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EFFECT OF HOUSEHOLD WASTE AND CHEMICAL FERTILIZERS ON THE YIELD OF RED AMARANTH, INDIAN SPINACH AND TOMATO

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Abstract

The study was conducted to quantify the overall effect of integrated use of nutrients from organic and inorganic sources on yields of four vegetables viz. red amaranth, spinach, Indian spinach and tomato through a series of trials at farmers' fields in the Monga affected areas of Badarganj and Kawnia upazilas under Rangpur district of Bangladesh during 2009-2011.Household waste (HW) compost was used as organic source of nutrients.The fresh yield of spinach was found to be 16 t ha^{-1} when recommended doses of inorganic fertilizers were applied, but it was 18.66 t ha^{-1} under combined application of HW at the rate of 10 t ha^{-1} plus the rest from inorganic fertilizers following integrated plant nutrient system (IPNS). The fresh yields of red amaranth, Indian spinach and tomato were found to be 35, 49 and 75 t ha^{-1}, respectively under combined application of organic and inorganic nutrients, while the yields of these vegetables under recommended inorganic fertilizers were 21, 45 and 64 t ha^{-1}, respectively. The results revealed that combined application of nutrients using organic and inorganic fertilizers provided higher crop yields over the solitary application inorganic fertilizers.

Keywords: Household waste, vegetables, Monga affected area.

1.0 Introduction

Intensification of limited land resource with modern high yielding crop varieties in Bangladesh is a must to meet up the huge demand of foods for its ever growing population (Rahman and Azam, 2005). Thus, heavy pressure on agricultural land through intensive cultivation of high yielding crop varieties using inorganic fertilizers solely and almost no recycling of organic residues has led to decline in organic matter and mining out the inherent plant nutrients from soils (Karim *et al.*, 1994). Soil organic matter is an indicator of its fertility and

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thereby crop productivity. According to BARC (2005), a good soil should have at least 2.5% organic matter, but most of the soils in Bangladesh have less than 1.5%, and some soils even less than 1% organic matter. The soils of the Monga area of Bangladesh are seriously depleted and organic matter contentis very low due to light soil textures as well as lessening organic recycling. Soil fertility of the region is declining in an alarming manner (Rahman and Rana Mukhaarachchi, 2003). Productivity of these soils cannot be increased and sustained unless arrangements are made to build up soil organic matter. Soil organic matter is an important factor to be considered in improving crop productivity. Because of the tropical climate, organic matter decomposition in Bangladesh soils is high (Bhuiyan *et al.*, 2011). Therefore, increase of soil organic matter through regular organic recycling is deemed necessary for sustainable crop production in the Monga area of Bangladesh.

Monga is seasonal food insecurity in the north-western part of rural Bangladesh. The employment and income opportunities of the farmers in the Monga area strongly decrease between transplantation and harvest of paddy. The lack of income reduces the ability of farmers to cover nutritional requirements. Therefore, cultivation of short duration vegetables more specifically leafy vegetables in the Monga area using different organic compost may help farmers to meet up nutritional requirements of the family members as well as provide additional source of income. The use of household waste, poultry manure and cow dung contributes to the requirement to maintain the long-term fertility by improving physical and chemical properties of soils (Rahman, 2010a). Cow dung and crop residues are used as fuel for cooking in many rural areas of Bangladesh and thereby are not available for use in the crop fields. But household waste is available every where and its composting is very easy. Household waste contains valuable plant nutrients especially N, P, S, K and many other macro and micronutrients, which may pollute the environment if not properly managed and utilized for crop production. Agricultural use of household waste may substantially cut down the cost of production reducing application of inorganic fertilizers especially for short duration vegetable production in the homestead and thus ensure an eco-friendly environment. So, household waste compost could be a good alternative for replenishment of organic matter in soils. Therefore, the present study was designed to investigate the effects of household

waste compost on growth and yield of four vegetables viz. red amaranth, spinach, Indian spinach and tomato.

2.0 Materials and Methods

2.1 Experimental Site

A total of eight experiments were conducted in the farmers' fields of rural Monga affected area of Kawnia and Badarganj upazila under Rangpur district of Bangladesh. The area belongs to the agro-ecological zone North Eastern Barind Tract (AEZ 27), which has silty or loamy top soil with strongly mottled clay (BARC, 2005). Deep red brown and deep grey terrace soils of the region have been developed from the deeply weathered Madhupur clay. The soils of the study area are strongly acidic and have low organic matter content (BARC, 2005).

2.2 Preparation of Household Waste Compost

First of all, pits were prepared with a plastic shed over the pit to protect rainfall and excessive sunlight in a corner of the homesteads of the selected seventeen farmers in Kawnia and Badarganj upazila. The size of individual pit was 2 m x 1 m x 1 m. The daily collected household wastes like kitchen waste that includes peel of fruits, vegetable and fish wastes, yard sweepings etc were gathered together and spread over the pit. When the pit was about 30 cm deep with wastes, approximately 250g of urea was applied over the surface to accelerate the microbial decomposition of wastes and then again wastes were placed into the pit and the practice was continued until the pit became full. Finally, a thin layer of cow dung or urea fertilizers were spread over the pit and covered with soils and kept for 4 months. After that compost was collected from the pit and used in the trials as an organic source of nutrients. Before applying to field compost was analyzed to determine the nutrient contents (Table 1). The soil samples were collected from selected farmers' fields under Badarganj and Kawnia upazilas and found that the values belongs to same fertility class as per BARC (2005) soil fertility ranking, therefore, individual nutrients were made average to get a generalized fertilizer rates of the crops under study (Table 2). The average total and available N of the plot soils were 0.097 and 0.040%, respectively, while available P was 6.20 mg kg^{-1} soil and exchangeable K was 0.25 meq 100 g^{-1}. Then soil test based fertilizer rates were calculated as per guideline given by BARC (2005). The IPNS based fertilizer requirements were calculated

using only the mean nutrient values of compost i.e. available N, available P and exchangeable K calculated in kg ha-1 (Table 1), which was deducted from the generalized recommended doses of N, P and K for the respective crops of the study area (Table 2).

Table 1. N, P and K content of household wastecompost (oven dried at 650C).

Materials	Total N (%)	Available N (%)	Total P (mg kg-1)	Available P (mg kg-1 soil)	Exchangeable K (mg kg-1 soil)
House hold waste compost	1.30 (78.00)*	0.088 (5.28)*	1750 (10.50)*	558.10 (3.35)*	1420 (8.52)*

*Values in the parenthesis indicate the total amount of nutrients added from household waste compost in kg ha-1. Total weight of applied household waste compost was 6 t ha-1 (oven dry basis).

Table 2. Recommended doses of N, P and K for different crops grown in the study area

Nutrients (kg ha-1)	Crops			
	Red amaranth	Spinach*	Indian spinach	Tomato
N	80	80	88	117
P	19	19	19	38
K	12	12	25	31

* Soil test based fertilizer recommendation for spinach is not available in the BARC Fertilizer Recommendation Guide Book (2005). Therefore, fertilizer doses recommended for red amaranth is applied for spinach.

2.3 Field Trials

A total of eight trials were conducted in different villages of Kawnia and Badarganj using spinach, red amaranth, Indian spinach and tomato as test vegetables during 2009-10 and 2010-11. Among the eight trials, five trialswere laid out in a factorial (nutrients x locations) randomized complete block design with four replications in Kawnia and Badarganj upazilas. The four levels of nutrient treatments were:(1) control, (2) recommended dose of fertilizers (RDF), (3) household waste compost (HW) at the rate of 10 tha-1, and (4) HW @ 10 t

ha-1 plus IPNS based RDF.Application of household compost supplied the required amount of P and K to plants, therefore, supplementation of only N was needed by inorganic fertilizer in the nutrient level 4. The locations were the villages of Kawnia and Badarganj upazilas. During the 2010-11Trials1 and 2 (Trial 1 as per nutrient treatments mentioned above and the Trial 2 using residual nutrients i.e. without applying either compost or inorganic fertilizers) with spinach were conducted in 17 locations/villages (Kawnia 7 and Badarganj 10). Dates of sowing of seeds of different vegetables widely varied because duration and starting dates of household waste compost preparation by the selected farmers varied from one location to another. Though spinach is a winter vegetable, it can be grown year round. Moreover, consecutive short duration vegetables were grown in the same field considering the farmers' preference in the study area. The dates of sowing of spinach seeds were November 3, 2010 to December 14, 2010 for the Trial 1, while for the Trial 2 were December 11, 2010 to January 20, 2011. The crop was harvested after 30-35 days of sowing. During the 2010-11, among 17 villages, ten were selected (Kawnia 5 and Badarganj 5) to grow red amaranth (Trial 3) as first crop using nutrients as per treatments, while second and third crops were Indian spinach (Trial 4) and spinach (Trial 5), respectively without applying nutrients. Though the Trial 5 was set up at Kawnia and Badarganj, however, there was a hailstorm at Badarganj area at the end of July 2011, which completely destroyed the crop. Therefore, the Trial 5 was conducted only in five villages of Kawnia upazila. The seeds of red amaranth was sown on February 10, 2011 and harvested on March 18, 2011. The Indian spinach was sown on April 10, 2011 and harvested on June 8, 2011, while spinach was sown on July 15, 2011 and harvested on August 26, 2011. During 2010-11, one farmer from Kawnia grew red amaranth (Trial 6), Indian spinach (Trial 7) and tomato (Trial 8) as first, second and third crops, respectively in the same piece of land using above mentioned four treatments. The red amaranth was sown on July 1, 2010 and harvested on August 4, 2010, while Indian spinach was sown on August 19, 2010 and harvested on September 25, 2010. Tomato seedlings were transplanted on November 23, 2010 and final harvest was done on March 25, 2011. In the treatment 4, where household waste compost was applied at the rate of 10 t ha-1 plus recommended doses of N, P and K as IPNS based before sowing red

amaranth and after that Indian spinach was grown without applying nutrients and tomato was grown using only nitrogen (N) at the rate of 117 kg ha^{-1}.

2.4 Data Collection and Analysis

Fresh yield data of all vegetables were recorded. Household waste compost and soil samples were analyzed using standard methods (Page *et al.*, 1982; Westerman, 1990). After harvesting the crops, soil samples were collected from each plot at 0-15 cm depth and were analyzed for pH, OM and residual nutrients. Soil pH was determined by Glass Electrode pH Meter method with soil water ratio 1:2.5, OM by Walkley-Black method, total N was determined by Kjeldahl method, total P was determined by the acid digestion method, available P by Olsen's method,and K by ammonium acetate extraction method. Available N (NO3--N plus NH4+-N) was determined using steam Distillation method.The analyses of variance for different parameters were done following the principle of F-statistics and the mean results were compared using Duncan's Multiple Range Test (DMRT).

3.0 Results and Discussion

3.1 Fresh Yields of Spinach under different Nutrient Levels and Locations (Trials 1 and 2)

Fresh yields of spinach were significantly affected by different nutrient levels over the control in both Trial 1 and 2 (Table 3). On the other hand, neither location nor the interaction of nutrient and location showed any significant effect on yield of spinach. It should be noted that crops grown using combined sources of nutrients i.e. organic form as household waste and inorganic form as urea to fulfill the recommended N requirements through IPNS approach were found 17% better over solitary application of inorganic nutrients. The fresh yield of spinach was found 16 t ha^{-1} when recommended doses of inorganic fertilizers were applied, but it was about 19 t ha^{-1} under combined application of organic and inorganic nutrients in both the trials. Interesting results were found that the fresh yield of spinach in the Trial2 (14.5 t ha^{-1}) was significantly higher over the Trial1 (13.4 t ha^{-1}), which was grown using only residual soil nutrients (Fig. 1).

Table 3. Fresh yield of spinachin Trials 1 and 2 under different nutrient levels in Rangpur conducted during November 2010 to January 2011

Nutrient levels	Fresh yield of spinach (t ha^{-1}) at harvest	
	Trial 1*	Trial 2*
Control	3.62c	4.91b
Recommended doses of NPK	15.79b	16.09a
Household waste 10 t ha^{-1}	15.67b	17.99a
Household waste 10 t ha^{-1} + RD of N (IPNS concept)	18.55a	18.86a
S.E. (±)	0.36	0.27
% CV	22.16	22.49

RD = Recommended dose

* First trial as per nutrient treatments and second trial using residual nutrients

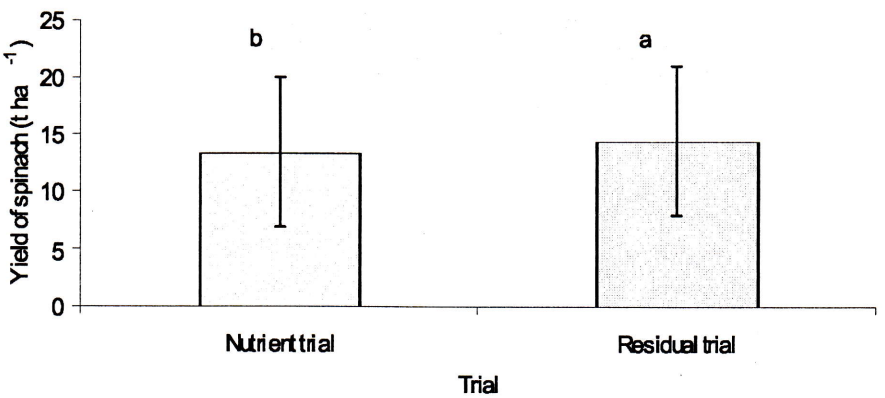

Fig.1. Difference in mean yields of spinach between Trial 1 (nutrient trial) and Trial 2 (residual trial) in Rangpur conducted during November 2010 to January 2011.

3.2 Fresh Yields of Red amaranth (Trail 3), Indian Spinach (Trial 4) and Spinach (Trial 5) under different Nutrient Levels and Locations in Rangpur

Fresh yields of red amaranth and Indian spinach were significantly influenced by different nutrient levels over the control (Table 4). Locations and the interaction of location and nutrient level did not show any significant effect on yields of red amaranth (Trial 3) and Indian spinach (Trial 4) in Kawnia and Badarganj. Yields of red amaranth grown using combined nutrients i.e.

household waste and recommended N following IPNS concept were found significantly higher over recommended doses of fertilizers and only household waste. In case of Indian spinach application of recommended fertilizers and only household waste provided same amount of yield i.e. 45 t ha^{-1}. However, combined applications of inorganic fertilizers and household waste gave significantly higher yield over solitary application of either organic or inorganic fertilizer. The fresh yield of Indian spinach was found 48.66 t ha^{-1} under combined application of organic and inorganic nutrients.

Table 4. Fresh yield of red amaranth (Trial 3)and Indianspinach (Trial 4) under different nutrient levels in Rangpur grown during February to June 2011

Nutrient levels	Fresh yield (t ha^{-1})	
	Red amaranth (Trial 3)	Indianspinach (Trial 4)
Control	9.91d	16.72c
Recommended doses of NPK	20.61c	45.19b
Household waste 10 t ha^{-1}	29.07b	45.36b
Household waste 10 t ha^{-1} + RD of N (IPNS concept)	34.79a	48.66a
S.E. (±)	0.65	1.13
% CV	17.51	18.41

RD = Recommended dose

Treatments containing different levels of nutrients significantly improved soil pH and OM in soils after harvesting of red amaranth (Trial 3) in Kawnia and Badarganj, Rangpur (Table 5). In upland condition soil nitrogen mainly remains in soils as NO3- form and when plant uptake this nitrate nitrogen its root releases OH- and HCO3- ions, which favor to neutralize soil acidity and thus increase soil pH. Though the treatments did not show any significant effects on soil N, P and K contents in soils after harvesting of the crop, however, these parameters were improved in soils with the application of household waste. The increment of nutrients in soils with the application of household waste compost indicated the improvement of soil fertility. Different locations did not show significant effect on residual nutrients in soils after harvesting of red amaranth.

Table 5. Soil properties after harvesting of red amaranth (Trial 3) under different nutrient levels in Rangpur

Nutrient levels	Soil properties at crop harvest				
	pH	OM (%)	N (%)	P (∝ g^{-1})	K (meq 100 g^{-1})
Control	5.15b	1.13b	0.10	14.12	0.17
Recommended doses of NPK	5.18b	1.14b	0.13	15.23	0.23
Household waste 10 t ha^{-1}	5.85a	1.30a	0.12	18.54	0.23
Household waste 10 t ha^{-1} + RD of N (IPNS concept)	5.71a	1.35a	0.14	17.09	0.25
S.E. (±)	0.11	0.04	0.004	0.44	0.01
% CV	12.61	19.20	30.40	17.23	14.37

RD = Recommended dose

In the Trial 5, the effect of different locations(village)and interaction of nutrient x locations on growing spinach were found insignificant. However, different nutrient levels showed significant effect on fresh yields of spinach (Table 6). Application of household waste compost along with chemical fertilizer produced significantly higher yields over the sole application of either chemical or organic fertilizers. The phenomenon can be explained in such a way that nitrogen was supplemented by urea fertilizer, which was readily available for plant at the very beginning of spinach growing and latter stage nutrients were also released from compost and influenced higher biomass production.

Table 6. Fresh yield of spinach (Trial 5) as a third crop under different nutrient levels in Kawnia, Rangpur grown during July to August 2011

Nutrient levels	Fresh yield of Spinach (t ha^{-1})
Control	3.65c
Recommended doses of NPK	18.23b
Household waste 10 t ha^{-1}	21.64ab
Household waste 10 t ha^{-1} + RD of N (IPNS concept)	24.95a
S.E. (±)	0.83
%CV	21.61

3.3 Yields of Red amaranth (Trail 6), IndianSpinach (Trial 7) and Tomato (Trial 8) under different Nutrient Levels

Yields of red amaranth, Indianspinach and tomato were significantly affected by different nutrient levels over the control (Table 7). The yields of red amaranth and Indian spinachdid not vary among the nutrient levels except the control. Tomato fruit yield was significantly higher in the household waste compost treatment over the recommended doses of NPK, while performance of only household waste compost and household waste compost plus recommended doses of nitrogen as IPNS based were found statistically similar in producing tomato fruits.

Islam (2010) found that the combined application of nutrients using organic and inorganic sources were significantly better over solitary application of inorganic fertilizers in producing fresh yields of red amaranth and spinach not only in the first crops but also in the second crops where no nutrients were applied using either organic or inorganic sources. According to BARC (2005), the high yield goals of red amaranth and Indian spinach were 14.0±1.4 t ha^{-1} and 40.0±4.0 t ha^{-1}, respectively. The results i.e. the yield data of red amaranth and Indian spinach of the present study were found higher over the yield goals set by BARC. Rahman (2010a, 2010b) quantified the potential of household waste compost in rice and tomato cultivation.

Table 7. Fresh yield of red amaranth (Trial 6), Indianspinach(Trial 7) and tomato (Trial 8) under different nutrient levels in Kawnia, Rangpur grown during July 2010 to March 2011

Nutrient levels	Trial 6	Trial 7	Trial 8
	Red amaranth (t/ha)	Indian spinach (t ha^{-1})	Tomato (t ha^{-1})
Control	7.15b	14.33b	24.10c
Recommended doses of NPK	17.35a	30.80a	63.70b
Household waste 10 t ha^{-1}	20.75a	33.48a	78.67a
Household waste 10 t ha^{-1} + RD of nutrients (IPNS concept)	20.85a	32.98a	75.35a
S.E. (±)	1.90	2.08	3.65
%CV	23.02	14.98	12.09

Though information given in the Table 7 disclosed the similar effect of household waste alone and household waste accompanied by urea fertilizer on crop yields, however, the available data on yields of different vegetables presented in the Table 3, 4 and 6 revealed that combined application of nutrients performed better in producing crop yields over the solitary application of either organic or inorganic fertilizers. Many explanations or possible reasons could be depicted why application of organic and inorganic fertilizers together are superior over the single application of either fertilizer. Solitary use of inorganic fertilizers in agricultural land has degraded physical, chemical and biological health of soil, which may negatively affect crop yields (Bahl and Toor, 2002). On the other hand, yield of different crops including tomato can significantly be increased if organic fertilizers applied along with inorganic fertilizers in a balanced manner (Heitkamp *et al.*, 2011). Most of the cultivated soils of Bangladesh are suffering from declining organic matter as well as plant nutrients. When the nutrient demands of crops are fulfilled using only inorganic fertilizers there is high risk of nutrient losses through many channels like leaching, runoff, percolation, chemical fixation and so on because of presence of readily available nutrients and plants can't uptake all the nutrients immediately after application to soil. It is reported by many researchers that the apparent recovery efficiencies of applied chemical fertilizers varied between 0 to 70% for N, 0 to 15% for P, and 0 to 52% for K (Tittonell *et al.*, 2008). On the other hand, when nutrients are applied using both organic and inorganic sources plants can get immediate nutrients from inorganic chemical fertilizers and with the advancement of growing stages of crops nutrients will be released from compost through microbial breakdown and will be utilized by crops more efficiently and therefore, better crop growth and yields can be obtained. The Integrated Plant Nutrition System (IPNS) approach combines the supply of plant nutrients from organic and inorganic sources, which could be considered as one of the best management practices to improve soil health encompassing physical, chemical and biological properties, which might have positive contribution to increase crop yields. Many researchers found that mixed or combined application of organic and inorganic fertilizers using household waste, poultry manure and cow dung with inorganic fertilizers provided higher yields of tomato and many other leafy vegetables over the single

application of either organic or inorganic sources of nutrients (Rahman, 2010a; Sultana, 2011).

4.0 Conclusions

Nutrients comprised with organic and inorganic sources were found significantly superior to the solitary application of inorganic fertilizers in producing yields of red amaranth, spinach and tomato. The significantly higher yields ofred amaranth and spinach were obtained in the residual studies where no fertilizer was used using either organic or inorganic sources. Application of household waste compost at the rate of 10 t ha^{-1} along with inorganic fertilizers following integrated plant nutrition systems (IPNS) was found to be the best for higher yields of spinach (19 t ha^{-1}), red amaranth (35 t ha^{-1}), Indian spinach (49 t ha^{-1}) and tomato (75 t ha^{-1}). Residual soil nutrients at crop harvest indicated the fertility improvement of soils with the application of household waste.

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