World Journal of Agricultural Sciences 17 (3): 252-258, 2021
ISSN 1817-3047

DOI: 10.5829/idosi.wjas.2021.252.258

Effect of Different Rates of Fulvic Acid and Compost on Growth, Yield and Nutritional Status of Fennel Plant Grown in Sandy Soil

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Abstract: Two field experiments were carried out at the Agricultural Production and Research Station, National Research Centre (NRC), Nubaria Province, Egypt during successive winter season 2019 and 2020. The experiment was designed to investigate the effect ofdifferent rates of compost (2.5 and 5 ton fed^{-1}) combined with three rates of fulvic acid (0, 1 and 2 ml L^{-1}) and its effect on growth , yield and nutritional status of sweet fennel plants (*Foeniculum vulgare* var. Dulce) grown in sandy soil. The results indicated that spraying fennel plants with different rates of fulvic acid greatly improved the growth and yield characteristics of fennel plants under both levels of organic fertilization (compost) in both seasons. The effect was more significant and positive when fulvic acid was sprayed at a rate of 2 ml per liter with compost fertilization at a rate of 5 ton per feddan. The same treatment was more effective in increasing the essential oil content in fennel plants, which improved the yield quality. The increase was 50.4 % in the first season and 49.7% in the second season. Thus, the herb uptake of the nutrients, whether major (N, P and K) or minor (Fe, Zn and Mn), greatly improved when spraying fulvic acid, especially at a rate of 2 ml per liter with the addition of an appropriate amount of compost (5 ton fed^{-1}). It can be said that spraying plants with a short carbon-chain organic acid (fulvic acid) greatly improves the growth, quality and cauterization of the sweet fennel plants grown in sandy soil, in combination with organic fertilization. The best values of vegetative growth, total yield and quality attributes of Fennel plants grown in sandy soil were attained with application of fulvic acid at rate 2ml/L incorporated with compost at rate of 5 ton/fed.

Key words: Fennel plants · Growth · Yield · Nutrients uptake · Fulvic acid · Compost · Sandy soil

INTRODUCTION

Fennel (*Foeniculum vulgare Mill.*) is a herbaceous perennial plant which belongs to the family of Apiaceae (*Umbell iferae*). Fennel plantsis contain essential oils in the leaves, roots and fruits. More than thirty types of compounds were found in Fennel essential oil such as anethole and fenchone [1] and [2]. Fennel fruits are commonly known for their nutritional and medicinal value where they are used in pharmaceutical and food purposes [3].It grows in several Mediterranean and Southern Europe countries [4]. Fennel is used inseveral purposes as an appetite stimulant, flavoring agents, estrogenic activities, antioxidant, antimicrobial and treatment of nervous disturbances [5].

Fulvic acid is produced by the biodegradation of organic matter with lignin content [6]. Fulvic acid stimulates plant growth [7] and [8], enhances minerals uptake [9] and [10], improves photosynthetic activities and protein synthesis [11], reduces toxicity levels and pathogens [12] and [13], promotes root growth [14], increase soil water holding capacity that reducing the

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irrigation needs and increases plant water stress tolerance [15] and increases soil microbial populations [16]. Fulvic acid contains many nutritional elementswhich are beneficial forimproving crop yield together with improvementof physicochemical and biological environment of soils [17]. One ofthe most important properties of fulvic acid is the productionof negative charge that arises essentially from thedissociation of acidic functional groups [18] and [19].

Composting is a biological process in which organic biodegradable wastes are converted into hygienic, hums rich product for use as a soil amendment and an organic fertilizer [20] and [21]. The use of compost is a natural and ecological means of beneficent soil fertility for improved the yield [22]. Application of compost contributes to the stabilization of soil aggregate framework and hence improves soil structure, porosity and baulk density [23].

The objective of this experiment wasto study the effect of organic fertilizer (compost) alone and in combinationwith different levels of fulvic acid ongrowth, yield and nutrients uptake of fennel plants grown in sandy soil.

MATERIALS AND METHODS

Two field experiments were carried out at the Agricultural Production and Research Station, National Research Centre (NRC), Nubaria Province, Egypt during successive winter season 2019 and 2020.The experiment was designed to investigate the effect of different rates compost and fulvic acid and its effect on growth, yield and nutritional status of sweet fennel plants grown in sandy soil. Seeds of head sweet fennel (cv. Dulce) were sown on September 2019 and 2020 in polystyrene trays. After four weeks from sowing, the transplants were planted in the open field. Sweet fennel seedlings were placed in double rows on October 2019 and 2020. Raised beds with one meter width were prepared one week before transplanting. Sweet fennel was cultivated two rows for every bed. The final plant spacing was 50 cm in the row, 60 cm between the rows and 70 cm in between the beds. Compost was added in two rates (2.5 and 5 ton fed^{-1}), which were added when preparing the soil for cultivation. The compost used in this experiment was made of cattle manure (20 %) mixing with plant residues (80 %). Compost was determined (Table, 1) using the standard procedures outlined by Cottenie [24].

Fulvic acid was used in three concentrations (0, 1, 2 ml per liter of water), where those concentrations were sprayed on fennel plants from the third week of planting the seedlings and this was repeated three times at a rate of once every two weeks.The experiment was arranged in a randomized split plot design with four replicates where the compost wascontributed as the main plot, while fulvic acid concentrations was distributed in the sub- plots.

Some physical and chemical properties of the soil used in Table (2) using the standard procedures outlined by [24].

Five plants of each experimental plot were taken at harvest (after 70 days from the transplanting date) to determine growth parameters. The following data were recorded, i.e., plant length (cm), number of branches per plant, bulb dimensions (thickness, width and length (cm) and dry weight of herb and bulb (g). All the plants of every plot of the experimental plot were harvested at 120 days from transplanting and the data were recorded: -

- Total yield of sweet fennel plants (ton fed^{-1}).
- Physical bulb quality: Bulbs of such plants were excised by cutting 5 cm above the bulb using a sharp stainless-steel knife. Also, roots were excised and the outer-leaf was removed for obtaining clean bulbs. Afterwards, flatten, cylinder and elongated shape ratios of bulbs were calculated according to Pascale and Barbieri [25] as follow:

- Flatten shape ratio = W/T
- Cylinder shape ratio = L/ (WT)*0.05
- Elongated shape ratio = L/W

where: W, width (cm); T, thickness (cm); L, length (cm).

Five plant samples of each plot were dried at 70°C in air forced oven until a constant mass was reached and then they were grounded for chemical analysis and wet digested using H_2SO_4:H_2O_2 method [24]. Total nitrogen was determined using the micro-Kjeldahl method; P was assayed using molybdenum blue method and determined by spectrophotometer, as well as K was determined by Flame Photometer [26], while Fe, Zn and Mn were determined using atomic absorption spectrophotometer using the method of A.O.A.C. [27]. Essential oil percentage was determined in dried samples in both seasons by subjecting to hydro distillation in Clevenger apparatus according to method described by the Egyptian Pharmacopoeia [28]. Then the essential oil percentage (%) was calculated.

Table 1: Some chemical properties of compost used

pH 1:2.5 extraction	EC (dS m^{-1}) 1:5 extraction	Moisture content (%)	Organic Matter	Organic Carbon	Ash	N	P	K	C:N ratio
8.10	2.20	21	30.8	17.9	69.2	0.86	0.16	0.59	1:20.8

Table 2: Physical and chemical properties of the field soil

Soil property	Value	Soil property	Value
Particle size distribution %		pH (1:2.5 soil suspension)	7.70
Sand	92.65	EC (dS m^{-1}), soil paste extract	1.60
Silt	5.07	Soluble ions (mmol L^{-1})	
Clay	2.28	Ca^{++}	8.02
Texture	Sandy	Mg^{++}	3.23
$CaCO_3$ %	2.20	Na^{+}	3.92
Saturation percent %	22.50	K^{+}	0.91
Organic matter%	0.11	CO_3^{-}	nd
Available N (mg kg^{-1})	20.2	HCO_3^{-}	2.20
Available P (mg kg^{-1})	3.50	Cl^{-}	3.98
Available K (mg kg^{-1})	66.4	SO_4^{-}	9.90
		CEC (cmol kg^{-1})	7.00

Statistical Analysis: All data were subjected to statistical analysis using Mstatc software [29]. Means of the treatments were compared by the Least Significant Differences Test at (0.05) level of significance.

RESULTS AND DISCUSSION

The results in Table (3) showed that during the two growing seasons, the growth of plants was improved, as well as a significant increase in the yield components (dry weight of herb and bulb, total green yield and essential oil content) as a result of spraying fulvic acid at a concentration of 2 ml L^{-1} on fennel plants. This was clearly and significantly demonstrated with the higher level of compost (5 ton fed^{-1}). The results also obtained in Table (3) showed that spraying fulvic acid at a concentration of 2 ml L^{-1} with the addition of compost at a rate of 5 ton per feddan led to a significant increase in the value of the total green yield of sweet fennel plants at a rate of 46.9% in the first season and 48% in the second season, which explains the very great effect of spraying fulvic acid with the addition of the optimum rate of good organic fertilizer.

Similarly, an improvement in the content of essential oils was also found as a result of spraying fulvic acid at a concentration of 2 ml L^{-1} with higher fertilization of compost (5 ton fed^{-1}). The increase was 50.4 % in the first season and 49.7% in the second season.

The addendum of compost to agricultural soils supplies organic matter, decreases leaching of mineral elements from the soil. Compost has already been established as a suitable fertilizer for improving the productivity of several medicinal and aromatic plants, such as *Dracocephalum moldavica* [30], peppermint, *Tagete serecta* [31] and sweet fennel [32]. It has been reported that fennel essential oil yield increased by different organic fertilizers [33] and [34]. Abdelaziz *et al*. [35] showed that the highest essential oil yield of rosemary was obtained from plants treated by compost. They suggested that the simulative effect of this treatment on increasing essential oil yield might be attributed to their enhancing effect on growth characteristics and nitrogen, phosphorus, potassium and total carbohydrates content of rosemary which can influence the yield and components of essential oil.

Foliar application of fulvic acid had a positive effect on the growth due to that these molecules could readily penetrate into the leaf cuticle and plasma membrane [36]. Fulvic acid has the capacity to sensitize plasma membrane to spread the ions into the cells and loading the ions into the conducting tissues [37].

It is evident from Table (4) that the experimental treatments affected thebulb dimensions and physical bulb quality of the fennel bulb (Flatten, Cylinder and Elongated shape ratio). Where the effective positive effect was happened when was increased the rate of organic fertilization and the concentration spraying of fulvic acid on fennel plants. The quality characteristics of sweet fennel bulbs were obtained a high value when spraying fulvic acid at a rate of 2 ml L^{-1}mixing with the high dose of compost (5 ton fed^{-1}). It is also evident the importance of adding organic fertilizer with good specifications and in the appropriate quantity to obtain the best result. It seems that using plant compost supported with cattle manure

Table 3: Effect of fulvic acid and compost on growth and yield parameters of sweet fennel plants at two seasons

Compost (ton fed^{-1})	Fulvic acid ml L^{-1}	Plant height cm	Number of main branches	Dry weight (g) Herb	Dry weight (g) Bulb	Total green yield ton fed^{-1}	Essential oil content %
				First season			
2.5	0	60.00	7.667	9.433	5.797	4.431	0.722
	1	64.67	8.333	16.23	7.310	5.762	0.988
	2	71.33	10.00	18.53	8.443	6.852	1.010
5	0	66.67	8.333	13.33	6.463	5.863	0.800
	1	72.67	9.333	20.53	8.157	7.445	1.224
	2	76.00	10.333	21.33	10.45	8.356	1.455
LSD $_{0.05}$		4.400	1.135	3.266	0.112	0.162	0.100
				Second season			
2.5	0	60.15	7.656	10.56	6.882	4.555	0.754
	1	65.22	8.341	15.11	7.890	5.851	1.001
	2	71.46	9.950	17.36	8.445	6.743	1.052
5	0	65.55	8.321	12.25	7.466	5.711	0.858
	1	71.12	9.411	17.35	9.000	7.894	1.259
	2	80.01	10.61	19.56	10.22	8.812	1.500
LSD $_{0.05}$		4.400	1.135	3.266	1.659	0.162	0.100

Table 4: Effect of fulvic acid and compost on bulb dimensions and physical bulb quality of sweet fennel plants at two seasons

		Bulb dimensions (cm)			Physical bulb quality		
Compost (ton fed^{-1})	Fulvic acid ml L^{-1}	Width	Length	Thickness	Flatten shape ratio	Elongated shape ratio	Cylinder shape ratio
				First season			
2.5	0	7.800	5.500	6.567	1.188	0.705	2.147
	1	9.063	6.583	7.403	1.224	0.726	1.962
	2	9.827	8.133	8.733	1.125	0.828	1.895
5	0	8.340	6.533	7.133	1.169	0.783	2.196
	1	12.83	8.500	8.733	1.469	0.663	1.517
	2	13.46	9.900	9.200	1.463	0.736	1.599
LSD$_{0.05}$		0.280	0.250	0.140	0.080	0.040	0.121
				Second season			
2.5	0	7.820	5.620	6.722	1.163	0.719	2.138
	1	9.122	6.695	7.512	1.214	0.734	1.954
	2	9.951	8.244	8.911	1.117	0.828	1.859
5	0	8.401	6.633	7.202	1.166	0.790	2.193
	1	11.92	8.711	8.834	1.349	0.731	1.654
	2	12.98	10.00	9.220	1.408	0.770	1.671
LSD$_{0.05}$		0.280	0.250	0.140	0.080	0.040	0.121

(20%) resulted in improving the nutrient content of the compost especially K which in turn reflected on sweet fennel characteristics of yield and quality. Moreover, K excreted in the wastes of domestic livestock is largely retained in the bedding material that forms the main bulk matrix of cattle manure. Consequently, cattle manure is a relatively rich source of K compared with other bio solids products [38]. The fulvic acid also stimulates the production of plant's own auxin and improving the capacity of the plasma membrane to the sense of the other growth hormones such as cytokinin and gabrillic acid. The positive influences of fulvic acid on the productivity and fruit quality could also be primarily due to hormone-like activities of the has through their participation in cell respiration, photosynthesis oxidative phosphorylation, protein synthesis and various enzymatic reactions [39].

Abd El-Rheem *et al*. [40] reported that the addition of vermicompost improved the bulb dimensions of sweet fennel, especially when adding vermicompost at 100%. However, there were no significant differences in improvingthe physical bulb quality of fennel bulb when adding vermicompost and compost.

Data presented in Table (5) demonstrated that, the N, P, K, Fe, Zn and Mn uptake in herb of sweet fennel plants were significantly increased by increasingthe application rates of compost. Also, the presence of spraying of fulvic

Table 5: Effect of fulvic acid and compost on nutrients uptake in herb of sweet fennel plants at two seasons

		Nutrients uptake (ppm)					
Compost (ton fed^{-1})	Fulvic acid ml L^{-1}	N	P	K	Fe	Zn	Mn
		First season					
2.5	0	13.65	4.367	30.09	0.161	0.016	0.021
	1	24.39	5.689	41.06	0.221	0.026	0.036
	2	25.70	6.206	50.77	0.498	0.031	0.056
5	0	16.04	5.398	39.23	0.203	0.016	0.030
	1	27.89	6.426	61.73	0.440	0.025	0.047
	2	28.17	7.255	78.92	0.471	0.043	0.049
$LSD_{0.05}$		3.110	1.655	6.402	0.020	0.001	0.001
		Second season					
2.5	0	14.85	4.256	32.29	0.165	0.017	0.025
	1	23.36	5.666	42.46	0.223	0.028	0.033
	2	25.65	6.256	51.27	0.466	0.033	0.049
5	0	15.94	5.188	39.33	0.200	0.018	0.031
	1	26.17	6.106	60.73	0.410	0.026	0.049
	2	29.10	7.275	76.52	0.470	0.040	0.052
$LSD_{0.05}$		3.110	1.655	6.402	0.020	0.001	0.001

acid improved the nutrients uptake compared to the compost fertilized alone. It was found that spraying with a high level of fulvic acid (2 ml L^{-1}) and high rate of compost used (5 ton fed^{-1}) gave the highest values to nutrients uptake in herb of sweet fennel, whether it was the major (N, P and K) or minor nutrients (Fe, Zn and Mn).

Many studiesdemonstrated that compost can improving root development, providing plant nutrients and enhancing nutrient uptake by plants [30], [41] and [22]. Many beneficial effects are attributed to foliar application of fulvic acid, including stimulation of plant metabolism, increased bioavailability and uptake of nutrients [42]. These finding could be attributed due the fact that fulvic acid and compost enhances soil aggregations which enhances minerals movements and increases synthesis activities in the plant [43]. Moreover, Bocanegra *et al.* [44] and Aminifard *et al*. [45] attributed the role of fulvic acids in increasing enzyme activities, micro and macro elements availability in the soil and minerals uptake.

CONCLUSION

From the above mention results it could be concluded that the application of fulvic acid and compost is considered as a useful in eco-friendly agriculture practices and sustainable crop production. Whereas, the best values of vegetative growth, total yield and quality attributes of Fennel plants grown in sandy soil were attained with application of fulvic acid at rate 2ml/L incorporated with compost at rate of 5 ton/fed.

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