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Response of Dragonhead Plant to Vermicompost and Nitrogen Fertilizer

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Abstract: Two field experiments were carried out during the two consecutive seasons of 2017/2018 and 2018/2019 at the Horticulture Research Station Farm in El-Quassassin, Ismailia Governorate, Egypt, to study the effect of vermicompost and nitrogen fertilizer (ammonium sulphate, 20.5% N) solely or together on growth parameters, yield, chemical composition and essential oil production of dragonhead plant (*Dracocephalum moldavica*). The results cleared that, significant increase in growth and yield were presented by the combination between 75% nitrogen fertilizer + 25% vermicompost during the two seasons. Also, the highest content of total phenols, flavonoids, antioxidant activity and essential oil production were recorded for the same treatment. Additionally, vermicompost had a significant effect on photosynthetic pigments compared with the control. However, the application of 100% nitrogen fertilizer leads to the highest tannins content. Treating the soil with vermicompost increased the availability of phosphorus and potassium in the soil after harvesting comparing with addition of inorganic (chemical) fertilizer or the control.

Key words: Dragonhead plant · Vermicompost · Ammonium sulphate · Essential oil and chemical composition

INTRODUCTION

Dragonhead plant (*Dracocephalum moldavica*, L.) known as Moldavian balm or Moldavian dragonhead, is an annual herb and branched plant belonging to the Lamiaceae family, cultivated for its important chemical composition and volatile oil [1]. Dragonhead plant is used for medical purposes as pain remover as well as for coronary diseases, sedative, wound-healing, antioxidant, antitumor, antiseptic, stimulant and has properties of antimutagens [2, 3]. Also, it used for the treatment of some problems of stomach, liver and headache [4]. It used for a flatulence, heart tonic, diaphoretic, for snakes bites and stings. Also, it using as a decoction in curing children's pyelonephritis [5]. Dragonhead extracts acting as efficient and biologically safe insect repellent using in storage of food [6].

Fertilizers are the substances that natural or synthetic origin used to add nutrients to the plant tissue or to soil to increase soil fertility and to supply one or more plant nutrients essential to increase plant growth or to overcome the plant nutrient deficiency [7]. Using synthetic chemical fertilizers, because it is easy to transport and can be quickly used by plants and produce high yields. However, with the benefit for crops, the soil fertility is low, so the amount of chemical fertilizer must be increased [8]. Excessive use of chemical fertilizers leads to many problems as increase salinity in the soil, has harmful effect on plant, human and animal lives. So, chemical fertilizers can enter the food chain and leads to water, soil and air pollution [9].

Nitrogen is an essential element required for plant growth. When nitrogen fertilizers are applied to agricultural systems, they are absorbed directly by plants or indirectly by converted into various other forms through oxidation process. Excess nitrogen is lost in ionic or gaseous form through leaching, volatilization and denitrification [10]. If nitrate is not absorbed by plant roots, it is carried away by runoff or leaches into the soil along with water and increase the potential threat to the surrounding environment [11]. So the excess application of nitrogen fertilizers causes many harmful effects as, it increases the amount of nitrates that consist of carcinogenic substances such as nitrosamines due to

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accumulation of NO_3 and NO_2 in drinking water and rivers which used by humans, animals and plants grown in soils [12].

Today, the world is heading towards using eco-friendly fertilizers as organic and biofertilizers to decrease consumption of chemical fertilizers. Organic fertilizers have helpful effects on structure of soil, nutrient availability, quality and yield of crop; also they are less expensive than chemical fertilizers [8, 13].

Vermicompost is an organic product that produced from biodegradation and stabilization of organic waste as vegetable or food waste through the interaction between earthworms and microorganisms, lead to break up organic matter residues into fine particles [14, 15]. Earthworm processing materials contain nutrients in forms readily available to plants [16]. Also, Earthworms produce plant hormones in their secretions [17]. It can increase the production of crops and protect them from harmful pests without polluting the environment. Vermicompost contains plant-growth regulating materials, such as humic acids and plant growth regulators like auxins, gibberellins, cytokinins, phosphorus, potassium and in micronutrients (Zn, Cu, Fe and Mn), exchangeable calcium and has high microbiological potential [18]. So, the application of vermicompost leads to better growth and yield of many plants [19]. Vermicompost stimulates microbial activity of soil, keep normal soil temperature, increases porosity of soil, infiltration of water, increase nutrient content and improves growth, yield and quality of the plant [20].

The aim of this research was to evaluate the effect of vermicompost application on plant growth, chemical compositions, volatile oil production of dragonhead plant with decreasing usage chemical fertilizers.

MATERIALS AND METHODS

Experimental Site: Two field experiments were conducted on Horticulture Research Station Farm at El-Quassassin, Ismailia Governorate, Egypt during 2017/2018 and 2018/2019 to evaluate the effect of vermicompost and nitrogen fertilizer (ammonium sulfate, 20.5% N) either solely or the interaction between different rates of both on growth parameters, yield, chemical composition and essential oil content of dragonhead plant.

The study experiment was allocated in a complete randomized block design with three replicates. The physical analysis of soil was carried out according to Jackson [21], while chemical properties were done according to the procedures outlined by Richards [22]. Analyses of soil were performed both prior to planting and after harvesting. The physical and chemical properties of soil samples are displayed in Table (1).

Experimental Details

Organic Fertilizer: The vermicompost fertilizer was obtained from Central Laboratory of Organic Agriculture (CLOA), Agricultural Research Center, Giza, Egypt. It was added at the rates, 0, 25, 50, 75 and 100% from the recommended dose of 2.65 ton/feddan which was incorporated into the soil 10 days before planting date. The analysis of the vermicompost fertilizer is presented in Table (2).

Chemical Fertilizers: Chemical fertilizers (N, P and K) were added as ammonium sulphate (20.5 % N) at 200 kg/feddan, calcium super phosphate (15.5 % P_2O_5) at 200 kg /feddan and potassium sulfate (48 % k_2O) at 100 kg/feddan. All phosphorous amount was added during soil preparation, while potassium was applied in two equal split doses, after 30 and 60 days from transplanted. Nitrogen fertilizer was divided into three equal portions to the soil as side dressing after 30, 50 and 70 days from transplanting.

The experiment comprised of six treatments:

T1: Control (No fertilizer)
T2: 100% Nitrogen fertilizer (200 kg/feddan)
T3: 75% Nitrogen fertilizer+ 25% Vermicompost
T4: 50% Nitrogen fertilizer + 50% Vermicompost
T5: 25% Nitrogen fertilizer + 75% Vermicompost
T6: 100% Vermicompost (2.65 ton/feddan)

Cultivation Process: Seeds of dragonhead plant (*Dracocephalum moldavica*) were obtained from Faculty of Agriculture, Moshtohor, Benha University, Egypt. In the first week of November, 2017 and 2018, the seeds were sown in the nursery. When the seedlings reach 8-10 cm in height, with 6-8 leaves, were transplanted into the open field on 60 cm apart rows, while the plants at 30 cm in between. The seedlings were sown in hills on one side of the row (one plant in the hill).

Sampling and Collecting Data

Morphology and Yield: Plant height (cm), branch number, fresh and dry weights (g) per plant, were recorded at full flowering stage. Also, fresh and dry herb yield per feddan (ton) were calculated.

Table 1: Some physical and chemical properties of the experimental soil at depth (0-30 cm) before planting in 2017/2018 and 2018/2019 seasons

Season	2017-2018	2018-2019
Clay	28.2	28.8
Silt	37.0	36.8
Sand	34.8	34.4
Texture	Sandy clay loam	Sandy clay loam
Organic matter content (%)	0.91	0.96
E.C (dS/m)	0.89	0.87
pH	7.92	7.89
SP (%)	53.5	53.5
Plant available nutrients contents in the soil (mg/kg)		
N	17.54	17.68
P	5.12	5.23
K	118	125

Table 2: Physical and chemical analysis of the used vermicompost fertilizer

Density (g/ml)	0.86	C:N	11:1
Moisture (%)	22	Total N (%)	1.55
pH	8.52	N-NH_4 (mg/kg)	28
EC (dS/m)	8.34	N-NO_3 (mg/kg)	157
OM (%)	22.03	Total P (%)	2.22
OC (%)	12.77	Total K (%)	1.90
Ash (%)	77.98	----	----

Chemical Analysis of Dragonhead Plant

Photosynthetic Pigments Content: Chlorophyll a, chlorophyll b and carotenoids contents (mg/g f. wt) were determined in dragonhead plant fresh leaves. Pigments content was determined according to the method mentioned by Saric *et al.* [23].

Total phenols were analyzed in leaf samples spectrophotometrically by using the method described by Amin *et al.* [24] as mg gallic acid/100 g d. wt.

Total flavonoids content was measured in leaf samples according to Zhuang *et al.* [25] as mg querstein per 100 g d. wt.

Tannins content was determined in leaf samples as mg tannic acid equivalent /100 g d. wt. by the method of Cam and Hisil [26].

Antioxidant activity of dragonhead plant: By DPPH assay, the antioxidant activity was evaluated in dragonhead plant leaves by 1, 1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging method according to the procedure of Chen *et al*. [27]. Essential oil from dragonhead aerial parts was isolated by steam distillation for 2 h. by a Clevenger apparatus using the method of Guenther [28]. Essential oil percentage (v/w %) was determined according to British Pharmacopoeia [29].

Nitrogen content (g/100 g d. wt) was assayed in the digested solution of dry leaves by the modified Micro-kjeldahl method as mentioned by Jones *et al.* [30].

Phosphorus content: (g/100g d. wt.) was determined in dry leaves colorimetrically using spectrophotometer according to the method of Peters *et al.* [31].

Potassium content (g/100g d. wt.) was determined in dry leaves against a standard using Flame-Photometer Peters *et al.* [31].

Crude protein is calculated by multiplying N content by 6.25 for dragonhead herb [32].

Statistical Analysis: The experiment layout was designed in complete randomized blocks included six treatments each treatment was replicated three times. The recorded data were statistically analyzed according to Snedecor and Cochran [33]. Averages between treatments were differentiated by using LSD at 5% level.

RESULTS AND DISCUSSION

Growth and Yield Parameters: Data in Table (3) pointed that, the application of vermicompost and nitrogen fertilizer alone or in combination enhanced growth and yield parameters of dragonhead plant at flowering stage during 2017/2018 and 2018/2019 seasons. Regarding to the effect of vermicompost treatment, it improved the morphological parameters during the two seasons with significant differences comparing with the control treatment. Most the results confirmed that vermicompost is benefit to plant growth and yield [34, 35].

The highest data of plant height (63.30 and 70.20 cm), number of branches/plant (17.00 and 20.25), fresh weight/plant (124.54 and 132.71 g), dry weight/plant (36.58 and 38.18 g), fresh weight/feddan (2.91 and 3.10 ton) and dry weight/feddan (0.85 and 0.89 ton) were obtained with the application of 75% nitrogen fertilizer+ 25% vermicompost during the two seasons, respectively. There were significant differences between the treatment of 75% nitrogen fertilizer + 25% vermicompost and other treatments in the two seasons. These may be as a result to the beneficial effects of the organic amendment in the form of vermicompost, when applied to the soil increase the growth and yield attributes of plant [36]. Moreover, the effects of vermicompost not only attributed to the quality of provided mineral nutrition but also to other growth regulating components as plant growth hormones and humic acids [37]. On the other hand, vermicompost contains most of the plant nutrients as; phosphates, nitrate, calcium and soluble potassium and microelements which improved plant growth and yield of many crops [38]. It is well known that chemical fertilizers (NPK) could improve plant growth due to the role of nitrogen in nucleic

Table 3: Influence of vermicompost application and nitrogen fertilizer alone and in combination on growth and yield parameters of dragonhead plant during the two seasons of 2017/2018 and 2018/2019

Treatments	Plant height (cm)	Number of branches/ plant	Fresh weight/plant (g)	Dry weight/plant (g)	Fresh weight/ feddan (ton)	Dry weight/ feddan (ton)
			1st season			
T1	48.70	10.33	83.61	22.85	1.95	0.53
T2	61.50	15.67	119.75	34.61	2.79	0.81
T3	63.30	17.00	124.54	36.58	2.91	0.85
T4	60.33	16.00	116.89	33.24	2.73	0.78
T5	54.70	12.67	102.93	28.37	2.40	0.66
T6	51.57	11.33	99.16	26.53	2.31	0.62
LSD at 5%	1.47	0.45	1.83	0.67	0.05	0.008
			2nd season			
T1	56.50	12.35	97.37	24.53	2.27	0.57
T2	69.07	19.00	129.83	37.53	3.03	0.88
T3	70.20	20.25	132.71	38.18	3.10	0.89
T4	68.17	18.50	121.90	36.58	2.84	0.85
T5	62.73	16.25	115.85	31.71	2.70	0.74
T6	60.03	14.00	105.61	27.03	2.46	0.63
LSD at 5%	1.93	0.47	1.95	0.20	0.03	0.004

Note: T1: Control (No fertilizer), T2: 100% nitrogen fertilizer, T3: 75% nitrogen fertilizer+ 25% vermicompost, T4: 50% nitrogen fertilizer + 50% vermicompost, T5: 25% nitrogen fertilizer + 75% vermicompost, T6: 100% vermicompost

acids and protein synthesis [39]. These results agreed with Singh and Wasnik [40] on rosemary; Mafakheri *et al.* [41] on dragonhead and Amooaghaie and Golmohammadi [42] on *Thymus vulgaris.*

Photosynthetic Pigments Content: Results presented in Table (4) showed that, the content of photosynthetic pigments in dragonhead plant was significantly affected with vermicompost application and nitrogen fertilizer alone or in combination, comparing with the control. The results were obtained from the application of 75% nitrogen fertilizer + 25% vermicompost treatment gave the highest content of photosynthetic pigments (0.841 and 0.872 mg/g f. wt) for chlorophyll a, (0.612 and 0.580 mg/g f. wt) for chlorophyll b, (1.453 and 1.452 mg/g f. wt) for total chlorophyll and (0.466 and 0.492 mg/g f. wt) for carotenoids content at 1st and 2nd seasons, respectively.

The beneficial effect of vermicompost on secondary metabolites production may be related to increase photosynthetic activity [42]. These results matched with Singh and Wasnik [40] on rosemary and Mostafa *et al*. [43] on dragonhead.

Total Phenols, Flavonoids, Tannins and Antioxidant Activity: Results in Table (5) display the effect of vermicompost application and nitrogen fertilizer either solely or in combination on total phenols, flavonoids, tannins contents and antioxidant activity of dragonhead plant. It was observed that, there were significant differences in the results obtained from application of 75% nitrogen fertilizer+ 25% vermicompost comparing with the control during the two seasons. The highest total phenols content (55.73 and 58.16 mg/100g d. wt.) was noted in the plants grown in the soil treated with 75% nitrogen fertilizer + 25% vermicompost followed by the plants treated with 100% nitrogen fertilizer. On the same way, flavonoids content (17.68 and 16.94 mg/100g d. wt.) and antioxidant activity (71.86 and 73.51%) had the same trend during the 1st and 2nd seasons, respectively. It has been recognized that the production of secondary metabolites in plants were related to its growing condition [44]. Total phenols and flavonoids may play an important role as scavengers for free radicals and other oxidative species [45].

The results revealed that, the antioxidant activity has acorrelation with both total phenols and flavonoids contents of the herbs. The present results show affinities with the findings of other investigators in certain other medicinal plants like that demonstrated by Khalil *et al*. [46], the total phenols and flavonoids contents related to quality and nutritional value of plants, also the antioxidants are vital substances which have the ability to protect body from damage by free radical induced oxidative stress. These results are in accordance with Yusof *et al*. [47] on *Clinacanthus nutans* and Mostafa *et al*. [43] on dragonhead plant.

In contrast, it was noted that, application of vermicompost led to decrease in tannins content. The minimum values (4.67 and 4.36 mg/100g) for tannins content were obtained with 100% vermicompost application during the 1st and 2nd seasons, respectively. This result agrees with Das *et al*. [48] who found that, the application of vermicompost to inorganic fertilization lead

Table 4: Influence of vermicompost application and nitrogen fertilizer alone and in combination on photosynthetic pigment of dragonhead plant during the two seasons of 2017/2018 and 2018/2019

Treatments	Chlorophyll a (mg/g f. wt)	Chlorophyll b (mg/g f. wt)	Total chlorophyll (mg/g f. wt)	Carotenoids content (mg/g f. wt)
		1st season		
T1	0.575	0.411	0.986	0.295
T2	0.821	0.599	1.420	0.459
T3	0.841	0.612	1.453	0.466
T4	0.731	0.491	1.222	0.386
T5	0.677	0.469	1.146	0.339
T6	0.635	0.468	1.103	0.326
LSD at 5%	0.008	0.006	0.013	0.006
		2nd season		
T1	0.582	0.435	1.017	0.310
T2	0.842	0.553	1.395	0.488
T3	0.872	0.580	1.452	0.492
T4	0.743	0.522	1.265	0.412
T5	0.682	0.484	1.166	0.322
T6	0.647	0.469	1.116	0.317
LSD at 5%	0.021	0.015	0.035	0.008

Note: T1: Control (No fertilizer), T2: 100% nitrogen fertilizer, T3: 75% nitrogen fertilizer+ 25% vermicompost, T4: 50% nitrogen fertilizer + 50% vermicompost, T5: 25% nitrogen fertilizer + 75% vermicompost, T6: 100% vermicompost.

Table 5: Influence of vermicompost application and nitrogen fertilizer alone and in combination on total phenols, flavonoids, tannins contents and antioxidant activity of dragonhead plant during the two seasons of 2017/2018 and 2018/2019

Treatments	Total phenols (mg/100g d. wt.)	Flavonoids (mg/100g d. wt.)	Tannins (mg/100g d. wt.)	Antioxidant activity %
		1st season		
T1	36.24	12.84	5.66	56.05
T2	52.36	15.21	8.72	70.77
T3	55.73	17.68	8.36	71.86
T4	47.23	14.09	6.55	64.48
T5	43.45	13.88	5.39	62.14
T6	39.56	13.24	4.67	60.49
LSD at 5%	2.3	0.024	0.020	1.540
		2nd season		
T1	37.68	13.60	5.82	58.62
T2	54.23	16.02	9.08	70.56
T3	58.16	16.94	8.88	73.51
T4	48.62	15.21	7.08	67.73
T5	45.46	15.38	5.64	64.57
T6	41.53	14.36	4.36	61.79
LSD at 5%	2.61	0.022	0.018	2.68

Note: T1: Control (No fertilizer), T2: 100% nitrogen fertilizer, T3: 75% nitrogen fertilizer+ 25% vermicompost, T4: 50% nitrogen fertilizer + 50% vermicompost, T5: 25% nitrogen fertilizer + 75% vermicompost, T6: 100% vermicompost

to decrease in the total tannins content of *Cajanus cajan* leaf. Harmful effects of various tannins include depression of food quality, decrease digestive enzymes, proteins and amino acids lead to low in mineral uptake [49].

Dragonhead Essential Oil Production: Data recorded in Table (6) revealed that, essential oil percentage of dragonhead herb, yield/plant and yield/feddan were significantly increased with application of vermicompost either solely or combined with nitrogen fertilizers during the two seasons.

The results show that, vermicompost improved the volatile oil production during both seasons with significant differences comparing with the control treatment. The maximum values (0.061 & 0.063 %; 0.076 & 0.084 ml/plant and 1.773&1.960 L/feddan) for essential oil percentage, yield per plant and feddan were obtained with 75% nitrogen fertilizer + 25% vermicompost application during the 1st and 2nd seasons, respectively. These results may be due to the influence of vermicompost on accelerating metabolic reactions, stimulating enzymes, increasing in vegetative growth and increasing leaf oil gland populations which lead to increase in essential oil yield.

Such results matched with Amooaghaie and Golmohammadi [42] that reported, effects of vermicompost could be related to nutrient release from the vermicompost and soil plant nutrient demand and suitable nutrients are essential for giving the highest herb and essential oil yield. Other researches agreed with our results such as Mafakheri *et al.* [41] on dragonhead and Singh and Wasnik [40] on rosemary.

Table 6: Influence of vermicompost application and nitrogen fertilizer alone and in combination on dragonhead essential oil production during the two seasons of 2017/2018 and 2018/2019

Treatments	Essential oil %	Oil yield (ml) /plant	Oil yield (L) /feddan
		1st season	
T1	0.045	0.038d	0.887
T2	0.057	0.068b	1.587
T3	0.061	0.076	1.773
T4	0.058	0.068	1.587
T5	0.055	0.057	1.330
T6	0.053	0.053	1.237
LSD at 5%	0.008	0.005	0.008
		2nd season	
T1	0.047	0.046	1.073
T2	0.057	0.074	1.727
T3	0.063	0.084	1.960
T4	0.059	0.072	1.680
T5	0.056	0.065	1.517
T6	0.053	0.056	1.307
LSD at 5%	0.006	0.006	0.009

Note: T1: Control (No fertilizer), T2: 100% nitrogen fertilizer, T3: 75% nitrogen fertilizer+ 25% vermicompost, T4: 50% nitrogen fertilizer + 50% vermicompost, T5: 25% nitrogen fertilizer + 75% vermicompost, T6: 100% vermicompost

Table 7: Influence of vermicompost application and nitrogen fertilizer alone and in combination on N, P and K content, their uptake and protein content of dragonhead plant during the two seasons of 2017/2018 and 2018/2019

Treatments	N (%) (d. wt)	N uptake (g/plant)	P (%) (d. wt)	P uptake (g/plant)	K (%) (d. wt)	K uptake (g/plant)	Protein (%)
				1st season			
T1	2.72	0.621	1.17	0.267	2.90	0.663	17.00
T2	3.51	1.214	1.33	0.460	3.09	1.069	21.94
T3	3.57	1.306	1.36	0.497	3.14	1.149	22.31
T4	3.28	1.090	1.38	0.458	3.20	1.064	20.50
T5	3.05	0.865	1.43	0.406	3.27	0.928	19.06
T6	2.89	0.767	1.49	0.395	3.38	0.897	18.06
LSD at 5%	0.08	0.021	0.038	0.012	0.043	0. 014	0.50
				2nd season			
T1	2.63	0.645	1.26	0.309	2.91	0.714	16.44
T2	3.58	1.344	1.38	0.517	3.22	1.208	22.38
T3	3.71	1.417	1.4	0.534	3.24	1.237	23.19
T4	3.48	1.273	1.42	0.519	3.30	1.207	21.75
T5	3.08	0.977	1.52	0.482	3.40	1.078	19.25
T6	2.95	0.797	1.55	0.419	3.47	0.938	18.44
LSD at 5%	0.06	0.026	0.049	0.017	0.064	0.024	0.38

Note: T1: Control (No fertilizer), T2: 100% nitrogen fertilizer, T3: 75% nitrogen fertilizer+ 25% vermicompost, T4: 50% nitrogen fertilizer + 50% vermicompost, T5: 25% nitrogen fertilizer + 75% vermicompost, T6: 100% vermicompost.

Table 8: Influence of vermicompost application and nitrogen fertilizer alone and in combination on available NPK in soil after harvest of crop during the two seasons of 2017/2018 and 2018/2019

Treatments	N (mg/kg)	P (mg/kg)	K (mg/kg)
		1st season	
T1	14.26	5.32	122.89
T2	18.11	5.38	123.27
T3	18.25	5.55	124.63
T4	16.85	5.73	130.65
T5	15.97	5.87	132.71
T6	14.52	6.00	135.00
LSD at 5%	0.12	0.11	0.64
		2nd season	
T1	14.40	5.44	129.00
T2	18.26	5.48	129.24
T3	18.31	5.64	132.19
T4	17.00	5.90	136.25
T5	16.06	6.02	139.62
T6	14.71	6.11	140.37
LSD at 5%	0.12	0.13	0.70

Note: T1: Control (No fertilizer), T2: 100% nitrogen fertilizer, T3: 75% nitrogen fertilizer+ 25% vermicompost, T4: 50% nitrogen fertilizer + 50% vermicompost, T5: 25% nitrogen fertilizer + 75% vermicompost, T6: 100% vermicompost

Nitrogen, Phosphorous and Potassium Contents and Their Uptake by Dragonhead Plant: The data presented in Table (7) showed that, the treatment of 75% nitrogen fertilizer + 25% vermicompost gave the greatest nitrogen content (3.57 and 3.71%) and protein content (22.31 and 23.19 %) during the two seasons, respectively, followed by application of 100% nitrogen fertilizer. It worth to mention that application of 100% vermicompost improved phosphorous and potassium content and gave the highest results (1.49 and 1.55%) for phosphorous and (3.38 and 3.47%) for potassium through 1st and 2nd seasons respectively. These findings may be due to the microorganisms in the rhizosphere area provided by vermicompost treatment increased the availability of nutrients [50]. Results in Table (7) cleared that, vermicompost had a significant effect on nutrient uptake. The highest values of nutrients uptake (1.306 &1.417, 0.497 & 0.534 and 1.149&1.237 g/plant) for N, P and K were achieved in treatment 75% nitrogen fertilizer + 25% vermicompost at 1st and 2nd seasons, respectively. This may be due to the effects of vermicompost on microorganisms in the soil. This leads to higher availability and uptake macro elements by the plant [51]. Higher nutrient uptake might be conducted to higher biomass yield. Vermicompost provided nutrients to be better uptake by the dragonhead plant by increasing the proportion of humus in the soil. Humic acid also enhances the plant growth although at a slower rate and is essential for plants through enabling the plant to extract nutrients from soil, helping the plant to dissolve minerals that were not dissolved for delivering organic matter to plants for use and stimulating root growth [52]. Even the chemical fertilizers are more effective when humus is present in the soil [53]. Similar results were obtained by Mafakheri *et al.* [41] on dragonhead; Singh and Wasnik [40] on rosemary and Zaman *et al*. [54] on stevia.

Available NPK in Soil after Harvest of Dragonhead Plant: The main nutrients in the soil after harvest of dragonhead plant were significantly affected by the treatments that applied before and through planting. As shown in Table (8) the lowest available N was recorded in control treatment. There were significant differences among all treatments in nitrogen uptake and the treatment of combination 75% nitrogen fertilizer + 25%vermicompost gave the highest N value (18.25 mg/kg) in the first season while in the second season there was no significant difference between the two treatments 100% nitrogen fertilizer and combined treatment 75% nitrogen fertilizer + 25%vermicompost.

On the other hand, the highest available of phosphorous and potassium contents were recorded in vermicompost treated soil giving (6.00 and 6.11 mg/ kg) for P and (135.00 and 140.37 mg/ kg) for K with treatment 100% vermicompost through 1st and 2 nd seasons, respectively. Vermicompost has a role in improving soil texture and aeration and in this way enhances more water and nutrients take-up by plants [55]. Vermicompost contained a higher concentration of exchangeable K and P due to microbial activity during the vermicomposting process, which increased rate of mineralization [56]. The application of vermicompost in the field improves soils quality by enhancing microbial activity and microbial biomass which are main components in nutrient cycling, production of plant growth regulators and protecting plants soil-borne disease [57]. This organic fertilizer considered as alternative to inorganic fertilizers [58]. These results agreed with Singh and Wasnik [40] on rosemary; Zaman *et al*. [54] on stevia and Mahmoud and Gad [37] on *Phaseolus vulgaris.*

CONCLUSION

Based on the obtained results, we can conclude that application of vermicompost improved growth, yield, nutrient content and essential oil content with significant differences comparing with control treatment. On the other hand, these traits reduced with increasing of vermicompost and decreasing of nitrogen. So, the highest values were recorded with application of combination 75% nitrogen + 25% vermicompost.

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