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INTEGRATED NUTRIENT MANAGEMENT FOR TOMATO-OKRA-INDIAN SPINACH CROPPING PATTERN

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Abstract

Field experiment on Tomato-Okra-Indian spinach cropping pattern was conducted at a farmer's homestead of Tangail (AEZ 8) during 2007-08 and 2008-09 to find out a suitable combination of chemical fertilizers and organic manure for sustainable crop yield. There were 5 treatments comprising different percentages of the recommended chemical fertilizers (RCF) with two levels (0 and 5 t/ha) for tomato and three levels (0, 2.5 and 5 t/ha) for okra each of poultry manure and cowdung. No organic manure was used for the third crop Indian Spinach. The treatments were arranged in Randomized Complete Block Design with four replications. An amount of 75% dose of RCF ($N_{150}P_{40}K_{80}S_{20}Zn_2B_1$ kg/ha) along with poultry manure @ 5 t/ha appeared as the best suited combination providing tomato yield 95.3 t/ha and 88.2 t/ha for the first year and second year, respectively. Again, an amount of 75% dose of RCF ($N_{120}P_{35}K_{70}S_{15}Zn_2B_1$ kg/ha) along with poultry manure @ 2.5 t/ha appeared as the best package providing the highest okra yield (15.03 t/ha and 12.98 t/ha). The highest yield (36.3 t/ha and 33.7 t/ha for the first and second year, respectively) of Indian Spinach was recorded from (75% recommended N + PM residue), which was statistically identical with (100 % recommended N), but significantly higher over rest of the treatments. Poultry manure performed better over cow dung. A package of 75% recommended chemical fertilizer along with 5 t PM/ha appeared as the best suited combination providing higher yield and economic return.

Keywords: Integrated nutrient management, tomato, okra, Indian spinach.

Introduction

Farmers are following different cropping patterns in different areas of the country depending on soil type, crop suitability and climatic conditions. Tomato-Okra-Indian Spinach cropping pattern is now being practiced in the homestead of the country. Generally, farmers use only chemical fertilizers with little or no organic manure for individual crop without considering cropping pattern for the whole year. As a result, large amount of fertilizers are being misused every year in pattern based crop cultivation. Organic matter and fertility status of Bangladesh soil is very low. Now it is well agreed that depleted soil fertility is a major constraint for higher crop production in Bangladesh and indeed, yield of several

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crops is declining in some soils. Moreover, less or no use of organic manure impairs soil physical, chemical, and biological properties. The beneficial effects of organic manure in vegetable production were demonstrated by many workers (Subhan, 1991; Khan *et al*., 2008; Islam, 2009). Nitrogenous fertilizers have very little residual effects on the following crops, as it is lost through leaching, volatilization and denitrification. But phosphorous, potassium, sulphur, and zinc fertilizers might have residual effects for the subsequent crops. Thus, the fertilizer requirements for the succeeding crops in the cropping pattern may be considerably reduced if the residual benefit is taken into account. On the other hand, organic manure improves soil health and productivity. Noor *et al.* (2005, 2006 and 2007a, b) conducted several on-station trials for several vegetable based patterns. Now, on-farm verification trials are required. Considerable work has been done on the residual effects of organic manure and chemical fertilizers on the succeeding crops in cereal based cropping patterns in Bangladesh condition, but work on inclusively vegetable cropping patterns is scarce. The present study was undertaken for the Tomato-Okra- Indian Spinach cropping pattern at FSRD site, Elenga, Tangail with the following objectives of minimizing the use of chemical fertilizers through the use of organic manure and finding out the suitable combination of chemical fertilizers and organic manure for sustainable crop yield.

Materials and Method

Field experiments on Tomato-Okra-Indian Spinach cropping pattern were conducted under irrigated condition at farmer's homestead of FSRD site, Elenga, Tangail during 2007-08 and 2008-09. The experimental site was medium high land which belongs to Young Brahmaputra and Jamuna Floodplain (AEZ # 8). The initial soil test values of the experimental field are presented in Table 1. Nutrient contents of the organic manure used in the experiment are shown in Table 2. Each ton of poultry manure may supply 4.82 kg N, 7.74 kg P, 4.94 kg K, and 2.58 kg S, while the contribution of cowdung estimated to be 3.48 kg N, 4.80 kg P, 3.0 kg K, and 1.8 kg S. The heavy metal content in poultry manure was found to be at minimum level. Organic matter (OM) content of the initial soil was very low. The soil was also deficient in total N, exchangeable K, available S, and Zn to a great extent. There were 5 treatment combinations taking 100%, 75%, and 50% recommended dose of chemical fertilizers (RCF) with or without manure. The manure dose for tomato was 5 t/ha cowdung or poultry manure in combination with both 75% and 50% RCF. For okra, the manure dose was 2.5 t/ha in combination with 75% RCF and 5 t/ha in combination with 50% RCF. Following crop, Indian Spinach was treated with 100%, 75%, and 50% recommended urea-N only (Table 3).

Table 1. Initial nutrient status of the experimental field.

Location	pH	OM (%)	Ca	Mg	K	Total N %	P	S	B	Cu	Fe	Mn	Zn
			meq100/g				µg/g						
Elenga, Tangail	5.9	0.75	5.6	1.5	0.12	0.08	17	15	0.34	6	228	25	1.3
Critical level	-	-	2.0	0.8	0.20	-	14	14	0.20	1	10	5	2.0

Table 2. Nutrient status of the organic manure used in the experimental field.

Name of the manure	Moisture (%)	pH	OM	Ca	Mg	K	N	P	S	B	Zn	Pb	Cd	As
			%									µg/g		
Poultry manure	57	7.4	20.1	5.50	2.60	1.15	1.12	1.8	0.6	0.012	0.11	10.0	Tr.	3.13
Cowdung	40	7.0	8.32	1.12	0.32	0.50	0.58	0.8	0.3	0.013	0.15	-	-	-

BARI Tomato-8, BARI Derosh-1, BARI Puishak-1 were tested varieties for Tomato, Okra, and Indian Spinach, respectively. The experiment was laid out in a Randomized Complete Block Design with four replications. The unit plot size was 2.4m x 2.2m. The experiment was initiated in the Rabi season with tomato (October- February) as the first crop followed by okra (March – Mid July) and Indian Spinach (Late July - September). The Spacing for both Tomato and Okra were 60 cm x 40 cm and for Indian Spinach was 30 cm × 10 cm. The sources of N, P, K, S, Zn, and B were urea, TSP, MoP, gypsum, zinc sulphate (monohydrate) and boric acid, receptively. In case of tomato, recommended chemical fertilizers dose was N_{150} P_{40} K_{80} S_{20} Zn_2 B_1 kg/ha, while it was $N_{120}P_{35}K_{70}S_{15}$ Zn_2B_1 kg/ha and N_{120} kg/ha for okra and Indian Spinach, respectively (FRG, 2005). In case of tomato, the whole amount of P, K, S, Zn, B, cowdung and poultry manure were applied during final land preparation and $^1/_3$ N was applied before transplanting. The remaining $^2/_3$ N was applied in two equal installments at 25 and 40 days after transplanting. In case of okra, the whole amount of P, K, S, Zn, B, cowdung and poultry manure were applied during final land preparation and N was applied in three equal installments at 20, 40, and 60 days after sowing. In case of Indian Spinach, the entire amount of N was applied in two equal installments at 15 and 30 days after sowing. After harvesting of the first crop (tomato), the plots were prepared for sowing the next crop okra. Again, after harvesting of the second crop, the plots were prepared for sowing Indian Spinach. All intercultural operations, such as weeding, mulching, irrigation, and pest management were done as and when required. The crops were harvested on whole plot basis. Data were analyzed by computer using MSTAT-C Package while mean separation was done by LSD.

Methods of chemical analysis

Soil pH was measured by a combined glass calomel electrode pH meter using soil: water ratio of 1:2.5 (Jakson, 1958). Organic carbon was determined by wet oxidation method as described by Walkley and Black (1935). Total N was determined by micro Kjeldahl method (Bremner and Mulvency, 1982). Ca and Mg were measured extracting with 1N KCl following ASI method (Hunter, 1984). P, K, Cu, Fe, Mn, and Zn were extracted by a single solution (0.25 N $NaHCO_3$, 0.01 M disodium EDTA and 0.01 N NH_4) as described by Hunter, 1984. Sulphur was extracted by calcium phosphate and the concentration of available S was determined by turbidimetrically with $BaCl_2$. Boron was determined by hot water extraction method. The total nutrient and heavy metal contents in manure samples were determined digesting with concentrated nitric and perchloric acid mixture (Yoshida *et al*, 1976).

Table 3. Treatment combinations for Tomato-Okra-Indian Spinach pattern.

Treat. No.	Treat. Combinations		
	Tomato	Okra	Indian Spinach
T_1 :	100% RCF*	100% RCF*	100% RCF* of N
T_2 :	75% RCF + 5 t/ha PM	75% RCF + 2.5 t/ha PM	75% RCF of N
T_3 :	75% RCF + 5 t/ha CD	75% RCF + 2.5 t/haCD	75% RCF of N
T_4 :	50% RCF + 5 t/ha PM	50% RCF + 5 t/ha PM	50% RCF of N
T_5 :	50% RCF + 5 t/ha CD	50% RCF + 5 t/ha CD	50% RCF of N
*RCF	$N_{150}P_{40}K_{80}S_{20}$ Zn_2B_1 kg/ha	$N_{120}P_{35}K_{70}S_{15}$ Zn_2B_1 kg/ha	N_{120} kg/ha

Results and Discussion

The yield and yield components of tomato, okra, and Indian Spinach were influenced significantly due to integrated use of chemical fertilizers and organic manure. The results have been presented in Table 4- 7.

Tomato

The highest fruit yield (95.3 and 88.2 t/ha) of tomato during 2007-08 (first year) and 2008- 09 (second year), respectively, was observed in T_2 (75 % RCF + 5 t PM/ha), which was statistically identical with T_1 (100 % RCF) and both of them were significantly higher over rest of the treatments (Table 4). These findings revealed that poultry manure @ 5 t/ha may compensate the requirement of 25% chemical fertilizers providing with considerable amount of yield advantage. The third highest yield (79.0 and 73.0 t/ha for the first year and second year, respectively) was found in T_4 (50% RCF + 5 t PM/ha), which was statistically identical with T_3 (75% RCF + 5 t CD/ha), but significantly higher over T_5 (50% RCF + 5 t CD/ha). These results implied that reduction of 50 % RCF might not

be well compensated with 5 t PM/ha and poultry manure was superior to cowdung in respect of tomato yield. The lowest yield (56.4 and 50.1 t/ha for the first and second years, respectively) was obtained from T_5 (50% RCF + 5 t CD/ha), which was significantly lower than all other treatments. The present findings suggested that cowdung @ 5 t/ha may not be enough to reduce the 25% chemical fertilizers from the present conventional recommendation. Yield components like number of fruits per plant and fruit weight per plant also showed almost similar trend of results. However, individual fruit weight was not influenced significantly in both years (Table 4). The yield components might have contributed to the yield, which ultimately resulted in significant yield variation among the different treatments.

Table 4. Effect of integrated nutrient management on yield and yield contributing characters of tomato in Tomato-Okra-Indian Spinach cropping pattern.

Tr.	Fruits/plant (No.)		Individual fruit wt (g)		Fruit wt/plant (kg)		Yield (t/ha)	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
T_1	35.98 ab	30.2 ab	51.4	45.3 ab	2.64 ab	1.94 ab	92.3 a	84.2a
T_2	37.79 a	32.4a	53.1	48.0 a	2.77 a	2.12 a	95.3 a	88.2 a
T_3	28.72 c	23.3c	49.2	40.2 c	2.24 c	1.60 c	70.1 b	63.1b
T_4	32.48 b	26.0bc	49.7	41.2 bc	2.33 bc	1.70 bc	79.0 b	73.0 bc
T_5	24.54 d	16.0 d	48.8	38.2 c	1.46 d	1.28 d	56.4 c	50.1 d
CV (%)	6.0	9.22	6.5	6.02	8.86	9.31	6.5	8.67

Means followed by same letter (s) do not differ significantly at 5% level by LSD.

Okra

Okra, the second crop of the pattern responded significantly to different treatments (Table 5). The highest fruit yield (15.0 and 13.0 t/ha for the first and second year, respectively) was recorded in T_2 (75 % RCF + PM 2.5/ha), which was statistically identical with T_1 but significantly higher over remaining treatments. Moderate fruit yield (12.5 and 10.3 t/ha) was found in T_3 (75 % RCF + 2.5 t CD/ha), which was statistically at par with T_1 and T_4. The lowest fruit yield of okra (9.3 and 8.6 t/ha) was found in T_5 (50% RCF + 2.5 t CD/ha), which was significantly lower than all other treatments. These findings revealed that addition of 2.5 t PM/ha along with 75% recommended chemical fertilizers for the second crop (okra) supplemented the need of 25% chemical fertilizers without compromising significant yield loss. Therefore, the dose of poultry manure can be reduced up to 50% from that of first crop when two successive crops grown in sequence. Yield components like number of fruits per plant and fruit weight per

plant also gave almost similar trend of results. In particular, the highest number of fruits (23.2 and 23.7 per plant) was recorded in T_2, which was significantly higher over other treatments. The second highest number of fruits (19.3 and 20.3 per plant) was found in T_1, which was statistically identical with T_4 but significantly higher over rest of the treatments. The fruit weight per plant varied significantly from 270 to 395 in the first year and 265 to 368 g in the second year, where the highest result was observed in T_2, which was closely followed by T_1 and the lowest in T_5. The significant variation in yield components ultimately contributed to augmenting yield. Noor *et al.* (2007a) observed a good harvest of okra as a second crop under broccoli-okra cropping sequence following integrated nutrient management approach. A package of 75% chemical fertilizers along with 5 t PM/ha for radish and tomato while 75% recommended N along with 2.5 t PM/ha for red amaranth and Indian spinach was found beneficial under radish-tomato-red amaranth-Indian spinach cropping pattern (Noor *et al*., 2007b).

Table 5. Effect of integrated nutrient management on yield and yield contributing characters of Okra in Tomato-Okra-Indian Spinach cropping pattern.

Tr.	Fruits/plant (No.)		Individual fruit wt (g)		Fruit wt/plant (kg)		Yield (t/ha)	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
T_1	19.3 b	20.3 b	16.0 ab	15.7 ab	384.3 ab	351.6 ab	13.8 ab	11.8 ab
T_2	23.2 a	23.7 a	18.0 a	16.3 a	394.8 a	368.1 a	15.0 a	13.0 a
T_3	15.4 c	15.1 c	12.2 c	13.7 bc	320.3 c	304.0 c	11.5 c	10.3 c
T_4	19.2 b	19.0 b	15.5 b	15.4 ab	345.8 bc	329.2 bc	12.9 bc	11.4 bc
T_5	15.10c	14.7 c	10.5 c	11.40c	270.0 d	265 d	9.3 d	8.6 d
CV (%)	11.59	8.66	7.50	8.61	7.30	6.30	7.00	7.35

Means followed by same letter (s) do not differ significantly at 5% level by LSD.

Indian Spinach

The highest yield (36.3 and 33.7 t/ha for the first and second years, respectively) of Indian Spinach was obtained with T_2 (75 % RCF of N + nutrient residue), which was statistically identical with T_1, but significantly higher over rest of the treatments (Table 6). An amount of 75% RCF of supplemental N in addition to the nutrient residue left by cowdung applied to the previous two crops (T_3) provided moderate yield (30.7 and 26.53 t/ha for the first year and second year, respectively), which was significantly higher only over T_5 (50 % RCF of N + nutrient residue). Yield component like number of leaves per shoot also showed similar kind of result.

The yield obtained in the second year for all three crops appeared to be lower than the first year, which might be due to climatic variation between the two years. The notable observations were short span winter, very hot summer and erratic rainfall. The residual effect contributed to the respective treatments and its contribution in general to the second year could not be visible, which might be due to climatic stress.

Table 6. Effect of integrated use of chemical fertilizers and organic manure on Indian spinach under Tomato-Okra-Indian Spinach cropping pattern.

Treatment	Yield (t/ha)		Leaves/shoot (No.)	
	2007-08	2008-2009	2007-08	2008-09
T_1	34.9 ab	30.5ab	14.8 ab	13.8a
T_2	36.3 a	33.7a	15.7 a	14.1a
T_3	28.8 c	26.5b	13.1 c	11.6b
T_4	31.0 bc	29.8ab	14.2 bc	12.9ab
T_5	22.7 d	21.5c	11.0 d	9.5c
CV (%)	8.95	9.00	5.23	8.97

Means followed by same letter (s) do not differ significantly at 5% level by LSD.

Cost and Return

The purpose of marginal analysis is to reveal how the net benefit from investment increases as the amount of investment increases (Perrin *et al*., 1979). Cost and return analysis showed (Table 7 and 8) that the highest gross margin (Tk 10,92,689/ha/year) along with the highest marginal rate of return (11,691 %) was obtained from T_2 (75% RCF + 5 t PM/ha), which was followed by T_4 (50 % RCF + 5 t PM/ha). Sole use of chemical fertilizer brought lower economic benefit. Cowdung treated package appeared as cost dominated. As such, treatment package T_2 where reduced rate of chemical fertilizers along with poultry manure (@ 5 t/ha) were used appeared as economically profitable.

Table 7. Tomato equivalent yield, cost of nutrients and gross return of the pattern.

Treatment	Tomato equivalent yield (t/ha)	Gross Return (Tk./ha/yr.)	Nutrient cost (Tk./ha/yr.)	Gross Margin (Tk./ha/yr.)	Remarks
T_1	134.1	10,72,800	42,775	10,30,025	CUD
T_2	142.0	11,36,000	43,311	10,92,689	CUD
T_3	109.4	8,75,200	39,582	8,35,618	CD
T_4	123.2	9,85,600	36,889	9,48,711	CUD
T_5	89.9	7,19,200	31,389	6,87,811	CUD

CUD = Cost un-dominated; CD = Cost dominated

Input Price:	1 kg N = Tk. 26	Output Price:	1 kg Tomato = Tk. 8
	1 kg P = Tk. 225		1 kg Okra = Tk.12
	1 kg K = Tk. 80		1 kg Indian Spinach = Tk. 5
	1 kg S = Tk. 45		
	1 kg Zn = Tk. 223		
	1 kg B = Tk. 647		
	1 kg PM = Tk. 0.75		
	1 kg CD = Tk. 0.50		

Table 8. Marginal analysis of cost un-dominated treatments.

Treat-ment	Gross margin (Tk./ha/yr.)	Marginal increase in gross margin (Tk./ha/yr.)	Nutrient cost (Tk./ha/yr.)	Marginal increase in variable cost of fertilizers as nutrients (Tk./ha./yr.)	MRR (%)
T_2	10,92,689	62,664	43,311	536	11691
T_1	10,30,025	81,314	42,775	5886	1381
T_4	9,48,711	2,60,900	36,889	5500	4744
T_5	6,87,811	-	31,389	-	-

Conclusion

The yield of the pattern Tomato-Okra-Indian Spinach increased significantly due to integrated use of chemical fertilizer and organic manure in the homestead under AEZ 8. Use of poultry manure may reduce the use of chemical fertilizer up to 25% from the conventional recommendation. A package of 75% recommended chemical fertilizer along with 5 t PM/ha appeared as the best suited combination providing higher yield and economic return.

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