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ORIGINAL REASERCH

Efficiency of compost and vermicompost in supporting the growth and chemical constituents of *salvia officinalis* L. cultivated in sand soil

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Abstract

Purpose The effect of using compost and vermicompost or their teas on the growth and biochemical profile of *Salvia officinalis* cultivated in sand soil were assessed.

Methods Plants were subjected to different treatments of compost, vermicompost and their teas. The growth of common sage, *Salvia officinalis* was monitored as shoot fresh and dry weights (g/plant) and their oil, N, P, and K contents.

Results Among the four tested treatments of vermicompost, the treatment no. 1 (prepared from rice straw supplemented by Trichoderma harzianum and Phanerochaete chrysosporium + Cattle dung + Rock phosphate + Feldspar "12 % K_2O"), showed the maximal values of shoot fresh and dry weights, oil, N, P, and K %, being in the first cut 820, 200 g/plant, 1.42, 2.80, 1.40 and 1.98 in respective order. The corresponding values in the second cut were 1152, 277 g/plant, 1.55, 3.56, 1.68 and 2.29%, respectively. Also, the maximal values of all previous parameters were recorded in the vermicompost tea treatment no1, treated as soil and foliar amendments being 730, 196 g/plant, 1.47, 2.4, 1.38 and 2.19% in the first cut and 1150, 270 g/plant, 1.64, 3.5, 1.68 and 2.38% in the second cut, respectively.

Conclusion The growth of *Salvia officinalis* was higher in plants treated by different vermicompost treatments, compared to those treated by compost or the control (without any supplementation).

Keywords Compost, Vermicompost, Compost tea, Vermicompost tea, *Salvia officinalis*, Foliar application

Introduction

Salvia officinalis "sage" is a common aromatic herb. Its Latin name, ''Salvia'' means "to cure" and ''Officinalis'' means "medicinal". It has a historical reputation for supporting health and treatment of illness, which are native of southern Europe, Western Mediterranean and now produced worldwide (Gorai et al. 2011; Kintzios 2003).

The leaves of *Salvia officinalis* L. contain numerous types of flavonoids and phenolics which grant it the antioxidant activity (Durling et al. 2007; Martins et al. 2015); therefore, it is used in the food processing industry (Pearson et al. 1997) and can be used in the preservation of food to prolong their shelf life (Wellwood and Cole 2004). Also, its' leaves are used for various medicinal properties like gastro antioxidant (Miura et al. 2002), anti-*Helicobacter pylori* (Cwikla et al. 2010) and anti-inflammatory activity (Johnson 2011).

Modern research has shown that sage's essential oil can improve the memory at which it gives progressive effect in the managing Alzheimer's disease (Perry et al. 2010). Oil extracted from *Salvia* spp. contains 1, 8-cineole (eucalyptol), and borneol which used as antimicrobial (Ayrle et al. 2016; Ozkan et al. 2010) and in the fragrance industry (Fellah et al. 2006; Vantarakis et al. 2018).

Compost is used for plant nutrition which considers as the cornerstone of nutrient resources for conserving soil fertility. It plays numerous roles in soil fertility and productivity including: providing soils with humus that improves the physical properties of soil, improving the soil's capacity to hold water, rebuilding soil structure, increasing the capability of the soil's molecules to exchange cation (Akhtar et al. 2016; Medina et al. 2015; Mtui 2009).

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Vermicompost is a peat-like material formed from earthworms (*Eisenia fetida*) in a non-thermophilic process. It is excellent nutrient-rich organic fertilizer and soil conditioner as well as having high porosity, high water-holding capacity and high microbial activity (Atiyeh et al. 2002; Singh et al. 2011).

Vermicompost contains different growth regulators like cytokinins and auxins which is produced by earthworm's *indigenous* microorganisms or by earthworms (Arancon et al. 2008; Atiyeh et al. 2000). Also, it contains large amounts of humic substances which reveal considerable impacts on plant performance (Atiyeh et al. 2002).

Teas of compost and vermicompost were produced through mechanical extraction and aeration methods which usually involve the addition of nutrient supplements (El-Haddad et al. 2014). The primary reason for producing compost and vermicompost teas is to transfer beneficial micro-organisms including aerobic bacteria, fungi, actinomycetes, fine particles of organic matter, as well as soluble chemical nutrients into an aqueous phase, which can be used in treating plants either as a surface spraying to plant foliage or as soil irrigators (Joshi et al. 2014; Kim et al. 2015; Pane et al. 2016). In addition, they assist in disease suppression (Zaller 2006).

In the soil application, the nutrients and microorganisms will move into the root zone and affect the rhizosphere of the plant. When the tea is implemented to plant foliage, it will affect the plant immediately. Therefore, it is believed that nutrients and growth regulators or phytohormones extracted from compost and vermicompost have stimulating effect on root development and plant growth (Singh et al. 2010; Tejada et al. 2008).

This investigation aims to study the effectiveness of compost, vermicompost and/or their teas, on growth parameters, nutrient contents and oil% of *Salvia officinalis.*

Materials and Methods

Soil used

Sandy soil was used to study the efficiency of using compost and vermicompost as well as their teas on the growth performance of *Salvia officinalis* under greenhouse conditions. The soil was collected from El-Ismalia station, Soil, Water and Environmental Res. Inst., A.R.C. Giza, Egypt. Samples were air-dried, crushed and sieved through a 2 mm sieve and analyzed at the Dept., Soil, Water and Environmental, Res. Inst., A.R.C. Giza, Egypt. The chemical analysis was conceded in accordance with the procedures outlined by Richards (1954), whereas the physical analysis was carried out according to Jackson (1973). The chemical and physical characteristics of the soil are presented in (Table 1).

Table 1 Physical and chemical characteristics of the used sandy soil

Soil characteristics	**Value**	**Soil characteristics**	**Value**
Particle size distribution %			
Clay	3.00	Coarse sand	89.4
Silt	7.60	Textural class	sandy
Soil physical properties			
Bulk density (g /cm^3)	1.78	Soil moisture at field capacity %	12.39
Total porosity %	39.75	Soil moisture at wilting point %	5.18
Soil chemical properties			
pH (1:2.5, soil water suspension)	7.72	$CaCO_3$ %	1.28
EC (1:5 dS.m^{-1})	0.195	Organic matter%	0.14
Available macro and micro nutrients (mg/kg)			
N	15.05	S	0.79
P	4.85	Mn	0.92
K	60.75	Zn	0.48
Fe	5.30	Cu	0.05
Soluble cations (soil past mmole$_c$ L^{-1})		Soluble anions (soil past mmole$_c$ L^{-1})	
Ca^{+2}	1.09	CO_3^{-2}	0
Mg^{+2}	0.39	HCO_3^-	0.4
Na^+	0.40	Cl^-	1.07
K^+	0.06	SO_4^{-2}	0.47

Plant material and experimental design

Seeds of *Salvia officinalis* L. were obtained from ENZA ZADEN Company, Hungary.

A pot experiment was executed under greenhouse conditions at Soil, Water and Environmental Res. Inst., A.R.C. Giza, Egypt. This experiment was designed to estimate the influence of compost, vermicompost, and their teas (Table 2), on the growth performance and nutrient contents of *Salvia officinalis* (El-Haddad et al. 2014).

Table 2 Treatments of the compost and vermicompost used in the pot experiment

Treatment (1)	Mature compost / **Vermicompost	One-ton Rice straw + 5L* *Trichoderma harzianum* and *Phanerochaete chrysosporium* 1:1 + 2-ton Cattle dung (2%N) + 25 kg Rock phosphate (18%P_2O_5) + 25 kg Feldspar (12 %) K_2O
Treatment (2)	Mature compost / **Vermicompost	One-ton Rice straw + 5L **Trichoderma harzianum* and *Phanerochaete chrysosporium* 1:1 + 15kg Ammonium sulfate (20.6%N) + 3kg Superphosphate (12%P_2O_5) +15kg Potassium sulfate (48%K_2O)
Treatment (3)	Mature compost / **Vermicompost	One-ton Rice straw + 2ton Cattle dung (2%N) + 25kg Rock phosphate (18%P_2O_5) +25kg Feldspar (12%K_2O)
Treatment (4)	Mature compost / **Vermicompost	One-ton Rice straw + 15kg Ammonium sulfate (20.6%N) + 3kg Superphosphate (12%P_2O_5) +15kg Potassium sulfate (48%K_2O)

* 5L from each *Trichoderma harzianum* NRRL 13019 (0.321 g. d. w/100ml) and *Phanerochaete chrysosporium* NRRL 6359 (0.2608 g. d. w/100ml)

** Vermicompost was prepared by daily addition of equal amount from immature compost (collected at the end of thermophilic phase) to worms' weight *Eisenia fetida* and this process was continued for up to 90 days

Plants were cultivated with 30 cm diameter and 6 kg sandy soil plastic pots. The pots were divided into four different treatments and each treatment contains two groups (mature compost and vermicompost). The experimental design is displayed in Table (2). Ten replicates were used for each treatment. Plants were watered once a week. The amount of irrigation water was applied according to the daily reference evapotranspiration (ET_o) computed from 10 daily climatic data, which were obtained from the Central Laboratory of Agricultural Climate CLAC (2004). The plants were collected twice a year by harvesting the aerial part of each plant 10 cm above the soil surface. The first cut was accomplished after 6 months of planting. The second cut was accomplished after two months of the first one.

Compost and vermicompost were solely mixed with sandy soil in amounts equivalent to 47.62 m^3 / hectare according to the recommendation of the Egyptian Ministry of Agriculture (El-Haddad et al. 2014).

Compost and vermicompost teas were prepared by drenching mature compost or vermicompost, produced from the four selected treatment in tap water at ratio 8:1 water, then 50 ml sugarcane molasses and 100 ml yeast 10^5 cfu/ ml were added and the mixture was aerated for 3 days using pump model SE-304, made in Germany. Compost and vermicompost teas were added solely, by spraying, using two methods (i.e. direct to the soil or to both soil and the aerial part of the plant).

Addition of the tea was performed four times for each cut within two- week interval in between. The first addition was done two weeks after emergence and the last one was conducted two weeks previously to the last cut. At each addition, 100ml tea /pot was used in soil application. While for soil and foliar application, the dose (100 ml/pot) was divided into two equal portions for each location. Foliar feeding was applied by spraying the teas on the leaves.

The general characteristics of compost, vermicompost, compost tea, and vermicompost tea, produced from the four treatments and used in this experiment are presented in (Tables 3a and 3b).

Table 3a Main characteristics of mature compost and vermicompost formed from rice straw treated with different supplements

Treatments	Parameters measured	C/N	Bulk Density (kg/m^3)	Soluble N (mg/kg)		Total N g/Kg	Organic Matter g/Kg	Organic Carbon g/Kg	Total P g/Kg	Total K g/Kg
				NH_4^+	NO_3^-					
Compost	Treatment (1)	17	639	42.5	449.2	16.9	496	288	15	17.3
	Treatment (2)	20.6	278	157	712.3	24.2	860	499	16.7	17.9
	Treatment (3)	17.2	620	50.3	426.3	15.3	455	264	14.9	15.8
	Treatment (4)	21.3	203	203.3	606	24	882	512	16.6	17.7
Vermicompost	Treatment (1)	10.4	636.7	31.7	210.9	18.8	338	196	20.5	20.1
	Treatment (2)	11.2	572	40.37	191.9	18.8	364	211	28.1	24.8
	Treatment (3)	10.4	624.7	30.7	202.6	17.4	313	181	20	19.3
	Treatment (4)	11.8	516.7	37.3	196.4	16.6	339	196	26	22.8

Table 3b Main characteristics of the prepared compost tea and vermicompost tea

Treatments	Parameters measured	O.M ppm	NH^+_4 ppm	NO^-_3 ppm	T.N ppm	T.P ppm	T.K ppm
Compost tea	Treatment (1)	8004.24	4.37	24.76	742.56	11000	12000
	Treatment (2)	2462.84	2.90	18.20	593.32	8200	9700
	Treatment (3)	7080.67	4.37	26.90	640.64	10500	11400
	Treatment (4)	2462.84	7.28	19.67	312.31	8000	8400
Vermicompost tea	Treatment (1)	12622.07	8.01	35.67	809.60	11200	13200
	Treatment (2)	8004.24	10.20	33.46	600.04	11500	11900
	Treatment (3)	8004.24	11.65	20.38	776.84	12200	12700
	Treatment (4)	6464.96	9.47	33.48	416.68	8600	9000

Treatment (1): Rice straw + cattle dung + *T. harzianum* and *P. chrysosporium* 1:1 + Rock phosphate18% and feldspar 12%K_2O 1:1
Treatment (2): Rice straw + *T. harzianum* and *P. chrysosporium* 1:1 + ammonium sulfate 20.6% N + Superphosphate 12% P_2O_5 + potassium sulfate 48% K_2O
Treatment (3): Rice straw + cattle dung + Rock phosphate18% P_2O_5 and feldspar12% K_2O 1:1
Treatment (4): Rice straw + ammonium sulfate 20.6% N + superphosphate12% P_2O_5+potassium sulfate 48% K_2O

Parameters measured

Vegetative growth, in the form of fresh and dry weights of herb (g / plant), total N, P, K % were estimated in accordance with the method stated by Jackson (1973) at the end of each cut.

The essential oil %

The proportion of essential oil was estimated in the harvested sage at the Department of Medicinal and Aromatic Plants, Horticulture Institute, El-Dokki, Agricultural Research Center, Giza, Egypt. The essential oil percentage in the new herb was evaluated in accordance with Pharmacopeia (1963).

Statistical analysis

The obtained results were analyzed using (SAS 2006). Tukey's Multiple Range Test (HSD) was used to test significance between means at level 0.05. The model used for statistical analyses was the one-way analysis.

Results and Discussion

Germination rates of *Salvia officinalis* as affected by compost, vermicompost, and their teas

Data recorded in (Table 4) represent the germination rates of *Salvia officinalis'* seeds as a result of applying compost, vermicompost and their teas. Germination percentages showed different responses to the applied treatments. The maximum significant percentages were documented with seeds treated by vermicompost, being 95% for all of the treatments (nos. 1, 2, 3 and 4). These results indicate that ingredients used in the preparation of vermicompost didn't affect the germination percentage.

Seeds treated with compost, which were prepared from rice straw augmented by organic amendments, exerted higher germination percentages compared to those augmented by inorganic amendments being 90 and 80%, respectively. It is worth to mention that seeds treated by compost tea, vermicompost tea as well as untreated plants (control) recorded approximately the same germination percentage of 70%.

The positive effect of compost and vermicompost on various aspects of plant development has been attributed to beneficial changes of soil edaphic properties, in the form of improvement of physical and mechanical characteristics as well as increased bioavailability of mineral nutrients (Ievinsh 2011; Marinari et al. 2000). Most of the literature data attributed the beneficial effects of vermicompost on seed germination, growth, and the phytochemical concentration to the occurrence of macro- and micro-elements that stimulate plant growth performance (Sinha et al. 2011). As well, it could be suggested that both of compost and vermicompost have the ability to improve the water holding capacity of the sandy soil which may be essential factor in increasing the germination percentage of seeds.

Table 4 Germination percentages of *Salvia officinalis* seeds as affected by compost, vermicompost, compost tea and vermicompost tea prepared from different treatments

	Treatments supplemented with efficient inoculants*		Treatments without efficient inoculants		Control (Sandy soil)
	**With organic amendments (treatment 1)	***With inorganic amendments (treatment 2)	**With organic amendments (treatment 3)	***With inorganic amendments (treatment 4)	
Compost	90	80	90	80	70
Vermicompost	95	95	95	95	70
Compost tea	70	70	70	70	70
Vermicompost tea	70	70	70	70	70
H.S.D at 5%			9		

* 5L from each *Trichoderma harzianum* NRRL 13019 (0.321 g. d. w/100ml) and *Phanerochaete chrysosporium* NRRL 6359 (0.2608 g. d. w/100ml) at rat 1:1 /ton rice straw

**Organic amendments/ ton rice straw	*** Inorganic amendments/ton rice straw
2ton Cattle dung (2%N)	15kg Ammonium sulphate (20.6%N)
25kg Rock phosphate (18%P_2O_5)	3kg Super phosphate (12%P_2O_5)
25kg Feldspar (12%K_2O)	15kg Potassium sulfate (48%K_2O)

Shoot fresh and dry weights, oil and NPK contents of *Salvia officinalis* as affected by the compost and vermicompost prepared from rice straw augmented by diverse amendments

Data provided in (Table 5) reveal that all the tested parameters verified significant increments in response to the applied treatments when compared to the control. The performance of *Salvia officinalis* as indexed by shoot fresh weight recorded significant increment in plants supplemented by vermicompost, compared to those received compost. Plants either treated by compost or vermicompost formed from rice straw amended by organic amendments recorded significant increments in all the parameters compared to those treated by compost or vermicompost formed from rice straw augmented by inorganic amendments within the same treatments. Plants treated by vermicompost, formed from rice straw augmented by fungal inoculants and organic amendments (treatment no. 1), showed the highest significant values in shoot fresh weights, being 820 and 1152 g/plant for both cuts, respectively. While the lowest fresh weight was produced by plants treated with compost formed from rice straw supplemented with inorganic amendments (treatment no. 4), being 360 and 790 g/plant of both cuts in respective order. Results have shown that values of shoot dry weights performed likewise to those of shoot fresh weights, either in the first or second stages.

Data documented in (Table 5) show that, in the first and second cuts, the values of oil (%) reached their highest significant values in plants treated by vermicompost, formed from treatment no. (1), being 1.42 and 1.55%, respectively. While plants treated by compost formed from treatment no. (4), recorded the lowest values, of 1 and 1.33%, respectively.

The maximum significant value of N (%) was recorded with plants treated by vermicompost, (treatment 1), being 2.8%. While plants treated by compost formed from treatment no. (4), recorded the lowest N%, being 1.65%. The corresponding values, in the second cut, reached 3.56 and 2.9% in treatments nos. 1 and 4, respectively.

Values of total phosphorus and potassium% in the first and second cuts reached their highest concentrations in plants treated by vermicompost, formed from treatment no. (1), being 1.4, 1.68% and 1.98, 2.29%, respectively.

The chemical profile of plants obtained in this study were on the same track with those achieved by (El-Sherbeny et al. 2007; Khalil and El-Sherbeny 2003; Pirdashti et al. 2010)

Compost and vermicompost are rich in humic compounds that bind numeral mineral nutrients and continuously releasing them during their degradation (Chen et al. 2004). These humic compounds can stimulate the signaling systems of plant roots through binding to certain receptors (Canellas et al. 2002) or directly by affecting enzyme activities of numerous metabolic pathways (Vaughan et al. 1985). Also, in this concern, different researchers suggested that establishing various food sources to plants, especially organic fertilizers, is probably the main aspect that causes an increase in the photosynthetic efficiency which is responsible for ameliorating plant growth performance and yield as well as improving some bioactive substances that present in plants. (Amooaghaie and Golmohammadi 2017; Kazimierczak et al. 2014; Sinha et al. 2011).

Also, these results are in line with those of (Liuc and Pank 2005), who exhibited that vermicompost can increase the growth, biomass, and essential oil production of Roman chamomile and they suggested that the stimulatory effect of vermicompost could be attributed to improving the mineral nutrition and enhancing the photosynthetic activity.

Shoot fresh and dry weights, oil and NPK contents of *Salvia officinalis* as affected by application methods of compost tea, made from rice straw augmented by different amendments

Data presented in (Table 6) show that all the measured parameters in the first and second cuts of the tested treatments significantly increased compared to control. The values of the tested parameters were greater in the second cut, compared to the first one. The growth performance of plants treated by compost teas, made from compost supplemented by organic amendments (treatments No. 1 and 3) significantly increased, compared to those treated by compost teas, formed from compost augmented by inorganic amendments (treatments nos. 2 and 4). The maximum significant accretion in shoot fresh weight was scored with plants augmented by compost tea formed from treatment no. 1, as soil and foliar application, being 460 and 700 g/plant of both cuts, respectively. The values of shoot dry weight performed similarly as those of shoot fresh weights for both first and second cuts.

It should be stated that in both cuts, no significant variation was recorded in oil (%) between all the tested treatments. The highest increases in oil % in both cuts were recorded with plants treated by compost tea formed from treatment no. 1, through soil and foliar application, being 1.32 and 1.39 % in respective order. While the lowest percentages of oil in both cuts were recorded with plants treated by the compost tea produced from treatment no. 4, through soil application, being 1.18 and 1.3%, respectively.

Total nitrogen (%), in the first cut, significantly increased in plants treated by compost tea as soil and foliar application when compared to plants treated by compost tea as a soil application with the similar treatments. In both first and second cuts, the N% significantly improved in plants treated by compost tea made from treatments 1 and 3 compared to those treated by teas formed from treatments 2 and 4. The maximum significant increase of N% was found in plants treated by compost tea formed from the treatment no. 1, as soil and foliar application in both cuts, being 1.84 and 2.38 % in respective order.

Table 5 Shoot fresh and dry weight, oil% and NPK contents of *Salvia officinalis* as affected by the application of compost and vermicompost formed from rice straw, augmented by different amendments

Type of compost	Treatments	First cut						Second cut					
		Shoot F.W (g/plant)	Shoot D.W (g/plant)	Oil %	N %	P %	K %	Shoot F.W (g/plant)	Shoot D.W (g/plant)	Oil %	N %	P %	K %
Control		150	36.83	0.64	1.10	1.13	0.57	148.00	34.76	0.56	0.63	0.49	0.21
Compost	Treatment (1)	480	139	1.16	1.85	1.30	1.52	1100	250	1.44	3.2	1.66	2.03
	Treatment (2)	420	112.5	1.03	1.73	1.20	1.21	820	211.2	1.38	3	1.57	1.88
	Treatment (3)	450	125	1.11	1.81	1.25	1.36	930	213.5	1.40	3.12	1.6	1.95
	Treatment (4)	360	100	1.00	1.65	1.14	1.18	790	199.2	1.33	2.9	1.43	1.82
Vermicompost	Treatment (1)	820	200	1.42	2.80	1.40	1.98	1152	277	1.55	3.56	1.68	2.29
	Treatment (2)	655	177	1.35	2.16	1.37	1.85	1110	255	1.47	3.21	1.63	2.18
	Treatment (3)	750	198	1.4	2.50	1.39	1.93	1130	264	1.51	3.50	1.66	2.22
	Treatment (4)	610	172	1.33	1.93	1.33	1.8	1050	222	1.43	3.12	1.60	2.11
H.S.D. at 0.05		50.8	22.8	0.32	0.14	0.59	0.25	11	5.7	0.13	0.28	0.11	0.14

Treatment (1): Rice straw + cattle dung + *T. harzianum* and *P. chrysosporium* 1:1 + Rock phosphate18% and feldspar12%K_2O 1:1
Treatment (2): Rice straw + *T. harzianum* and *P. chrysosporium* 1:1 + ammonium sulfate 20.6% N + superphosphate 12% P_2O_5 + potassium sulfate 48% K_2O
Treatment (3): Rice straw + cattle dung + Rock phosphate18% P_2O_5 and feldspar12% K_2O 1:1
Treatment (4): Rice straw + ammonium sulfate 20.6% N + superphosphate12% P_2O_5+potassium sulfate 48% K_2O

Table 6 Shoot fresh and dry weight, oil% and NPK contents of *Salvia officinalis* as affected by application methods of compost tea made from rice straw, augmented by different treatments

Treatments	Application Methods	First cut						Second cut					
		Shoot F.W (g/plant)	Shoot D.W (g/plant)	Oil %	N %	P %	K %	Shoot F.W (g/plant)	Shoot D.W (g/plant)	Oil %	N %	P %	K %
	Control	150	36.83	0.64	1.10	1.13	0.57	148.0	34.76	0.56	0.63	0.49	0.21
Treatment (1)	Soil application	410	107	1.26	1.69	1.19	1.58	680	189.1	1.38	2.2	1.38	1.88
Treatment (2)		315	92	1.22	1.48	1.04	1.46	520	163.8	1.34	1.9	1.32	1.83
Treatment (3)		400	102	1.24	1.67	1.16	1.55	620	126.0	1.36	2.05	1.34	1.85
Treatment (4)		300	88	1.18	1.42	1	1.28	460	128.0	1.3	1.74	1.26	1.78
Treatment (1)	Soil & foliar application	460	129	1.32	1.84	1.28	1.7	700	192.50	1.39	2.38	1.39	1.9
Treatment (2)		350	99	1.28	1.62	1.13	1.61	550	170.43	1.35	1.92	1.33	1.85
Treatment (3)		420	118	1.3	1.72	1.3	1.65	650	189.0	1.37	2.13	1.37	1.87
Treatment (4)		310	96	1.26	1.52	1.1	1.52	480	131.0	1.33	1.85	1.29	1.80
	H.S.D. at 0.05	56	11	0.27	0.06	0.06	0.28	45	21.79	0.19	0.39	0.11	0.33

Treatment (1): Rice straw + cattle dung + *T. harzianum* and *P. chrysosporium* 1:1 + Rock phosphate18% and feldspar12%K_2O 1:1
Treatment (2): Rice straw + *T. harzianum* and *P. chrysosporium* 1:1 + ammonium sulfate 20.6% N + superphosphate 12% P_2O_5 + potassium sulfate 48% K_2O
Treatment (3): Rice straw + cattle dung + Rock phosphate18% P_2O_5 and feldspar12% K_2O 1:1
Treatment (4): Rice straw + ammonium sulfate 20.6% N + superphosphate12% P_2O_5+potassium sulfate 48% K_2O

Total phosphorus percentage of the first cut significantly increased in plants treated by compost tea formed from treatments 1 and 3 compared to those treated by teas prepared from treatments 2 and 4. While for the second cut, no specific direction of results was obtained to discriminate between the treatments. The maximum significant increment in phosphorus (%) was scored in plants treated by compost tea formed from treatment no. 1, as soil and foliar treatment in both cuts being 1.28 and 1.39% in respective order.

The values of K% were greater in the second cut plants in all the tested treatments compared to those of the first cut with the same treatments. The highly significant K% was documented in both cuts in plants treated by compost tea formed from treatment no. 1, as soil and foliar application being 1.7 and 1.9 % in respective order.

The obtained results are in the same line with Pane et al. (2012), who reported that diversity of microbial profile in compost tea support plant leaves to absorb nutrients when it is applied as a foliar application, and when they added to soil, they support the root system to absorb nutrients from the soil. In this concern, Hargreaves et al. (2009) mentioned that compost tea improves the uptake of most macronutrients, micronutrients and show beneficial impact on strawberry's yield. While Mohammed et al. (2010) reported that using compost tea as a soil application gave a better effect on all vegetative characteristics of pear trees and improves the chemical constituents of their leaves as well as fruit yield, compared to control treatments.

Many researchers also reported that compost tea h as similarly positive effects as a biofertilizer on sever al plants like: *origanum majorana*, Edris et al. (2003), *Ruta graveolens*, El-Sherbeny et al. (2007) and *Plantago arenaria*, Hendawy (2008).

Various studies confirm the beneficial influence of compost tea as a foliar application on plant due to its direct nutrients supplying and/or its microbial functions (Pane et al. 2012; Pane et al. 2016; Pant et al. 2009).

Shoot fresh and dry weights, oil and NPK contents of *Salvia officinalis* as affected by application methods of vermicompost tea produced from pre-composted rice straw amended by different treatments

Data presented in (Table 7) show that all the treatments recorded significant increments in all the tested parameters compared to control. However, all the parameters under investigation, i.e. shoot fresh and dry weights, oil and N, P and K % reached their highest values in plants, treated with vermicompost tea, as soil and foliar amendments when compared to those treated only with soil application. The maximum values were obtained in plants treated by vermicompost tea formed from the treatment no. 1 being 730, 196 g/plant, 1.47, 2.4, 1.38 and 2.19 for fresh and dry weights, oil, N, P and K% in the first cut, respectively. The corresponding values in the second cut were 1150, 270 g/plant, 1.64, 3.5, 1.68 and 2.38 % in respective order. In this respect, Pant et al. (2009) stated that treatment of Pak choi (Chinese cabbage) with vermicompost tea increased the aboveground fresh and dry weights, leaf area as well as mineral contents. While Arancon et al. (2007); (Ievinsh 2011) stated that vermicompost tea is a very effective plant growth promoter and is used as foliar spray easily. Also, Amooaghaie and Golmohammadi (2017) reported that using vermicompost tea as a foliar application achieved increment equal to 400 % in the yield of 'pecan nuts' as well as improving its resistance against insects.

Conclusion

Vermicompost achieved stimulatory effect on the performance of *Salvia officinalis* in all considerations compared to those received compost.

The ingredients used in the preparation of vermicompost, compost or their teas strongly affects its efficiencies. Plants treated by vermicompost, compost or their teas, formed from rice straw augmented by fungal inoculants and organic amendments, displayed the best growth performance in all parameters measured when compared to those prepared from other constituents.

Using soil and foliar application supports the growth of *Salvia officinalis* and provides superior performance than soil application due to its direct nutrients supplying to leaves that causes roots simultaneously which consequently enhanced all vegetative characteristics and chemical constituents. Also, because a less leaching of nutrient is mainly found in a sandy soil. This investigation could suggest that leaves treatment may enhance nutrient use efficiency.

Table 7 Shoot fresh and dry weights, oil and NPK contents of *Salvia officinalis* as affected by application methods of vermicompost tea made from pre-composted rice straw augmented by different treatments

Treatments	Application Methods	First cut: Shoot F.W (g/plant)	Shoot D.W (g/plant)	Oil %	N %	P %	K %	Second cut: Shoot F.W (g/plant)	Shoot D.W (g/plant)	Oil %	N %	P %	K %
	Control	150.00	36.83	0.64	1.10	1.13	0.57	148.00	34.76	0.56	0.63	0.49	0.21
Treatment (1)	Soil application	488	145	1.32	1.86	1.31	1.7	797	199.8	1.54	2.9	1.41	2.29
Treatment (2)		465	130	1.29	1.84	1.29	1.61	700	194	1.48	2.35	1.38	2.2
Treatment (3)		472	140	1.3	1.85	1.3	1.65	780	199.4	1.52	2.8	1.4	2.26
Treatment (4)		454	126	1.27	1.81	1.26	1.6	620	176.6	1.47	2.1	1.36	2.17
Treatment (1)	Soil & foliar application	730	196	1.47	2.4	1.38	2.19	1150	270	1.64	3.5	1.68	2.38
Treatment (2)		590	171	1.39	1.9	1.32	1.89	985	217	1.58	3.11	1.62	2.3
Treatment (3)		650	187	1.42	2.15	1.37	1.98	1000	223	1.62	3.2	1.63	2.35
Treatment (4)		550	168	1.37	1.92	1.31	1.87	920	206.6	1.56	3	1.6	2.29
	H.S.D. at 0.05	33	16	0.30	0.21	0.11	0.25	34	17.56	0.19	0.42	0.27	0.26

Treatment (1): Rice straw + cattle dung + *T. harzianum* and *P. chrysosporium* 1:1 + Rock phosphate18% and feldspar12%K_2O 1:1

Treatment (2): Rice straw + *T. harzianum* and *P. chrysosporium* 1:1 + ammonium sulfate 20.6% N + superphosphate 12% P_2O_5 + potassium sulfate 48% K_2O

Treatment (3): Rice straw + cattle dung + Rock phosphate18% P_2O_5 and feldspar12% K_2O 1:1

Treatment (4): Rice straw + ammonium sulfate 20.6% N + superphosphate12% P_2O_5+potassium sulfate 48% K_2O

Compliance with ethical standards

Conflict of interest The authors declare that there are no conflicts of interest associated with this study.

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