Int J Recycl Org Waste Agricult (2014) 3:47
DOI 10.1007/s40093-014-0047-1

ORIGINAL RESEARCH

Influence of vermicompost application in potting media on growth and flowering of marigold crop

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Received: 28 July 2013 / Accepted: 20 January 2014 / Published online: 25 February 2014
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Abstract

Introduction This paper reports the influence of vermicomposts prepared from cow dung and house hold waste on the growth and flowering of marigold crop. A total of seven potting media were prepared containing soil, cow dung vermicompost and cow dung + house hold waste vermicompost. The fertility status of soil and vermicomposts was quantified. In these media, growth and flowering of marigold plant seedlings was studied for 60 days.

Results The results showed that the vermicomposting process converted the cow dung and household waste into a highly stabilized product having C:N ratio <20.0. The NPK content of vermicomposts was higher than soil. The plant grown in vermicompost-containing potting media had 2.3 times more plant height than control. Results showed that the addition of vermicompost, in appropriate quantities, to potting media has significantly positive effects on growth and flowering of marigold seedlings including plant biomass, plant height, number of buds and flowers.

Conclusions It was concluded that addition of vermicompost, in appropriate quantities, to potting media has synergistic effects on growth and yield of marigold.

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Keywords Plant nutrients · C:N ratio · Trace elements · Household solid waste · Growth and yield · Plant height

Abbreviations

NPK	Nitrogen phosphorous and potassium
EC	Electric conductivity
TOC	Total organic carbon
TKN	Total Kjeldhal nitrogen
OM	Organic matter
TK	Total potassium
TP	Total phosphorus
C:N	Carbon nitrogen ratio
HSW	Household solid waste
CD	Cow dung

Introduction

There is a growing concern to decrease the application of chemical fertilizer to soils using soil nutrients more efficiently and by more application of organic matter. Excessive applications of agro-chemicals in crops have adversely affected the soil flora, fauna and enzymes which help to maintain the natural fertility of soil. Higher usage of fertilizers and pesticides has also desired more irrigation causing additional stress on water sources (Yadav and Garg 2011). Ground water pollution due to leaching of agrochemical is other ill-effects on environment. Organic fraction of solid wastes contains significant quantities of plant nutrients. But these wastes cannot be directly applied to the agricultural fields since these can destroy the natural fertility of the soil and may lead to phytotoxicity. The availability of nutrients to plants from organic manure is closely related to its maturity. Matured organic manure is well balanced in nutrients (NPK) with low C:N and C:P ratio, which indicates slow rate of nutrients release. While in case of unstabilized and fresh organic waste materials, higher nutrient release rates may limit the microbial growth which may retard or even stop decomposition and mineralization of wastes (Senesi 1989). So prior to land application of the solid wastes their biostabilization is essential. Among various methods of organic matter, vermicomposting is known to produce highly stabilized and non-thermophilic product, which has a great potential as soil amendment (Arancon et al. 2003a, b). Vermicompost is finely divided peat-like material with high porosity, aeration, drainage and water-holding capacity (Edwards and Burrows 1988). It contains nutrients in such forms that are readily available to the plants, such as nitrates, exchangeable phosphorus, soluble potassium, calcium, magnesium, etc. (Edwards and Burrows 1988; Orozco et al. 1996). Tomati et al. (1990) reported that vermicomposts contain biologically active substances such as plant growth regulators, and have great potential in maintaining the soil fertility. If vermicomposts are integrated in nutrient management in agricultural fields, the costs of crop production may be reduced significantly (Sangwan et al. 2010).

A number of studies have been undertaken in the yesteryears on the production and characterization of vermicomposts from different wastes, but the studies on the application of vermicomposts prepared from different solid wastes in potting media are scarce (Edwards and Burrows 1988; Wilson and Carlile 1989; Atiyeh et al. 1999). Mba (1996) reported that cassava peel vermicomposts enhanced cowpea aerial biomass production. Jeyabal and Kuppuswamy (2001) reported that application of vermicompost in agricultural fields increased the N, P, and K uptake by rice crop.

Gutiérrez-Miceli et al. (2007) reported that application of sheep-manure vermicompost in tomato crop increased the plant heights and crop yield. Addition of sheep-manure vermicompost decreased soil pH and acidity. The tomatoes harvested from the vermicompost applied agricultural fields had higher carbohydrate content. Arancon et al. (2008) reported that application of vermicomposts produced enhanced germination, growth and flowering of petunia plant. The effects of neem (*Azadirachta indica*) vermicompost were studied on the growth and yield of Brinjal (*Solanum melongena*) by Gajalakshmi and Abbasi (2004). Sangwan et al. (2010) conducted a pot culture experiment to assess the quality of vermicompost produced from filter cake mixed with cow and horse dung on the growth and productivity of marigold. The filter cake + cow dung and horse dung vermicomposts have higher manurial value and synergistically affected the growth and productivity of crop. Addition of 10 and 20 % pig manure-based vermicompost in media mixes had positive effects on plant growth (Bachman and Metzger 2008). Roberts et al. (2007) investigated the effect of *Dendrobaena veneta*-derived vermicompost on the germination, growth, yield, marketability and vitamin C content of tomatoes. The results showed that vermicompost significantly increased germination rates (176 %) and improved the marketability of fruits at 40 and 100 % substitution rates due to the lower incidence of physiological disorders (blossom end rot and fruit cracking).

Singh and Wasnik (2013) studied the effect of vermicompost and chemical fertilizer on growth, herb, oil yield, nutrient uptake, soil fertility, and oil quality of Rosemary (*Rosmarinus officinalis* L.). Results revealed that application of vermicompost (8 t ha^{-1}) + fertilizer nitrogen (N)–phosphorus (P)–potassium (K) (150:25:25 kg ha^{-1}) produced optimum herbage and oil yield of rosemary compared with control (no fertilizer) and was found to be on par with application of fertilizer NPK 300:50:50 kg ha^{-1}.

Doan et al. (2013) studied that the interactions between compost, vermicompost and earthworms influence plant growth and yield in greenhouse experiment on maize–tomato–maize cycle for 1 year. The results revealed that application of vermicompost led to a similar yield as the control treatment for the first maize planting. However, its beneficial influence decreased during the experiment until it was similar to that of the compost treatment. The presence of earthworms reduced the C content in soil mixed with compost and vermicompost but only influenced plant growth and yield in the compost treatment. The effect of earthworms was initially null (i.e., for the first maize crop), positive (i.e., for tomato planting) and finally negative (i.e., for the second maize planting), thereby underpinning the complexity of the interactions between the quality of organic matter in soil, earthworm activity and plant growth.

Sarangi and Lama (2013) studied the vermicomposting of rice straw using earthworm (*Eudrilus eugeniae*) or fungal inoculant (*Trichoderma viridae*) and its utilization in rice (*Oryza sativa*)–groundnut (*Arachis hypogaea*) cropping system. The results revealed that application of vermicompost prepared with 5.0 % of lime increased the soil microbial biomass by 147 % over control and the same was increased by 51 % due to application of *T. viridae* compost prepared with 2.5 % lime. The grain and pod yields of upland rice and groundnut increased by 120 and 107 %, respectively, over control due to application of vermicompost prepared with 5.0 % lime @ 6.0 t/ha in rice crop. A bibliographic survey indicated that vermicompost produced from different wastes have different physico-chemical properties and different vermicomposts may have different impacts on the crops. So it is essential to study the effects of different vermicomposts on crops to explore their beneficial effects and avoid phytotoxicity, if any. Marigold is one of the most commonly grown flowering plants for garden decoration due to its easy culture and wide adaptability. It is extensively used as loose flowers for making garlands for religious and social functions. Marigold is a short duration crop to produce marketable flowers. But very few studies have focused on growth and productivity of ornamental plants in organic potting media (Arancon et al. 2008). The present investigation was undertaken to investigate the effect of the application of vermicompost prepared from household solid waste on the growth and productivity of marigold.

Materials and methods

The source-separated household solid waste containing mainly kitchen waste, vegetable peel off, paper products, plant leaves and other organic refuge was collected from a residential area of Sector 7 in Gurgaon city, India. Since one of the most notable characteristics of household solid waste is its heterogeneity, a large quantity of waste material was collected and representative organic waste samples were obtained after a thorough mixing of all samples. The non-biodegradable materials such as glass, gravel, plastics, metals, etc., were removed with hand sorting. Then, the organic waste was crushed, shredded and used for further vermicomposting studies. The cow dung (CD) was used as the bulking agent to enhance the efficiency of vermicomposting process. It was procured from an intensively livestock farm at Hisar, Haryana, India. The initial physico-chemical characteristics of raw HSW and CD wastes are given in Table 1. *E. fetida* hatchlings as well as clitellated adults were randomly picked for use in the experiments from stock cultures, maintained in the laboratory. The nutrient status of the soil and different vermicomposts is given in Table 2. The soil was procured from the Energy Park of G.J.U.S&T, Hisar. It was sandy loam (Ustic Haplocambid) in nature with average phosphorus, sufficient potassium and deficit nitrogen content.

Table 1 Physico-chemical characteristics of CD and HSW (Mean ± SE, $n = 3$)

S. no.	Parameter	CD	HSW
1	pH	8.2 ± 0.12	7.6 ± 0.17
2	EC (dS m^{-1})	1.26 ± 0.02	1.96 ± 0.05
3	Ash content (g/kg)	220 ± 13.3	140 ± 7.5
4	TOC (g/kg)	452.4 ± 7.7	498 ± 3.9
5	OM (%)	78 ± 1.33	86 ± 0.75
6	TKN (g/kg)	8.1 ± 0.23	11.2 ± 0.40
7	TP (g/kg)	7.45 ± 0.30	2.06 ± 0.05
8	TK (g/kg)	9.48 ± 0.42	10.5 ± 0.23
9	C:N ratio	55.8 ± 2.4	44.5 ± 1.85
10	Total-Cu (mg/kg)	82.8 ± 4.04	146.1 ± 5.7
11	Total-Fe (mg/kg)	1,545 ± 12.7	536 ± 5.3
12	Total-Mn (mg/kg)	111 ± 6.9	29 ± 1.4
13	Total-Zn (mg/kg)	183 ± 2.9	113 ± 5.7

To prepare vermicompost, 10 kg (on dry weight basis) of each waste mixture [100 % Cow dung (V_1), and 30 % House hold waste + 70 % Cow dung (V_2)] were prepared, pre-composted for 1 month and vermicomposted using *Eisenia fetida* earthworm species for 3 months in circular plastic bins. The composition of the CD and HSW in the waste mixture was decided on the basis of the available literature. The waste mixtures were maintained in triplicates. The moisture content was maintained at 60–80 % of water holding capacity, during the study period, by periodic sprinkling of water. The bins were covered with jute cloth to protect from light and predators. At the end of experiment, worms, cocoons and hatchlings were removed from the vermicomposts and vermicomposts were stored for 1 month for maturation for further use in potting media experiments.

The physico-chemical analysis of raw wastes and vermicomposts was done on dry weight basis. All the chemicals used were analytical reagent (AR) grade supplied by S.D. Fine Chemicals, Mumbai, India. Double-distilled water was used for analytical work. The Physico-chemical analysis was carried out as reported by Gupta and Garg (2008).

French marigold (*Tagetes patula)* saplings were procured from Shyam Nursery, Hisar (India). The plants were in a four and a half leaf stage and almost of same size. Seven potting media were prepared by mixing soil and vermicomposts. The composition of different potting media is given below:

Table 2 Physico-chemical characteristics of soil and vermicomposts used in this study (Mean ± SE, $n = 3$)

Parameter	Soil (control)	Cow dung vermicompost (V_1)	HSW + cow dung vermicompost (V_2)
pH	8.7 ± 0.4	7.3 ± 0.05	7.5 ± 0.11
EC (dS/m)	0.1 ± 0.01	1.72 ± 0.02	1.75 ± 0.03
OM (%)	3.2 ± 0.3	49.0 ± 3.98	58.0 ± 3.46
TOC (g/kg)	18.6 ± 1.3	352 ± 5.2	336 ± 13.8
TKN (g/kg)	1.2 ± 0.4	16.5 ± 0.40	16.1 ± 0.64
TP (g/kg)	0.4 ± 0.06	12.48 ± 0.42	10.3 ± 0.68
TK (g/kg)	1.97 ± 0.3	13.7 ± 0.27	12.5 ± 0.35
Fe (mg/kg)	3,874 ± 114	3,667 ± 31.7	3,145 ± 38.1
Mn (mg/kg)	76 ± 12	257 ± 6.3	212 ± 6.9
Zn (mg/kg)	98 ± 23	378 ± 15.0	342 ± 10.9
Cu (mg/kg)	23 ± 04	167 ± 8.08	172 ± 6.06
C: N ratio	15.5 ± 3.2	17.3 ± 1.13	20.9 ± 0.98

1. T_1 Soil (S)—control (without vermicompost)
2. T_2-5 % V_1 + soil
3. T_3-10 % V_1 + soil
4. T_4-20 % V_1 + soil
5. T_5-5 % V_2 + soil
6. T_6-10 % V_2 + soil
7. T_7-20 % V_2 + soil

The marigold seedlings were planted in the potting media containing pots in first week of November as 18–20 °C climatic temperature is best for their growth. All the vermicomposts were applied as pre-plantation manures and no additional manure was added at any stage during the experiment. The vermicomposts were mixed thoroughly with soil before planting the saplings. Three replicates were maintained for each potting media. The plants were irrigated with tap water as and when required. The plant heights, total number of buds, total number of flowers, diameter of the biggest flower were recorded on 30, 45 and 60th day of the experiment. At the end of the experiment, plants were removed carefully from the potting media and separated in root and shoot. Then fresh root and shoot biomass was measured. After harvesting, soil samples were collected from each potting media, dried at room temperature and analyzed for various physico-chemical parameters as reported earlier by Sangwan et al. (2010).

All the data were subjected to mean averages and standard deviation. *t* test (test of significance) was applied to analyze the significant differences among different treatments for studied parameters. The probability levels used for statistical significance were $p < 0.05$ for the tests. The values shown in the figures are the mean values of three replicates with standard deviation.

Results and discussion

Initial characteristics of raw materials and different growth media

It is evident from Table 1, the pH of HSW and CD was alkaline (7.6 ± 0.17 and 8.2 ± 0.12, respectively). The EC of HSW was higher than CD. The ash content of HSW was lesser than CD; as a result, HSW contained more OM content (86 ± 0.75 %) than CD (78 ± 1.33 %). The TKN content in raw HSW was 11.2 ± 0.40 g/kg, and in CD, it was 8.1 ± 0.23 g/kg. The TP content of HSW was very low, i.e., 2.06 ± 0.05 g/kg as compared to CD, i.e., 7.45 ± 0.30 g/kg. The TK content was 9.48 ± 0.42 and 10.5 ± 0.23 g/kg in CD and HSW, respectively. The C: N ratio of HSW and CD was high, i.e., 44.5 ± 1.85 and 55.8 ± 2.4, respectively. The trace elements content (Cu, Fe, Mn and Zn,) in CD was comparatively higher than HSW.

Vermicomposting process significantly changed the physico-chemical properties of different waste mixtures (Table 2). The vermicompost was much darker in color, had good esthetics and processed into a homogeneous mixture after earthworm activity. The total amount of waste mixture was reduced 1.4–2.5 times after vermicomposting. This clearly indicated that the vermicomposting process significantly helps in abatement of organic matter pollution load in the environment. The physico-chemical characteristics and nutrient status of different substrates used as growing media in this study are given in Table 2.

The NPK content of both the vermicomposts was almost same but significantly higher than soil. The sandy-loam soil used in study was deficit in nitrogen and phosphorus (Table 2). Electrical conductivity (EC) of vermicompost was higher than soil, which may be due to the presence of more salts in the feed of cattle (Sangwan et al. 2010). The micronutrients content was significantly higher in vermicomposts than soil but was within permissible limits as recommended by European and American limits of micronutrients in the compost (Brinton 2000). The C:N ratios of the vermicomposts were 17.3 (V_1) and 20.9 (V_2). It was in range of a stabilized product for all types of growing media. It is reported that if C:N ratio is >20 plants cannot assimilate mineral nitrogen (Edwards and Bohlen 1996) and may affect the growth and flowering of marigolds in different growing media.

Effect of vermicomposts on marigold plant

Figure 1 represents the heights of marigold plants in different treatments with time. The minimum height was observed in control (soil) and maximum was observed in T_4 (at the end of the experiment). It was 2.3 times greater than control. In all the treatments, plant height increased with the percentage of the vermicompost in the soil. In cow dung vermicompost-containing treatments, maximum plant height was observed in treatment T_4 (Fig. 1). Similarly, in treatments containing HSW + cow dung vermicompost-containing potting media(T_5, T_6 and T_7), maximum plant height was observed in treatment T_7. Similar results of higher plant height with the use of pig manure vermicompost-amended potting media on tomatoes plants were observed by Atiyeh et al. (2000). The results revealed that the plants grown in potting media containing 20 % cow dung vermicompost had highest plant height followed by HSW + cow dung vermicompost. It may be due to more nutrient availability for plant growth in vermicomposts. Raviv et al. (1998) have attributed it to slow release of nutrients for absorption with additional nutrients like

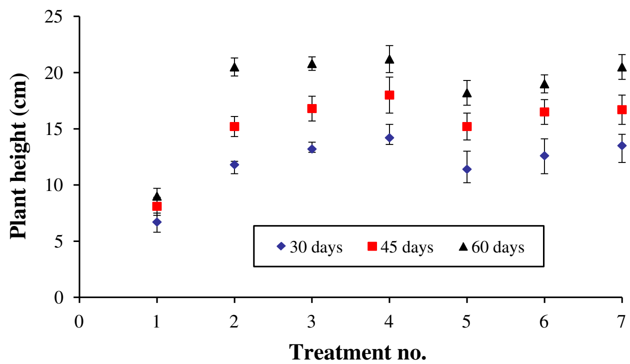

Fig. 1 Height of marigold plants grown in different treatments

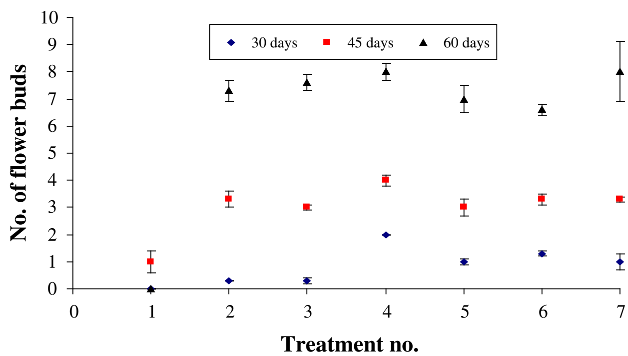

Fig. 2 Production of flower buds in marigold plants grown in different treatments

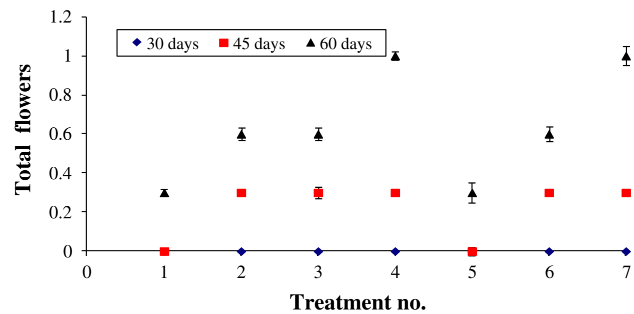

Fig. 3 Total number of flowers produced in different treatments

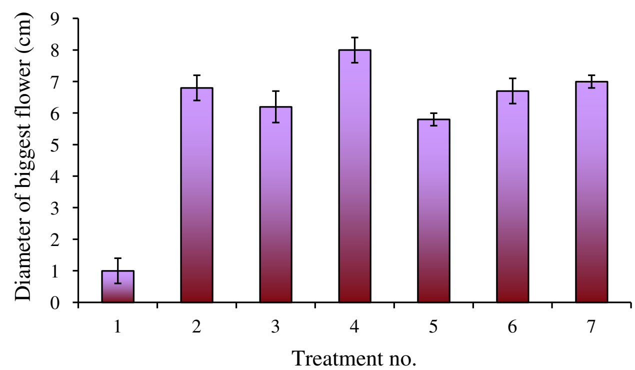

Fig. 4 Diameter of biggest flower of marigolds grown in different treatments

gibberellins, cytokinins and auxins, by the application of organic inputs like vermicompost in combination with vermin-wash. Arancon et al. (2008) have reported that different vermicompost dosages have different effects on plant growth. At higher vermicompost dosages in the potting media plant growth may be adversely affected due to higher salt content or excessive nutrient levels. Production of flower buds in different treatments at 30, 45 and 60 day is given in Fig. 2. The bud formation was started in first 30 days in all treatments except control (T_1). It was started after 40 days in T_1. After 60 days, total no. of buds was same in plants grown in cow dung vermicompost and HSW + cow dung vermicompost-containing potting media (Fig. 2). The flowering first sets in the potting media containing cow dung vermicompost (V_1), followed by HSW + cow dung vermicompost (V_2), and in last in the control (T_1) (Fig. 3). Maximum number of flowers was produced in treatments T_4 and T_7, i.e., 20 % cow dung vermicompost and 20 % HSW + cow dung vermicomposts, respectively. The diameters of the biggest flower in different treatments are given in Fig. 4. The diameter of the flowers was higher in vermicompost-containing potting media than control. The largest diameter was recorded in treatment T_4 followed by treatment T_7 and smallest diameter of plants was recorded in control (T_1). In control, the lesser growth of the plants resulted in production of smaller-sized flowers. The diameter of the flowers was 8.0 and 7.0 times more than control in treatment T_4 and T_7, respectively. The diameter of biggest flower increased with vermicomposts content in the potting media except in treatment T_3 (Fig. 4).

These results indicate that addition of vermicomposts enhanced the growth and productivity of marigold plants. Atiyeh et al. (2000) have reported that after amendments of 10–20 % vermicompost in potting media, the tomato fruit yields increased significantly. Subler et al. (1998) reported that optimum plant growth responses occurred when 10–20 % vermicompost was amended with potting media which may be due to enhanced micronutrient availability, the presence of plant growth regulators, or the activity of beneficial microorganisms in the vermicompost. But when vermicompost concentration was >40 % in the potting media then the number and diameter of the flowers reduced than control. These antagonistic effects at higher vermicomposts dosage may be due to reduction in aeration and porosity and increased salt concentrations (Tucker 2005). In the present study, potting media was amended up to 20 % with vermicomposts and no adverse effect of vermicomposts was recorded on any studied parameters.

The fresh shoot biomass, fresh root biomass and shoot root ratio are given in Figs. 5, 6 and 7, respectively. The

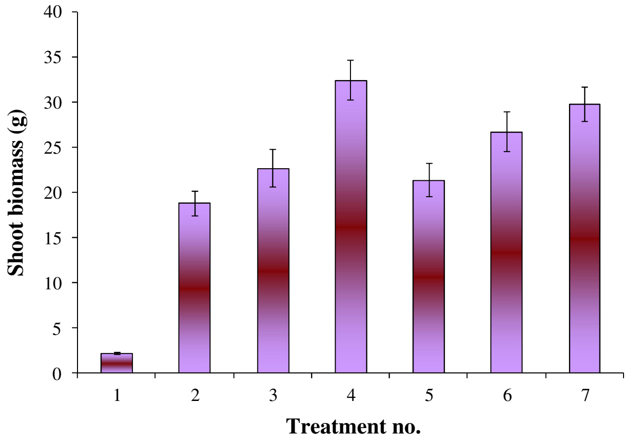

Fig. 5 Fresh shoot biomass of marigold plants in different treatments

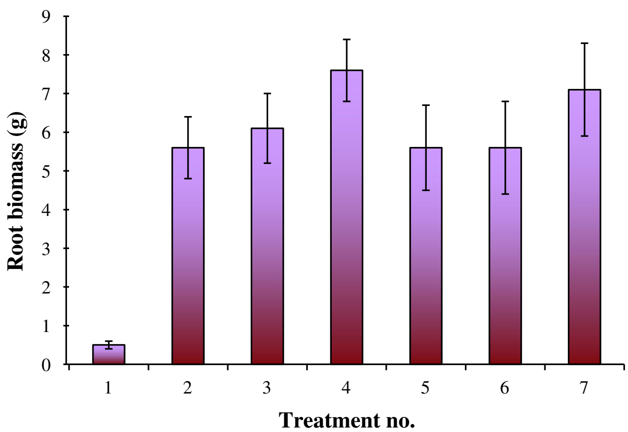

Fig. 6 Fresh root biomass of marigold plants in different treatments

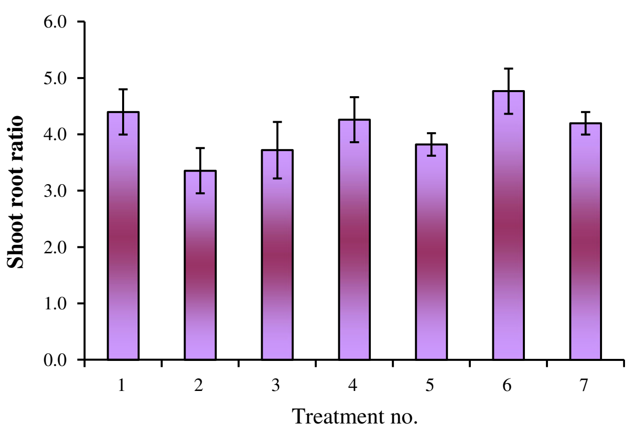

Fig. 7 Shoot root ratio of marigold plants in different treatments

fresh shoot biomass was highest in treatment T_4 followed by treatment T_7 and T_6, i.e., 14.7, 13.5 and 12.1 times higher than control, respectively (Fig. 5). Shoot biomass of the plants was directly influenced by the vermicompost content in the potting media. Maximum shoot biomass was recorded in the 20 % vermicompost-containing potting media (Fig. 5). Similar trend was observed for root biomass (Fig. 6). Lowest root biomass was recorded in control (T_1) and highest root biomass was recorded in T_4 (20 % cow dung vermicompost). The root biomass increased with the percentage of amendment in the potting media in different treatments. Maximum shoot root ratio was observed in treatment T_1 (Fig. 7). Keeling et al. (2003) reported that applying vermicompost tea to oilseed rape plants at the initial stage of growth increased both root development and plant growth.

Conclusions

The results indicate that the vermicompost prepared from cow dung and HSW + cow dung have higher manurial value and had significant effects on the growth and productivity of marigold plants than control (without amendments). The growth and flowering of plants was improved with the addition of vermicomposts in potting media in appropriate quantities. Maximum growth and productivity of marigold plants was observed in cow dung vermicompost-amended potting media. Although vermicomposts have shown potential in sustainable crop production but further studies are required to determine the long-term effects of vermicompost application in field conditions.

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