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Effect of Organic Composts in Red Amaranth and Spinach Productivity and Soil Fertility

M. M. Rahman,[1*] G. K. M. M. Rahman[1], M. S. I. Afrad[2] and S. Islam[1]
[1]Department of Soil Science
[2]Department of Agricultural Extension & Rural Development
Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706
*Corresponding author: mizan@bsmrau.edu.bd

Abstract
An experiment was conducted at the experimental farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh during December 2009 to March 2010 to study the effect of household wastes compost, palli compost and quick compost on growth and yield of red amaranth and spinach and improvement of soil fertility. The first time red amaranth and spinach were grown using compost and inorganic fertilizers, while the second time crops grown using only residual nutrients in soil. Yield data revealed that combined application of organic and inorganic fertilizers were significantly better than the solitary application of inorganic fertilizers. The fresh yield of red amaranth in the second harvest where no fertilizers were used recorded 13 t ha^{-1}, which appeared significantly higher over the first harvest (10 t ha^{-1}) and there was no significant difference between the yields of first and second harvest of spinach (18 t ha^{-1}). Different composts increased OM, N, P and K contents, which indicated the fertility improvement of soil. The performance of composts at the rate of 20 t ha^{-1} in producing yields of vegetables was insignificantly different with the rates of 5-10 t ha^{-1}. Among the different composts, household waste is available in the rural areas and its preparation is easy with minimum costs. Therefore, considering the availability and costing, household waste compost at the rate of 5-10 t ha^{-1} is recommended as a soil amendment for improving soil fertility and crop productivity.

Key words: Composts, Fertility, Leafy vegetables, Productivity

Introduction

The soil fertility in Bangladesh has deteriorated over the years and the productivity of some crops have either stagnated or declined (Karim, *et al*., 1994). It is believed that the declining productivity of this country's soils is the result of depletion of organic matter due to increasing cropping intensity, higher rates of decomposition of organic matter under the prevailing hot and humid climate, use of lesser quantities of organic manure, little or no use of green manure practices etc (BARC, 2005). A good soil should have at least 2.5% organic matter, but in Bangladesh most of the soils have less than 1.5%, and some soils even less than 1% organic matter (BARC, 2005). If the present rate of its degradation is continued, in near-future the soil would become barren. The use of household waste, poultry manure, cow dung and other available organic materials contributes in maintaining the long-term fertility of soils by improving its physical and chemical properties (Rahman, 2010). The importance of organic compost is profound, which increases soil fertility and substitutes the missing soil nutritional elements, improve soil aeration and considered as a suitable place for the growth of beneficial bacteria. Therefore organic compost is vital in producing productive crops; it is also widely demanded by customers rather than the harmful products of chemical compost. Organic compost contains mainly nitrogen, potassium, and phosphorus that are major element for crops and releases them over a longer period of time than chemical fertilizers. Application of organic and inorganic combination is very effective in receiving high yield and high responses to added nutrients (Sarker *et al*., 1989). Organic manure plays key role in transformation cycling and availability of nutrients to the crop. It is true that sustainable production of crops cannot be maintained by using only chemical fertilizer and similarly it is not possible to obtain higher yield by using organic manure alone (Bair, 1990). Thus conjoint use of organic manures and chemical fertilizers can help in enhancing and maintaining stability in crop production. Household waste compost can be prepared easily at farm household levels, and there is some other organic compost available in the market, however, their performance in crop productivity and soil health improvement is not well documented. Therefore, the present study was conducted to quantify the effect of household wastes compost (HW), palli compost (PC) and quick compost (QC) on growth and yield of two vegetables viz. red amaranth and spinach and enhancement of soil fertility.

Materials and Methods

A field experiment was conducted at the research farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh during December 2009 to March 2010 using two short duration and popular leafy vegetables red amaranth (BARI lal shak-1) and spinach (SHATHI) in 11 treatments laid out in a randomized complete block design. The treatments were (1) absolute control; (2) recommended doses (RD) of N, P & K; (3) HW 5.0 t/ha; (4) HW 10.0 t/ha; (5) HW 20.0 t/ha; (6) PC 5.0 t/ha; (7) PC 10.0

t/ha; (8) PC 20.0 t/ha; (9) QC 5.0 t/ha; (10) QC 10.0 t/ha; and (11) QC 20.0 t/ha.

Household wastes were collected and sorted from BSMRAU campus and biodegradable portions were composted in a pit for 4 months. Quick compost was prepared at the ratio of 1:2:4 of oil cake, rice husk and cowdung as per guidelines of BRAC, Bangladesh, while Palli compost was purchased from Rural Development Academy (RDA) Bogra. During final land preparation composts were applied to plots and before that the plot soil and composts were analyzed for N, P and K. Based on soil test results recommended doses of N, P and K were set at 68, 23 and 17 kg/ha, respectively for both red amaranth and spinach, while inorganic fertilizers were supplemented following integrated plant nutrition systems (IPNS). Recommended doses (RD) of N, P & K Half of urea and full amount of TSP and MP were applied and thoroughly mixed with soil three days prior to seed sowing. The remaining half of urea was applied in two splits first at 7 days and second at 15 days after sowing (DAS) as top dressing. The unit plot size was 2 m x 1 m. The seed rates were 3.0 and 25.0 kg/ha for red amaranth and spinach, respectively. Intercultural operations were done when needed. Crops were harvested after 30 days of seed sowing. After first harvesting, the seeds of second crops of same vegetables were sown in the same plots where no fertilizer either organic or inorganic was applied.

Yield data of red amaranth and spinach were recorded at harvest (30 DAS). Soil samples at harvest of first and residual cropping were taken from each treatment under both red amaranth and spinach experiments. Samples were analyzed for N using Kjeldhal systems (Bremner and Mulvaney, 1982), while P and K were determined by the Acid Digestion method (Jones and Case, 1990; Watson and Issac, 1990). Soil pH and OM were determined by Glass Electrode method (McLean, 1982) and Walkley-Black method (Nelson and Sommers, 1982), respectively.

SPSS version 12.0 statistical software was used to analyze the data. One-way-ANOVA and Univariate analysis were performed. Means were separated by LSD.

Results and Discussion

Yields of red amaranth and spinach

Fresh yields of red amaranth and spinach were significantly affected by different treatments in both the cases of first and second harvest (Table 1). It should be noted that crops grown under the first harvest were nourished with the combined application of organic and inorganic fertilizers, but the second crops (second harvest) were grown solely on residual soil nutrients without application of either organic or inorganic fertilizers. All the treatments gave significantly higher yields of red amaranth and spinach over the control ($p<0.05$). In case of red amaranth the recommended doses of inorganic fertilizers (RD) produced significantly higher yields (8-11 t/ha) over the control (3-4 t/ha), however the treatment (RD) was found significantly inferior to all other treatments. On the other hand, the result was found different in case of spinach, where the recommended doses of inorganic fertilizers produced significantly higher yield (17-21 t/ha) over the control (6-8 t/ha), which was insignificantly different with the yields obtained in other treatments in the first harvest. In case of second harvest of spinach, the effect of RD was significantly lower than the treatments HW and QC 5 t/ha and PC 10 t ha^{-1}.

Table 1. Yield data of red amaranth and spinach under different treatments

Treatment	Fresh yield of red amaranth (t/ha)		Fresh yield of spinach (t/ha)	
	1st harvest	2nd harvest (residual)	1st harvest	2nd harvest (residual)
Control	3.33	4.17	6.83	7.83
RD	8.00	10.83	20.67	16.83
HW 5.0 t ha^{-1}	10.33	12.33	15.17	17.00
HW 10.0 t ha^{-1}	11.17	13.33	20.17	20.33
HW 20.0 t ha^{-1}	15.67	13.83	18.83	18.50
PC 5.0 t ha^{-1}	9.17	15.77	17.50	15.50
PC 10.0 t/ha	11.67	13.83	19.67	17.92
PC 20.0 t ha^{-1}	10.83	16.33	22.67	21.00
QC 5.0 t ha^{-1}	8.17	13.33	18.33	18.33
QC 10.0 t ha^{-1}	9.83	12.33	22.17	20.18
QC 20.0 t ha^{-1}	14.33	13.50	20.33	19.08
S.E.(±)	*1.59*	*1.03*	*2.69*	*1.95*
%CV	*26.93*	*14.01*	*25.32*	*23.62*
LSD (0.05)	*4.69*	*3.23*	*7.93*	*3.28*

RD = recommended fertilizers, HW = household waste, PC = Palli compost, QC = quick compost

Table 2. Dry matter yields of red amaranth and spinach under different treatments

Treatment	Dry yield of red amaranth (kg/ha)		Dry yield of spinach (kg/ha)	
	1st harvest	2nd harvest (residual)	1st harvest	2nd harvest (residual)
Control	266.65	366.42	899.43	571.95
RD	725.57	1048.58	1335.33	804.68
HW 5.0 t ha^{-1}	758.03	1285.25	996.77	1107.20
HW 10.0 t ha^{-1}	560.48	1319.83	948.87	1326.32
HW 20.0 t ha^{-1}	1073.88	1409.35	1251.92	1285.67
PC 5.0 t ha^{-1}	595.15	1347.33	1023.25	989.92
PC 10.0 t/ha	739.97	1435.55	1188.48	916.10
PC 20.0 t ha^{-1}	648.40	1748.90	1372.32	1174.97
QC 5.0 t ha^{-1}	673.25	1265.35	1193.50	1209.20
QC 10.0 t ha^{-1}	646.67	1053.60	1173.40	900.88
QC 20.0 t ha^{-1}	987.02	1444.87	944.62	988.55
S.E.(±)	*117.78*	*102.52*	*185.59*	*84.73*
%CV	*29.73*	*14.23*	*28.68*	*14.25*
LSD (0.05)	*347.44*	*302.45*	*NS*	*248.90*

RD = recommended fertilizers, HW = household waste, PC = Palli compost, QC = quick compost

Dry matter yields of red amaranth were significantly affected by different treatments in both the cases of first and second harvest (Table 2). In case of spinach the difference in dry matter production under different treatments in the first harvest was insignificant; however it was significant in the second harvest (Table 2). Interesting results were found that the fresh yield of red amaranth in the second harvest (13 t/ha) was significantly higher over the first harvest (10t/ha) and there was no significant difference between the yields of first and second harvest of spinach (Table 3).

It was observed that when nutrients were applied using organic and inorganic sources the crop yields were increased, which signified the contribution of organic fertilizers in producing higher yields. It is supposed that the nutrient use efficiency might be increased because of combined application of organic and inorganic sources. Many research works supported the current findings. Mixed application of household waste, poultry manure and cow dung with inorganic fertilizers provided higher yields of tomato over the single application of either organic or inorganic sources of nutrients (Rahman, 2010; Rahman, 2013).

Table 3. Differences in yield data between 1st and 2nd harvest of Red amaranth and Spinach under different treatments (mean ± s.d.)

Harvesting of crop	Red amaranth (t/ha)	Spinach (t/ha)
1st harvest	10.23±3.87[b]	18.39±6.42
2nd harvest (residual)	12.68±3.43[a]	17.50±5.34

Residual nutrients in soils after harvesting of red amaranth and spinach

Treatments containing different levels of organic wastes significantly improved the OM and P contents in soils after the first harvest of red amaranth (Table 4). Second to nitrogen, phosphorus is the most limiting plant nutrient and its improvement in soil obviously a very good indicator of soil quality enhancement. Though the treatments did not show any significant effects on soil pH, nitrogen and K contents in soils after first harvest, however these parameters were improved in soils with the application of different organic wastes. Considering all these the application of different organic wastes improved the fertility of soils. The treatments did not show any significant effects on changing soil pH, OM, N and P contents after the second harvest of red amaranth (Table 5). As the second crop was grown solely on residual nutrients and the yields at second harvest were significantly higher over the first harvest, a large amount of nutrients were used up by the crop. Therefore, the nutrient contents in soils reduced substantially from the first harvest to second harvest.

Table 4. Residual nutrients in soils at 1st harvest of red amaranth

Treatment	pH	OM (%)	Total N (%)	P (µg/g)	K (meq/100g)
Control	6.07	1.78	0.17	13.72	0.27
RD	6.00	1.81	0.20	31.05	0.54
HW 5.0 t ha^{-1}	6.19	1.97	0.22	31.27	0.42
HW 10.0 t ha^{-1}	6.23	2.07	0.25	35.18	0.31
HW 20.0 t ha^{-1}	6.50	2.35	0.28	36.84	0.38
PC 5.0 t ha^{-1}	6.14	2.42	0.22	38.25	0.54
PC 10.0 t/ha	5.92	2.07	0.21	33.69	0.47
PC 20.0 t ha^{-1}	6.26	2.20	0.20	40.70	0.36
QC 5.0 t ha^{-1}	6.25	2.45	0.22	29.18	0.38
QC 10.0 t ha^{-1}	6.09	2.20	0.21	29.91	0.39
QC 20.0 t ha^{-1}	6.62	2.32	0.27	29.91	0.36
S.E.(±)	0.15	0.12	*0.03*	3.01	0.07
%CV	*4.20*	*9.97*	*24.43*	*16.39*	*28.44*
$LSD_{(0.05)}$	*NS*	*0.36*	*NS*	*7.84*	*NS*

RD = recommended fertilizers, HW = household waste, PC = Palli compost, QC = quick compost

The treatments did not show any significant effects on pH and OM statuses of soil; however N, P and K contents in soils after first harvest of spinach were significantly increased (Table 6). On the other hand, treatments had no significant effects on soil chemical properties after second harvest of spinach (Table 7). The compost from different wastes possesses a high amount of N, P and K (Hogland *et al.,* 2003; Rahman, 2010). The fertility enhancement of soils using organic fertilizers is well documented by many researchers. Dao and Cavigelli (2003) reported that animal manure had long been used as an organic source of plant nutrients and organic matter to improve the physical and fertility condition of agricultural soils. The residual nutrients in soils after crop harvest revealed that application organic fertilizer 'Lalon' in tomato cultivation improved soil fertility (Islam *et al.,* 2008). Rahman (2010) did an experiment using household waste, cow dung and poultry manure in tomato and found that the potential supplies of N, P and K of soils treated by all these waste were high enough, which indicated the fertility improvement of soils. Application of different organic fertilizers in agricultural land increases N, P and K contents and sustains soil fertility (Zahid, 2001; Katyal *et al.,* 2002; Bhadoria *et al*., 2003).

Table 5. Residual nutrients in soils at 2nd harvest of red amaranth

Treatment	pH	OM (%)	Total N (%)	P (µg/g)	K (meq/100g)
Control	6.35	1.40	0.12	10.08	0.19
RD	6.36	1.83	0.14	10.68	0.38
HW 5.0 t ha^{-1}	6.33	1.59	0.19	10.38	0.31
HW 10.0 t ha^{-1}	6.32	1.59	0.17	10.70	0.22
HW 20.0 t ha^{-1}	6.56	1.48	0.16	11.87	0.29
PC 5.0 t ha^{-1}	6.47	1.52	0.17	10.98	0.37
PC 10.0 t/ha	6.43	1.49	0.21	9.97	0.34
PC 20.0 t ha^{-1}	6.49	1.62	0.17	13.12	0.18
QC 5.0 t ha^{-1}	6.47	1.49	0.17	11.33	0.26
QC 10.0 t ha^{-1}	6.42	1.59	0.18	10.62	0.25
QC 20.0 t ha^{-1}	6.58	1.52	0.23	10.76	0.23
S.E.(±)	*0.10*	*0.15*	0.03	*0.62*	*0.04*
%CV	*2.35*	*16.96*	*31.28*	*9.79*	*23.07*
$LSD_{(0.05)}$	*NS*	*NS*	*NS*	*NS*	*0.11*

RD = recommended fertilizers, HW = household waste, PC = Palli compost, QC = quick compost

Table 6. Residual nutrients in soils at 1st harvest of Spinach

Treatment	pH	OM (%)	Total N (%)	P (µg/g)	K (meq/100g)
Control	6.49	1.87	0.14	15.21	0.19
RD	6.05	2.04	0.16	35.97	0.47
HW 5.0 t ha^{-1}	6.23	1.97	0.20	41.76	0.31
HW 10.0 t ha^{-1}	6.18	2.14	0.25	36.24	0.32
HW 20.0 t ha^{-1}	6.53	1.81	0.23	44.55	0.29
PC 5.0 t ha^{-1}	6.06	2.04	0.24	34.86	0.35
PC 10.0 t/ha	6.43	2.04	0.23	39.12	0.48
PC 20.0 t ha^{-1}	6.04	2.11	0.25	38.96	0.29
QC 5.0 t ha^{-1}	6.15	2.36	0.25	34.88	0.33
QC 10.0 t ha^{-1}	6.22	2.11	0.24	36.38	0.29
QC 20.0 t ha^{-1}	6.42	1.83	0.23	33.77	0.24
S.E.(±)	*0.13*	*0.15*	*0.02*	*4.84*	*0.03*
%CV	*3.61*	*13.25*	*14.32*	*23.52*	*19.57*
LSD (0.05)	*NS*	*NS*	*0.05*	*14.26*	*0.11*

RD = recommended fertilizers, HW = household waste, PC = Palli compost, QC = quick compost

Table 7: Residual nutrients in soils at 2nd harvest of Spinach

Treatment	pH	OM (%)	Total N (%)	P (µg/g)	K (meq/100g)
Control	6.53	1.55	0.17	6.95	0.12
RD	6.23	1.76	0.19	10.05	0.29
HW 5.0 t ha^{-1}	6.35	1.45	0.30	11.95	0.18
HW 10.0 t ha^{-1}	6.44	1.76	0.14	11.71	0.19
HW 20.0 t ha^{-1}	6.38	1.51	0.25	11.46	0.17
PC 5.0 t ha^{-1}	6.29	1.52	0.19	8.83	0.23
PC 10.0 t/ha	6.52	2.08	0.20	15.27	0.31
PC 20.0 t ha^{-1}	6.30	2.01	0.19	11.19	0.19
QC 5.0 t ha^{-1}	6.42	2.00	0.21	13.96	0.20
QC 10.0 t ha^{-1}	6.42	1.62	0.21	10.43	0.18
QC 20.0 t ha^{-1}	6.44	1.73	0.21	11.57	0.15
S.E.(±)	*0.06*	*0.21*	*0.03*	*1.96*	*0.03*
%CV	*1.56*	*20.25*	*26.71*	*30.27*	*27.42*
LSD (0.05)	*NS*	*NS*	*NS*	*NS*	*0.10*

RD = recommended fertilizers, HW = household waste, PC = Palli compost, QC = quick compost

Conclusions

Combined application of different composts and inorganic fertilizers produced significantly higher yields of red amaranth and spinach over the recommended doses of inorganic fertilizers. Interesting results were found that the fresh yield of red amaranth in the second harvest was significantly higher (13 t ha^{-1}) over the first one (10 t ha^{-1}) and there was no significant difference between the yields of first and second harvest of spinach (18 t ha^{-1}). Application of wastes significantly increased OM, N, P and K and their potential supplies in soils, which indicated the fertility enhancement of soil. Growing short duration leafy vegetables second and even third time using residual soil nutrients can be practiced as a best management tool. The performance of the highest rates of different composts in producing yields of vegetables was insignificantly different with the lower rates of 5-10 t ha^{-1}. Palli compost is a finished product and need to be purchased from market. Different raw materials viz. oil cake, rice husk and cowdung are to be purchased to prepare quick compost. However, household waste compost can be prepared using available household waste materials very easily and with minimum cost. Therefore, considering the availability and low cost, household waste compost at the rate of 5-10 t ha^{-1} is recommended for using as a soil amendment, while improving soil fertility and crop productivity.

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