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PERFORMANCE OF ORGANIC MANURES ON THE GROWTH AND YIELD OF RED AMARANTH (*Amaranthus tricolor*) AND SOIL PROPERTIES

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ABSTRACT

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The experiment was carried out at the research farm of Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh during December 2015 to January 2016 to evaluate the effects of cow dung (CD), poultry manure (PM) and mustard oil cake (MOC) along with NPK fertilizer amendments on the growth and yield performances of red amaranth in silty loam soil. The treatments were (i) NPK (control), (ii) NPK + CD, (iii) NPK + PM and (iv) NPK + MOC. All three types of manures significantly increased the plant height and numbers of leaves plant⁻¹, thereby fresh weight, yield compared with the control (NPK). The best results in terms of vegetable fresh yield were obtained in the following order: NPK > CD > PM > MOC. Application of MOC is not beneficial due to 30 times higher price than CD and PM. PM added NPK fertilizer combination showed higher vegetable yield (10.87 t ha⁻¹) than CD added NPK fertilizer combination (10.17 t ha⁻¹). PM added fertilizer combination also had almost equal investment and cost-benefit ratio in comparison with CD. The lowest marginal benefit-cost ratio (1.09) was observed in MOC added NPK fertilizer combination though it showed higher vegetable yield (11.08 t ha⁻¹). The farmers' can be recommended to follow NPK + CD fertilizer combination. Manures applied post soil analysis showed improves the soil physiochemical properties.

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INTRODUCTION

Red amaranth (*Amaranthus tricolor*) is now widely grown as vegetables both in tropics and sub-tropics area of the world. It can be grown throughout the year and can be harvested in a very short time. For vegetables and seed production, red amaranth is the best grown in winter. As one of the nutritious and delicious vegetables, red amaranth is a popular vegetable in Bangladesh. It has also quick growing character and higher yield potential. Thus red amaranth plays a predominant role both in nutrition and food security. 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, 2012). Moreover, organic matter content in Bangladesh soils is very low (<1.5%) and is being gradually depleted (Ullah *et al.*, 2008).

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. Both manures and fertilizers enhance the growth and yield of red amaranth to a great extent. The effect of organic manure on red amaranth is crucial as it is a heavy feeder. Organic manure improves soil structure through aggregation favourably influencing tillage properties, crusting, water infiltration, moisture retention, aeration and temperature. Moreover, organic manures do not create any health hazards and environmental pollution. But in Bangladesh, most soils have less than 1.5%, and some even less than 1% organic matter contents (FAO, 2014). So, to check soil health hazard and environmental pollution, the use of organic fertilizers should be encouraged. In Bangladesh, now a day, the organic fertilizers like cowdung and chicken manure are available due to increasing dairy and poultry farm. On the other hand, the price of oil cake is very high (30 times higher) comparable to cowdung and chicken manure. Mentioned above three organic fertilizers, which is more effective to red amaranth yield with more economic, needs investigation.

Farmers of Bangladesh are mostly habituated with the use of macro-nutrients, especially nitrogen, phosphorus, sulphur and potassium for crop production. Use of manures is limited. Response of red amaranth to cowdung application is also evident (Sanni, 2016). In addition, application of organic manure can increase the efficiency of chemical fertilizers and also improve the soil condition for the production of garlic (Mondal *et al.*, 2016). Also, there are some reports on combined effect of NPKS (25%) and vermicompost (75%) have given higher yield of tomato, cabbage, okra compared to recommended dose of full amount NPKS and control (Islam *et al.* 2017, Farzana *et al.*, 2019, Akhter *et al.*, 2019). However, information on the use of poultry and oil cake manures in combination with inorganic fertilizers for red amaranth is scanty in Bangladesh. Therefore, an attempt was made to study the response of red amaranth to manures (cowdung, chicken manure and oil cake) in presence of N, P and K and its impact on soil quality in the Old Brahmaputra Flood plains, Bangladesh.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted at the research farm of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh during December 2015 to January 2016. The soil was silty loam belonging to the non-calcareous darkgrey floodplain soil of Old Brahmaputra Floodplains, Bangladesh. Some physical and chemical properties of the experimental soil collected from a depth of 0-15 cm prior to the application of fertilizer were analyzed. The physical and chemical characteristics of the collected soil were determined by Hunter method (1984). The soil was slightly acidic (pH 6.58), low in fertility status having organic matter 1.69%, available $\text{NH}_4\text{-N}$ 65 $\mu\text{g/g}$, phosphorus 16 $\mu\text{g/g}$, potassium 0.15 meq/100g.

Experimental design and treatments

Experiment was laid out in Randomized Complete Block Design (RCBD) with three replicates. The unit plot size was 2 m × 1.5 m with spacing of 20 cm × 5 cm. The treatments were (i) NPK (115-65-60 kg ha⁻¹ (control), (ii) NPK + cowdung @ 8 t ha⁻¹, (iii) NPK + poultry manure @ 8 t ha⁻¹ and (iv) NPK + mustard oil cake @ 5 t ha⁻¹. The whole amount of TSP, MoP, CD, PM, MOC and half urea were applied during final land preparation three days before seed sowing. The remaining urea was applied in the third weeks after seed sowing followed by weeding and thinning. It is noted that cowdung contain 0.77% N, 0.44% P₂O₅ and 0.46% K₂O, chicken manure contain 1.15% N, 1.19% P₂O₅ and 0.85% K₂O and mustard oil cake manure contain 5.07% N, 1.77% P₂O₅ and 1.25% K₂O.

Intercultural operations and data collections

The seeds of local variety were sown on December 8 and harvested on January 15. Single weeding and sprinkler irrigation was done at 18 and 20 days after sowing, respectively. At harvest, the whole plot was harvested, fresh weighted were taken per plot and converted into ton per hectare and then oven dried at 80 °C for 72 hours.

Statistical analyses

The collected data were analyzed statistically using computer package program, MSTAT-C. Partial budget analysis and marginal analysis of undominated fertilizer response to vegetable yield was done following Elias and Karim (1984).

RESULTS AND DISCUSSION

Soil physio-chemical properties

The chemical properties of the the experiment soil before and at harvest are presented in Table 1. The soil was silty loam in texture, slightly acidic and low in total N, exchangeable K and available P. The low nutrient status of the soil indicates that it needs additional nutrient for optimal red amaranth performance. Hence, application of nutrients from organic and mineral fertilizers was justified. Post cropping soil analysis revealed that the soil pH across various treatment drop from 6.58 to a range between 6.38-6.47 making the soil acidic in nature. Available P, exchangeable K and total N increased in all treatments. Organic carbon increased in cowdung (CD), poultry manure (PM) and mustard oil cake (MOC) treated plots but reduced in NPK treated (control) plots.

Table 1. Effect of different organic manures on soil physio-chemical properties at 38 days after sowing

Treatment	Post experiment soil analyses				
	pH	Organic matter (%)	Total N (%)	Available P (ppp)	Exchangeable K (me/100 g soil)
NPK (control)	6.47	1.82 b	0.690 c	14.88 b	0.157 c
NPK + CD	6.40	2.33 a	0.880 b	15.74 ab	0.180 b
NPK + PM	6.38	2.48 a	1.000 ab	16.70 a	0.193 ab
NPK + MOC	6.42	2.58 a	1.190 a	16.92 a	0.205 a
Pre expt. soil	6.58	1.89 b	0.118 d	14.24 b	0.137 c
F-test	NS	**	**	**	**
CV (%)	4.56	8.38	4.30	5.70	8.11

In a column, same letter (s) indicates do not differ significantly at P ≤0.05;** indicate significant at 1% levels of probability; NS indicates not significant; NPK = Nitrogen Phosphorus Potassium; CD = Cowdung; PM = Poultry manure; MOC = Mustard Oil Cake

The productivity of many soils is normally limited by N, P and K deficiency which is a major constraint to small holder vegetable producers in Bangladesh. Continuous cropping without an input of organic fertilizer is common practice in many tropical and subtropical countries. The low soil nutrient status of the experimental site could be attributed to the previous continuous cropping without manure application thereby justifying the site for the research. Results indicated that growth and yield of red amaranth respond positively to the amendment of the soil with the addition of CD, PM and MOC compared to control (NPK). Miah *et al.* (2013) reported that amaranthus require soils with high organic content, and adequate mineral nutrients favoured the production of higher plant height.

The high nitrogen, phosphorus and potassium level recorded in all the treatment could be attributed to high rate of mineralization of NPK fertilizer that makes the NPK readily available. The higher organic matter content in the plot treated with CD, PM and MOC as compared to control plot agreed with many workers (Ayodele, 1983; Islam *et al.*, 2006; Noor *et al.*, 2007; Sanni 2016). The increases in soil organic carbon, N, P, and K observed after harvest in soils treated with CD, PM and MOC might be as a result of the slow rate in which their nutrients are released into the soil. Therefore, the crop could not make use of these nutrients due to its short vegetative life cycle.

Table 2. Effect of different organic manures on growth and yield of red amaranth

Treatment	Plant height (cm)	Root length (cm)	Leaves plant ⁻¹ (no)	Fresh weight (t ha ⁻¹)	Dry matter content (%)
NPK (control)	23.17 c	4.49 c	14.10 c	6.03 c	6.63
NPK + CD	29.51 b	5.85 b	18.32 b	10.17 b	6.46
NPK + PM	31.92 ab	6.39 ab	20.21 ab	10.87 ab	6.42
NPK + MOC	32.86 a	6.70 a	22.27 a	11.08 a	6.44
F-test	**	**	**	**	NS
CV (%)	6.78	8.82	8.77	10.02	4.03

In a column, same letter (s) indicates do not differ significantly at $P \leq 0.05$; ** indicates significant at 1% levels of probability; NS indicates not significant; NPK = Nitrogen Phosphorus Potassium; CD = Cowdung; PM = Poultry manure; MOC = Mustard Oil Cake

Growth and yield

Results indicated that all three types' manures increased plant height, root length, leaf number and plant fresh weight (Table 2). The dry matter content had no significant effect on any type of manures application but dry matter content was apparently lower in manures applied plant than in control plant. The taller plant, longer root length and higher number of leaves plant⁻¹ was observed in NPK + CM and NPK + MOC applied plot with being the highest in NPK + MOC. The lowest plant height, root length and leaf number was obtained from plants in the control (NPK) plots. In general, CM and MOC added fertilizer always showed high growth performance than CD added fertilizer. The higher growth performance of red amaranth plants in CM and MOC amended soil because of greater nutrients content (N, P, K) in CM and MOC than in cowdung. Similar result was also reported by Miah *et al.* (2013) in amaranth. The highest fresh yield of red amaranth was recorded in MOC applied plot (11.08 t ha⁻¹) followed by CM applied plot (10.87 t ha⁻¹) with same statistical rank. The third highest yield was recorded in CD applied plot (10.17 t ha⁻¹). The yield was higher in CM and MOC applied plot might be due to greater number of leaves production plant⁻¹. The lowest fresh yield was observed in control (NPK only) plot (6.03 t ha⁻¹) might be due to fewer number of leaves production plant⁻¹.

Plant height is an important component that helps to determine plant growth. The increase in height of red amaranth plants amended with organic is probably due to release of nutrients which promoted vigorous plant growth through efficient photosynthesis (Sanni, 2016). Nitrogen fertilization had a tendency to increase plant height as nitrogen involves in cell division and cell elongation of plants (Mazumder *et al.*, 2019). An optimum plant height is claimed to be positively correlated with productivity of garlic plants (Mondal *et al.*, 2016). Also,

there are some reports on combined effect of NPKS (25%) and vermicompost (75%) have given higher yield of tomato, cabbage, okra compared to recommended dose of full amount NPKS and control (Islam *et al.*, 2017, Farzana *et al.*, 2019, Akhter *et al.*, 2019). Changes in the number of leaves are bound to affect the overall performance of amaranth as the leaves serve as photosynthetic organ of the plant (Miah *et al.*, 2013). Increased in leaf number in soil amended with organic fertilizer could probably be attributed to N availability which promoted leaf area during vegetative development and also helped to maintain functional leaf area during the growth period (Cox *et al.*, 1995). Many researchers reported that application of CD or CM or MOC along with chemical fertilizers increased plant height and leaf number in leafy vegetable crops that supported the present results (Islam *et al.*, 2006; Noor *et al.*, 2007; Sanni, 2016). Addition of CD or PM or MOC greatly improved the yield of red amaranth in this study compared to NPK fertilizers and this confirms the findings of Xu *et al.* (2005) who stated that the yield and quality of leafy vegetables grown with organic fertilizers grew better and resulted in a higher total yield than those grown with synthetic fertilizers.

The performance of the crops could be as a result of the high content of nitrogen, phosphorus and potassium contained in CD, PM and MOC (Reyhan and Amisalani, 2006). Application of organic fertilizers probably increased nitrogen in the soil which positively affected leaf fresh weight and quality of the leaves because nitrogen stimulates plant vegetative growth and increases leaf area. This is in line with the findings of different studies elsewhere (Islam *et al.*, 2006; Noor *et al.*, 2007; Sanni, 2016). The poor performance of red amaranth grown in control plots revealed that when nutrients are available in adequate amount, plants tends to grow at their optimum potential. These nutrients deficient were probably the limiting factor of plant growth and productivity in control treatment.

Table 3. Partial budget analysis for fertilizers and manures of yield in red amaranth

Treatment	Economic yield (t ha ⁻¹)	Gross margin profit (Tk. ha ⁻¹)	Variable cost (Tk. ha ⁻¹)	Net margin benefit (Tk. ha ⁻¹)	Marginal net benefit (Tk. ha ⁻¹)	Marginal benefit-cost ratio
NPK (control)	6.03	1,20,600.00	8,880.00	1,11,720.00	---	12.35
NPK + CD	10.17	2,03,400.00	15,280.00	1,88,120.00	76,400.00	12.31
NPK + PM	10.87	2,17,400.00	16,880.00	2,00,520.00	88,800.00	11.88
NPK + MOC	11.18	2,23,600.00	1,08,800.00	1,14,800.00	3,080.00	1.09

NPK = Nitrogen Phosphorus Potassium; CD = Cowdung; PM = Poultry manure; MOC = Mustard Oil Cake; The price rate of manures and fertilizers: Taka (Tk) 16.00 kg⁻¹ urea, Tk. 22.00 kg⁻¹ TSP, Tk. 15.00 kg⁻¹ MP, Tk. 0.80/kg CD, Tk. 1.00/kg PM and Tk. 20/kg MOC. The fresh red amaranth rate was Tk. 20.00 kg⁻¹

Table 4. Marginal analysis of undominated fertilizers response to vegetable fresh yield of red amaranth

Treatment	Net margin benefit (Tk. ha ⁻¹)	Variable cost (Tk. ha ⁻¹)	Marginal increase in net margin (Tk. ha ⁻¹)	Marginal increase in variable cost (Tk. ha ⁻¹)	Marginal rate of return (%)
NPK + PM	2,00,520.00	16880.00	12,400.00	1,600.00	7.75
NPK + CD	1,88,120.00	15,280.00	73,320.00	6,400.00	11.45
NPK + MOC	1,14,800.00	1,08,800.00	3,080.00	---	---
NPK (control)	1,11,720.00	8,880.00	---	---	---

Partial budget analysis

Application of manures with NPK had positive effect on economic return over control (Table 3). In general, PM added plots had higher benefit than CD and MOC added plots. PM added plots showed higher benefit as compared to CD added plots due to greater yield performance of red amaranth in PM than in CD. Amongst manures added nutrient combinations, NPK + PM had the highest benefit over control (88,800 Tk. ha⁻¹) followed by NPK + CD (76,400 Tk. ha⁻¹). The lowest benefit over control was observed in NPK + MOC (3,080 Tk. ha⁻¹). Marginal benefit-cost ratio was the highest in control plots which was apparently similar to CD added plots. The lowest marginal benefit-cost ratio was observed in MOC added fertilizer combination though it showed higher vegetable yield.

Marginal analysis of undominated fertilizer response data recorded the highest marginal rate of return (11.45%) in NPK + CD fertilizer added plots followed by NPK + PM added plots (7.75%) (Table 4). The marginal rate of return was almost nil in NPK + MOC fertilizer added plots (0.05%, not shown in Table).

Conclusion

Based on marginal rate of return, it can be concluded that for red amaranth cultivation under silty loam soil, the marginal farmers' can apply NPK + CD fertilizer combination. The farmers having ability to invest more may go to the treatment of NPK + PM for maximum economic benefit and also sustainable soil health.

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CONFLICT OF INTEREST

There is no conflict of interest among the authors about this research.

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