguminous crop is important for soil fertility concern because of its nitrogen fixation ability and subsequent adding to the soil. After the first picking of mungbean pod, incorporation of brown biomass may lead to improved soil fertility and supply of available nutrients to the growing plants. Organic matter through adding mungbean biomass may exert subsequent effect on succeeding T. aman rice. In addition to that soil test based (STB) fertilizer management is deemed great significance for improvement of soil health and sustainable crop yield. Therefore, the present study was undertaken to explore the benefits of IPNS approach in terms of improvement of soil health as well as crop productivity.

2. Materials and Methods

The field experiment was conducted in the Tista Meander Floodplain (AEZ 3) at Sherpur, Bogura during 2014-2015 and 2015-2016. The initial soil samples collected from 0-15 cm depth was analyzed in the laboratory following standard methods. The analytical results are presented in Table 1. The different nutrient status of the cowdung (CD) and poultry manure (PM) used in the experiment are shown in Table 2.

The experiment was laid out in a randomized complete block design with three replications. The different fertilizer treatments were T_1: Control (no use of manure or fertilizer), T_2: 75% soil test based (STB) fertilizer dose, T_3: 100% STB, T_4: 75% STB + 3 t ha^{-1} poultry manure (PM), T_5: 3 t ha^{-1} PM + IPNS, T_6: 75% STB + 5 t ha^{-1} cowdung (CD), T_7: 5 t ha^{-1} CD + IPNS and T_8: 125% STB; for the manure + fertilizer treatments, the amount of nutrients release from cowdung and poultry manure were subtracted from 100% chemical fertilizers dose (FRG, 2012). The unit plot size was 3m × 4m. Tested crops and varieties were maize (var. BARI hybrid maize 5), mungbean (BARI mung 6) and T. Aman rice (BRRIdhan 57). Maize seeds were sown in line with 60 cm row to row and 25 cm seed to seed spacing on 24 November 2014 and 25 November 2015. Two seeds were placed in each hole and thinned out to one when the seedlings were established. Seeds were treated with vitavex prior to seeding.

The legume crop, mungbean, was cultivated after maize had been harvested. Except the native fertility plot, all mungbean plots received 20 kg N ha^{-1} from urea, not any other fertilizers. Mungbean seeds were sown in line with 30 cm row to row on 24 March 2015 and 20 March 2016. After two picking of pods, the green biomass was ploughed down into the soil and left for decomposition until the T. Aman was transplanted.

Seedlings of T. Aman rice were transplanted in line to line with 20 cm and row to row with

15 cm on 01 August 2015 and 02 August 2016. Fertilizer N-P-K-S-Zn-B were supplied from urea, TSP, MoP, gypsum, zinc sulphate and boric acid, respectively. All PKSZnB and one-third of N were applied at the time of final land preparation. The remaining two-thirds of N were added as top dress at 25 and 45 days after sowing. Three irrigations and other intercultural operations were done as and when required.

Crops were harvested i.e. maize on 03 May 2015 and 24 April 2016, mungbean on 15 June 2015 and 20 June 2016 and T. aman rice on 04 November 2015 and 30 October 2016. Data on the yield and yield contributing characters were recorded and statistically analyzed. MSTATC and Statistics 10 were used to determine the significant differences between the treatments. DMRT & LSD were used to determine the significant differences between treatments (Steel and Torrie, 1960). Plant samples and post-harvest soil samples were collected from each plot for chemical analysis.

Table 1. Chemical properties of experimental soil (initial status)

Location	pH	OM	Ca	Mg	K	Total N	P	S	B	Cu	Fe	Mn	Zn
		(%)	meq 100g^{-1}			(%)	µg g^{-1}						
Bogura	6.5	1.06	4.5	2.1	0.25	0.069	14.4	18.0	0.10	2.6	81	14	2.12
Critical Level	-		2.0	0.5	0.12	0.12	7	10	0.20	0.2	4	1	0.6

Table 2. Nutrient status of poultry manure and cowdung used in the experimental field

Name of the manure	pH	OM	Ca	Mg	K	Total N	P	S	B	Zn
		%								
Poultry manure	8.1	18.7	13.0	2.8	0.87	2.13	2.55	0.90	0.011	0.11
Cowdung	7.5	12.4	1.50	0.44	0.53	1.15	1.32	0.38	0.013	0.15

Moisture content: CD = 18.5%, PM = 16.3%.

3. Results and Discussion

Maize

The information regarding yield and yield contributing characters of maize as affected by the treatments are summarized in Tables 3 and 4. Treatment effects were significant for both years. The highest plant height was observed in T_5 treatment (T_5: 3 t ha^{-1} PM + IPNS). Significantly the shortest plant was found in the control. The highest cob length was observed in T_5 treatment (27.0 cm in 2014-2015 and 28.1 cm in 2025-16) which was statistically similar to the cob length against T_4, T_6 and T_7 treatments. The lowest cob length was attained in the native nutrient treatment i.e. control treatment. The highest cob diameter of 5.80 cm and 5.87 cm in two consecutive years was noted for T_5 treatment in the two years, respectively. This cob diameter is statistically similar with T_4, T_6, and T_7 treatments. The lowest cob diameter of 3.82 and 4.76 cm was obtained from T_1 treatment (control) during 2014-2015 and 2015-2016, respectively. Like cob length, the highest number of grains cob^{-1} were recorded with T_5 treatment (505 & 601 in 2014-2015 and 2015-2016, respectively) which were statistically similar to T_6 and T_7 treatments. Like others, the lowest number of grains cob^{-1} was attained in the control. Unlike others, weight of grains cob^{-1} was not significantly influenced by the treatments, although like others T_5 treatment demonstrated the highest result. Significant results happened for the case of 500-grain weight as influenced by the different treatments. The highest 500-grain weight of 166g and 186g were found with T_5 treatment during 2014-2015 and 2015-2016, respectively. These results were statistically similar with T_3, T_4, T_6, & T_7 treatments. The lowest 500-grain weight of 105g and 121g were noted from T_1 treatment (control) in the years 2014-2015 and 2015-2016, respectively.

Similar trend of influence of the treatments were observed with the stover and grain yields per hectare (Table 4). The highest stover yield of 11.95 t ha^{-1} in 2014-15 and 18.0 t ha^{-1} were obtained with T_5 treatment in both years. The highest stover yield of 18.0 t ha^{-1} in 2015-16 was observed with T_5 treatment which was statistically similar to all treatments except control. The lowest stover yield of 7.10 and 11.3 t ha^{-1} were obtained from T_1 treatment (control) during the year 2014-2015 and 2015-2016, respectively. Similarly, grain yield of maize was significantly influenced by the different treatments. The highest grain yield of 8.11 t ha^{-1} in 2014-15 and 9.67 t ha^{-1} in 2015-16 were observed in T_5 treatment. These grain yields were statistically similar with T_4, T_6, T_7 and T_8 treatments. Rahman *et al.,* (2012) found that the application of FYM alone with inorganic fertilizer applied for HYG produced the maximum grain and straw yields of maize. These results are also in close agreement with the findings of many other researchers (Rahman *et al.,* 2013). The lowest grain yield of 4.27 and 5.67 t ha^{-1} were obtained from T_1 treatment (control) during the year 2014-2015 and 2015-2016, respectively.

Table 3. Effects of different treatments on plant height, cob length, cob diameter and grains cob^{-1} of maize under Maize-Mungbean-T. aman rice cropping pattern

Treatments	Plant height (cm)		Cob length (cm)		Cob diameter (cm)		Grains cob^{-1} (no.)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
T_1 = Control	210b	191c	22.2d	23.5b	3.82c	4.76b	381b	372c
T_2 = 75% STB	219b	218b	24.2c	26.7a	5.48b	4.82b	389b	562b
T_3 = 100% STB	229ab	222b	25.7b	27.3a	5.68ab	5.87a	471a	594a
T_4 = 75% STB + 3 t PM	229ab	222b	27.0a	27.4a	5.58ab	5.65a	489a	591a
T_5 3 t PM + IPNS	246a	235a	27.0a	28.1a	5.80a	5.87a	505a	601a
T_6 = 75% STB + 5 t CD	229ab	226ab	26.9a	27.2a	5.58ab	5.82a	481a	592a
T_7 = 5 t CD + IPNS	242a	221b	26.9a	27.1a	5.57ab	5.86a	485a	592a
T_8 = 125% STB	237ab	218b	25.5b	27.2a	5.50b	5.71a	459ab	594a
CV (%)	8.23	7.02	5.35	5.27	7.56	8.74	5.89	8.03

Means followed by the same letter in a column are not statistically significant at 5% level

Table 4. Effects of different treatments on grain weight cob^{-1}, 500-grain weight, stover yield and grain yield of maize under Maize-Mungbean-T. aman rice cropping pattern

Treatments	Wt. of grain cob^{-1} (g)		500 grain wt. (g)		Stover yield (t ha^{-1})		Grain yield (t ha^{-1})	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
T_1 = Control	124	231	105b	121c	7.10c	11.3b	4.27c	5.67b
T_2 = 75% STB	188	245	110b	158b	11.3b	16.3a	7.13b	8.33ab
T_3 = 100% STB	191	249	158a	175ab	11.7ab	16.3a	7.32ab	8.50ab
T_4 = 75% STB + 3 t PM	190	254	158a	180a	11.7ab	17.7a	7.99a	9.10a
T_5 = 3 t PM + IPNS	201	261	166a	186a	12.0a	18.0a	8.11a	9.67a
T_6 = 75% STB + 5 t CD	191	255	157a	175ab	11.6ab	16.7a	8.00a	8.85ab
T_7 = 5 t CD + IPNS	190	260	165a	175ab	11.7ab	17.0a	7.80ab	9.00a
T_8 = 125% STB	189	257	156a	175ab	11.7ab	17.0a	7.99a	9.33a
CV (%)	8.06	8.40	5.10	7.05	5.65	8.11	8.26	10.84

Means followed by the same letter in a column are not statistically significant at 5% level.

Mungbean

The seed yield of mungbean ranged from 0.43 t ha^{-1} in the control treatment to 1.06 t ha^{-1} in the T_5 treatment where 3 t ha^{-1} PM with IPNS basis nutrient was added (Table 5). There was a significant effect of different treatments on green biomass and grain yield of mungbean in both years. The highest grain yield of mungbean 1.04 t ha^{-1} in 2014-15 was found in T_5 treatment. In 2015-16, the highest mungbean grain yield 1.06 t ha^{-1} was obtained in T_5 treatment which was statistically similar to all other treatments except control treatment. Similar trend was found in green biomass, the highest green biomass 11.7 t ha^{-1} in 2014-15 and 13.3 t ha^{-1} in 2015-16 was noted in T_5 (3 t ha^{-1} PM + IPNS) treatment which was statistically similar to that of T_4 (75% STB + PM) treatment in both years. Anower *et al.* (2012) reported the highest green biomass, grain and stover yields of mungbean produced by the IPNS basis chemical fertilizer for HYG treatment.

Table 5. Effects of different treatments on the yield of mungbean under maize-mungbean-T. aman rice cropping pattern

Treatments	MB Green biomass ($t\ ha^{-1}$)		MB Grain yield ($t\ ha^{-1}$)	
	2014-15	2015-16	2014-15	2015-16
T_1 = Control	6.05b	6.90d	0.43e	0.57b
T_2 = 75% STB	8.50b	10.19c	0.70d	0.87ª
T_3=100% STB	9.35ab	10.77bc	0.80cd	0.90ª
T_4= 75% STB + 3 t PM	11.65a	12.60a	0.96ab	1.02ª
T_5= 3 t PM + IPNS	11.70a	13.29a	1.04a	1.06ª
T_6 = 75% STB + CD	9.95ab	11.77bc	0.89bc	0.91a
T_7 = 5 t CD + IPNS	10.05ab	12.20ab	0.93ab	1.03a
T_8 = 125% STB	10.15ab	11.50ab	0.90bc	1.01a
CV (%)	12.75	9.60	10.82	16.43

Means followed by the same letter in a column are not statistically significant at 5% level by DMRT.

T. Aman rice

The yield as well as yield contributing characters of T. aman rice were significantly influenced by different IPNS treatments in both 2014-2015 and 2015-2016 (Tables 6 and 7). The tallest plant of 86.8 cm and 104.2 cm were obtained from T_5 treatments during 2014-2015 and 2015-2016, respectively. Growing of mungbean after maize cultivation would reduce 14 kg N ha^{-1} to the subsequent rice crop (Rahman *et al.,* 2013). Significantly the shortest plant, 82.8 cm & 97.0 cm were noted for the control treatment in 2014-2015 and 2015-2016, respectively. Like plant height, the highest number of tillers $hill^{-1}$ (17.43 in 2014-2015 and 16.37 in 2015-2016) were obtained from T_5 treatment. This result was statistically similar to all treatments except control treatment across the years. The lowest number of tillers $hill^{-1}$ i.e. 12.1 & 14.2 were noted for the native nutrient treatment (T_1) in both years. The highest panicle lengths were 29.7 cm in 2014-2015 and 22.7 cm in 2015-2016 as observed in T_5 treatment. The lowest panicle lengths were 27.4 cm in 2014-2015 and 16.7 cm in 2015-2016 which noted for T_1 (control) treatment. These results are in agreement with the findings reported by Bilkis *et al.* (2017). Rahman *et al.* (2009) observed that, poultry manure at the rate of 3 t ha^{-1} applied with 80 kg N ha^{-1} in rice crop produced the longest panicle. The number of grains $panicle^{-1}$ significantly varied among the treatments. The highest number of grains $panicle^{-1}$ (102.5 in 2014-2015 and 116.7 in 2015-2016) were found in T_5 treatment which were statistically similar to all other treatments except control in both years. This result might be due to the adequate availability of nutrients from manure and fertilizers (T_5) throughout the growing period. The lowest number of grains $panicle^{-1}$ of 85.5 & 95.33 were observed with native nutrient treatment (T_1) during the year 2014-2015 and 2015-2016, respectively. Different treatments significantly influenced the 1000-grain weight, showing the maximum 1000-grain weight of 19.19 g in

2015-2016 from T_5 treatment but in the year 2014-2015, 1000-grain weight did not differ significantly between the treatments. The lowest 1000-grain weight, 18.73 g & 15.53 g in the respective two years were recorded with the control treatment. Howlader *et al.* (2020) found that the 1000-grain weight of rice was increased by the application of PM at the rate of 3 t ha^{-1} in combination with 94:19:18:2 kg N: P: K: Zn ha^{-1}.

The straw yield of rice significantly differed with the treatments. The highest straw yield, 7.02 t ha^{-1} in 2014-2015 was noted in T_5 treatment that was statistically similar to all treatments except control treatment. In the year 2015-2016, the highest straw yield of 7.81 t ha^{-1} was found in T_4 treatment which was statistically similar to all the treatments except control. The lowest straw yields 4.35 and 6.90 t ha^{-1} were obtained from control treatment during the two years, respectively. Similarly, the grain yield of rice was significantly influenced by the different treatments. The highest grain yield of 4.81 t ha^{-1} and 5.40 t ha^{-1} were found in T_5 treatment (3 t PM + IPNS)) during 2014-2015 and 2015-2016, respectively. These grain yields were statistically similar with T_4, T_6 and T_7 treatments. The lowest grain yield, 2.44 t ha^{-1} in 2014-15 and 3.32 t ha^{-1} in 2015-16 were obtained from T_1 treatment (control). The higher grain yield recorded from the use of organic manure especially poultry manure at the rate of 3 t ha 1 might have effect of continuous supply of sufficient nutrients to support growth and reproductive organs of the crop. Rahman *et al.* (2013) reported that, the grain and straw yield of T. aman rice was significantly increased due to mungbean residue incorporation with STB chemical fertilizers. Saha *et al.* (2016) observed that the grain and straw yields of T. aman rice was significantly increased by application of 3 t ha^{-1} PM with IPNS basis chemical fertilizers which supports the result of the present study.

Table 6. Effects of different treatments on plant height, tillers $hill^{-1}$ and panicle length of T. Aman rice Under Maize-Mungbean-T. aman rice cropping pattern

Treatments	Plant height (cm)		Tillers $hill^{-1}$ (no.)		Panicle length (cm)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
T_1 = Control	82.8b	97.0b	12.13b	14.17b	27.37b	16.67b
T_2 = 75% STB	85.1ab	101.8a	15.83ab	15.83a	28.67ab	20.67a
T_3 = 100% STB	85.1ab	102.4a	17.27a	16.03a	29.43ab	21.0a
T_4 = 75% STB + 3 t PM	86.4ab	103.6a	17.30a	16.20a	29.13ab	21.33a
T_5 = 3 t PM + IPNS	86.8a	104.2a	17.43a	16.37a	29.73a	22.67a
T_6 = 75% STB + 5 t CD	86.3ab	102.9a	17.13a	15.83a	29.10ab	21.33a
T_7 = 5 t CD + IPNS	86.0ab	103.3a	16.90a	16.20a	28.80ab	21.33a
T_8 = 125% STB	85.4ab	103.0a	16.67a	16.17a	28.97ab	21.00a
CV (%)	8.30	7.54	7.30	6.53	7.94	7.48

Means followed by the same letter in a column are not statistically significant at 5% level in DMRT Test.

Table 7. Effects of different treatments on grains panicle-1, 1000-grain weight, straw yield and grain yield of T. Aman rice under Maize-Mungbean-T. aman rice cropping pattern

Treatments	Grains panicle^{-1} (no.)		1000-grain wt. (g)		Straw yield (t ha^{-1})		Grain yield (t ha^{-1})	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
T_1 = Control	85.5b	95.33b	18.73	15.53c	4.35b	6.90b	2.44c	3.32c
T_2 = 75% STB	90.6ab	114.0a	19.37	15.97c	5.02b	7.74a	2.69c	3.99bc
T_3 = 100% STB	99.0a	115.7a	19.37	18.87a	6.28a	7.75a	3.43b	4.54ab
T_4 = 75% STB + 3 t PM	102.3a	116.0a	20.27	18.50ab	6.63a	7.81a	4.71a	5.35a
T_5 = 3 t PM + IPNS	102.5a	116.7a	20.27	19.19a	7.02a	7.76a	4.81a	5.40a
T_6 = 75% STB + 5 t CD	97.8a	114.3a	19.57	18.67ab	6.79a	7.74a	4.44a	5.06a
T_7 = 5 t CD + IPNS	97.8a	115.7a	19.57	18.41ab	6.80a	7.78a	4.70a	5.33a
T_8 = 125% STB	97.3a	115.3a	19.57	17.43b	6.49a	7.75a	4.30a	5.05ab
CV (%)	8.86	6.67	5.01	7.74	7.20	6.77	9.42	12.80

Means followed by the same letter in a column are not statistically significant at 5% level by DMRT.

Chemical properties of post-harvest soil

The data of different nutrients in post-harvest soil as influenced by the different treatments are displayed in Table 8. Organic matter content of soil increased in the integrated nutrient treated plots and decreased in control plot. The highest level of soil organic matter (SOM), 1.21% was observed in both T_5 (3 t PM + IPNS) and T_7 (5 t CD + IPNS) treated plots. Similarly, The N content of soil increased in the INM treated plots and decreased in control plots. The highest N content of 0.10% was obtained in T_5 (3 t PM + IPNS) treated plot. Urea-N along with poultry manure or cowdung increased the N content in soil for all the treatments except T_1 treatment (control). This is closely related to SOM content. The lowest total N content in soil (0.05%) was noted in T_1 (control). Soil pH remained unaffected by the treatments. The exchangeable K content in post-harvest soils increased due to the combined application of chemical fertilizers and organic manures (Table 8), The range of exchangeable soil K content was 0.16-0.26 meq 100 g^{-1}, the lowest values being noted in T_1 (control) treatment and the highest value in T_5 (3 t PM + IPNS). It was reported that the application of fly ash alone or in combination with 100% NPK + 5 t FYM + 20 t fly ash increased total N, available P, exchangeable K and organic carbon content in soil (Ramteke *et.al.,* 2017). The maximum available P content in soil of 19.37 µg g^{-1} was recorded in T_5 (3 t PM + IPNS) treatment and the minimum P content in T_1 (control) treatment. The available S content in the post-harvest soils varied from 15.65 to 25.50 µg g^{-1}, the highest value being 25.50 µg g^{-1} recorded in T_5 treatment. The available B content of the post-harvest soils ranged from 0.09 to 0.18 µg g^{-1}, showing the highest B value being recorded in treatment T_5. The results stated above are in agreement with the findings of Hossain *et al.* (2008), Saha (2007) and Sandhu *et al.* (2020).

Table 8. Chemical properties of post-harvest soils after completion of maize-mungbean-T. aman cropping pattern in 2015-2016

Treatments	Soil pH	OM	Total N	K	P	S	B
		%		meq $100g^{-1}$	mg kg^{-1}		
T_1 = Control	6.5	0.98	0.05	0.16	15.7	15.8	0.09
T_2 = 75% STB	6.5	1.15	0.07	0.19	17.6	20.4	0.11
T_3 = 100% STB	6.6	1.17	0.09	0.22	18.6	23.6	0.13
T_4 = 75% STB + 3 t PM	6.8	1.19	0.10	0.24	19.4	24.8	0.17
T_5 = 3 t PM + IPNS	6.9	1.21	0.10	0.26	19.4	25.5	0.18
T_6 = 75% STB + 5 t CD	7.0	1.20	0.08	0.26	19.3	25.2	0.16
T_7 = 5 t CD + IPNS	6.8	1.21	0.08	0.24	19.0	25.0	0.17
T_8 = 125% STB	6.4	1.18	0.08	0.22	18.3	23.2	0.14
Initial status	*6.5*	*1.06*	*0.069*	*0.25*	*14.4*	*18.0*	*0.10*

4. Conclusions

Combined application of organic manure and chemical fertilizers produced higher crop yield in the maize-mungbean-T. aman cropping pattern than the solitary application of chemical fertilizers. Between the two manure, performance of poultry manure was better than that of cowdung. Soil test-based IPNS treatment through poultry manure always recorded higher grain yield of all the three crops (maize, mungbean & T. aman rice that grown in sequence). IPNS treatment improved the soil properties. So, it can be inferred that integrated use of poultry manure (3 t ha^{-1}) as IPNS basis could be an effective nutrient management strategy for sustained soil fertility and crop productivity of the maize-mungbean-T. aman cropping pattern.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

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