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Research Article

Co-Composting of Water Hyacinth with Cattle Manure and its Effects on Growth and Yield Of Okra

S. Akber, J. C. Joardar*

Soil, Water and Environment Discipline, Khulna University, Khulna-9208, Bangladesh.

*Corresponding author's e-mail: jcjoardar@swe.ku.ac.bd

Abstract

Water hyacinth (WH), a floating aquatic weed, has conquered many tropical water bodies including Bangladesh and is considered the most damaging weed of the world due to its harmful effects on watercourses and livelihood. Due to its rapid growth, it reduces clean water supply, causes problems in water extraction, blocks irrigation canals, increases transport costs and decreases fishing by making dense mats. As a management and utilization tool of this WH, co-composting of WH with cattle manure (CM) was done to produce a nutrient rich organic soil amendment. Co-composting of WH with CM was done at five combinations (WH:CM, 1:0, 0:1, 1:1, 1:2 and 2:1). Prepared co-compost was analyzed for nutrient elements. Pot experiment was carried out to assess the effects of co-compost on growth and yield of okra (*Abelmoschus esculentus*). Organic carbon, P, K and Na content was higher in WH whereas N content was higher in CM. CM alone was found the best performer on the basis of growth and yield of okra plant. But WH in combination with CM, the ratio WH:CM, 1:2 was second best yielder. Considering the growth and yield of okra, WH in combination with CM (WH:CM, 1:2) could be efficiently used through co-composting. The approach used in this study could be a better practice for the areas people facing difficulties with WH and also might be a nutrient rich source of organic amendment for marginal farmers.

Keywords: Co-composting; Water hyacinth; Cattle manure; Okra; Organic amendment; Management.

Introduction

Water hyacinth (*Eichhornia crassipes*), is an invasive floating aquatic weed and one of the world's most harmful weed because of its negative effects on waterways and people's livelihoods [1-2]. Water hyacinth can cause considerable damage to local environments, human health and economic development [3-4]. It is documented as very aggressive species of aquatic plants that grows very fast and eliminates other aquatic species in its competition [5]. It is very much difficult to control of water hyacinth due to its rapid growth and dispersal, regeneration from fragments of stems and seed can also remain viable for more than six years [6].

Composting is the most promising technique for treatment of organic waste. This weed can be composted because this weed can be biodegraded and stabilized by composting. Water hyacinth composting can solve two problems such as checks the growth of water hyacinth and reduces the application of chemical fertilizers to the agricultural field in the form of organic fertilizer or soil conditioner as a nutrient source. Composting is the practice of creating humus like organic materials outside of the soil by mixing, pilling or otherwise storing organic materials under conditions conducive to both aerobic and anaerobic decomposition and nutrient conservation [7]. Whereas, co-composting is a process where low C:N ratio materials (such as livestock manure and sewage sludge) is mixed with high C:N ratio materials (such as sawdust, wood chips, senescent tree leaves, or municipal solid waste). It provides sufficient C for microbes to immobilize the excess N and minimize any nitrate leaching hazard from low C:N ratio materials and also provides sufficient N to speed the decomposition of the high C:N materials [7]. Animal manures are also well known for supplying many nutrients to crop production and organic matter which in turn helps in improving soil structure, water holding capacity, drainage; reduces wind

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and water erosion; provides a source of slow release nutrients; promotes growth of earthworms and beneficial microbes [8]. Bangladesh being an agricultural country there are a lot of dairy farms. Proper utilization of cattle manure (CM) and cow urine into manure can protect soil from chemical fertilizers and improve soil fertility [9].

Though the nutrient concentration in WH vary with the environment where it grows such as lakes, marshlands, ponds and ditches, compost obtained from WH had acceptable composition of N, P, K, and pH [10-13] and could be used in agricultural land for crop production [14] which had shown positive effects on plant growth[15–18]. Composting of only WH is less efficient than composting of manure because leaves are mainly composed of hemicellulose and cellulose, which is easier to biodegrade than lignin, which is the main substance of WH [19]. Co-composting as an alternative treatment has the advantage of producing a product that is easy to work into the soil compared with dried WH. Many efforts were made to identify different ways to exploit these aquatic weeds to partly reduce operation costs, including agricultural soil amendment, mushroom cultivation, phytoremediation of contaminated soil and industrial effluent, biogas and power alcohol production, animal fodder, raw materials for rope, basket etc. [6,20]. Several successful studies were conducted on pile composting of cattle manure, swine manure, municipal bio-solids, animal mortalities and food residuals [21-23]. Though very few studies have been made on composting of WH with saw dust, cattle manure and rice husk [24-26] and is used in many countries as compost material. But it is not so well known as composting material in Bangladesh. The present research was conducted in aiming at a management approach of WH through co-composting with CM to evaluate some properties of the co-compost prepared from and to assess the effectiveness of the co-compost using as an organic fertilizer on the growth and yield of okra.

Materials and methods

Study site

Co-compost preparation and pot experiment was carried out in the field laboratory of Soil, Water and Environment Discipline, Khulna University, Bangladesh and all the analyses were performed in the laboratory of the Discipline.

Water hyacinth and cattle manure collection

Water hyacinth was collected from the nearby water bodies inside Khulna University campus. Cattle manure was collected from a farmer's cattle farm nearby a village. Co-composting was done in plastic pots (5 L) with lid. The co-compost was prepared with different proportions of the materials shown in Table 1.

Table 1. Mixing proportion of composting materials

Treatment	Proportion (WH:CM)	Water hyacinth (kg)	Cattle manure (kg)	Total amount (kg)
WH	1:0	1.5	0	1.5
CM	0:1	0	1.5	1.5
WH_1CM_1	1:1	0.75	0.75	1.5
WH_1CM_2	1:2	0.5	1.0	1.5
WH_2CM_1	2:1	1.0	0.5	1.5

WH= Water hyacinth; CM= Cattle manure

Co-compost preparation

The collected WH was cut into small pieces and then sun dried to remove the excess water. Cattle manure was also sun dried. The compost materials were mixed well according to the ratios (Table 1). The mixture was then transferred into the plastic pots, watered to moisten the mixture and closed with lids. The lids were open at regular interval for proper aeration. The composting period was four months.

Soil sample collection and preparation

Soil sample was collected from the surface of agricultural field behind the Khulna University campus (N22°45.122′/ E89°31.456′). Collected soil was air dried, and visible roots and other debris were removed. The larger soil particles were broken gently using a wooden hammer, sieved through a 2.0-mm sieve and mixed thoroughly to prepare a composite soil sample [27]. The sieved soil was used for plant growth. A portion of the soil sample was further passed through 0.5-mm sieve for laboratory analyses. There were five ratios of co-compost as treatment along with control and three replications for each treatment. So, eighteen earthen pots of similar size (3L) were collected and each pot was poured with 2.0 kg pre-processed soil. Co-compost was applied at 10 t ha^{-1} from each treatment. Considering the

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volume of the pot 30g co-compost from each treatment was added to each pot.

Collection of okra seed and time of sowing

The okra seed (BARI *Dherosh*-1) was bought from local market situated at Gollamari, Khulna. Seeds were soaked in clean water for 24 hours before sowing. Three okra seeds were shown in each pot. The pots were arranged randomly and positions were changed every alternative day to allow equal exposure of sunlight to each pot. One week after germination, the plants were thinned keeping one healthy and strong plant in each pot.

Irrigation and pest management

Tap water was used for irrigation. First irrigation was done immediately after seed sowing. After germination, irrigation was done with same volume of water for each pot when necessary. Pest attach was observed and pesticide was sprayed.

Chemical analysis of prepared co-compost and soil

Four grab samples from the pot were collected after mixing the whole materials thoroughly by hand for each treatment. All the grab samples were mixed thoroughly and considered to be a homogenized sample and this method was applied for each treatment. Triplicate homogenized samples were collected and air dried immediately, grind in a grinder to obtain finely powdered homogenous sample and analyzed in the laboratory.

Agronomic attributes

For convenience of agronomic observation on the plant attributes (plant growth and yield) data were collected as follows: Plant height (cm) was measured with the help of a meter scale from the ground level to the tip of the upper most leaf. Number of fruit was counted and recorded. Length (cm) of fruits was measured with the help of a meter scale. Weight (g) of fruit was weighed by electric balance.

Statistical analysis

Results are the means of three replicates. Data were analyzed statistically, following ANOVA technique, by using MINITAB-18. Graphs were prepared by using Microsoft Excell-2010 program.

Results and discussion

Some properties of the experimental soil used for plant growth are presented in Table 2. The soil is clay loam in texture; slightly alkaline and non-saline [28].

Table 2. Some properties of the soil

Parameters	Values
pH	8.25
Electric conductivity (dS/m)	0.77
Organic carbon (%)	0.68
Total Nitrogen (%)	0.08
Total Phosphorus (%)	0.13
Total Potassium (%)	0.43
Total Sulfur (%)	0.72
Total Sodium (%)	3.64

Properties of prepared co-compost

Different analyzed properties of prepared co-compost are represented in Table 3. The maximum moisture content (13.63%, air dried basis) was found in WH and lowest (2.94%) in CM. The moisture content of each treatment was significantly ($p<0.05$) different and followed the order $WH>WH_2CM_1>WH_1CM_1>WH_1CM_2>CM$. The pH was found significantly higher in WH (7.70 ± 0.14) and WH_2CM_1 (7.75 ± 0.14) than any other combinations whereas lowest in CM (6.14 ± 0.09). The EC value reflected the degree of salinity in the compost, indicating its possible phytotoxic or phytoinhibitory effects on the growth of plant if applied to soil [22]. The maximum EC value was found in WH and lowest in CM. The EC value of each treatment was significantly different and followed the order $WH>WH_1CM_1>WH_2CM_1>WH_1CM_2>CM$. Nitrogen content was found significantly higher in CM (3.09 ± 0.11) and lowest in WH (0.18 ± 0.03) and WH_2CM_1 (0.17 ± 0.01). Phosphorus content was significantly higher (2.51 ± 0.07) in WH than any other combinations and lowest in CM (1.83 ± 0.01). Potassium was also found higher in WH (2.83 ± 0.11) and lowest in WH_1CM_1 (1.28 ± 0). There was no significant difference among WH, CM and WH_2CM_1. Though sulphur content was higher in WH there was significant difference among the combinations. Sodium content was found significantly higher in WH (5.82 ± 0.13) than any other combinations and lowest in WH_1CM_2 (3.64 ± 0.13).

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Table 3. Properties of prepared co-compost

Properties	Treatment				
	WH	CM	WH_1CM_1	WH_1CM_2	WH_2CM_1
Moisture content (%)	13.63	2.94	6.25	6.15	10.84
pH	7.70	6.14	7.67	7.30	7.75
EC (dS/m)	9.86	1.92	6.08	3.58	3.58
Organic Carbon (%)	$19.43{\pm}1.38^{b}$	$16.81{\pm}0.55^{c}$	$22.31{\pm}0.12^{a}$	$20.10{\pm}0.42^{b}$	$18.37{\pm}0.32^{bc}$
Total Nitrogen (%)	$0.18{\pm}0.03^{c}$	$3.09{\pm}0.11^{a}$	$0.51{\pm}0.03^{b}$	$0.38{\pm}0.02^{b}$	$0.17{\pm}0.01^{c}$
Total Phosphorus (%)	$2.51{\pm}0.07^{a}$	$1.83{\pm}0.01^{c}$	$2.04{\pm}0.08^{b}$	$2.09{\pm}0.07^{b}$	$2.14{\pm}0.03^{b}$
Total Potassium (%)	$2.83{\pm}0.11^{a}$	$2.50{\pm}0.22^{a}$	$1.28{\pm}0.00^{c}$	$2.03{\pm}0.15^{b}$	$2.52{\pm}0.04^{a}$
Total Sulphur (%)	$1.46{\pm}0.10^{a}$	$1.26{\pm}0.35^{a}$	$1.26{\pm}0.06^{a}$	$1.04{\pm}0.02^{a}$	$1.23{\pm}0.09^{a}$
Total Sodium (%)	$5.82{\pm}0.13^{a}$	$4.26{\pm}0.63^{cd}$	$4.66{\pm}0.00^{bc}$	$3.64{\pm}0.13^{d}$	$5.06{\pm}0.00^{ab}$

Data represent the average value ± the standard deviation (n = 3); Different letters indicate the significant differences among the treatments

Visual observation

All seeds were germinated within four days. First germination was found in pots treated with CM. Thirty five days after seed sowing (DAS) plants were started to flowering. Early flowering was observed in the CM, WH_1CM_2 and WH_1CM_1 treated plants. First fruiting was also found in CM, WH_1CM_2 and WH_1CM_1 treated plants.

Plant height

Plants height at three different times (30, 45 and 60 DAS) are shown in Figure 1. The maximum plant height was found at 60 DAS. No significant difference was found on plant height for any treatment at 30 DAS and 45 DAS. At 60 DAS plant height was found significantly higher on plant treated with CM (44.33 ± 1.53) and lowest plant height was found in control (31 ± 1.00). No significant difference found among WH, WH_1CM_2, WH_1CM_1 and WH_2CM_1.

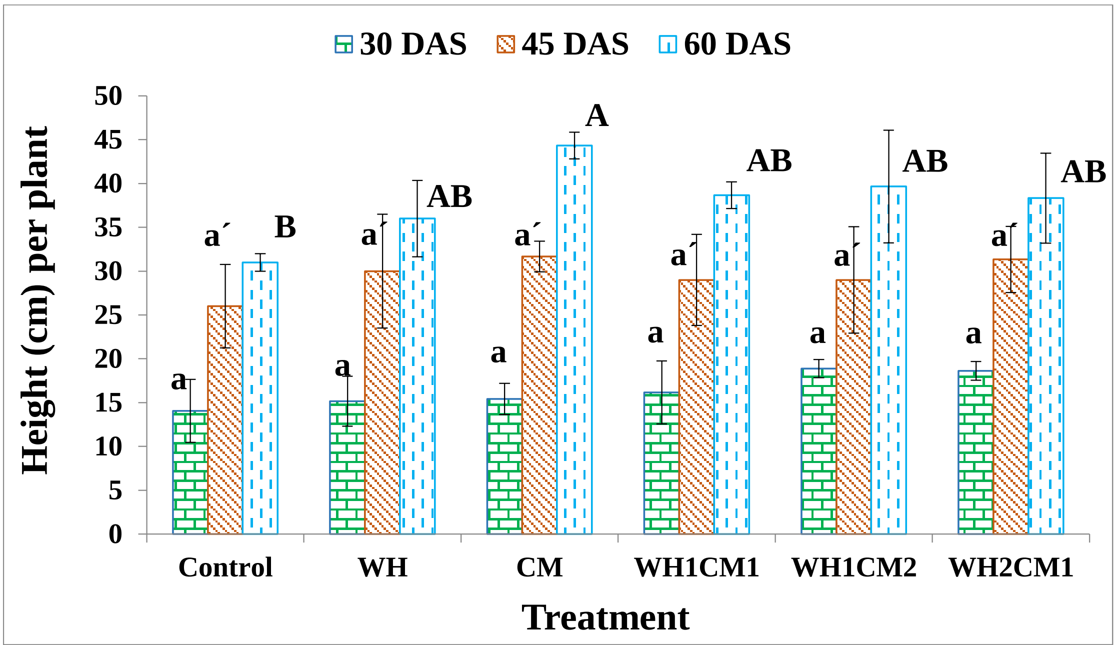

Figure 1. Plant height (cm) at different DAS sowing as influenced by co-compost application [Data represent the average value (n = 3); Error bars indicate the standard deviations (n=3); Different letters above the bars indicate the significant differences

Yield

The maximum no of fruit was found in the plants treated with CM. Similar numbers of fruits were counted in rest of all treated plants. Length (cm) per fruit was found significantly higher in the plant where CM was applied as treatment and lowest length (9.17±0.14) was found in control. There were no significant ($p<0.05$) difference in length of fruit among the plants treated with WH, WH_1CM_1, WH_1CM_2 and WH_2CM_1 but

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were significantly ($p<0.05$) different compared to control (Table 4). Weight (g) per fruit was significantly higher (12.15 ± 1.49) from plant treated with CM. Lowest weight (8.4 ± 0.38) was found in control. There were no significant ($p<0.05$) difference between WH_1CM_1, WH_1CM_2, and WH_2CM_1; WH, WH_1CM_1 and WH_2CM_1 (Table 4). But significant ($p<0.05$) difference were found between WH and WH_1CM_2.

Table 4. Length (cm) and weight (g) of okra per fruit

Treatment	Length (cm) per fruit	Weight (g) per fruit
Control	9.17 ± 0.14^{c}	8.40 ± 0.38^{d}
WH	10.13 ± 0.12^{bc}	8.80 ± 0.26^{cd}
CM	12.94 ± 1.26^{a}	12.15 ± 1.49^{a}
WH_1CM_1	10.33 ± 0.29^{bc}	10.67 ± 0.29^{abc}
WH_1CM_2	11.33 ± 0.29^{b}	10.83 ± 0.29^{ab}
WH_2CM_1	11.33 ± 0.29^{b}	10.0 ± 0.5^{bcd}

Data represent the average value ± the standard deviation (n = 3); Different letters indicate the significant differences

Conclusions

Co-composting of WH in combination with CM was performed and the nutrients content was evaluated. Lower pH was observed in all the treatments due to higher amount of CM. Higher final concentration of nutrients and low EC ensured the quality of co-compost prepared from WH in combination with CM. Addition of CM provided easily available carbon sources for composting microorganisms. Considering growth and yield of okra CM itself was found the best performer. But WH in combination with CM, the ratio WH_1CM_2 was second best yielder. This study concluded that the addition of optimum amount of CM was very efficient for co-composting of WH on the basis of growth and yield of okra. Bangladesh being a riverine country a lot of WH is locally available, plentiful and cost free. So its use in co-composting with CM could be an effective method for soil restoration and would minimize partially and/or totally the negative impacts of this weed on the aquatic ecosystem and socioeconomic activities. Nutrient recycling through the co-composting of WH in combination with CM can reduce application of chemical fertilizers to the agricultural field and problems related to its profligate growth rate of WH.

Conflict of interest

Authors have declared no competing of interests.

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