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Effect of different tannery sludge compost amendment rates on growth, biomass accumulation and yield responses of *Capsicum* plants

Jayara D.C. Silva [a], Tamara T.B. Leal [a], Ademir S.F. Araújo [a,*], Raul M. Araujo [a], Regina L.F. Gomes [a], Wanderley J. Melo [b], Rajeev P. Singh [c]

[a] *Federal University of Piauí, Agricultural Science Center, Soil Quality Lab., Teresina, PI, Brazil*
[b] *São Paulo State University, UNESP, Faculty of Animal and Agricultural Sciences, FCAV, Jaboticabal, SP, Brazil*
[c] *School of Industrial Technology, Universiti Sains Malaysia, Pulau Penang, Malaysia*

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ABSTRACT

Composting has been recognized as one of the most cost effective and environmentally sound alternatives for organic wastes recycling from long and composted wastes have a potential to substitute inorganic fertilizers. We investigated the potential of composted tannery sludge for ornamental purposes and to examine the effects of two different composts and concentrations on ornamental *Capsicum* growth. The two composts were produced with tannery sludge and the composition of each compost was: compost$_1$ of tannery sludge (C_1TS) – tannery sludge + sugarcane straw and cattle manure mixed in the ratio 1:3:1 (v:v:v); compost$_2$ of tannery sludge (C_2TS) – tannery sludge + "carnauba" straw and cattle manure in the ratio 1:3:1 (v:v:v). Each compost was amended with soil at rates (% v:v) of 0%, 25%, 50%, 75% and 100% (designation hereafter as T_1–T_5, respectively). The number of leaves and fruits were counted, and the stem length was also measured. Chlorophyll content was recorded on three leaves of each harvested plant prior to harvest. Number of leaves and fruits, stem length, dry weight of shoot and roots did not vary significantly between the plants grown in two tannery composts. All the treatments with composted tannery sludge application (T_2–T_5) significantly increased the number of leaves and fruits, stem length and chlorophyll content compared with the control (T_1). The chlorophyll content was higher in plants growing in the C_1TS compared to C_2TS. The results of the present study further suggest that *Capsicum* may be a good option to be grown on composted tannery amended soil.

1. Introduction

Tannery industries occupies important place in a Brazilian economy, with assets of about 21 billions of dollars, and release, annually, more than 1 million tonnes of tannery sludge (Pacheco, 2009) with 3% total solids (Silveira et al., 2002). In Brazil, there is no set methodology for tannery sludge disposal and the common disposal method is land filling. The high annual production of tannery sludge has created a series of economical, social and environmental problems.

The tannery sludge usually contains high organic matter, chemical nutrients and heavy metal, mainly chromium (Cr^{3+}) (Castilhos et al., 2002). The occurrence of metals (especially Cr, Fe, Mn, Zn, Cu, Pb, Ni and Cd) in complex form in tannery sludge is cause of serious concern due to chances of food chain contamination and risk to human health (Gupta and Sinha, 2007). Tannery sludge, which are classified as hazardous, are frequently deposited above the ground, representing a serious risk for soil, vegetation and groundwater. The safe disposal of sludge is one of the major environmental concerns worldwide.

Land filling and land application of the sludge are suggested as the most commonly recommended disposal techniques (Singh and Agrawal, 2009, 2010). However, land filling is not suitable method due to the fact that a large volume of soil is required to cover the waste in order to prevent the leaching of potentially toxic compounds (Chandra et al., 2008).

Additionally, land filling is also becoming more expensive due to limited land mass and industries consequently have to look for cheaper ways of disposal their wastes. Thus, there is a necessity to find news methods for recycling and recovery of organic waste as an alternative to land filling (Ahlberg et al., 2006). Composting has been recognized from long as one of the most cost effective and environmentally sound alternative for organic wastes recycling (Araújo and Monteiro, 2006; Araújo et al., 2007; Singh and Agrawal, 2010). During composting process, there is decomposition of organic matter to carbon dioxide, water vapor, inorganic nutrients and stable organic material containing humic-like substances (Senesi, 1989). Additionally, composting can also be applied to reduce pathogens and toxic organic compounds (Araújo

* Corresponding author. Tel.: +55 86 3215 5740; fax: +55 86 3215 5743.
E-mail address: asfaruaj@yahoo.com.br (A.S.F. Araújo).

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and Monteiro, 2005; Singh and Agrawal, 2010). This method has been used to process the sludge of different origins, such sewage sludge and textile sludge (Bernal et al., 1998; Araújo and Monteiro, 2006; Araújo et al., 2007).

However, heavy metals do not biodegrade during composting process and can be concentrated due to the loss of carbon and water from the compost due to microbial respiration (Richard, 1992). Thus, the application of composted tannery sludge in agriculture may lead a risk for humans and the environment as a result of heavy metals and toxic organic compounds accumulation to high levels enough to cause damage, such as soil contamination, phytotoxicity, and the accumulation of trace elements in the food supply. On the other hand, the application of composted tannery sludge to flowering or ornamental plants in pots has several advantages such as: (i) these crops are non-edible therefore minimizes the direct human exposure; and (ii) plants are generally located in small pots. Thus, the more suitable recycling of sludge is its application on flowering and ornamental plants, which reduces the risks of potential toxins entering into the human food chain (Gao et al., 2008).

Capsicum sp. is used as ornamental plant in all Northwest of Brazil due the color of flowers and fruits. In order to improve its growth and commercial value fertilizers are needed. Composted tannery sludge may have a potential to be used as fertilizer. With this point of view, we investigated the potential of composted tannery sludge for ornamental plant and to examine the effects of two different composts incorporated in soil at five different concentrations on ornamental *Capsicum* growth, biomass and yield.

2. Materials and methods

2.1. Study area

The study was conducted in Zootecny Department from Agriculture Science Center, Federal University of Piauí, Brazil (05° 05′21″ S latitude, 42° 48′07″ W longitude and 74 m above the sea level). The climate is tropical dry ($C_1WA_4^{a'}$) according to Köppen with a mean precipitation of 1300 mm year^{-1} (Peel et al., 2007). The soil type is an Orthic Acrisol (FAO Soil Classification).

2.2. Experimental design

The two composts were produced with tannery sludge obtained from the wastewater treatment plant of a tannery mill located at Teresina City, Piauí State, Brazil. The composition of each compost was: compost$_1$ of tannery sludge (C_1TS) – tannery sludge + sugarcane straw and cattle manure mixed in the ratio 1:3:1 (v:v:v); compost$_2$ of tannery sludge (C_2TS) – tannery sludge + "carnauba" straw and cattle manure in the ratio 1:3:1 (v:v:v). The chemical characteristics of each raw material used in the mixture are shown in Table 1. The composting processes (for research facility) were carried out using the Beltsville aerated-pile method (USDA, 1980) for 85 days. The size of each pile was 2 m by 1 m (side to side) and 1.5 m of height. The piles were turned twice during the first and second week and once a week during the rest of the bio-oxidative phase. The bio-oxidative phase of composting was considered finished when the temperature of the pile was stable and near to that of the surrounding atmosphere (30 °C). This stage was reached after 55 days of composting and then the turnings were stopped to allow the compost to mature over a period of 30 days. In both piles, the temperature increased quickly at the beginning of the process to high thermophilic values (70 °C), which contribute to the hygiene of the end product due to pathogen, weed and seed reduction.

At 85th day, twenty subsamples were collected, randomically, from each compost to produce a composite sample. The chemical characteristics of both composts were determined by EPA 3051 method (USEPA, 1986).

Table 1
Chemical properties of the raw materials used in both composts.

Parameters	Cattle manure	Sugarcane straw	"Carnauba" straw
C_{org} (g kg^{-1})	10.9	5.4	6.7
N (g kg^{-1})	1.2	0.2	0.1
P (g kg^{-1})	1.5	0.5	0. 3
K (g kg^{-1})	0.8	0.4	0.5
Ca (g kg^{-1})	4.7	3.1	2.5
Mg (g kg^{-1})	2.5	1.0	1.7
S (g kg^{-1})	9.4	0.9	0.5
Cu (mg kg^{-1})	7.4	1.6	1.5
Fe (mg kg^{-1})	163.3	nd	nd
Mn (mg kg^{-1})	nd	nd	nd
Zn (mg kg^{-1})	0.3	nd	nd
Mo (mg kg^{-1})	0.1	nd	nd
Ni (mg kg^{-1})	nd	nd	nd
Cd (mg kg^{-1})	nd	nd	nd
Cr (mg kg^{-1})	nd	nd	nd
Pb (mg kg^{-1})	nd	nd	nd

C_{org} – organic carbon.
nd – Not detected.

Table 2
Chemical properties of compost$_1$ of tannery sludge (C_1TS) and soil at different C_1TS ratios.

Parameters	0% C_1TS	25% C_1TS	50% C_1TS	75% C_1TS	100% C_1TS
C_{org} (g kg^{-1})	5.2	41.5	75.4	135.2	187.5
Humic substances (g C_{org} kg^{-1})	0.32	2.32	5.19	8.1	9.72
Humic acid (g C_{org} kg^{-1})	0.29	1.65	2.83	3.52	5.45
Fulvic acid (g C_{org} kg^{-1})	0.21	1.01	1.82	2.51	4.22
Humin (g C_{org} kg^{-1})	3.1	31.6	69.0	138.6	177.8
N (g kg^{-1})	0.12	0.45	1.2	1.7	2.37
P (g kg^{-1})	0.41	0.91	1.89	2.94	4.02
K (g kg^{-1})	1.5	0.87	1.93	2.43	3.25
Ca (g kg^{-1})	2.36	23.1	40.5	73.2	95.33
Mg (g kg^{-1})	0.47	2.0	3.7	6.2	8.80
S (g kg^{-1})	0.7	2.4	5.3	7.4	9.39
Cu (mg kg^{-1})	1.9	3.6	6.5	13.7	17.8
Fe (mg kg^{-1})	53.1	1238.7	2781.9	3791.0	5171.6
Mn (mg kg^{-1})	93.2	459.0	783.1	1383.7	1848.7
Zn (mg kg^{-1})	5.2	41.2	91.2	118.6	141.67
Mo (mg kg^{-1})	0.2	2.8	5.3	7.3	9.28
Ni (mg kg^{-1})	1.7	7.3	12.4	16.9	21.9
Cd (mg kg^{-1})	nd	0.79	1.43	1.80	2.87
Cr (mg kg^{-1})	nd	4530.7	10428.4	17835.9	22255.0
Pb (mg kg^{-1})	nd	9.7	17.5	26.7	42.6

C_{org} – organic carbon.
nd – Not detected.

2.3. Soil analysis

Soil samples collected in triplicate from 0 (control), 25%, 50%, 75% and 100% C_1TS and C_2TS amendment and they were air dried, crushed, passed through a sieve of 2 mm mesh size and then stored separately for further chemical analyses.

Soil organic C content was measured by the loss on ignition method with sample ashing at 550 °C. The total N was measured with the Kjeldahl method. Total P was determined by the Olsen method. Exchangeable K, Ca and Mg were measured by extracting the soil sample with 1 N CH_3COONH_4. Extractable Zn, Cu, Fe, Mo, Mn, Ni, Cd, Cr and Pb were measured by extraction using DTPA with quantitative determination by atomic absorption spectrometry (USEPA, 1986).

2.4. Raising of plants

Capsicum spp. from germplasm bank of UFPI (genotype UFPI-12) was chosen for the experiment, which is a special kind of plant used in Brazil for ornamental use. Each compost was amended with soil at rates (% v:v) of 0 (control), 25%, 50%, 75% and 100% (designation hereafter as T_1–T_5, respectively). Four pots each were prepared for different treatments, having total number of 20 pots per compost. Composted tannery sludge was mixed uniformly with soil and left for 10 days in the field for stabilization. Before filling the pots of respective treatments, separate heaps were again mixed properly. No fertilization was provided before or during the entire study. Two seeds per pot were sowed at 0.5 cm depth and after emergence seedlings were thinned to one plant per pot. The plants were grown in pots (15 cm diameter and 10 cm height, respectively) located in a greenhouse.

The plant was grown for 150 days in a greenhouse with controlled temperature (28–30 °C) and relative humidity (60–70%). During this period, no additional sludge or soil was applied, nor any pesticides. The plants were irrigated, in accordance with their water demand, with distilled water during the growing period, the irrigation scheduling and water quantity being equal for all treatments. The plants were harvested after 150 days of sowing and repeatedly washed with tap water to remove any attached particles.

The number of leaves and fruits were counted, and the stem length (from the soil level to the end of the plant) was also measured. Prior to harvest, chlorophyll content was recorded for three leaves of each plant with a hand-held meter (Minolta, SPAD-502®) operating at 640 and 940 nm wavelengths.

The plants were dried at 65 °C until constant weight was achieved. The dry weights of shoot and roots were then measured to determine the effect of various compost loadings on the growth of *Capsicum* plants.

2.5. Statistical analysis

Statistical analysis were performed using analysis of variance, with Tukey's multiple-range test used to evaluate the significance of the effects of these composts and concentrations on plant growth.

3. Results

Chemical properties of both C_1TS and C_2TS concentrations in this study are shown in Tables 2 and 3. Both composts were found to be higher in organic carbon as well as humic substances as compared to unamended soil (T_1, control). The C_1TS and C_2TS amendment in soil also led to higher nutrients and heavy metal content when compared with unamended soil. Concentration of Cd, Cr and Pb was undetectable in control soil. The concentration of nutrients as well as heavy metals increased with increase of compost amendment ratios being higher at higher compost ratio. The trend was similar after both the C_1TS and C_2TS amendments. Increase in concentration of nutrients as well as heavy metals with increasing compost ratio can be attributed to high nutrients as well as heavy metal concentration in both composts.

Number of leaves and fruits, stem length, dry weight of shoot and roots did not vary significantly between the plants grown in the C_1TS and C_2TS (Tables 4 and 5). All the treatments with tannery sludge compost application (T_2–T_5) significantly increased the number of leaves and fruits, stem length and chlorophyll content compared with the control (T_1). Number of leaves did not vary significantly between plants grown at T_2, T_3 and T_4 treatments by use of C_1TS. Stem length of *Capsicum* plant was not different, significantly, between plants grown in T_3, T_4 and T_5 treatments of C_1TS (Table 4). There were not differences for root biomass between plants grown in T_3, T_4 and T_5 treatments of C_2TS (Table 5). All the parameters increased at highest amendment rate of both composts. The highest mean values for number of leaves (85 and 125 leaves pot^{-1} with C_1TS and C_2TS, respectively) and fruits (20 fruits pot^{-1} with the both C_1TS and C_2TS) and stem length (22.3 and 23.3 cm with C_1TS and C_2TS, respectively) chlorophyll content (45.0 and 37.2 with C_1TS and C_2TS, respectively) were obtained in the T_5 treatment (100% compost) whereas the lowest values were observed in the T_1 (control). Among the treatments with compost application, the maximum values for number of leaves and fruits and chlorophyll content occurred in T_5 that were significantly different from the T_4, T_3 and T_2. The lowest weights of shoot (0.27 and 0.33 g per pot with C_1TS and C_2TS, respectively) and roots (0.10 and 0.12 g per pot with C_1TS and C_2TS, respectively) were found in the T_1 (control) that were significantly lower than others treatments. The highest values of dry weight of shoot and roots were observed in the T_5 treatment being significantly different from each other (Table 5).

The chlorophyll content was higher in plants growing in the C_1TS and C_2TS compared with control (Table 6). The highest mean values for chlorophyll content (45.0 and 37.2 with C_1TS and C_2TS, respectively) were obtained in the T_5 treatment (100% compost) whereas the lowest values were observed in the T_1 (control) (Table 5).

These results indicate that composted tannery sludge at 100% promotes a beneficial effect on number of leaves and fruits and increase chlorophyll content. The application of maximum concentration of both composts (T_5) promoted an increase in stem length that was slightly but not significantly more than in the T_4 treatment. Both these lengths were significantly higher than in the T_3, T_2 and T_1 (control).

4. Discussion

All the chemical parameters such as C_{org}, humic substances, nutrient contents and heavy metal content in soil increased with increasing compost rates. As the tannery sludge (100%) contains

Table 3
Chemical properties of compost$_2$ of tannery sludge (C_2TS) and soil at different C_2TS ratios.

Parameters	0% C_2TS	25% C_2TS	50% C_2TS	75% C_2TS	100% C_2TS
C_{org} (g kg^{-1})	5.2	76.5	128.5	193.8	266.5
Humic substances (g C_{org} g^{-1})	0.32	2.17	4.9	8.2	11.07
Humic acid (g C_{org} kg^{-1})	0.29	1.13	2.6	4.14	5.54
Fulvic acid (g C_{org} kg^{-1})	0.21	1.56	2.89	3.92	5.32
Humin (g C_{org} kg^{-1})	3.1	40.6	73.8	183.7	255.5
N (g kg^{-1})	0.12	0.27	0.49	0.89	1.28
P (g kg^{-1})	0.41	1.16	2.53	2.96	3.80
K (g kg^{-1})	1.5	3.7	8.3	10.5	11.46
Ca (g kg^{-1})	2.36	11.46	20.2	32.8	49.38
Mg (g kg^{-1})	0.47	1.69	2.87	3.91	5.84
S (g kg^{-1})	0.7	2.0	4.7	5.32	6.74
Cu (mg kg^{-1})	1.9	3.6	5.6	7.3	14.4
Fe (mg kg^{-1})	53.1	582.5	1373.0	1529.0	1832.5
Mn (mg kg^{-1})	93.2	429.7	791.6	986.8	1290.0
Zn (mg kg^{-1})	5.2	13.6	30.2	40.2	59.5
Mo (mg kg^{-1})	0.2	0.93	1.59	2.48	3.29
Ni (mg kg^{-1})	1.7	6.4	13.4	15.7	19.0
Cd (mg kg^{-1})	nd	0.43	0.79	1.14	1.48
Cr (mg kg^{-1})	nd	2831.5	4421.3	5928.3	7852.5
Pb (mg kg^{-1})	nd	4.82	7.36	11.7	15.7

C_{org} – organic carbon.
nd – Not detected.

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Table 4
Variations in number of leaves and fruit, and length of stem plant of *Capsicum* plant grown at different composted tannery sludge (C_1TS and C_2TS) amendment ratios (mean ± SE).

Treatment	Number of leaves (plant^{-1})		Number of fruits (plant^{-1})		Stem length (cm) (plant^{-1})	
	C_1TS	C_2TS	C_1TS	C_2TS	C_1TS	C_2TS
T_1	34 ± 5.9^c	29 ± 3.1^d	2 ± 0.3^d	5 ± 1.2^c	13.4 ± 1.6^c	16.4 ± 2.7^d
T_2	62 ± 9.2^b	53 ± 6.7^c	5 ± 0.8^c	7 ± 2.0^c	15.6 ± 1.9^b	19.9 ± 2.6^c
T_3	69 ± 8.4^b	92 ± 9.5^b	12 ± 1.4^b	13 ± 4.1^b	20.5 ± 3.5^a	20.9 ± 3.1^{bc}
T_4	69 ± 9.7^b	100 ± 10.4^b	13 ± 1.3^b	19 ± 4.9^a	20.6 ± 3.9^a	22.6 ± 3.9^{ab}
T_5	85 ± 11.3^a	125 ± 11.7^a	20 ± 1.9^a	20 ± 4.6^a	22.3 ± 4.1^a	23.3 ± 4.3^a

T_1: 0% (control); T_2: 25%, T_3: 50%; T_4: 75%; T_5: 100%.
Different letters in each group show significant difference at $p < 0.05$.

Table 5
Effect of composted tannery sludge (C_1TS and C_2TS) on the biomass of *Capsicum* plant grown at different amendment ratios (mean ± SE).

Treatments	Shoot biomass (g plant^{-1})		Root biomass (g plant^{-1})	
	C_1TS	C_2TS	C_1TS	C_2TS
T_1	0.27 ± 0.01^d	0.33 ± 0.06^e	0.10 ± 0.02^d	0.12 ± 0.03^c
T_2	0.57 ± 0.02^c	0.59 ± 0.05^d	0.21 ± 0.05^c	0.32 ± 0.07^b
T_3	0.76 ± 0.04^b	0.88 ± 0.05^c	0.34 ± 0.07^b	0.45 ± 0.11^a
T_4	0.78 ± 0.03^b	1.13 ± 0.08^b	0.36 ± 0.08^b	0.47 ± 0.10^a
T_5	1.06 ± 0.08^a	1.31 ± 0.10^a	0.51 ± 0.12^a	0.53 ± 0.09^a

T_1: 0% (control); T_2: 25%, T_3: 50%; T_4: 75%; T_5: 100%.
Different letters in each group show significant difference at $p < 0.05$.

Table 6
Effect of composted tannery sludge (C_1TS and C_2TS) on the chlorophyll content of leaves of *Capsicum* grown at different amendment ratios (mean ± SE).

Treatments	Chlorophyll content	
	C_1TS	C_2TS
T_1	30.7 ± 5.6^c	22.6 ± 5.6^c
T_2	36.7 ± 5.6^b	30.9 ± 5.6^b
T_3	36.2 ± 5.6^b	35.4 ± 5.6^a
T_4	38.7 ± 5.6^b	36.0 ± 5.6^a
T_5	45.0 ± 5.6^a	37.2 ± 5.6^a

T_1: 0% (control); T_2: 25%, T_3: 50%; T_4: 75%; T_5: 100%.
Different letters in each group show significant difference at $p < 0.05$.

higher organic carbon, nutrient and heavy metal concentrations as compared to unamended soil, their amendment at different ratios led to higher concentrations of C_{org}, humic substances, nutrient contents i.e. total N, K and heavy metals at different compost rates. Gupta and Sinha (2006, 2007) reported increase in different chemical properties such as C_{org}, available nutrient and heavy metal content at different tannery sludge amendment rate in soil. Others authors reported an increase in soil chemical properties due to sewage sludge amendment (Moreno et al., 1997; Logan and Harrison, 1995; Singh and Agrawal, 2007, 2009, 2010).

Concentrations of heavy metals were higher with increase in compost amendment rates. Ailincăi et al. (2007) found a similar trend of Cu, Ni and Cr in 40 and 60 t ha^{-1} sewage sludge amended soil. The composted tannery sludge obtained from the wastewater treatment plant of a tannery mill located at Teresina City, Piauí State, Brazil was found to be lower in heavy metal concentration than that of Jajmau, Kanpur, India reported by Gupta and Sinha (2007). Also, the concentrations of heavy metals were below the limits established by Brazilian legislation (CETESB, 1999). On the hand, the Cr content was higher than the more restrictive maximum value allowed by the Brazilian legislation for use in agricultural soil. On the other hand, we used these tannery sludge composts as media growth for ornamental plant that it does not need to be planted in field.

Growth parameters and component wise biomass accumulation are frequently used for monitoring the effects of various variables, as these are the first and most easily accessible response of plants to any factors. Use of both composted sludge promoted differences in all variables of plant growth. Singh and Sinha (2004) reported an increment in root length of *Helianthus annus* up to 30% tannery sludge amendment thereafter it decreased significantly at 50%, 75% and 100% tannery sludge amendment at all the ages of observations. Shoot length, however increased at the tannery sludge amendment at all the ages of observations.

Similar effects of composts in growth media have been referred to by other researchers (Pinamonti et al., 1997; Atiyeh et al., 2001; Garcia-Gomez et al., 2002; Gupta and Sinha, 2006; Singh and Agrawal, 2009), which were mainly due to the great contribution of nutrients, especially N and P, by the tannery sludge composts.

Increments in plant biomass and yield (number of fruits) even at higher tannery sludge compost amendment rate suggest that *Capsicum* could be tolerant to increase in heavy metal concentrations. Total biomass of lady's finger plants (*Ablemuschus esculentus* L.) increased about 32% and 43% by use of 20% and 40% (v/v) concentration of sewage sludge amendment, respectively (Singh and Agrawal, 2009). Root, shoot and total biomass of *Beta chinensis* increased significantly due to sewage sludge amendment at the rate of 5%, 10%, 25% and 50% (v/v) (Wong et al., 1996). Gupta and Sinha (2006) reported that shoot length of *Sesamum indicum* var. T55 increased significantly up to 35% tannery sludge amendment thereafter it decreased. However root length was unaffected due to tannery sludge amendments.

As composted tannery sludge is rich in major nutrients, its amendment favoured the growth and development of *Capsicum* as compared to the plants grown in unamended soil. On the other hand, the tannery sludge compost caused no negative effects on total biomass of *Capsicum* once that according to Kapustka (1997), the total dry biomass provides the best indication of an adverse plant response to toxic substances.

In the present study significant increase in root biomass of *Capsicum* has been reported due to different CTS amendment as compared to plant grown in unamended soil. As the heavy metals pass through the root before they could affect the meristematic tissue and other activity in shoot. On the basis of the result of present study it can be interpretated that there was no hinderence with biomass allocation in root. However, the better chlorophyll content in plant grown in C_1TS indicates that the high plant nutrients contents, mainly N, P, K, and Mg in C_1TS may have increased the content of this pigment in plant. Increase in chlorophyll content in these plants could be due to a high accumulation of essential metals required for the growth of the plant. The chlorophyll formation is dependent of nitrogen, magnesium (Neals, 1956) and others nutrients such as sulphur, calcium, manganese and zinc (Mengel and Kirkby, 1987). Additionally, there were no negative effects of both composts to plant growth and chlorophyll formation. Sinha et al. (2007) reported increase in chlorophyll content of fenugreek (*Trigonella foenum-graecum* L.) grown at lower (10%, 25% and 35%), however the chlorophyll content decreased at higher tannery sludge amendment ratios (50% and 100%) as compared to control.

Singh and Agrawal (2007) reported 27% and 89% increase in total chlorophyll content of *Beta vulgaris* plant grown at 20% and 40% sewage sludge amendment (SSA), respectively, at 40 DAS, whereas total chlorophyll content decreased by 10% and 47%, in the same rates, at 60 days after sowing. The decrease in total chlorophyll content in *B. vulgaris* plant at 60 days of sowing can be attributed to high heavy metal accumulation in plants at later growing stage (Singh and Agrawal, 2007).

5. Conclusion

The present study clearly showed that tannery sludge compost amendment increased the different soil chemical parameters and nutrients contents in soil. Concentrations of Cu, Cd, Cr, Zn, Pb, Ni, Mo and Mn increased in soil due to composted tannery sludge amendment.

Availability of essential nutrients through tannery sludge compost amendment favourably affected the growth of plants leading to significant increases in biomass accumulation, chlorophyll content and yield of *Capsicum* grown under compost amendment.

The results of the present study further suggests that the use of ornamental plants, like *Capsicum*, may be a good option to be grown on tannery sludge compost amended soil as the plants showed tolerance under elevated heavy metal concentrations in soil.

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