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Investigating the possibility of producing compost enriched with plant residues and evaluating its effect on strawberry vegetative growth indices under drought stress

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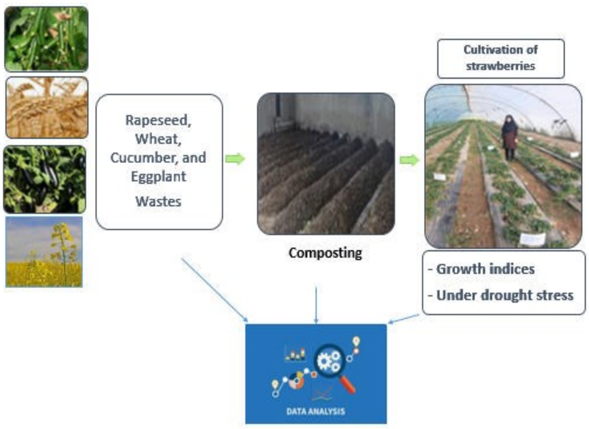
Graphical abstract



Abstract

This research was conducted to investigate the possibility of producing compost from the residues of rapeseed, wheat, cucumber, and eggplant and evaluate the effect of biocompost produced and enriched with zinc and manganese on strawberry vegetative growth indices under drought stress. For this purpose, five treatments including one treatment with an equal mixture of produced biocomposts and four separate treatments of biocompost arisen from the residues of the studied plants enriched with zinc and manganese elements at a rate of 1 kg per square meter in all treatments under drought stress of 65% in a completely randomized design with three replications in greenhouse conditions were studied. The research results showed a significant difference at the levels of 1% and 5% in terms of vegetative growth indices including plant height, internode distance, fresh and dry weight of the plant, stalk diameter, and the number of strawberry tillers. In such a way that the highest amount of vegetative growth characteristics in strawberry bush was related to the treatment containing rapeseed–enriched biocompost under drought stress, and the lowest amount of them was related to the treatment containing an equal combination of biocompost from green cucumber, wheat, rapeseed, and eggplant. The analysis of variance results showed that the effect of biocomposts produced and enriched with elements of zinc and manganese under drought stress in treatments T1 (equal mixture of produced biocomposts) and T2 (biocompost produced from residues of wheat plant) and T5 (biocompost produced from residues of rapeseed plant) on strawberry vegetative growth indices was statistically significant. In such a way that the difference was observed at a level of 1% for all three aforesaid treatments in terms of plant height and the difference was observed at a level of 5 % for other vegetative characteristics (internode distance, fresh and dry weight of the plant, stalk diameter, and the number of tillers and fresh and dry weight of the root). The results indicated that the use of biocompost remain the positive effects on strawberry vegetative growth indices, and biocomposts produced individually (not combined) may be used under drought stress to improve the performance of strawberry vegetative growth.

Keywords: Biocompost, plant residues, drought stress, plant performance, strawberry

1. Introduction

Compost, a processed mixture of organic materials, has long been of interest to farmers due to its unique and specific modifying effects on the physical, chemical, and biological properties of soil, as well as the improved growth and increased yield. The organic content of agricultural soils in Iran is mainly less than one percent. Therefore, as the use of mineral fertilizers may reduce soil quality in the long term, in recent years, sustainable production of agricultural products using organic fertilizers such as compost has had beneficial effects on plant growth and nutrient concentration in crops, leading to soil productivity and health preservation (Hamdpour Sefidkoohi *et al*. 2012). Findings of a research conducted by Pergola *et al*. (2018) demonstrated a significant positive impact of compost application on growth parameters such as plant height, number of tillers, spike length, straw yield and thousand-grain weight. Aynehband *et al*. (2023) compared the production of compost fertilizer from the residues of rice, rapeseed, and wheat crops, as well as sugar beet, and its effect on the grain yield and some agronomic characteristics of wheat. They found that the highest grain yield of wheat and also the highest protein content of the grain were obtained under the application of compost produced from rice residues with a weight percentage of 20%. Therefore, from an agroecological perspective, it was determined that in order to reduce the use of chemical fertilizers and replace them with compost, attention to the quantity, quality, and type of raw material in compost production will be essential.

Additionally, using natural substances such as organic fertilizers in the soil is one of the solutions to reduce the impact of drought stress on crops (Namarvari *et al*. 2013), which leads to an increase in water holding capacity of the soil, enhancement of organic substances and pH balance in the soil, improvement of cation exchange capacity, provision of essential plant nutrients such as nitrogen, soil structure amendment, increase in microorganism activity, creation of a suitable environment for root growth, increase in photosynthesis, aerial organ growth, dry matter production, and ultimately plant performance improvement. Additionally, these substances create less pollution in the environment compared to chemical fertilizers (Sajadink *et al*. 2011). In a study examining the effects of different organic fertilizers and arbuscular mycorrhizal fungi on the performance and yield components of wheat varieties, it was reported that the highest spike length, thousand-grain weight, grain yield, biological yield, and wheat harvest index were obtained in the treatment using vermicompost fertilizer + arbuscular mycorrhizal fungi (Gholamalizade Ahangar *et al*. 2014). Some studies have shown that in plants exposed to drought stress, the use of compost fertilizer increases plant tolerance to drought stress and enhances plant performance (Safi *et al*. 2022). In a study evaluating the effects of water cut stress and the application of compost fertilizer on the performance and yield components of the cranberry bean, it was observed that drought stress led to a decrease in performance and yield components. However, the application of 10 tons per hectare of compost fertilizer resulted in an increase in these characteristics (Najarian *et al*. 2016). In another study, the effects of vermicompost fertilizer and chemical fertilizer on the performance and yield components of chickpea varieties under drought stress were studied and it was reported that under drought stress in the pod filling stage, the number of grains per pod, thousand-grain weight, grain yield, biological yield, and harvest index were obtained in the treatment using 50% chemical fertilizer + 50% vermicompost (Kahrizi and Sepehri 2019). Pandiyana *et al*. (2020) stated that the characteristics of vermicompost, in addition to being rich in elements and some growth-stimulating enzymes, gradually release nutrients, leading to an increase in phosphorus and nitrogen levels in the soil, a decrease in soil bulk density, and an improvement in soil water holding capacity. These conditions improved the plant height, the number of branches, root length, as well as the number and weight of the capsules in the sesame plant, so that the application of 10 to 30 tons per hectare vermicompost improved the weight of sesame capsules by 25 to 50% on average. Mahmoudi *et al*. (2020) demonstrated that the combined application of vermicompost, nitrogen, and phosphorus fertilizers had the highest impact on the morphological characteristics of peppermint *(Mentha piperita L.*) such as plant height and node number, as well as the highest quantity and quality of essence (including alpha-pinene, limonene, isomenthone, menthol, 1,8-cineole, and menthone). The beneficial impact of biofertilizers has been proven in various studies, including on plants such as garden sage (Yadegari 2018) and saffron (Omidi *et al*. 2009).

Moradi and Sheikhi (2020), in their study on the effect of mycorrhizal fungi and vermicompost on the growth and composition of mineral elements of strawberry cultivars demonstrated that the use of organic fertilizers increased the growth of strawberry plant by increasing in absorption of nutrients, which vermicompost played a more prominent role due to its nutrient content and beneficial soil organisms.

In another study, Ghaem Maghami *et al*. (2020) examined the effects of different levels of nitrogen, vermicompost, and nitrazine on the morphological characteristics, chlorophyll index, and strawberry yield in greenhouse conditions and the results showed that the growth and performance of strawberry with the application of 75 kilograms per hectare of nitrogen along with nitrazine and vermicompost were similar to those with the application of 100 kilograms of nitrogen alone. Therefore, the use of organic fertilizers can not only improve plant performance, but also reduce the consumption of chemical fertilizers up to 25%. Also, the research results of Arancon *et al*. (2004) showed that the use of vermicompost increases the dry weight of strawberry. Khaleeq and Shokohian (2018) in a study investigating the effect of vermicompost extract (compost tea) on the growth and yield of strawberry showed that the effect of different treatments of compost tea on all the measured characteristics were statistically significant at the probability level of 1%. Given the use of biocompost arisen from plant residues, disposal of which causes pollution in the environment, may optimally improve the vegetative growth and reproductive performance of agricultural products in agricultural fields and greenhouses and reduce drought stress Abyar *et al*. 2016). Therefore, this study aims to investigate the possibility of producing and comparing the quality of compost produced from residues of different plants, as well as to evaluate its effect on strawberry vegetative growth indices.

2. Methodology

This experiment was conducted in two stages in the summer of the year 2021 at a greenhouse site in Jiroft city in Kerman province. Jiroft city, due to locating in the southern latitudes of Iran and medium height, is spread out in a wide valley and enjoys a plain and mountainous locations, which bears hot and relatively humid summers and mild and short winters; So that the days with a temperature of 0°C or less during the cold season may not exceed one week.

The first stage of the experiment including production of compost fertilizer from plant residues, was carried out using windrow compost production method. The studied treatments were made up of greenhouse residues of cucumber and agricultural residues of wheat, eggplant and rapeseed crops. The moisture percentage of plant residues ranged from 10 % to 15% on average. Animal (sheep) manure was used as the initial substrate to prepare compost. The chemical characteristics of plant residues are presented in Table 1. Before compost production and after compost processing, pH parameters, percentage of organic carbon as well as percentage of total nitrogen, phosphorus, potassium, low consumption elements such as iron, manganese and zinc were measured and C/N ratio was calculated. During the compost production process, urea fertilizer was used to adjust the C/N ratio. Also, the amounts of humidity, temperature, and pH were measured and controlled every 15 days to supervise the production process.

Table 1. Average values of the physicochemical characteristics of the initial substrates before starting production of compost from residues of wheat, eggplant, cucumber and rapeseed

Type of plan residues	C/N	% (N)	(P)%	% K_20	(Fe) mg/kg	(Mn) mg/kg	(Zn) mg/kg	pH
Wheat	19.42	1.13	1.15	1.16	7124	394	142	7.97
Eggplant	17.10	1.54	1.27	1.69	7346	519	149	7.91
Cucumber	18.61	1.47	1.35	1.93	7249	476	140	7.92
Rapeseed	18.04	1.72	1.89	1.74	8136	593	157	7.90
Animal manure	33.24	1.65	1.003	1.29	8153	234	69.7	7.82

Table 2. Average values of physicochemical properties of initial substrates in the first and final stages of compost production from wheat, eggplant, cucumber, and Rapeseed residues

Type of compost produced from plant residues	Compost production stages	C/N	(N) %	(P)%	K_2O %	(Fe) mg/kg	(Mn) mg/kg	(Zn) mg/kg	pH
Wheat	First stage	24.32	0.69	0.36	0.43	5349	184	89	6.91
	Final stage	19.42	1.16	1.19	1.18	7264	398	146	7.86
Eggplant	First stage	10.2	0.93	0.58	0.73	5149	217	92	6.93
	Final stage	17.23	1.58	1.29	1.75	7469	523	151	7.89
Cucumber	First stage	13.29	0.96	0.74	0.85	5132	192	83	6.84
	Final stage	18.67	1.68	1.39	1.95	7389	481	147	7.94
Rapeseed	First stage	12.21	0.98	0.83	0.78	6123	318	102	6.92
	Final stage	18.15	1.76	1.93	1.76	8167	601	162	7.91

During compost processing, the temperature ranged from 37°C to 60°C and also, the piles were manually turned upside down twice a week for proper aerobic decomposition. Irrigation and aeration of experimental substrates were performed two to three times a week for four months. After the end of the test period and production of compost fertilizer, it was passed through a 3.5 mm sieve (Lataverma and Marshner, 2013) and then weighed. The moisture content of air-dried fertilizer samples was about 15%. The produced composts were sampled and then, values of phosphorus were measured by vanadate molybdate method through a spectrophotometer at a wavelength of 470 nm (Emami, 1996). Meanwhile, nitrogen was measured by Kjedal method, potassium and calcium by film photometer, as well as micro elements (zinc, manganese, iron) by atomic absorption device.

The second stage consisted of investigating the effect of different types of compost fertilizers produced from residues of cucumber, eggplant, wheat and Rapeseed plants as well as adding urea fertilizer, manganese and iron (each at a rate of 1 kg per one square meter of substrate) and applying drought stress on strawberry vegetative growth performance. This experiment was conducted as a factorial experiment in a completely randomized design (CRD) with 5 treatments in 3 replications under drought stress of 65% by weight of field moisture. Five treatments were used as follows:

- Treatment 1 (drought stress and equal composition of biocompost produced from green cucumber, wheat, rapeseed, eggplant at a rate of 1 kg per square meter),
- Treatment 2 (drought stress and wheat biocompost enriched with zinc and manganese at a rate of 1 kg per square meter),
- Treatment 3 (drought stress and green cucumber biocompost enriched with zinc and manganese at a rate of 1 kg per square meter),
- Treatment 4 (drought stress and eggplant biocompost enriched with zinc and manganese at a rate of 1 kg per square meter)
- Treatment 5 (drought stress and rapeseed biocompost enriched with zinc and manganese at a rate of 1 kg per square meter).

The studied and cultivated plant was Paros variety strawberry. After preparing the greenhouse land, some plots with dimensions of 2 m × 2 m were created and covered with black plastic mulch afterward. In early November, 100 bushes were cultivated in each plot and they were harvested once. The fruit yield was measured at the time of harvesting in January and February, and fresh and dry weights of the plant at the end of February. The measured indices in this research included vegetative growth components such as, plant height, internode distance, fresh weight of the plant, dry weight of the plant, number of tillers, stalk diameter as well as fresh and dry weight of the root. Vegetative growth characteristics were measured after removing the margins in each plot. The fresh weights of leaves and roots were measured immediately after transfer from the greenhouse to the laboratory through a digital scale with an accuracy of 0.01 grams. The samples were placed in paper pockets and then were dried in an oven at a temperature of 80°C for 72 hours, next, the dry weight of the samples was measured using a scale (Tabatabaei 2013). SAS software was used for statistical calculations and data variance analysis. Meanwhile, comparison of averages was carried out with Duncan's multiple range test at a level of 5 %.

Table 3. Average values of the physicochemical properties of compost produced from wheat, eggplant, cucumber, and rapeseed residues

Type of treatment / Parameter	Wheat	Eggplant	Cucumber	Rapeseed
C/N	24.2±0.06^{d}	21.67±0.07^{b}	22.6±0.03^{e}	20.51± 0.09^{a}
% (N)	1.37±0.07^{a}	1.83 ±0.08^{c}	1.77±0.09^{c}	1.99 ± 0.04^{d}
(P)%	0.03±1.32^{a}	1.94±0.06^{e}	1.64 ± 0.02^{c}	2.03 ± 0.05 e
% K_20	1.44 ± 0.03^{a}	1.95 ± 0.04^{ab}	2.08±0.08^{ab}	2.4 ± 0.07^{b}
(Fe) mg/kg	7222 ± 0.03^{a}	7859 ± 0.02^{e}	7733 ± 0.05^{d}	8423 ± 0.08^{f}
(Mn) mg/kg	430±0.06^{a}	583 ± 0.04^{c}	529 ± 0.03^{bc}	670± 0.08^{d}
(Zn) mg/kg	154 ± 0.5^{bc}	158 ±0.9^{c}	151 ± 0.3^{ab}	165 ± 0.7^{d}
pH	7.97 ±0.04^{d}	7.91 ± 0.03^{a}	7.92±0.08^{ab}	7.90 ± 0.3^{a}
Water storage capacity (litter/square meter)	4± 0.4^{a}	1.97±0.05^{ab}	53.1±0.07^{ab}	3.19 ± 0.3^{b}

Table 4. Analysis of variance of the effect of biocompost produced from rapeseed, eggplant, cucumber and wheat enriched with zinc and manganese on strawberry vegetative growth indices under drought stress (source: research findings)

Root dry weight (g/plant)	Root Fresh weigh (g/plant)	Stalk diameter (mm)	Number of Tiller	Dry weight (g/plant)	Fresh weight (g/plant)	Internode distance (cm)	Plant height (cm)	df	S.O.V
2.36*	6.42*	5.24*	3.17*	4.16*	6.42*	1.53*	304.34**	2	T1
2.94*	6.75*	5.49*	3.24*	4.68*	6.75*	1.98*	257.01**	2	T2
3.48 ns	7.04 ns	6.08 ns	3.68 ns	4.93 ns	7.04 ns	2.13 ns	269.25 ns	2	T3
3.62 ns	7.20 ns	6.31 ns	4.01 ns	5.14 ns	7.20 ns	2.19 ns	231.58 ns	2	T4
4.18*	7.59*	6.61*	4.73*	5.39*	7.59 *	2.45 *	219.81**	2	T5
0.22	2.33	0.05	0.67	0.16	0.88	0.01	0.44	18	Error
3.18	3.57	3.90	5.81	3.34	2.18	5.71	2.70		Cv (%)

(**) Significance was achieved at the 1% level, (*) significance was achieved at the 5% level, (ns) significance was not achieved.

3. Results and discussion

This study investigated the possibility of producing compost from residues of cucumber, wheat, eggplant, and rapeseed remained in the agricultural fields and greenhouses and evaluated its effect on strawberry vegetative growth indices under drought stress, considering the nutrients such as zinc and manganese. The physicochemical characteristics of the produced compost are tabulated in Table 3.

Sd: Standard deviation is obtained from the average of repetitions related to each treatment.

After producing biocompost from residues of wheat, cucumber, eggplant and rapeseed, these biocomposts enriched with zinc and manganese elements were added separately to each plot in 5 treatments in a rate of one kilogram per square meter under drought stress. Then strawberry plants were planted in these plots so that the effect of these biocomposts on strawberry vegetative growth may be measured. The analysis of variance results for the effects of different treatments on strawberry vegetative growth indices are demonstrated in Table 4.

The analysis of variance results showed that the effect of biocomposts produced and enriched with elements of zinc and manganese under drought stress in treatments T1 (drought stress and equal mixture of biocomposts produced from residues of green cucumber, wheat, rapeseed and eggplant) and T2 (biocompost produced from residues of wheat plant) and T5 (biocompost produced from residues of rapeseed plant) on strawberry vegetative growth indices was statistically significant. In such a way that the difference was observed at a level of 1% (confidence level of 99 %) for all three aforesaid treatments in terms of plant height and the difference was observed at a level of 5 % (confidence level of 99 %) for other vegetative characteristics (internode distance, fresh and dry weight of the plant, stalk diameter, and the number of tillers and fresh and dry weight of the root)

(Table 4). The average comparison results of vegetative growth characteristics for the studied plant are presented in Table 5.

Table 5. Comparison of the average effect of biocompost produced from rapeseed, eggplant, cucumber and wheat enriched with zinc and manganese on growth indices of strawberry under drought stress

Root dry weight (g/plant	Root Fresh weight (g/plant	Stalk diameter (mm)	Number of Tiller	Dry weight (g/plant)	Fresh weight (g/plant)	Internode distance (cm)	Plant height (cm)	Treatment
14.02±0.01d	43.11±0.05d	5.01±0.003d	12.79±0.02d	11.61±0.01d	42.27±0.2d	1.04±0.002d	23.17±0.04[d]	T1
14.60±0.03c	43.58±0.06c	5.76±0.004c	13.44±0.03c	12.23±0.02c	43.01±0.3c	1.67±0.004c	24.39±0.05[c]	T2
15.05±0.04b	44.12±0.08b	6.18±0.005b	14.03±0.04b	12.98±0.04b	44.21±0.4b	2.08±0.003b	26.04±0.03[b]	T3
15.13±0.05b	44.20±0.06b	6.27±0.006=5b	14.11±0.05b	13.05±0.04b	44.30±0.4b	2.21±0.005b	26.15±0.02[b]	T4
15.97±0.07a	46.14±0.08a	6.89±0.006a	15.68±0.06a	14.2±0.05a	48.13±0.5a	2.51±0.007b	30.42±0.06[a]	T5

Sd: Standard deviation is obtained from the average of repetitions related to each treatment. In each treatment, the highest value is indicated by the letter "a" and the lowest value by the letter "d"

The average comparison results of the treatments showed that the highest amount of strawberry vegetative growth components was in rapeseed biocompost treatment (treatment 5) followed by treatments 4 and 3 (biocompost produced from residues of eggplant and cucumber) as well as treatment 2 (biocompost produced from residues of wheat), respectively. The lowest amount was obtained in treatment 1 (drought stress and equal composition of biocompost produced from residues of green cucumber, wheat, rapeseed and eggplant) (Table 4). Although there was no statistically significant difference in the characteristics studied in two treatments T3 (biocompost produced from residues of eggplant) and T4 (biocompost produced from residues of cucumber), the values of the measured agricultural characteristics were high and close to each other. In such a way that the measured values of vegetative growth characteristics in these two treatments were at the level "b" of the treatments' average.

The comparison of different treatments showed that the effect of biocomposts in an unmixed form and alone had more effects on vegetative growth components, which was caused by the difference in the amounts of macro and micro elements in the produced biocomposts (Table 2). In such a way that the lowest vegetative growth was observed in the biocomposts' mixture treatment, because the obtained composition could not provide the appropriate amount of growth essential elements in this biocompost. Therefore, it can be stated that the use of biocomposts bearing high amounts of micro and macro elements is able to increase strawberry vegetative growth indicators. Mafakheri *et al*. (2011) stated that the use of vermicompost at a level of 1%, due to having high percentage of nitrogen, had a significant effect on the leave greenness index of Dracocephalum Moldavica. Fernandez *et al*. (2010), in an experiment conducted on beans, showed that the addition of 8.2 of the weight percent of vermicompost had the greatest contribution in increase of leave greenness index of beans due to having high percentage of nitrogen. Because such leaves are not able to consume the light and convert the light energy into the energy needed by the plant during the process of photosynthesis (Theunissen *et al*. 2010) as well as, chlorophyll is the main pigment for light absorption and photosynthesis in plants, in which food elements are involved in its structure (Wang and Chen 2023). Therefore, nutrients such as nitrogen, phosphorus, potassium, iron and copper are easily available to plants through application of vermicompost and are used in the formation of chlorophyll, which is needed to collect light and convert it into chemical energy (Zhao *et al*. 2022).

The results showed that the highest amount of vegetative growth indicators was related to rapeseed biocompost treatment. The reason can be due to the high amount of macro elements (nitrogen, phosphorus, potassium) and micro elements (iron, manganese and zinc) in this treatment compared to other treatments (Table 3). Ghaem Maghami *et al*. (2020) and Mirshekari *et al*. (15) also announced that the high level of macro elements through biofertilizers resulted in the highest greenness index in corn and strawberry plants. In addition, the results of a research conducted by Pour Moghaddas and Zafarzadeh (2016) also showed that the combination of biocompost with animal and chemical fertilizers causes better performance of strawberry plant. The analysis of variance results and comparison of data average in different treatments showed that the effect of different biocompost treatments obtained from different plant residues on dry weight of strawberry aerial organ was significant. In such a way that the highest dry weight of aerial organs by 14.2 grams per plant was related to rapeseed biocompost treatment and the lowest amount by 11.61 grams per plant was related to the mixed biocomposts treatment obtained from residues of rapeseed, cucumber, eggplant and wheat. As mentioned above, this difference in plant dry weight may be caused by the high amount of macro elements in the biocompost of the treatments, so that the highest amount of nitrogen by 1.99% was related to the rapeseed treatment and the lowest amount by 1.37% was related to the wheat biocompost treatment. On the other hand, the highest amounts of phosphorus and potassium elements were related to rapeseed biocompost by 2.03% and 2.4%, respectively, while the lowest amounts of this elements belonged to wheat biocompost by 1.32% and 1.44%, respectively.

When enough nitrogen is available to the plant, the need for other principal nutrients such as phosphorus and potassium increases. This element accelerates the growth. Therefore, nitrogen influences all the characteristics affecting the performance and biological performance

(Sajjadi *et al*. 2011). Also, Ghaem Maghami *et al*. (2020) showed that the highest dry weight of aerial organ was obtained with application of nitrogen in a rate of 100 kg/ha, 1% vermicompost inoculated with nitrazine in strawberry plants in greenhouse conditions. They stated that the use of biological fertilizers can reduce the use of chemical fertilizers by 25% while increasing plant yield. Moradi and Sheikhi (2020) also achieved the conclusion that the use of biological fertilizers increases the growth of strawberry plants by increasing the absorption of nutrients. Wang and Lin (2002) showed that the use of compost mixed with soil significantly increased dry weight of aerial organs of strawberry cultivars. Arancon *et al*. (2004) stated that the use of vermicompost significantly increased the growth and yield of strawberry. The results of the present study are in line with the results of the study conducted by Abyar *et al*. (2017), who investigated the effects of drought stress and macro elements of zinc and manganese on the morphological characteristics and performance of common millet (Panicum Miliaceum) plant. The results of both studies showed that under drought stress, the use of micro elements of zinc and manganese increases vegetative growth characteristics and finally plant yield. Also, the results of the present study are consistent with the results of a research conducted by Terry *et al*. (2020) on the effect of micro elements of zinc and manganese as well as vermicompost produced from plant residues on strawberry yield and vegetative growth characteristics under drought stress. The results of this research indicate that drought stress can affect the quantitative and qualitative performance of strawberry without having a significant negative effect on fruit weight and having a significant positive effect.

In the study on the effect of biocompost on fresh and dry weight of roots, Armand *et al*. (2015) and Pant *et al*. (2012) reported that by increasing levels of vermicompost and compost tea in the soil, root characteristics such as length, fresh weight and dry weight were enlarged. In the present study, the effect of biocompost on the number of tillers and fresh and dry weight of strawberry roots was significant. In such a way that the highest dry and wet weight of strawberry roots by 46.14 gram and 14.97 grams per plant, respectively, were related to rapeseed biocompost treatment, and the lowest ones by 43.11 gram and 14.02 grams per plant, respectively, were related to the treatment with an equal composition of produced biocomposts. The results showed that under drought stress and water reduction, application of biocompost obtained from the residues of rapeseed enriched with zinc and manganese elements was able to overcome the negative effects of the applied stress and acquire the highest strawberry vegetative growth components. The high level of vegetative growth indicators in the rapeseed biocompost treatment can be related to increase in supply and absorption of nutrients through reduction of soil pH and nitrogen fixation and production of hormones increasing strawberry growth (Das *et al*. 2008; Juan *et al*. 2018). In such a way that the lowest pH value was related to rapeseed biocompost by 6.44 and the highest value was related to cucumber biocompost by 7.53.

4. Conclusion

The superficial root system, large leaf surface and high-water content of strawberry fruits cause the consumption of large amounts of water. Strawberry plant is very sensitive to drought stress during flowering and fruit ripening. In this research, biocompost was produced from residues of rapeseed, eggplant, cucumber and wheat, then, each of these biocomposts produced in different treatments were mixed with zinc and manganese elements and evaluated and measured under drought stress for the effect on strawberry vegetative growth indicators. As per the results observed in the experiment, it was determined that the biocompost produced from residues of rapeseed enriched with zinc and manganese elements, led to better growth of the plant vegetative indicators than other treatments. In such a way that under drought stress, this treatment showed a better result and increased the tolerance of the plant to drought stress and made the plant performance better. In general, as per the results obtained from the strawberry plant, the use of each biocompost produced from residues of rapeseed, eggplant, cucumber, and wheat enriched with zinc and manganese elements can alone lead to proper growth of vegetative growth indices and performance of strawberry plant under drought stress than mixing equal proportions of these biocomposts.

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Data availability statement

The authors confirm that the data supporting the findings of this study are available in the article and its supplementary materials as PhD Thesis at Islamic Azad University of Damavand Branch, Iran

Conflicts of interest

The author declares no conflict of interest.

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