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Effects of organic manure and chemical fertilizers on crops in the radish-stem amaranth-Indian spinach cropping pattern in homestead area

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Abstract

The effect of organic manure and chemical fertilizers on vegetable crops and soil properties in the radish-stem amaranth-Indian spinach cropping pattern was studied in a homestead area of Gazipur district in Bangladesh. There were eight treatments - poultry manure (PM) 5 t ha^{-1} (T_1), cowdung (CD) 10 t ha^{-1} (T_2), household waste (HW) 10 t ha^{-1} (T_3), PM 2.5 t ha^{-1} + reduced RDF (recommended dose of fertilizer) (T_4), CD 5 t ha^{-1} + reduced RDF (T_5), HW 5 t ha^{-1} + reduced RDF (T_6), 100% RDF (T_7) and Control (T_8). The 100% RDF treatment (T_7) gave the highest radish yield, however identical yield was obtained with T_5 and T_6 treatments. The maximum yield of stem amaranth and Indian spinach was obtained with T_4 and T_6 treatments, respectively. The highest N, P, K and S uptake was found in T_7 for radish, T_4 for stem amaranth and T_6 for Indian spinach. Soil bulk density and organic carbon were improved due to application of organic manure. The highest nutrient availability was recorded with T_4 treatment that was followed by T_6. Among the treatments, the poultry manure 2.5 t ha^{-1} + reduced dose of recommended fertilizer and house hold waste 5 t ha^{-1} + reduced dose of recommended fertilizer were found suitable for achieving sustainable vegetable crop yield as well as for susteanace of soil health at homestead area.

Key words: Nutrient management, Vegetable production, Soil fertility, Homestead garden.
Abbreviation: CD= Cowdung, HW=Household waste, PM= Poultry manure, N= Nitrogen, P= Phosphorous, K = Potassium, S= Sulphur, RDF= Recommended dose of fertilizer, AEZ= Agro-ecological zone, DMRT = Duncan's Multiple Range Test.

Introduction

Homestead is an operational farm unit in which a number of crops (including tree crops), vegetables, fruits and medicinal plants are grown along with livestock, poultry, and/or fish production mainly to satisfy the farmers basic need (Tejwani, 1994). It plays an important role in the economy of third world countries including Bangladesh. It is the fixed asset for poor farmers and obviously shows many important roles in their household economy. Total homestead area of Bangladesh is increasing at the rate of 5 m^2 ha^{-1} $year^{-1}$ due to increasing population. Approximately 5% area of the 8.3 million hectares of cultivable land in Bangladesh is occupied by homesteads (BBS, 2004); only 13% of the total homestead area is under vegetable cultivation (Hossain et al., 1988). Due to increasing population pressure cultivated land is decreasing and demand for food is increasing. In this context, the homestead gardening has become an important component of household security, cash income and savings. To grow year round vegetables, the BARI (Bangladesh Agricultural Research Institute) has recommended five promising vegetable pattern for different regions of Bangladesh (Karim et al., 1991) of which radish-stem amaranth-Indian spinach could be suitable for the homestead area in Gazipur district of Bangladesh. Frequent crop cultivation using modern / high yielding varieties to meet the demand for increasing population has led to a depletion of soil fertility. Due to continuous exhaustion of plant nutrients from the soil, farming system has become unstable. No crop cultivation system will be sustained if the nutrients input and output in the soil is least balanced. The farmers use chemical fertilizers as a supplemental source of nutrients but they do not apply in balanced proportion (BARC, 2005). Moreover, organic matter content in Bangladesh soils is very low (<1.5%) and is being gradually depleted (Ali et al., 1997). Neither the chemical fertilizer nor organic manure alone can help achieve sustainable crop production. Even with balanced use of only chemical fertilizer, high yield level could not be maintained over the years because of deterioration in soil physical and biological environments (Khan et al., 2008). The integrated nutrient management is the best approach to restore/ maintain soil fertility and productivity on sustainable basis. In Bangladesh, fertilizer management practices of the homestead area is very poor where most of the farmers use only urea as a fertilizer which is sometimes above recommended dose. They are not sufficiently aware of management practices and use of other fertilizers and organic manure (Khan et al., 2008). Possibly these are the main causes of poor yield and soil health deterioration. The present study was undertaken to develop a

suitable fertilizer package in combination with organic manure and chemical fertilizers for sustainable homestead gardening in the radish-stem amaranth-Indian spinach cropping pattern.

Results and discussion

Effects of organic manure and chemical fertilizer on crop production

Effects on growth parameters and yield of radish

Growth parameters and yield of radish varied significantly ($P \leq 0.05$) due to application of different organic manure and inorganic fertilizers (Table 2). The highest total length of radish (72.1 cm in 2007-08 and 70.0 cm in 2008-09) was found in T_7 (100% RDF), which was identical to T_4, T_5 and T_6 but different from the rest of the treatments. The lowest total length (49.9 cm in 2007-08 and 45.7 cm in 2008-09) was recorded in the control. Treatment T_7 produced the maximum number of leaves (18.0 in 2007-08 and 17.7 in 2008-09 plant^{-1}) and it was followed by T_5 (16.47 in the 1st year and 15.2 in the 2nd year) and the minimum (12.5 in the 1st year and 10.0 in the 2nd year) was in the control. The highest leaf length (43.9 cm in the 1st year and 42.5 cm in the 2nd year) was also found in T_7. In 100% RDF treated plots, the plants received more readily available applied nutrients, which might have encouraged more vegetative growth. Similar results were reported by Sultana (2006) and Sarkar (2005). Treatment T_7 also demonstrated the highest root length (28.8 cm in the 1st year and 29.5 cm in the 2nd year), which was identical to T_5 and T_6. Like root length, the root circumference varied due to different treatments (Table 2). The maximum root circumference (21.6 cm in the 1st year and 20.4 cm in the 2nd year) was recorded with 100% RDF, which was statistically similar with T_4, T_5 and T_6, but different from rest of the treatments. The minimum root circumference was observed in the control. Proper supply of plant nutrients as well as deep and loose soil is essential for proper expansion of edible roots. Organic matter might have created favorable environment for better root growth and development. Parraga et al. (1995) reported that poultry dropping produced the minimum root diameter and they also mentioned that application of organic matter with NPK fertilizers increased the diameter of root per plant, which supports the findings of the present study. The T_7 treatment also showed the highest individual fresh weight (0.98 kg in the 1st year and 0.93 kg in the 2nd year), followed by T_5 (0.94 kg) in the 1st year and T_6 (0.89 kg) in the 2nd year, but they were identical to each other. The lowest fresh weight was recorded in the control. Sultana (2006) noted the highest fresh weight of radish (731.7 g) with $N_{200}K_{140}$ kg ha^{-1}. Similar results were also reported by Sarker (2005). Asghar et al. (2009) also noted that enriched compost along with 100% N produced the maximum biomass (701.4 g), which are in agreement with the findings of this study.

Marketable yield of radish

The highest marketable yield (55.8 and 53.4 kg t ha^{-1} in the 1st and 2nd years, respectively) was found in T_7, which was statistically similar to T_5 and T_6. The lowest yield was recorded in the control. Among the exclusive organic manure treatments, the HW 10 t ha^{-1} produced the highest root yield (25 and 35.2 t ha^{-1} in the 1st and 2nd years, respectively).

Nutrient uptake by radish

The N, P, K and S uptake by radish was significantly influenced by different treatments (Fig. 1). Treatment T_7 showed the highest N uptake (141.5 kg ha^{-1}) which was significantly higher than that of all other treatments. Treatments T_4, T_5 and T_6 exhibited statistically similar N uptake and the control treatment did the lowest. The total N uptake ranged from 26.8 to 141.5 kg ha^{-1} with the following treatment orders - $T_7 > T_5 > T_6 > T_4 > T_3 > T_2 > T_1 > T_8$ (Fig. 1). Asghar et al. (2009) reported that integrated use of organic waste and N fertilizer significantly increased the N uptake by radish. Similar results were also reported by Djurovka et al. (2009). Total P uptake by radish varied from 4.62 to 24.82 kg ha^{-1} showing the highest (24.82 kg ha^{-1}) in T_7 which was identical to T_4, T_5 and T_7 treatments and the minimum was in the control (4.62 kg ha^{-1}). Sole organic manure treated plots (PM, CD and HW) also showed statistically similar P uptake. Significant increment of P concentration was observed where 75% and 100% N was integrated with enriched compost (Asghar et al., 2009). The use of organic manure enhanced the fertilizer use efficiency (Muneshwar et al., 2001; Nevens and Reheul, 2003). The maximum K uptake by radish (150.2 kg ha^{-1}) was found in T_7 followed by T_5 (133.9 kg ha^{-1}) and T_6 (124.5 kg ha^{-1}) (Fig. 1). The control showed the minimum uptake (35.2 kg ha^{-1}). Asghar et al. (2009) reported a maximum K concentration where only recommended N fertilizer was applied and it was significantly higher than all other treatments except the compost with 100% recommended N fertilizer treatment which support the findings of the present study. The total S uptake varied from 2.17 to 15.32 kg ha^{-1}, with the highest S uptake in T_7 followed by T_5 and T_6 treatments and the lowest was recorded in the control (2.17 kg ha^{-1}).

Effects on growth parameters and yield of stem amaranth

The highest plant height (105 cm in the 1st yr and 97.4 cm in the 2nd yr) was found in T_4 which was significantly higher than that of all other treatments and the lowest plant height was in the control. It was observed that organic manure alone had no significant effect on plant height, but a manure in combination with chemical fertilizers had a significant impact on plant height. The number of leaves plant^{-1} ranged from 9.53 to 21.5 and 7.82 to 18.7 in 2007-08 and 2008-09, respectively, showing a maximum number of leaves plant^{-1} in T_4 (21.5 in 2007-08 and 18.7 in 2008-09) that was followed by T_6 and T_5. The chemical fertilizers along with PM had a marked influence on the number of leaves plant^{-1}. Similar results were reported by Noor et al. (2008) in case of red amaranth production. The maximum leaf length (15.9 cm in 2007-08 and 14.5 cm in 2008-09) was found in T_4 treatment (Table 3), which was identical to T_6 treatment. The leaf width varied from 3.63 to 11.1 cm in 2007-08 and 3.04 to 10.9 cm in 2008-09, with the maximum in T_4 treatment. The lowest leaf size was noted in the control. Treatment T_4 gave the highest stem circumference (6.11 cm in 2007-08 and 5.95 cm in 2008-09) followed by T_6 and the lowest result was in the control (Table 3). It was observed that the combined application of organic manure and chemical fertilizers significantly increased the size of stem amaranth. Uddin et al. (2004) and Iqbal (2008) also reported the similar results. The highest fresh weight of five plants (1.22 kg in 2007-08 and 1.14 kg in 2008-09) was recorded in T_4 treatment, followed by T_6 and the lowest weight (0.04 kg in 2007-08 and 0.03 in 2008-09) was observed in the control. The highest stem amaranth yield (34.9 t ha^{-1} in 2007-08 and 31.4 t ha^{-1} in 2008-

Table 1. Treatment combination for radish-stem amaranth-Indian spinach cropping pattern

First crop	Second crop	Third crop
T_1) PM (Poultry manure) @ 5 t ha^{-1}	T_1) PM (Poultry manure) @ 5 t ha^{-1}	T_1) PM (Poultry manure) @ 5 t ha^{-1}
T_2) CD (Cowdung) @ 10 t ha^{-1}	T_2) CD (Cowdung) @ 10 t ha^{-1}	T_2) CD (Cowdung) @ 10 t ha^{-1}
T_3) HW (Household waste) @ 10 t ha^{-1}	T_3) HW (Household waste) @ 10 t ha^{-1}	T_3) HW (Household waste) @ 10 t ha^{-1}
T_4) PM @ 2.5 t ha^{-1} + rest from RDF	T_4) PM @ 2.5 t ha^{-1} + rest from RDF	T_4) PM @ 2.5 t ha^{-1} + rest from RDF
T_5) CD @ 5 t ha^{-1} + rest from RDF	T_5) CD @ 5 t ha^{-1} + rest from RDF	T_5) CD @ 5 t ha^{-1} + rest from RDF
T_6) HW @ 5 t ha^{-1} + rest from RDF	T_6) HW @ 5 t ha^{-1} + rest from RDF	T_6) HW @ 5 t ha^{-1} + rest from RDF
T_7) 100% RDF	T_7) 100% RDF	T_7) 100% RDF
T_8) Control (Native nutrient)	T_8) Control (Native nutrient)	T_8) Control (Native nutrient)

Note **:** For the 2nd and 3rd crops, the doses for P, K and S were reduced by 30%, as suggested by BARC (2005).
100% RDF for radish = $N_{180}P_{30}K_{120}S_{20}$ kg ha^{-1}, 100% RDF for stem amaranth = $N_{100}P_{18}K_{50}S_5$ kg ha^{-1}
100% RDF for Indian spinach = $N_{100}P_{12}K_{50}S_{12}$ kg ha^{-1}(BARC, 2005)
RDF= Recommended dose of chemical fertilizers

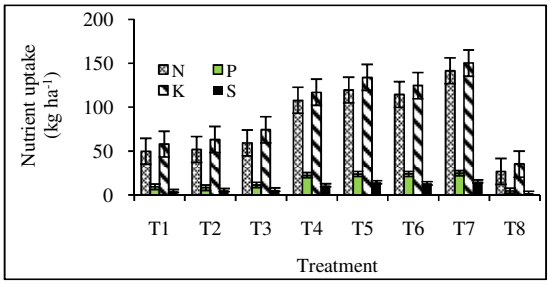

Fig 1. Effects of manure and fertilizer on nutrient uptake by radish

09) was found in T_4. Treatment T_6 gave the second highest yield (28.3 t ha^{-1} in 2007-08 and 25.8 t ha^{-1} 2008-09, respectively) followed by T_5 and the control treatment recorded the lowest. Noor et al. (2007) reported the highest yield (17.06 t ha^{-1}) of red amaranth from 75% RDF with 5 t ha^{-1} PM, which also corroborates the findings of the present study.

Nutrient uptake by stem amaranth

The uptake of N, P, K and S by stem amaranth was significantly influenced (P≤0.05) by different treatments. The N, P, K and S uptake increased with the increase of TDM (total dry matter) yield. The N uptake varied from 8.23 to 78.45 kg ha^{-1}, the highest uptake being recorded with T_4, which was significantly different from all other treatments. The ranking of the treatments in respect of total N uptake was in the order of $T_4 > T_6 > T_5 > T_7 > T_3 > T_2 > T_1 > T_8$ (Fig. 2). Kumar and Sharma (2004) reported a maximum nutrient uptake in cabbage and tomato with FYM + 150 % NPK treatment. Verma et al. (2006) also found a significantly higher NPK uptake by maize-wheat cropping system by the application of 100% NPK + FYM 10 t ha^{-1}. The highest P uptake (7.17 kg ha^{-1}) was recoded in T_4 followed by T_6 (5.16 kg ha^{-1}). The maximum P uptake was noted when 25 % N was substituted by green leaf (*sesbania*) manure (Yadav et al., 2005). Recommended NPK + FYM 10 t ha^{-1} followed by 50% recommended NPK + FYM 10 t ha^{-1} resulted in higher nutrient uptake compared to the recommended rate of NPK alone (Chaturved and Chandel, 2005). The highest K uptake (37.3 kg ha^{-1}) was observed in T_4 followed by T_6 (26.9 kg ha^{-1}) and T_5 (23.0 kg ha^{-1}) (Fig. 2). The effect of PM 2.5 t ha^{-1}+ reduced RDF on K uptake was more pronounced in this experiment. In barely, the highest K uptake (146 kg ha^{-1}) was found due to an addition of vermicompost at 4.5 t ha^{-1} along with 60 kg N ha^{-1} (Kumawat and Jat, 2005), which partly supports our findings. The highest S uptake (2.31 kg ha^{-1}) was also recorded in the plots receiving PM 2.5 t ha^{-1} + reduced RDF and the minimum S uptake was in the control.

Effects on growth parameters and yield of Indian spinach

Both growth parameters and yield of Indian spinach were significantly influenced (P≤0.05) by the combined application of different organic manure and chemical fertilizer treatments (Table 4). The stem length ranged from 21.4 to 76.7 cm in 2007-08 and 18.8 to 72.2 cm in 2008-09 having the longest size in T_6 which was significantly higher than all other treatments. The shortest stem length was found in T_8 treatment. Three types of organic manure alone produced moderate plant height and they were statistically similar with each other. The maximum stem circumference (4.21 cm in 2007-08 and 4.14 cm in 2008-09) was found in T_6 and the minimum was in the control, but the integrated effect had no significant influence on stem circumference. Treatment T_6 gave the maximum number of leaves plant^{-1} (15.1 in 2007-08 and 14.8 in 2008-09) followed by T_5 and T_4 treatment. The minimum number of leaves plant^{-1} (7.57 in 2007-08 and 7.1 in 2008-09) were found in the control. It was observed that organic manure or chemical fertilizers alone did not produce higher number of leaves plant^{-1}. In our study, the lower number of leaves plant^{-1} was observed as the growing period was rainy season. Again due to monsoon rains, the nutrient loss might occur from chemical fertilizers

Table 2. Yield contributing characters and yield of radish as influenced by manure and fertilizer application

Treat	Total length (cm)		Leaves plant^{-1} (no.)		Root length (cm)		Root Circum. (cm)		Leaf length (cm)		Fresh wt. (kg)		Yield (t ha^{-1})	
	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr
T_1	58.3 bc	54.7 d	13.13 d	11.8 de	20.0 b	19.5 d	26.7 c	15.3 d	32.0 cd	29.0 de	0.47 ef	0.45 de	22.0 e	30.3 de
T_2	58.7 bc	57.7 d	14.97 c	13.5b-d	21.4 b	19.3 d	17.7 c	16.7 c	32.5 cd	30.4 d	0.50 ef	0.49 de	24.2 de	33.0 d
T_3	60.1 b	59.3 cd	15.23 c	12.7 cd	21.5 b	18.4 d	19.3 b	17.7 bc	33.1 cd	31.2 d	0.58 de	0.57 cd	25.0 c	35.2 d
T_4	64.3 ab	61.3b-d	15.6 bc	14.2b-d	22.2 b	22.7 cd	20.0 ab	18.3 b	35.8 bc	33.5 c	0.72 cd	0.73 bc	45.3 c	44.0 c
T_5	70.8 a	65.0 a-c	16.47 b	15.2 b	27.6 a	25.2 bc	20.9 ab	19.2 ab	37.8 b	35.0 c	0.94 ab	0.78 ab	52.5 ab	47.5 bc
T_6	68.0 ab	67.7 ab	15.9 bc	14.2 bc	24.3ab	27.3 ab	20.1 ab	19.8 a	38.6 b	39.0 b	0.82 bc	0.89 ab	48.5 b	49.9 ab
T_7	72.1 a	70.0 a	18.00 a	17.7 a	28.8 a	29.5 a	21.6 a	20.4 a	43.9 a	42.5 a	0.98 a	0.93 a	55.8 a	53.4 a
T_8	49.9 c	45.7 e	12.53 d	10.0 e	14.4 c	11.1e	14.9 d	13.0 e	30.7 d	26.0 f	0.35 g	0.33 e	15.6 f	13.5 f
CV (%)	8.33	5.96	4.14	9.36	12.3	11.0	4.64	4.54	5.86	4.38	12.8	14.7	8.40	4.46

Figures in a column having common letter (s) do not differ significantly (P≤0.05). T_1= PM (Poultry manure) @ 5 t ha^{-1} ,T_2= CD (Cowdung) @ 10 t ha^{-1},T_3= HW (Household waste) @ 10 t ha^{-1}, T_4= PM @ 2.5 t ha^{-1} + rest from RDF* , T_5= CD @ 5 t ha^{-1} + rest from RDF, T_6= HW @ 5 t ha^{-1} + rest from RDF, T_7= 100% RDF, T_8= Control. RDF= Recommended dose of chemical fertilizers

Table 3. Yield contributing characters and yield of stem amaranth as influenced by manure and fertilizer application

Treat	Plant height (cm)		leaves plant^{-1} (no.)		Leaf length (cm)		Leaf breadth (cm)		Stem circum. (cm)		Fresh wt. of 5 Plant (kg)		Yield (t ha^{-1})	
	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr
T_1	39.2 de	34.9e	11.0 cd	9.92f	6.60 d	6.55e	5.28 d	5.01d	2.50 ef	2.49e	0.17 e	0.06ef	6.59 f	7.12g
T_2	44.9 d	39.4e	12.4 c	10.8ef	7.25 d	7.28de	5.97 d	5.48cd	2.83 de	3.17d	0.24 de	0.14de	9.48 e	9.24f
T_3	53.1 d	48.5d	13.4 c	11.8e	8.35 d	8.07d	6.69 d	6.36c	3.29 de	3.29d	0.31d	0.22d	11.3 e	11.2e
T_4	105 a	97.4a	21.5 a	18.7a	15.9 a	14.5a	11.1 a	10.6a	6.11 a	5.95a	1.22 a	1.14a	34.9 a	31.4a
T_5	82.8 bc	75.8c	17.1 b	15.2c	13.2 bc	12.3b	9.51 bc	9.04b	5.01 bc	5.01b	0.76 b	0.65b	24.5 c	22.8c
T_6	91.1 b	86.2b	18.8 b	16.9b	14.3 ab	13.5a	10.8 ab	10.5a	5.40 ab	5.85a	0.81 b	0.72b	28.3 b	25.8b
T_7	75.7 c	71.1c	16.7 b	13.8d	11.9 c	11.1c	8.64 c	8.12b	4.12 cd	4.16c	0.46 c	0.36bc	21.8 d	20.7d
T_8	26.7 e	21.6f	9.53 d	7.82g	4.55 e	4.49f	3.63 e	3.04e	1.73 f	1.74f	0.04 f	0.03f	3.92 g	3.46h
CV (%)	12.3	5.11	10.1	4.71	9.71	6.17	10.9	9.63	14.2	6.50	14.2	12.8	6.53	6.28

Figures in a column having common letter (s) do not differ significantly (P≤0.05). T_1= PM (Poultry manure) @ 5 t ha^{-1} ,T_2= CD (Cowdung) @ 10 t ha^{-1},T_3= HW (Household waste) @ 10 t ha^{-1}, T_4= PM @ 2.5 t ha^{-1} + rest from RDF* , T_5= CD @ 5 t ha^{-1} + rest from RDF, T_6= HW @ 5 t ha^{-1} + rest from RDF, T_7= 100% RDF, T_8= Control. RDF= Recommended dose of chemical fertilizers

(e.g. urea) and on the other hand, the organic manure alone was unable to provide sufficient nutrient supply. Noor et al. (2007) observed similar results where 75% RDF along with CD 10 t and PM 5 t ha^{-1} gave higher number of leaves plant^{-1}, which corroborates the finding of our study. The maximum leaf length found in T_6 which was identical to T_4 and T_5, but different from rest of the treatments and the minimum was in the control. The T_6 treatment also produced the highest leaf breadth and the control treatment demonstrated the lowest leaf breadth. The significantly highest fresh weight of 4 plants (1.71 kg in 2007-08 and 1.57 in 2008-09) was recorded in T_6 followed by T_5 and the lowest result was in the control. It indicated that HW performed better than PM and CD did in recording the plant weight. Indian spinach being the third crop of the pattern also responded significantly to the integrated use of manure and fertilizer (Table 4). The highest edible fresh yield (38.8 t ha^{-1} in 2007-08 and 36.5 t ha^{-1} in 2008-09) was found in T_6 which was significantly higher than all other treatments. Treatment T_5 gave the second highest yield which was identical with T_4 and T_7 and the lowest yield exhibited by the control. Application of chemical fertilizer or organic manure alone gave poor result compared to the integrated use of organic manure coupled with a reduced dose of chemical fertilizers in the present study. These findings reveal that addition of HW at 5 t ha^{-1} could reduce the requirement of a crop for chemical fertilizers by 25%. However, to optimize the yield, addition of HW 5 t ha^{-1} along with reduced RDF was found suitable for Indian spinach cultivation when it was grown in the radish-stem amaranth-Indian spinach cropping pattern. The present results are in agreement with the findings of Noor et al. (2007).

Nutrient uptake by Indian spinach

The total N uptake ranged from 6.64 to 70.6 kg ha^{-1} having the significantly highest N uptake (70.6 kg ha^{-1}) in T_6 followed by T_5 (59.3 kg ha^{-1}) and T_4 (47.9 kg ha^{-1}) (Fig. 3). The ranking of the treatments with respect to total N uptake was in the order of $T_6 > T_5 > T_4 > T_7 > T_3 > T_2 > T_1 > T_8$. Like N, treatment T_6 showed the maximum P uptake (2.81 kg ha^{-1}) and the minimum P uptake (0.33 kg ha^{-1}) was observed in the control (Fig.3). Meena and Gautam (2005) reported that the application of FYM resulted in higher nutrient concentration and higher nutrient uptake. The K and S uptake by Indian spinach varied from 2.50 to 21.5 kg ha^{-1} and 0.43 to 3.35 kg ha^{-1}, respectively. The significantly highest K (21.5 kg ha^{-1}) and S (3.35 kg ha^{-1}) uptake were noted in T_6 and the lowest result was recorded in the control. Kumawat and Jat (2005) found higher K uptake by barely with combined application of vermicompost at 4.5 t ha^{-1} + 60 kg N ha^{-1}. Chaturvedi and Chandel (2005) also reprted a highest K uptake with recommended NPK + FYM 10 t ha^{-1}.

Effects of manure and fertilizers on soil properties

Bulk density

Soil bulk density was reduced due to application of organic manure having the minimum (1.41 g cm^{-3}) in both T_2 and T_3 treatments. The maximum bulk density (1.52 g cm^{-3}) was found in the control followed by T_7 (1.5 g cm^{-3}), where no any manure was used (Fig. 4a). The higher bulk density in control and in only fertilizer treated plots may be due to very low organic matter content in soil and formation of compact layer. It was also viewed by Islam et al. (2006). Mathur (1997) observed that soil treated with organic matter decreased bulk density from 1.46 to 1.40 g cm^{-3} which confirms the present findings.

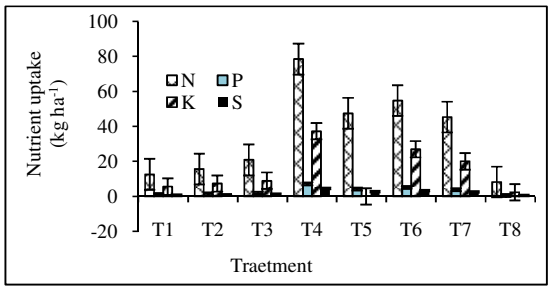

Fig 2. Effects of manure and fertilizer on nutrient uptake by stem amaranth

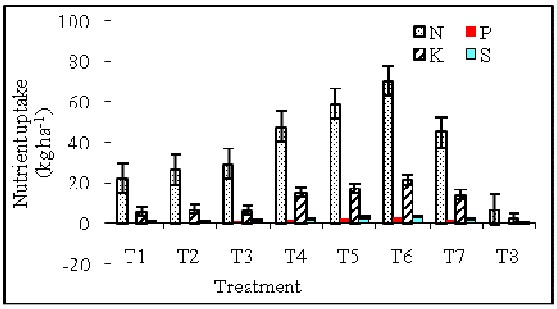

Fig 3 Effects of manure and fertilizer on nutrient uptake by Indian spinach. T_1= PM (Poultry manure) @ 5 t ha^{-1} ,T_2= CD (Cowdung) @ 10 t ha^{-1},T_3= HW (Household waste) @ 10 t ha^{-1}, T_4= PM @ 2.5 t ha^{-1} + rest from RDF* , T_5= CD @ 5 t ha^{-1} + rest from RDF, T_6= HW @ 5 t ha^{-1} + rest from RDF, T_7= 100% RDF, T_8= Control. RDF= Recommended dose of chemical fertilizers

Soil pH

The pH value was largely maintained in manure treated plots. The organic manure applied plots and control plot showed the minimum variation. However, the plots receiving only RDF gave the maximum reduction in pH value (5.85), showing an increase in acidity (Fig. 4b). Among the organic treatments, the PM treatment resulted in the highest pH value as because poultry manure contained varying amounts of calcium carbonate (Camberato and Mitchell, 2011). The maximum increase in acidity was noted in treatment having the highest dose of inorganic fertilizers (T_7). ***Organic carbon*****:** Organic carbon was found to vary from 0.70 to 1.0 % having the highest in T_2 (CD 10 t ha^{-1}) followed by T_1 (0.98%) and T_3 (0.96%). The initial organic-C of the soil was 0.87%, which was reduced to 0.70% in T_8, where no manure or fertilizer was applied (Fig.4c). However, the organic carbon was maintained at around 0.81 % in chemical fertilizer treated plots. Singh et al. (1999) reported drastic reduction in organic carbon concentration on continuous application of chemical fertilizer whereas addition of 5 t FYM ha^{-1} along with fertilizer N helped in maintaining the original organic matter status in soil.

Table 4. Yield contributing characters and yield of Indian spinach as influenced by manure and fertilier application

Treat	Stem length (cm)		Stem circum. (cm)		Leaves plant^{-1}		Leaf length (cm)		Leaf breadth (cm)		Fresh wt of 4 plants (kg)		Yield (t ha^{-1})	
	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr
T_1	34.0 e	40.0 d	3.37 bc	3.75a-c	10.7 c	10.8 cd	12.1 d	13.5c	9.66 cd	11.2d	0.48 e	0.49ef	16.3 d	17.4 d
T_2	40.2 de	35.0 e	3.82 ab	3.36cd	10.9 c	10.6 cd	13.8 c	12.2cd	11.4 bc	10.1e	0.54 de	0.53e	17.2 d	15.6 d
T_3	37.1 de	34.2 e	3.63 a-c	3.62bc	10.7 c	10.1 d	13.4 cd	13.2cd	10.9 bc	10.2e	0.47 de	0.45f	19.1 d	18.5 d
T_4	53.1 bc	50.3 c	3.88 ab	3.86ab	13.3 b	12.9 b	15.7 ab	15.5b	13.2 ab	13.0b	0.93 bc	0.88c	29.8 bc	30.0 b
T_5	62.8 b	60.5 b	4.00 ab	3.95ab	13.7 b	13.2 b	16.8 a	16.6a	13.5 ab	13.4ab	1.18 b	1.17b	32.3 b	31.4 b
T_6	76.7 a	72.2 a	4.21 a	4.14a	15.1 a	14.8 a	17.0 a	16.8a	14.9 a	14.0a	1.71 a	1.57a	38.8 a	36.5 a
T_7	46.5 cd	43.4 d	3.86 ab	3.80ab	11.6 c	11.2 c	14.3 bc	14.1c	12.1 a-c	12.0c	0.82 cd	0.80d	27.5 c	26.1 c
T_8	21.4 f	18.8 f	3.01 c	2.96d	7.57 d	7.10 e	10.4 e	10.0e	7.41 d	7.30f	0.32 e	0.30g	5.24 e	5.00 e
CV (%)	10.3	5.23	6.89	6.65	4.56	5.01	4.50	4.31	9.54	3.20	16.5	5.66	9.35	7.82

Figures in a column having common letter (s) do not differ significantly (P≤0.05). T_1= PM (Poultry manure) @ 5 t ha^{-1} ,T_2= CD (Cowdung) @ 10 t ha^{-1},T_3= HW (Household waste) @ 10 t ha^{-1}, T_4= PM @ 2.5 t ha^{-1} + rest from RDF* , T_5= CD @ 5 t ha^{-1} + rest from RDF, T_6= HW @ 5 t ha^{-1} + rest from RDF, T_7= 100% RDF, T_8= Control. RDF= Recommended dose of chemical fertilizers

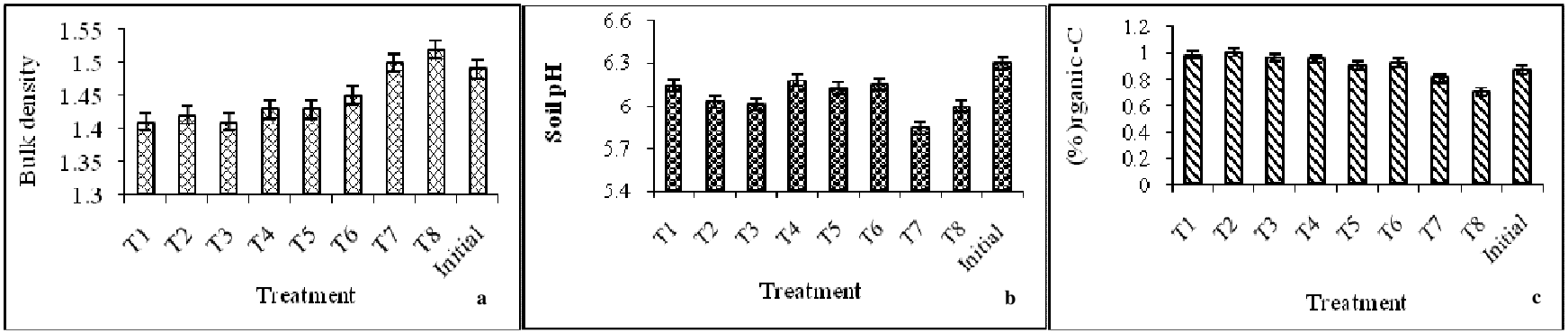

Fig 4. Effects of manure and fertilizer on bulk density (a), soil pH (b) and soil organic-C % (c). T_1= PM (Poultry manure) @ 5 t ha^{-1} ,T_2= CD (Cowdung) @ 10 t ha^{-1},T_3= HW (Household waste) @ 10 t ha^{-1}, T_4= PM @ 2.5 t ha^{-1} + rest from RDF* , T_5= CD @ 5 t ha^{-1} + rest from RDF, T_6= HW @ 5 t ha^{-1} + rest from RDF, T_7= 100% RDF, T_8= Control. RDF= Recommended dose of chemical fertilizers

Nutrient availability

Incorporation of organic manure and chemical fertilizer had a positive effect on the availability of N, P, K and S in soil as recorded after completion of radish-stem amaranth-Indian spinach cycle. Total N (%) varied from 0.08 to 0.15 having the highest (0.15%) in T_4 followed by T_6 (0.14%) and the minimum (0.08%) was in the control (Fig. 5a). Among the treatments, T_4 treated plots had the highest available P content (Fig.5b) and the lowest P content was found in the control. The increase in P might be due to addition of P through inorganic fertilizer and organic manure. Like N and P, the maximum available K (0.20 c mol kg^{-1}) and S (18.2 mg kg^{-1}) were observed in T_4 treatment. The control plots showed the minimum soil available K (0.11 c mol kg^{-1}) and S (12.4 mg kg^{-1}), where no manure or fertilizer was used (Fig. 5c). Available K content was found higher in PM treated plots which can be attributed to higher supply of K from PM compared to CD and HW. The higher availability of N, P, K and S in soil might be due to their release from poultry manure, household waste and cowdung.

Materials and methods

Experimental site and soil characteristics

The experiment was conducted on farmers homesteads at Toratpara village of Dhirrashram union under Gazipur district of Bangladesh during the period from November 2007 to July 2009. The experimental site was located in the centre of the Madhupur Tract (AEZ-28) at about 24^0 23´ north latitude and 90^0 08´ east longitude having a mean elevation of 8.4m above mean sea level and about 34 km north of Dhaka city. The experimental field was a high land having silty clay soil. The soil was slightly acidic (pH 6.4) and low in organic matter (0.87%), total N (0.09%) and exchangeable K (0.13 c mol kg^{-1}). The soil S content was at par with critical level, while P and Zn contents were above the critical level (Critical levels of P, S and Zn were 14, 14 and 0.2 mg kg-1, respectively and that of K was 0.2 c mol kg^{-1}). Poultry manure contained 0.99% N, 1.10% P, 1.1% K and 0.5% S; cowdung had 0.55% N, 0.80% P, 0.56% K and 0.12%S and the nutrient composition of household waste was 0.65% N, 0.70% P, 0.85 % K and 0.15% S.

Treatment details and fertilizer application

There were eight treatments as shown in Table 1. The experiment was laid out in a randomized complete block design (RCBD) with four dispersed replications. Urea, triple superphosphate (TSP), muriate of potash (MoP) and gypsum were used as sources of N, P, K and S, respectively. Full amount of P, K, S, CD, HW and PM were applied as per treatments at the time of final land preparation. The one-third N for radish, one-half N for stem amaranth and one-half N and K for Indian spinach were applied during final land preparation and the remaining N was applied in equal splits for radish at 15 and 30 days after sowing (DAS), for stem amaranth at 10 and 25 DAS and for Indian spinach the remaining N and K were supplied at 10 and 25 DAP (days after planting).

Planting / sowing and harvesting

The vegetable crops of the pattern radish (*Raphanus sativus* L.) (November-January) - stem amaranth (*Amaranthus dubius*) (February-April) - Indian spinach (*Basella alba*)

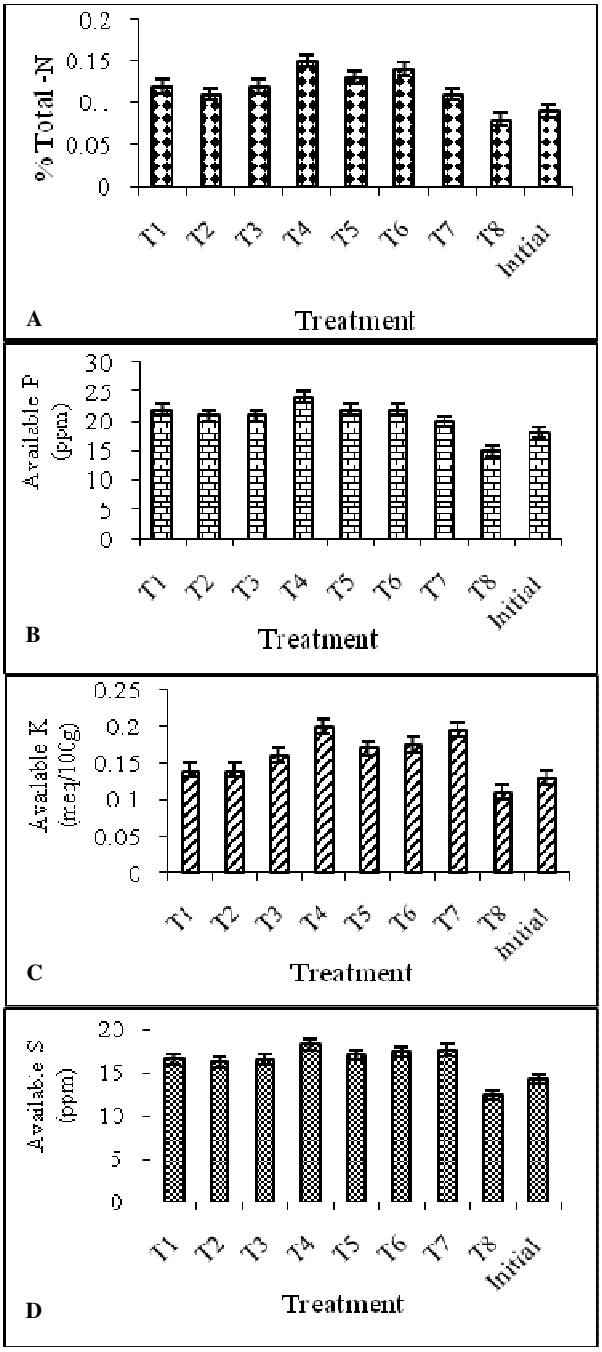

Fig. 5 Effects of manure and fertilizer on total N (a), available P (b), available K (c) and available S (d) after radish-stem amaranth- Indian spinach cropping sequence.
T_1= PM (Poultry manure) @ 5 t ha^{-1} ,T_2= CD (Cowdung) @ 10 t ha^{-1},T_3= HW (Household waste) @ 10 t ha^{-1}, T_4= PM @ 2.5 t ha^{-1} + rest from RDF* , T_5= CD @ 5 t ha^{-1} + rest from RDF, T_6= HW @ 5 t ha^{-1} + rest from RDF, T_7= 100% RDF, T_8= Control. RDF= Recommended dose of chemical fertilizers

(May-July) was grown in the plots in succession. The unit plot size was 2.3m x 1.3m and the experimental plots were kept fixed during the entire period of the experiment. Seeds

of first crop radish (*cv.* Tashakisan) were sown with a spacing of 45cm x 30cm on 5 and 7 November of 2007 and 2008, respectively. After harvest of radish, stem amaranth (cv. Red tower) seeds were sown on 25 and 20 February of 2008 and 2009, respectively. After harvest of the second crop, the seedlings of the third crop (Indian spinach, cv. Jessore local) were transplanted maintaining a 40cm x 30cm spacing on 15 and 10 May of 2008 and 2009, respectively. The experimental plots were kept fixed over the years. All intercultural operations such as weeding, mulching, irrigation and pest management were done as and when required. The crops were harvested at the right stage of growth depending on the nature of the crop. Radish was harvested from 29 December 2007 to 5 January 2008 in the first year and 2 January to 6 January 2009 in the second year. Stem amaranth was harvested from 20 to 26 March in 2008 and 24 to 28 March in 2009. The edible part of Indian spinach was harvested from 4 June to 9 July in 2008 and 8 June to 12 July 2009, respectively.

Plant and soil sampling and chemical analysis

Different parts of plant sample and soil were collected, dried and ground for chemical analysis. Bulk density was determined by core sampler Method (Blake, 1965). Soil pH was determined by using glass electrode pH meter (Jackson, 1973) and organic carbon by wet oxidation method (Walkley and Black, 1935). Total N content of soil determined by Kjeldahl method (Jackson, 1973), available P by ascorbic acid and blue color method (Watanabe and Olsen, 1965), exchangeable K by flame photometer (Gallenkamp) and available S by turbidimetric method (Chesnin and Yien, 1951). Concentrated HNO_3 was used for digestion of plant samples. Total P concentration was determined by Vanadomolybdate yellow color method (Jackson, 1973), K concentration by flame atomic absortion spectrophotometer and S concentration by Bardsley and Lancaster (1965) method, respectively.

Statistical analysis

The analysis of variance for various crop characters and nutrient uptake by plant were done following the ANOVA test and the mean values were adjudged by DMRT (P=0.05) (Steel and Torrie, 1960). Computation and preparation of graphs were done following the Microsoft EXCEL 2003 program.

Conclusion

Application of organic manure in combination with reduced rate of chemical fertilizers had significant effect on the yield parameters and yield of vegetable crops in the radish-stem amaranth-Indian spinach pattern. The maximum radish yield was recorded with 100% RDF treatment (T_7) which was identical with the yield obtained with T_5 and T_6. The T_4 performed the highest stem amaranth yield and the maximum Indian spinach yield was noted in T_6 treatment. The N, P, K and S uptake by the vegetable crops increased significantly due to combined application of organic manure and chemical fertilizers. The highest N, P, K and S uptake by radish was observed in T_7 treatment, while T_4 and T_6 showed the maximum nutrient uptake by stem amaranth and Indian spinach, respectively. Soil properties have been improved by the incorporation of organic manure with the record of the lowest bulk density in both T_1 and T_3 treatments. The highest amount of organic carbon (1.0%) was found in T_2 treatment. The maximum availability of N, P, K and S in soil was found in T_4 treatment. So, the two treatments poultry manure 2.5 t ha^{-1} + reduced dose of recommended fertilizer and household waste 5 tha^{-1} + reduced dose of recommended fertilizers can ensure satisfactory vegetable crop cultivation without affecting soil health at homestead area.

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