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Influence of organic fertilizers on the yield, essential oil and mineral content of onion

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A b s t r a c t. Two experiments were carried out under sandy soil conditions at the experimental station of the National Research Centre in Nubaria region during two successive seasons of 2006/2007 and 2007/2008 to study the productivity of onion (*Allium cepa* L.) as influenced by different organic manure rates and sources. All organic fertilizer treatments *ie* mixture of farmyard and chicken manure, overcame the control treatment (recommended NPK) and improved the vegetative growth characters, essential oil, some of the main constituents of essential oil and NPK contents.

K e y w o r d s: Onion (*Allium cepa* L.), organic fertilizers, vegetative growth, essential oil and minerals

INTRODUCTION

Onion (*Allium cepa* L.) is a vegetable that is widely consumed due to its flavouring and health-promoting properties. It has been reported that onion extract can be a potent cardiovascular and anticancer agent with hypocholesterolemic, thrombolitic and antioxidant effects (Block, 1985). Several antioxidant compounds, mainly polyphenols such as flavonoids and sulphur-containing compounds have been described in onion (Nuutila *et al*., 2003).

Proper fertility is important in onion production. Onions require fertile, well drained, non-crusting soils, and are often produced in muck soils. A slightly acid pH in the 6-6.8 range is optimum. Onions require substantial amounts of nutrients. Based on a yield of 36 ton of bulbs, the plants remove about 124, 22.5, and 135.5 kg, respectively, of nitrogen, phosphorus, and potassium per hectare (Peirce, 1987). Nutrient requirements vary with production location, variety, and soil type, soil test recommendations should be used to determine specific application rates for individual fields, since it is important to avoid over fertilization with nitrogen or phosphorus, as this will contribute to increased pest problems. Excess nitrogen also causes onions to be more susceptible to storage pathogens. Adequate potassium levels are especially important in improving bulb quality and storage life. Organic matter in the form of either barnyard or green manure should be added to the soil (Ware and McCollum, 1980).

Hornok (1980) indicated that NPK fertilization was not only effective on the quantity of vegetative and generation mass, but on the essential oil content of *Anethum graveolens* L. (dill). Also Hussien (1995) reported that nitrogen fertilisation had a strong effect on the dill essential oil constituents. NPK fertilization and micronutrients increased the vegetative growth and essential oil content of some medicinal *Apiaceae* plants (Khalid, 1996).

Sandy soils in Egypt are characterised with poor nutrients (including macro- and micronutrients) and unfavourable environmental conditions which negatively affect growth and productivity of vegetables including onion plants (Abd-Allah *et al*., 2001). In addition, pollution with chemical fertilizers arose as an aim of health care, thus attempts were made for solving problems of chemical fertilization, and the organic farming technique represents a move towards an alternative system of agriculture (Abd-Allah *et al*., 2001). Organic material, such as sheep and chicken manure, improves soil physical properties (structure and aggregation) and soil chemical properties (decrease soil pH, increase cation exchange capacity and enhance most nutrients) that are important for plant growth (Snyman *et al*., 1998).

Application of organic fertilizer increased the biomass yield of the main crop and total essential oil yields of davana plant (Parakasa Rao *et al.,* 1997). Marculescu *et al.* (2002)

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revealed that the soil, with its content in macro and micro-elements enhanced by the use of organic fertilizers, plays an essential role in the plants growing and development, in the biosynthesis of organic substances, also it can be noted that the vegetative mass is rich and the amount of essential oil is high in *Chrysanthemum balsamita* L. plant when using organic fertilizer. Khalid and Shafei (2005) indicated that treatment of plants with different combinations of organic fertilizers and its rates resulted in a significant increase in growth, yield characters, essential oil and main components of essential oil extracted from dill (*Anethum graveolens* L.). Khalid *et al*. (2006b) reported that organic farming increased the vegetative growth, essential oil and mineral content of *Calendula officinalis* L. (marigold) plants. Hussein *et al.* (2006) revealed that organic fertilizers had a promoting influence on most of vegetative growth parameters and accelerated essential oil accumulation of *Dracocephalum moldavica* L. (dragonhead). Applying organic fertilizers improved vegetative growth characters, essential oil, some chemical composition of essential oil, and phosphorous content of *Ocimum basilicum* L. (sweet basil) plants (Khalid *et al.,* 2006a). Barker and Bryson (2002) reported that heavy metal pollutants are not degraded during composting but may be converted into organic combinations that have less bio-availability than mineral combinations of the metals, so the pollution can decrease with organic fertilizers.

The main objective of the present investigation was to study the effect of different levels of some organic fertilizers on the yield, essential oil and metals content of onion (*Allium cepa* L.) plants.

MATERIALS AND METHODS

The two experiments were carried out on sandy soil (85.8% sand, 11.8% silt, and 2.4 clay) at the experimental station of the National Research Centre in Nubaria region during two successive seasons of 2006/2007 and 2007/2008. Chemical properties of the soil were determined according to Jackson (1973) and Cottenie *et al.* (1982) (Table 1).

Seeds of onion 'Giza 6 improved' were kindly produced from Medicinal and Aromatic Plants Department, Ministry of Agriculture, Egypt. Onion seeds were sown in the first week of October during both seasons. The seedlings were transplanted 70 days after sowing. Transplanting was done in rows (2 per each ridge) with spacing of 10 cm in the row. The experimental design was complete randomised blocks with four replicates. The experimental area (plot) was 4 m^2 (2 x 2 m) containing 4 rows. The experiment included 7 treatments representing different combinations of farmyard manure (FYM) and chicken manure (CM), in addition the control treatment (recommended chemical fertilizers), as follows:

1. Control or recommended NPK = 146.4 N ha^{-1}: 73.19 P_2O_5 ha $^{-1}$: 48.8 K_2O ha^{-1},
2. 71.4 + 0,
3. 59.5 + 11.9,
4. 47.6 + 23.8,
5. 35.7 + 35.7,
6. 23.8 + 47.6,
7. 11.9 + 59.5, and
8. 0 m^3 FYM ha^{-1} + 71.4 m^3 CM ha^{-1}.

Chemical properties of the organic fertilizers applied are presented in Table 2.

All agriculture practices operation other than the experimental treatments were done according to the recommendations of Ministry of Agriculture, Egypt.

At harvesting stage, the bulb fresh mass (g plant $^{-1}$ or kg m^{-2}), bulb dry mass (g plant $^{-1}$ or kg m^{-2}) and bulb diameter (cm) were recorded.

Fresh bulbs were collected from each treatment during harvesting stage. They were dried by air and weighed to extract the essential oil. Dry plant material (300 g) from each replicate of all treatments was subjected to hydrodistillation

T a b l e 1. Chemical properties of the soil

Available (mg g^{-2})		Total (mg g^{-2})	Soluble anions ($Cmol_c$)				Soluble cations ($Cmol_c$)			EC (dS m^{-1})	pH 1. 2.5
P	K	N	CO_3	HCO_3	Cl	SO_4	Na	Mg	Ca	1.11	8.15
9.30	16	45	-	2.79	5.81	2.50	5.10	1.57	4.03		

T a b l e 2. Chemical properties of organic fertilizers

Contents	O.M	pH	EC	N	P	K	Fe	Mn	Zn	Cu
	(g kg^{-1})		(dS m^{-1})	(g kg^{-1})			(mg kg^{-1})			
Farmyard manure	32	7.3	4.3	1.65	0.51	1.8	1 625	245	181	18
Chicken manure	21.2	7.4	3.71	2.59	0.74	2.2	1 136	320	204	35

for 3 h using a Clevenger-type apparatus according to the method of Dadalioglu and Evrendilek (Giray *et al.,* 2008). The essential oil content was calculated as g kg^{-1}. In addition, total essential oil as ml plant $^{-1}$ was calculated by using the dry mass of the bulb. The essential oils extracted from *Allium cepa* L. were collected from all treatments to identify the chemical constituents of the essential oil.

Constituents of essential oil were determined by gas-liquid chromatography. The chromatograph (Model Perkin Elmer 3920B) was equipped with a thermal conductivity detector and 2 m x 0.3 cm column packed with 10% Carbwax 20M on 80/100 Chromsorb WAW and hydrogen was used as the carrier gas at 0.5 cm^3 s^{-1}. The column temperature was 130°C and detector and injector temperatures were 200°C. Constituents were identified by retention times and conjunction with known structures.

Total nitrogen, phosphorus, and potassium in the bulbs were determined using the methods described by the Association of Official Agricultural Chemists (A.O.A.C. 1970).

The averages of data from the two seasons were statistically analysed using analysis of variance (ANOVA) and values of least significant difference (LSD) at 5% according to Snedecor and Cochran (1990).

RESULTS AND DISCUSSION

Data presented in Table 3 showed the response of growth characters in onion plant to the different rates of farmyard and chicken manures. The data indicated that all organic fertilizer treatments *ie* mixture of farmyard and chicken manure, overcame the control treatment and improved the vegetative growth characters. The highest values of vegetative growth characters were recorded with 23.8 m^3 ha^{-1} farmyard manure + 47.6 m^3 ha^{-1} chicken manure. This significantly overcame other treatments. It could be concluded from the data that increasing the ratio of chicken manure in fertilizer up to 47.6 m^3 ha^{-1} and decreasing farmyard manure fertilizer up to 23.8 m^3 ha^{-1} improved the measurement of growth characters. Obtained results agreed with those of Borin *et al.*, 1987 and Brwaldh (1992) who reported that organic manure is a rich and a slow release fertilizer, the usage of which leads to a clean product of plants. They added that using organic fertilizer improves the soil texture. The structu- ral improvement can encourage the plant to have a good root development by improving the aeration in the soil, which leads to a higher plant growth. Also the obtained results indicated the favourable effect of chicken manure on onion plant productivity; this result might be due to the role of organic manure for continues supply of nutrients which improve some physical properties of soil and increase water retention than that for chemical fertilizers (Abd-Elmoez *et al.,* 1995; 1996; Fliessbach *et al*., 2000).

Data in Table 4 showed the response of essential oil extracted from onion plant to the different rates of farmyard and chicken fertilizers. The data indicated that all organic fertilizer treatments *ie* mixture of farmyard manure and chicken manure, overcame the control treatment and improved the essential oil content. The highest values of essential oil, g kg^{-1} or ml $plant^{-1}$, were recorded with 23.8 m^3 ha^{-1} farmyard manure + 47.6 m^3 ha^{-1} chicken manure, which significantly overcame the other treatments, and the lowest with control treatment in. Obtained results agreed with those of Parakasa Rao *et al*., (1997), who reported that application of organic fertilizer increased total essential oil yields of davana plant, and Marculescu *et al.*, (2002), who revealed that the soil, with its content in macro- and microelements enhanced by the use of organic fertilizers, plays an essential role in the plants development, in the biosynthesis of organic substances at all levels, also it can be noted that, when using manure, the amount of active principal (essential oil) is high in *Chrysanthemum balsamita* L. plant.

T a b l e 3. Effect of organic fertilizers on the vegetative growth characters of onion bulbs

Treatmnets	Fresh mass		Dry mass		Diameter (cm)
	(g $plant^{-1}$)	(kg m^{-2})	(g $plant^{-1}$)	(kg m^{-2})	
Control	102.33	2.05	52.4	1.05	5.4
71.4 m^3 FYM ha^{-1}+ 0 m^3 CM ha^{-1}	110.23	2.21	55.4	1.11	6.3
59.5 m^3 FYM ha^{-1}+ 11.9 m^3 CM ha^{-1}	114.6	2.29	60.9	1.22	6.8
47.6 m^3 FYM ha^{-1}+ 23.8 m^3 CM ha^{-1}	121.8	2.44	67.5	1.35	6.9
35.7 m^3 FYM ha^{-1}+ 35.7 m^3 CM ha^{-1}	125.6	2.51	71.6	1.43	7.56
23.8 m^3 FYM ha^{-1}+ 47.6 m^3 CM ha^{-1}	138.4	2.77	82.3	1.65	8.96
11.9 m^3 FYM ha^{-1}+ 59.5 m^3 CM ha^{-1}	111.2	2.22	57.3	1.15	6.3
0 m^3 FYM ha^{-1}+ 71.4 m^3 CM ha^{-1}	117.6	2.35	55.6	1.11	5.63
LSD (0.05)	2.11	0.05	1.14	0.02	0.19

T a b l e 4. Effect of organic fertilizers on the essential oil content extracted from onion bulbs

Treatments	Essential oil content	
	(g kg^{-1})	(ml plant^{-1})
Control	0.028	0.0029
71.4 m^3 FYM ha^{-1}+ 0 m^3 CM ha^{-1}	0.032	0.0035
59.5 m^3 FYM ha^{-1}+ 11.9 m^3 CM ha^{-1}	0.029	0.0033
47.6 m^3 FYM ha^{-1}+ 23.8 m^3 CM ha^{-1}	0.037	0.0046
35.7 m^3 FYM ha^{-1}+ 35.7 m^3 CM ha^{-1}	0.041	0.0051
23.8 m^3 FYM ha^{-1}+ 47.6 m^3 CM ha^{-1}	0.045	0.0057
11.9 m^3 FYM ha^{-1}+ 59.5 m^3 CM ha^{-1}	0.039	0.0043
0 m^3 FYM ha^{-1}+ 71.4 m^3 CM ha^{-1}	0.034	0.0040
LSD (0.05)	0.002	0.0001

Results in Table 5 reveal also an effect of organic fertilizers on the chemical composition of essential oil extracted onion bulbs. A quantitative comparison of the constituents present with the organic fertilizers in the hydro-distilled onion essential oil was performed. The identified components and their percentages are given in Table 5. The variations in chemical composition are important between the treatments. The major components (more than 50 g kg^{-1}) were 3,5-Diethyl-1,2,4-trithionale; 5,6-bDihydro-2,4,6-triethyl-4H-1,3,5-dithiazine; Propyl 1-propenyl disulphide, *cis*; and Propyl 1-propenyl disulphide, trans. All the treatments of organic fertilizers *ie* farmyard manure and chicken manure, increased the major constituents of essential oil extracted from onion bulbs compared with the recommended chemical fertilizers treatment.

The major constituents (less than 50 g kg^{-1}) were:
– 6-Ethyl-4,5,7,8-tetrathiaundecane;
– Dihydro-6-methyl-2,4-diethyl-4H-5,6-1,3,5-dithiazine;
– 3.4-Dimethylthiophene;
– Methylpropyl trisulphide;
– 6-Ethyl-4,5,7-trithiadecane;
– 2,4,6-Triethyl-1,3,5-trithiane.

All the treatments of organic fertilizers *ie* farmyard manure and chicken manure, made different effects (increased or decreased) on minor constituents of essential oil extracted from onion bulbs. These results are in accordance with those obtained by Farkas *et al.* (1992). The effect of different treatments on essential oil and its constituents may be due to its effect on enzyme activity and metabolism (Burbott and Loomis, 1969).

The effects of organic fertilizer (farmyard manure and chicken manure) on N, P and K content and its uptake by onion plant are shown in Table 6. The data show that the application of different rates of organic fertilizer gave a slight increase in N, P and K content as compared to the control (recommended chemical fertilizer). With respect to the effect of farmyard manure and chicken manure at different rates, the data declared that applying the two sources with other gave increase in total N compared to farmyard manure

T a b l e 5. Effect of organic fertilizers on the chemical constituents of essential oil extracted from onion

No.	Components (g kg^{-1})	Treatments							
		Control	71.4 m^3 FYM + 0 m^3 CM	59.5 m^3 FYM + 11.9 m^3 CM	47.6 m^3 FYM + 23.8 m^3 CM	35.7 m^3 FYM + 35.7 m^3 CM	23.8 m^3 FYM + 47.6 m^3 CM	11.9 m^3 FYM + 59.5 m^3 CM	0 m^3 FYM + 71.4 m^3 CM
1	3.4-Dimethylthiophene	20.0	21.0	21.0	18.0	21.0	16.0	17.0	24.0
2	Propyl 1-propenyl disulphide, cis	95.0	96.0	10.5	107.0	119.0	109.0	119.0	125.0
3	Propyl 1-propenyl disulphide, trans	58.0	76.0	75.0	81.0	59.0	70.0	64.0	67.0
4	Methylpropyl trisulphide	21.0	18.0	20.0	28.0	25.0	33.0	35.0	26.0
5	3,5-Diethyl- 1,2,4-trithionale	262.0	28.0	291.0	295.0	316.0	413.0	320.0	292.0
6	Dihydro-6-methyl-2,4-diethyl-4H-1,3,5-dithiazine 5,6-	22.0	25.0	26.0	29.0	25.0	20.0	29.0	24.0
7	5,6- b Dihydro-2,4,6-triethyl-4H-1,3,5-dithiazine	89.0	109.0	112.0	123.0	116.0	110.0	97.0	107.0
8	6-Ethyl-4,5,7-trithiadecane	15.0	18.0	14.0	25.0	24.0	27.0	23.0	28.0
9	2,4,6-Triethyl- 1,3,5-trithiane	15.0	13.0	19.0	14.0	22.0	18.0	16.0	12.0
10	6-Ethyl-4,5,7,8-tetrathiaundecane	24.0	25.0	23.0	23.0	22.0	22.0	25.0	29.0

T a b l e 6. Effect of organic fertilizers on the minerals content of onion dry bulbs

Treatments	N	P	K	N	P	K
	(g kg^{-1})			Uptake (mg $plant^{-1}$)		
Control	17.2	4.0	15.2	98.60	22.90	87.00
71.4 m^3 FYM ha^{-1}+ 0 m^3 CM ha^{-1}	16.9	4.1	16.9	93.60	22.70	93.60
59.5 m^3 FYM ha^{-1}+ 11.9 m^3 CM ha^{-1}	17.6	4.4	18.9	107.10	26.70	115.10
47.6 m^3 FYM ha^{-1}+ 23.8 m^3 CM ha^{-1}	17.8	4.5	17.4	102.20	30.30	117.50
35.7 m^3 FYM ha^{-1}+ 35.7 m^3 CM ha^{-1}	17.9	4.6	17.5	158.80	32.90	125.30
23.8 m^3 FYM ha^{-1}+ 47.6 m^3 CM ha^{-1}	19.3	4.8	17.7	188.16	39.50	145.60
11.9 m^3 FYM ha^{-1}+ 59.5 m^3 CM ha^{-1}	18.0	4.6	18.3	94.30	24.10	95.80
0 m^3 FYM ha^{-1}+ 71.4 m^3 CM ha^{-1}	12.2	3.4	13.9	67.80	18.90	77.20
LSD (0.05)	0.02	0.04	0.03	2.80	3.90	2.90

and chicken manure applied alone; the same trend was observed in N uptake. A pronounced increase in N content and uptake was noticed when farmyard manure at the rate of 23.8 m^3 ha^{-1} was combined with chicken manure at rate of 47.6 m^3 ha^{-1}. These results could be explained by positive effect of farmyard manure and chicken manure on improving nutritional status of soil. Also, due to rapid mineralization of organic matter. With regarded to P concentration in plant, a pronounced increase in P was observed with chicken manure, when compared with farmyard manure. An increase in the value of potassium content was noticed when we applied 59.5 m^3 ha^{-1} FYM+ 11.9 m^3 ha^{-1} CM followed by 11.9 m^3 ha^{-1} FYM+ 59.5 m^3 ha^{-1} CM. In general, the maximum NPK contents (g kg^{-1} and mg $plant^{-1}$) were noticed when farmyard manure was applied at the rate of 23.8 with 47.6 m^3 ha^{-1} chicken manure, as compared with other treatments. These results are in accordance with those obtained by Sadhu *et al*. (1996). They found that application of organic manure significantly increased nutrient content of mustard and groundnuts crops.

CONCLUSIONS

1. Organic fertilizers *ie* mixture of farmyard and chicken manure, improved the vegetative growth characters of onion plants.

2. Farmyard and chicken manure improved the chemical compositions of onion plants such as essential oil, main constituents of essential oil and NPK contents.

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