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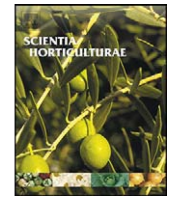

Sequential foliar application of vermicompost leachates improves marketable fruit yield and quality of strawberry (*Fragaria* × *ananassa* Duch.)

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ABSTRACT

The objective of the study was to determine the effect of foliar application of vermicompost leachates on growth, yield and quality of strawberry (Cv. Chandler). For this, three leachates collected from vermicomposting of cow dung (FCD), vegetable waste (FVW) and mixture of cow dung and vegetable waste in 1:2 ratio (FCVW) were used at 2 ml l^{-1} at monthly interval (total five sprays) in strawberry. The results indicated that foliar application of vermicompost leachates improved leaf area (10.1–18.9%), dry matter of plant (13.9–27.2%) and fruit yield (9.8–13.9%) significantly over control (water spray only). Foliar application of FCVW reduced albinism (from 12.1 to 5.7%), fruit malformation (11.2–8.5%) and grey mould (5.1–2.6%) thus improving marketable fruit yield (26.5% higher) with firmer fruits of better quality. The foliar application of FCD and FVW also improved these parameters and resulted in to higher marketable fruit yield (12.6 and 17.8% higher, respectively) compared to control. The study confirmed that leachates derived from composting processes have potential use as foliar fertilization for strawberry.

1. Introduction

With the increasing need to conserve natural resources, recycling of organic wastes assumes major importance. The organic refuse wastes of plant and animal origin provides a good source of nutrients to improve soil productivity. The recycling of organic residues in soil can mitigate environmental hazards resulting from intensive agriculture. In this respect, vermicomposting technology using earthworms as versatile natural bioreactors for effective recycling of organic wastes is an environmentally acceptable means of converting waste into nutritious compost (Edwards, 1988; Orozco et al., 1996). During vermicomposting, the vermin-beds filled with composted wastes are fitted with a drainage and collection system (Gutierrez-Miceli et al., 2008). Vermicomposting process produces leachate due to the activities of micro-organism and draining of leachates is important to prevent saturation of the vermicomposting unit. Leachates thus derived from vermicomposting are regarded as beneficial and can be used as liquid fertilizer due to high concentration of plant nutrients (Jarecki et al., 2005; Gutierrez-Miceli et al., 2008; Tejada et al., 2008). Apart from its high nutrient content, vermicompost leachates also contribute to plant development due to presence of humic acids (Atiyeh et al., 2002; Arancon et al., 2004; Ordonez et al., 2006) which regulate many processes of plant development including macro and micronutrients absorption. Additionally, extract of composts are effective in the control of some diseases like apple scab and late blight of tomato (Weltezien, 1991; Utkhede and Koch, 2004). Gutierrez-Miceli et al. (2008) reported the use of vermicompost leachates as liquid fertilizer in sorghum. Similarly, Tejada et al. (2008) also reported the beneficial use of vermicompost leachates for production of good quality tomatoes and recommended that these leachates can effectively be utilized for agricultural purposes.

Strawberry is one of the most delicious fruit of the world, which is a rich source of vitamins and minerals, and has fabulous flavour and tantalizing aroma. In India, strawberry has become the most favourite fruit crop among the growers, especially near towns and cities, which has resulted a phenomenal increase in its area and production (Singh et al., 2007). The authors of this paper have

Abbreviations: FCD, leachate collected from cow dung vermicomposting; FVW, leachate collected from vegetable waste vermicomposting; FCVW, leachates collected from mixture of cow dung and vegetable waste (1:2 ratio) vermicomposting.

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earlier reported that vermicompost substitution improved marketable fruit yield of strawberry by reducing the incidence of physiological disorders and occurrence of gray mould indicating that vermicompost had significant role in reducing nutrient-related disorders and disease like Botrytis rot (Singh et al., 2008). However, there is no report available in literature, which indicates influence of leachates obtained during vermicomposting processes on strawberry production. It is hypothesized that application of leachates derived from vermicomposting may have positive effects on growth, marketable fruit yield and quality of strawberry. Hence, systematic and precise studies were conducted on 'Chandler' strawberry, which is the most favourite cultivar of this region.

2. Materials and methods

2.1. Experimental site and material

The studies were conducted at Central Institute of Post Harvest Engineering and Technology, Abohar (Lat 30 °09′N, Long. 74 °13′E, 185.6 m above mean sea level), Punjab, India. This region falls in semi-arid zone having hot summers (May–June) and mild winter (December to mid-February) with annual rainfall of about 180 mm, restricted mainly during July and August.

2.2. Collection of leachates during vermicomposting process

The organic solid wastes selected for this study were cow dung (CD), vegetable waste alone (VW) (constituted basically chopped stalk and leaves of vegetable waste); and a mixture of cow dung and vegetable waste in 1:2 proportion (CVW). The general properties of organic wastes at the start of the vermicomposting process are shown in Table 1. Plastic circular containers of appropriate size (25 cm diameter and 30 cm in depth) with pierced lid for aeration were used for the vermicomposting. The moisture levels of all the three organic wastes were maintained about 65–70% during the vermicomposting period by periodic sprinkling of water. All containers were kept in darkness at room temperature (24–26 °C). Five adult epigeic earthworms (*Eisenia fetida*) were introduced in each container. The vermicomposting process lasted 75 days for all the three processes. During this period, the leachate collected from each organic waste was took shelter and kept in refrigerator at 4 °C. The chemical composition of the leachates derived from organic wastes (CD, VW, and CVW) is shown in Table 1.

2.3. Treatments

Soil of experimental field was thoroughly ploughed and raised beds (25 cm height) of 4 m length and 1 m width were prepared at a distance of 50 cm. Healthy and disease free runners of 'Chandler' strawberry were planted at a spacing of 25 cm × 25 cm on raised beds during first week of October. The experiment was laid out in randomized block design with five replications. Each treatment consisted of 64 plants in a plot size of 400 cm × 100 cm and replicated five times. Irrigation was applied through drip system and all necessary cultural practices and plant protection measures were followed uniformly for all the treatments during the entire period of experimentation. The following treatments were applied: (1) FC, control, foliar spray with water only; (2) FCD, foliar fertilization with leachate collected from CD vermicomposting applied at 2 ml l^{-1}; (3) FVW, foliar fertilization with leachate collected from VW vermicomposting applied at 2 ml l^{-1} and (4) FCVW, foliar fertilization with leachates collected from mixture of CD and VW in 1:2 ratio vermicomposting applied at 2 ml l^{-1}. The foliar sprays (total five sprays) were made at the interval of 1 month, i.e. 30, 60, 90, 120 and 150 days after planting (DAP). All these sprays were done using a hand pressure sprayer at a volume of 1000 l ha^{-1} in the morning (9–10 a.m.) when wind speed was less than 10 km h^{-1}.

2.4. Observations recorded

Observations on plant mean leaf area (cm^2) and plant dry weight (g) were recorded on randomly selected five plants from each replication at 100 and 165 days after planting (DAP). The plants were harvested for assessment of plant mean leaf area, fresh and dry weight. For recording leaf area, all leaves of the randomly selected plants were removed and passed through leaf area meter (Singh et al., 2007). Leaves and stems were put in paper bags, dried at 60 °C for 92 h and weighed to measure dry weight. Data on fruit yield and yield attributing parameters were recorded on all harvest dates. Total fruit yield was calculated by taking all the harvested fruit on each picking and thereafter, fruit which were free from injury, albinism and malformation incidence and those with Botrytis rot symptoms were sorted out to calculate the marketable fruit yield. Randomly selected 100 normal fruit from each treatment were taken to calculate mean berry weight. Quality parameters like acidity, TSS, ascorbic acid content were measured as per AOAC (1989).

Table 1
Details of chemical composition of organic wastes before vermicomposting and leachates obtained during the vermicomposting.

Characteristics	Organic waste			Leachates		
	CD	VW	CVW	FCD	FVW	FCVW
pH (1:10 ratio)	7.2	7.9	7.4	–	–	–
Total C (g kg^{-1})	342	487	421	–	–	–
Total N(g kg^{-1})	6.1	4.9	5.4	–	–	–
Total P (g kg^{-1})	5.9	4.4	5.1	–	–	–
Total K (g kg^{-1})	6.8	5.1	5.6	–	–	–
Calcium (g kg^{-1})	21.2	14.1	17.5	–	–	–
Boron (g kg^{-1})	17.1	8.3	11.7	–	–	–
pH (1:10 ratio)	–	–	–	6.7	7.5	7.1
Total C (g l^{-1})	–	–	–	8.2	9.4	8.9
Total N(g l^{-1})	–	–	–	0.8	0.7	0.7
Total P (g l^{-1})	–	–	–	0.6	0.4	0.5
Total K (g l^{-1})	–	–	–	0.6	0.5	0.5
Calcium (mg l^{-1})	–	–	–	71	94	85
Boron (μg l^{-1})	–	–	–	151	182	191

CD: cow dung; VW: vegetable waste; CVW: mixture of cow dung and vegetable waste; FCD: leachate collected from cow dung vermicomposting; FVW: leachate collected from vegetable waste vermicomposting; FCVW: leachates collected from mixture of cow dung and vegetable waste vermicomposting. For organic wastes before the vermicomposting, data are the mean of seven samples. For leachates, data are the mean of five samples.

Table 2
Effect of vermicompost leachates on leaf area, dry weight of plant and total fruit yield of strawberry.

Treatments	Plant leaf area (cm^2)	Dry weight of plant ($g\,plant^{-1}$)		Fruit weight (g)		Total fruit yield ($g\,plant^{-1}$)
		100 DAP	165 DAP	100 DAP	165 DAP	
FC	211.5a*	517.4a	13.7a	32.4a	12.5a	281.7a
FCD	226.3 (7.0)b**	569.1 (10.1)b	14.6 (6.6)a	36.9 (13.9)b	12.8a	309.2 (9.8)b
FVW	232.4 (9.9)bc	589.8 (14.0)bc	15.3 (11.7)ab	38.2 (17.8)b	13.1a	314.2 (11.5)b
FCVW	238.9 (12.9)c	615.7 (18.9)c	15.8 (15.3)ab	41.2 (27.2)c	13.4a	320.8 (13.9)b

FC: foliar spray with water only (control); FCD: foliar fertilization with leachate collected from cow dung vermicomposting); FVW: foliar fertilization with leachate collected from vegetable waste vermicomposting); FCVW: foliar fertilization with leachates collected from mixture of cow dung and vegetable waste (2:1 ratio) vermicomposting).
* Means within the column with the same letter are not significantly different at $P \leq 0.05$).
** Figures in parenthesis is percentage increase over control (FC).

Firmness was determined on 25 fruit samples from each replicate with texture analyzer (TA-Hdi, Stable Micro Systems, UK) with the 2 mm diameter stainless steel probe. Fruit were tested equatorially at their maximum diameter with speed of cross-head 50 cm min^{-1}. The force was expressed in Newton (N). The fruit colour in terms of L, a, b values was determined using Hunterlab miniScan XE Plus colourimeter (HAL, USA, Model 45/0-L), where 'L' denotes the lightness or darkness, 'a' green or red, and 'b', blue or yellow colour of the samples. Before measuring the colour of samples, the colourimeter was standardized with black and white calibration tiles provided with the instrument. Incidence of albinism and malformation fruit were determined at each harvest by counting all albino, malformed and normal fruit and represented as percentage (%) (Singh et al., 2007). Incidence of grey mould (*Botrytis cinerea*) was determined in 50 randomly selected fruit from each treatment replication.

Twenty-five leaves with petiole from each plot were collected at 70, 105, 140 DAP and at final harvest for analysis of leaf Ca content. Similarly, 25 medium-sized fruit of equal weight and same ripening stage were collected for determining fruit Ca content. Leaves and fruit were washed in distilled water and bottled dry. Leaf samples were dried in a forced-draft oven at 70 °C and ground. Fruit samples were homogenated and then heated in a water bath at 50 °C. Finally, these samples were ashed and then dissolved in 0.5% HCl. Calcium content in the samples were determined by spectroscopy.

2.5. Data analysis

The data of different parameters were averaged and subjected to analysis, following standard procedures (Panse and Sukhatme, 1984). Data in percentage units (incidence of albinism, malformed fruits and grey mould) underwent arcsin transformation before subjected to analysis. Differences between means were evaluated using Duncan's Multiple Range Test at $P \leq 0.05$.

3. Results

3.1. Effect on growth and total fruit yield

Foliar application of vermicompost leachates (FCD, FVW and FCVW) improved the growth parameters like leaf area and dry weight of plant (Table 2). In general, application of vermicompost leachates produced significantly higher leaf area and dry weight of plant compared to control. Foliar application of FCVW resulted into highest leaf area and dry weight of plants at both stage of observation (Table 2). Application of FCVW produced 18.9 and 27.2% higher leaf area and dry weight of plant, respectively at final harvest compared to control (FC). Further, application of vermicompost leachates (FCD, FVW and FCVW) produced significantly higher fruit yield (9.8–13.9%) compared to control (FC), however, effect on fruit weight was found non-significant (Table 2). Foliar application of FCVW produced 13.9% higher fruit yield compared to control, however, the effect was at par among different vermicompost leachates (FCD, FVW and FCVW). Foliar application of FCD and FVW produced 9.8 and 11.5% higher fruit yield compared to control (FC).

3.2. Effect on nutrient content of leaf and fruits

Application of vermicompost leachates influenced the nutrient content of leaf at different stages of growth (Table 3). Leaf N, P, K and Ca content during experimentation period had highest values in plants fertilized with FCVW followed by plants fertilized with FCD and FVW and least in FC (Table 3). In general, N, P, K and Ca content of leaves fertilized with vermicompost leachates at different stages had higher concentration of these nutrients compared to control, however, some values were non-significant. Similarly, nutrient content of fruits were highest in plants fertilized with FCVW followed by FVW and FCD and least in control (Table 4). However, the effects of FCD and FVW on nutrient content of fruits were intermediate but significantly higher than control, except Ca concentration (Table 4).

3.3. Effect on physiological disorders, gray mould and marketable fruit yield

Foliar application of vermicompost leachates (FCD, FVW and FCVW) has influenced the occurrence of physiological disorders,

Table 3
Effect of vermicompost leachates on nutrient content of leaf at different stages.

Treatments	70 DAP	105 DAP	140 DAP	At final harvest
N ($g\,kg^{-1}$)				
FC	3.4a*	4.3a	4.9a	5.2a
FCD	3.9ab	4.8a	5.7b	6.0b
FVW	4.1b	5.0ab	6.4bc	6.4bc
FCVW	4.2b	5.4b	6.9c	7.3c
P ($g\,kg^{-1}$)				
FC	5.7a	6.5a	7.1a	8.6a
FCD	6.4a	7.4b	8.4b	9.3ab
FVW	6.8ab	7.9bc	8.9b	10.1b
FCVW	6.9ab	8.3	9.3bc	10.4b
K ($g\,kg^{-1}$)				
FC	17.2a	19.1a	21.4a	23.2a
FCD	18.4b	20.4ab	22.8b	24.5b
FVW	19.3bc	21.7b	23.4bc	25.7c
FCVW	20.1c	21.9b	24.1c	26.4c
Ca ($g\,kg^{-1}$)				
FC	8.4a	10.2a	12.4a	13.2a
FCD	8.6a	11.1a	12.7a	14.0a
FVW	9.0a	11.7a	13.1a	14.4ab
FCVW	9.1a	12.1ab	13.8ab	15.0b

FC: foliar spray with water only (control); FCD: foliar fertilization with leachate collected from cow dung vermicomposting); FVW: foliar fertilization with leachate collected from vegetable waste vermicomposting); FCVW: foliar fertilization with leachates collected from mixture of cow dung and vegetable waste (2:1 ratio) vermicomposting); *Means within the column with the same letter are not significantly different at $P \leq 0.05$.

Table 4
Effect of vermicompost leachates on nutrient content of fruit of strawberry.

Treatments	N ($g\,kg^{-1}$)	P ($g\,kg^{-1}$)	K ($g\,kg^{-1}$)	Ca ($mg\,kg^{-1}$)
FC	1.7a*	4.3a	11.2a	124a
FCD	2.3b	4.9a	12.3b	131a
FVW	2.4b	5.2ab	12.4bc	135a
FCVW	2.6b	5.6b	13.1c	139ab

FC: foliar spray with water only (control)); FCD: foliar fertilization with leachate collected from cow dung vermicomposting; FVW: foliar fertilization with leachate collected from vegetable waste vermicomposting; FCVW: foliar fertilization with leachates collected from mixture of cow dung and vegetable waste (2:1 ratio) vermicomposting; *Means within the column with the same letter are not significantly different at $P \leq 0.05$.

like albinism and fruit malformation and incidence of gray mould of 'Chandler' strawberry significantly (Table 5). Fruit harvested from plants, which were sprayed with vermicompost leachates (FCD, FVW and FCVW) have lesser incidence of albinism (8.4, 7.8 and 5.7%, respectively), fruit malformation (9.1, 8.7 and 8.5%, respectively) and gray mould (3.0, 2.8 and 2.6%, respectively) than those harvested from plants under control (FC). Interestingly, among vermicompost leachates (FCD, FVW and FCVW), foliar application of FCVW produced significantly lesser albino-fruits (5.7%), however, the effect on fruit malformation and occurrence of gray mould was found at par (Table 5).

Foliar application of FCD, FVW and FCVW has influenced the fruit number and marketable fruit yield significantly compared to control (Table 5). Maximum fruit numbers was observed with FCVW which was at par with FCD and FVW but significantly higher than control. With regard to marketable fruit yield, foliar application of FCD, FVW and FCVW resulted into significantly higher marketable fruit yield, which was 12.6, 17.8 and 26.5% higher, respectively, compared to control (Table 5).

3.4. Effect on fruit firmness, external colour and quality parameters

Foliar application of FCD, FVW and FCVW has significantly influenced fruit firmness, external colour and quality parameters (TSS, acidity, ascorbic acid content) of strawberry (Table 6). Fruit harvested from plants fertilized with vermicompost leachates (FCD, FVW and FCVW) were firmer (1.61, 1.64 and 1.68N) than those harvested from plants under control (1.48N). Further, fruit which received foliar fertilization of vermicompost leachates (FCD, FVW and FCVW) had more brightness (L: 34.2, 34.9 and 35.2, respectively), redness (a: 39.4, 39.9 and 40.1, respectively) and yellowness (b: 29.1, 28.7 and 29.1, respectively) than those in control, however the effect was non-significant. Similarly, such fruit have significantly higher TSS (7.9, 8.2 and 8.4%); ascorbic acid content (45.3, 46.4 and 47.3 mg/100 g pulp) and lower acidity (1.04, 0.98 and 0.95%) compared to control (Table 6).

4. Discussion

In our study, foliar application of vermicompost leachates (FCD, FVW and FCVW) at monthly interval improved the growth parameters like leaf area and dry weight of strawberry. This might be attributed to higher availability of nutrients and growth regulators to the plant fertilized with foliar application of vermicompost leachates. Tejada et al. (2008) have also reported higher plant growth of tomato with the foliar application of vermicompost leachates mainly due to presence of humic acid in the leachates. It has been demonstrated that humic acids increase the number of roots thereby stimulating nutrient uptake and plant growth and development (Alvarez and Grigera, 2005). Similarly, many workers have reported synergistic effect of vermicompost leachates on growth and yield of many crops (Jarecki et al., 2005; Gutierrez-Miceli et al., 2008; Ordonez et al., 2006; Tejada and Gonzalez, 2003). Thus, present study confirms our hypothesis that foliar application of vermicompost leachates has positive effect on the growth of strawberry plants when applied through foliar application.

Further, among different vermicompost leachates (FCD, FVW and FCVW), foliar application of FCVW showed superiority in terms of plant growth clearly indicating that FCVW have higher content of nutrients and humic acid, which might have influenced the plant growth favourably. The response of vermicompost leachates mainly depend on the chemical composition of the substrate used in the vermicomposting process (Tejada et al., 2008). In present study, leachates from FCVW might have produced higher content of humic acid thus improved the growth of plants remarkably compared to FVW and FCW. Tejada et al. (2008) also reported that vermicompost leachates developed from cow dung had higher

Table 5
Effect of vermicompost leachates on physiological disorders, fruit weight and marketable fruit yield of strawberry.

Treatments (g $plant^{-1}$)	Albinism (%)	Fruit Malformation (%)	Gray mould (%)	Number of fruits $plant^{-1}$	Marketable fruit yield
FC	12.1a*	11.2a	5.1a	17.6a	211.6a
FCD	8.4b	9.1b	3.0b	18.7ab	238.2 (12.6)b**
FVW	7.8b	8.7b	2.8b	19.8b	249.3 (17.8)bc
FCVW	5.7c	8.5b	2.6b	20.6b	267.7 (26.5)c

FC: foliar spray with water only (control); FCD: foliar fertilization with leachate collected from cow dung vermicomposting; FVW: foliar fertilization with leachate collected from vegetable waste vermicomposting; FCVW: foliar fertilization with leachates collected from mixture of cow dung and vegetable waste (2:1 ratio) vermicomposting.
* Means within the column with the same letter are not significantly different at $P \leq 0.05$.
** Figures in parenthesis is percentage increase over control (FC).

Table 6
Effect of vermicompost leachates on fruit firmness, colour and quality of strawberry.

Treatments	Firmness (N)	Colour			TSS (%)	Acidity (%)	Ascorbic acid (mg/100 g pulp)
		L	a	b			
FC	1.48a*	33.1a	38.6a	28.6a	7.3a	1.11a	43.1a
FCD	1.61b	34.2a	39.4a	29.1a	7.9b	1.04a	45.3b
FVW	1.64b	34.9a	39.9a	28.7a	8.2b	0.98ab	46.4bc
FCVW	1.68bc	35.2a	40.1ab	29.1a	8.4b	0.95b	47.3c

FC: foliar spray with water only (control); FCD: foliar fertilization with leachate collected from cow dung vermicomposting; FVW: foliar fertilization with leachate collected from vegetable waste vermicomposting; FCVW: foliar fertilization with leachates collected from mixture of cow dung and vegetable waste (2:1 ratio) vermicomposting; L: brightness; a: redness; b: yellowness.
* Means within the column with the same letter are not significantly different at $P \leq 0.05$.

nutrient content but performed poor in terms of growth and development of tomato mainly due to lesser amount of humic acid whereas vermicompost leachates derived from green foliage had higher content of humic acid that resulted into higher growth of tomato. In present study, foliar application of FCVW produced higher leaf area and dry weight of plant compared to application of FCD and FVW, respectively showed that FCVW might be having higher amount of humic acid, which favoured higher growth of strawberry. Further, application of vermicompost leachates (FCD, FVW and FCVW) produced significantly higher total fruit yield (9.7–13.8%) compared to control. The higher fruit yield of strawberry with foliar fertilization of leachates might be attributed to higher plant growth. Our results are in conformity with the findings of other workers who reported higher yield of many crops with the use of vermicompost leachates (Gutierrez-Miceli et al., 2008; Ordonez et al., 2006; Tejada and Gonzalez, 2003, 2004; Tejada et al., 2008).

In our study, foliar application of vermicompost leachates resulted into higher nutrient content of leaf at different stages of growth. The higher nutrient content in leaf and fruit after foliar application of leachates are in agreement with the results obtained from Gutierrez-Miceli et al. (2008), Tejada and Gonzalez (2003) and Tejada et al. (2008), who reported an increased level of macronutrients in different crops after foliar application of leachates. Further, there are many reports, which suggest that foliar application of fertilization is an effective mean of supplying nutrients to the plants (Tejada and Gonzalez, 2004; Singh et al., 2007; Tejada et al., 2008; Fageria et al., 2009). In our study, among different vermicompost leachates (FCD, FVW and FCVW), concentration of N, P, K and Ca in leaves were highest with the foliar application of FCVW showing that higher humic acid content resulted into higher absorption of these nutrients.

Foliar application of vermicompost leachates (FCD, FVW and FCVW) influenced the occurrence of physiological disorders, like albinism and fruit malformation; gray mould incidence and marketable fruit yield of 'Chandler' strawberry significantly over control. In present study, foliar application of vermicompost leachates reduced the incident of albinism and fruit malformation in strawberry which might be attributed to higher concentration of nutrients in leaves and fruits, which might have helped the plants in producing albino and malformed fruits in lesser number. However, there is no report available in literature, which support our hypothesis. Available literature reveals that nutrients like calcium and boron may be related to the occurrence of albinism and fruit malformation in strawberry (Sharma et al., 2006; Singh et al., 2007, 2008). In present study, calcium or boron were not applied separately but traces of calcium or boron might have been supplied through foliar application of vermicompost leachates, which might have resulted into lesser proportion of albino and malformed fruits. Higher content of calcium in plants fertilized with vermicompost leachates might have resulted in to lesser proportion of albino-fruits. Further, vermicompost leachates contained micronutrients that might have resulted into lesser incidence of malformed fruits. Jarecki et al. (2005) reported that leachates collected from the run-off compost contained significant amount of micronutrients (63 mg Ca l^{-1}, 81 mg Mg l^{-1}, 150 μg Mn l^{-1}, 60 μg Cu l^{-1}, 220 μg B l^{-1} and 350 μg Fe l^{-1}) thus confirming our hypothesis that availability of these nutrients might have stimulated the plant growth and improved the absorption of these nutrients thus resulting into better growth and lesser incidence of mal-formed fruits. Further, foliar application of vermicompost leachates resulted into reduction in incidence of gray mould which might be attributed to increased calcium content in the cell wall of fruit tissue which can help to delay softening and mould growth and thus reduce the incidence of grey mould (Hernandez-Munoz et al., 2006; Naradisorn et al., 2006; Singh et al., 2007). Further, foliar application of vermicompost leachates resulted into higher marketable fruit yield of strawberry, which might be ascribed to reduction in albino and malformed fruits and occurrence of gray mould thus increasing the marketable fruit yield. Thus, present study indicated that foliar application of vermicompost leachates in strawberry have synergistic influence on marketable fruit yield by reducing not only the proportion of albino and malformed fruit and lesser incidence of Botrytis rot, but by increasing number of berries as well. Interestingly, foliar application of vermicompost leachates have produced firmer fruits with better TSS and ascorbic acid content which might be attributed to better growth of plants, higher nutrient content of fruits particularly higher calcium content, which favoured the production of firmer fruits (Singh et al., 2007, 2008). Tejada et al. (2008) also reported significant increase in quality of tomato probably caused by an increase in uptake of macronutrients and by an increase of chlorophyll concentration.

5. Conclusions

It can be concluded from the present study that sequential foliar application of leachates derived from mixture of cow dung and vegetable waste can has a prominent role in field-grown strawberries for higher marketable fruit yield of firmer fruit with attractive colour and good quality attributes. Application of leachates reduced not only the physiological disorders like albinism and fruit malformation but also reduced the occurrence of gray mould. Leachates collected from vermicomposting can also be tried in other crops for higher yields.

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