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Effect of Vermicompost and Sulfur on Growth, Yield and Nutritional Status of Tomato plants grown on Calcareous Soil

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Abstract
The experiment was designed to investigate the effect of vermicompost and sulfur applications on growth, yield and nutritional status of tomato plants (*Lycopersicum esculentum* L. cv Kasel rock) grown in calcareous soil in a private farm –Komoshim El-Fayoum Governorate.

The results indicated that adding the vermicompost to the calcareous soil led to the improvement of the growth parameters of tomato plant where the increasing of plant height (cm), number of leaves, leaf area (cm^2) and plant dry weight (g) of tomato plants were 33.7, 29.4, 27.9 and 39.5 %, respectively. Increasing vermicompost from 0 to 7.5 ton fed^{-1} increased significantly plant height, number of leaves, leaf area and plant dry weight of tomato plants when S increased from 0 to 200 kg fed^{-1}. The increase in the rate of vermicompost under different rates of sulfur led to a significant increase in fruit yield, TSS and total sugar of tomato under the conditions of calcareous soil. The high values of fruit yield, TSS and total sugar were obtained under high rate of vermicompost (10 ton fed^{-1}) and sulfur (200 kg fed^{-1}); which were 31.67 ton fed-1, 6.74 % and 2.340 %, respectively. Data revealed that the lowest nutrient balance index was recorded by the high rates of vermicompost (10 ton fed^{-1}) combined with 200, 150 Kg fed^{-1} of sulfur respectively.

Keywords: Calcareous soil, Vermicompost, Sulfur, Tomato, Growth, Yield and Nutritional status

Introduction

Calcareous soils were cover more than 30% of the earth's surface and their $CaCO_3$ content varies from a few percent to 95 % (Marschner, 1995). It wasoccurring naturally in arid and semi – arid zones as well as in humid and semi – humid zones particularly where their parent material were rich in $CaCO_3$. (Brady and Weil, 1999).Calcareous soils have alkaline reactions because of the presence of $CaCO_3$ which dominates their chemistry. Carbonates,in soil contribute the pH buffering of most calcareous soils within the range of 7.5 to 8.5. The presence of $CaCO_3$ in calcareous soils affects their physical properties such as soil – water availability to plants and soil surface crust. Carbonates, directly or indirectly, affect the chemistry and availability of N, P, K, Mg,Zn, Cu, and Fe (Obraza *et al.*, 1993).Cultivation of calcareous soils presentsmany challenges, such as low water holding capacity, highinfiltration rate, poor structure, low organic matter and clay content, low CEC, loss of nutrients via leaching ordeep percolation, surface crusting and cracking, high pH andloss of nitrogen fertilizers, low availability of nutrients particularlyphosphorous and micronutrients, and a nutritional imbalance between elements such as potassium, magnesium and calcium (El-Hady and Abo-Sedera, 2006 and FAO, 2016).

Vermicompost is produced by earthworms' digestion of organicwaste (e.g., food waste, horticultural waste, poultrydroppings, and food industry sludge) (Yadav and Garg 2011). This material has received increased attention inrecent years because of its interesting physical, chemical, andbiological characteristics (Huang *et al.*, 2014). Vermicompost is a sustainable source of macro- and micro-nutrients, and the mineral nutrient elements in vermicompost are easily absorbed by plants (Atiyeh *et al*., 2000). Furthermore,vermicompost has a fine granular structure with a largesurface area, which allows it to absorb and retain nutrients(Lalander *et al.*, 2015).A large number of plant hormonesare found in vermicompost (e.g., IAA, GA3, kinetin) and theirpresence may be the result of jointing activity of earthworms and microorganisms **(**Ravindran *et al*. 2016). Overall, vermicompost has the basic characteristics associated with amaterial that could be employed to improve soil quality. The application of vermicompost has been found to be an effectivemethod for rejuvenation of soil fertility, enrichment of availablenutrient pools, and conservation of water (Makode, 2015).

Elemental sulfur is known not only to decrease the soil pH in the alkaline soil but also to use as soil regulators. However, it is generally used in problematic soils. Elemental sulfur is oxidized to SO_4 -S mainly by microbial action of autotrophic Thiobacillus spp. (Germida and Janzen (1993) The microbial conversion of elemental sulfur to sulfate is dependent on many factors, such as microbial biomass, soil type, fertilizer formulation, soil moisture and aeration, temperature, pH, organic matter content, S particle size and other chemical properties(Jaggi *et al*., 1999).The oxidation of elemental sulfur increases as the particle size decreases conversely to temperature. The higher soil temperature the higher microbial oxidation as this induces microbial activity (Sameni and Kasraian, 2004).Furthermore, microbial sulfur oxidative reactions are generally optimum at soil moisture tension near field capacity. Sulfur is an essential element required for plant growth and development as it is required for synthesis of proteins and chlorophyll (Ghosh *et al*., 2007 and Orman and Kaplan, 2011).

The paper aimed to study the effect of vermicompost and sulfur elemental on growth, yield and nutritional status of tomato plants grown in calcareous soil.

Materials and Methods:

The experiment was designed to investigate the effect of vermicompost and sulfur applications on growth, yield and nutritional status of tomato plants (*Lycopersicum esculentum* L. cv Kasel rock) grown in calcareous soil in a private farm –Kom oshim El-Fayoum Governorate. Each plot was planned to include 20 rows, and the interplant spacing was 50 cm within each row. Some chemical characteristics of the soil are given in Table (1) using the standard procedures outlined by Cottenie (1980).

Field experiment was arranged as factorial experiment (two way) based on randomized complete block design with three repetitions. First factor was rates of vermicompost (0, 5, 7 and 10 ton fed^{-1}). The second factor was rates of sulfur (0, 50, 150 and 200 Kg fed^{-1}). The vermicompost and sulfur were thoroughly mixed with surface soil at the depth (0-20 cm) during soil preparation process. Elemental sulfur was purchased from Al-Ahram Mining Co. Egypt. The vermicompost used in this experiment was made of cattle manure, and using one species of earthworm (*Eisenia fetida*). Vermicompost was determined (Table, 2) using the standard procedures outlined by Cottenie (1980).

Table (1): Some chemical properties of soil used:

Soil property	**Value**
pH (1:2.5 soil suspension)	**7.50**
EC (dS m^{-1}), soil paste extract	**1.90**
$CaCO_3$ (%)	**20.0**
Soluble ions (mmol L^{-1})	
Ca^{++}	**5.73**
Mg^{++}	**4.21**
Na^{+}	**1.54**
K^{+}	**0.52**
CO_3^{--}	**nd***
HCO_3^{-}	**1.10**
Cl^{-}	**0.96**
SO_4^{--}	**9.94**

Table (2): Some chemical properties of vermicompost used:

Analyses	**Vermicompost**
pH	6.90
EC (dS m^{-1})	2.00
Moisture content (%)	15
Organic matter (%)	50.3
Organic carbon (%)	29.2
Ash (%)	49.7
C/N ratio	1:24.3
N (%)	1.20
P (%)	0.50
K (%)	0.80

Results and Discussion

The effect of vermicompost application on some growth parameters of tomato plants such as plant height (cm), number of leaves, leaf area (cm^2) and plant dry weight (g) were present in Table (3). Increasing vermicompost rates from 0 to 10 ton fed^{-1} increased significantly plant height from 36.8 to 55.50 cm, number of leaves from 53.17 to 75.33, leaf area from 32.87 to 45.60 cm^2 and plant dry weight from 43.87 to 72.47 g. Therefore, it can be said, adding the vermicompost to the calcareous soil led to the improvement of the growth parameters of tomato plant where the increasing of plant height (cm), number of leaves, leaf area (cm^2) and plant dry weight (g) of tomato plants were 33.7, 29.4, 27.9 and 39.5 %, respectively.Organic fertilizers such as vermicompost act not only as a source of nutrients and organic matter, but also increased size, biodiversity and activity of the microbial population in soil, influence structure, nutrients turnover and many other related physical, chemical and biological parameters of the soil (Albiach *et al*., 2000). Vermicompost was the microbial composting of organic wastes through earthworm activity to form organic fertilizer which contained higher level of organic matter, organic carbon, total and available N, P, K and micronutrients, microbial and enzyme activities (Ranganathan, 2006 and Parthasarathi *et al*., 2007).

Regarding to the effect of different rates of sulfur on some growth parameters data in Table (3) indicated that,Increasing S element rates from 0 to 200 kg fed^{-1} increased significantly plant height from 36.8 to 41.87cm, number of leaves from 53.17 to 64.93, leaf area from 32.87 to 38.47 cm^2 and plant dry weight from 43.87 to 53.33 g. The amount of increasing of plant height (cm), number of leaves, leaf area (cm^2) andplant dry weight (g) of tomato plantswere 12.1, 18.1, 14.6 and 17.7 %, respectively. Elemental sulfur was known not only to decrease the soil pH in the calcareous soil but also to use as soil regulators. Elemental sulfur is oxidized to SO_4-S mainly by microbial action of autotrophic *Thiobacillus* spp. (Aguilar *et al*., 2008).It is well known that, the reduction in soil pH enhances nutrients availability and leading to well grown vegetation (Sameni and Kasraian, 2004).

The effect of interaction between vermicompost and S element application on plant height (cm), number of leaves, leaf area (cm^2) and plant dry weight (g) of tomato plants grown on calcareous soil were present in Table (3). Increasing vermicompost from 0 to 7.5 ton fed^{-1} increased significantly plant height, number of leaves, leaf area and plant dry weight of tomato plants when S increased from 0 to 200 kg fed^{-1}. The high values of growth parameters of tomato plants grown on calcareous soil (79.00, 95.63, 70.90 and 90.47 ofplant height, number of leaves, leaf area and plant dry weight, respectively were achieved when highest level of vermicompost (7.5 $tonfed^{-1}$) added with highest level of sulfur (200 kg fed^{-1}). Application of vermicompost in combination with chemical fertilizer resulted in larger leaf area index. With a higher leaf area index, plants become photosynthetically more active, which would contributeto improvement in yield attributes(Jeyabal and Kuppuswamy, 2001).

Table (3): Effect of vermicompost and Sulfur rates on growth parameters of tomato plants

Vermicompost ton fed^{-1}	S Kg fed^{-1}	Plant height cm	No. leaves	Leaf area cm^2	Dry weight/plant g
0	0	36.80 o	53.17 k	32.87 n	43.87 m
	50	37.80 n	55.40 j	34.47 m	47.17 l
	150	38.97 m	58.87 i	37.10 l	51.40 k
	200	41.87 k	64.93 g	38.47 k	53.33 j
Mean		**38.78**	**58.09**	**35.73**	**48.94**
5	0	40.73 l	61.27 h	36.93 l	51.33 k
	50	44.67 i	64.23 g	41.50 j	53.33 j
	150	50.63 h	69.07 f	46.73 h	56.23 i
	200	57.97 e	74.63 d	52.40 e	60.60 h
Mean		**48.50**	**67.30**	**44.39**	**55.37**
7.5	0	47.30 i	70.53 e	42.10 j	61.97 g
	50	53.20 g	75.60 d	47.70 g	66.73 f
	150	58.30 e	81.23 c	54.90 d	72.70 e
	200	63.77 c	88.37 b	60.77 c	77.93 d
Mean		**55.64**	**78.93**	**51.37**	**69.83**
10	0	55.50 f	75.33 d	45.60 i	72.47 e
	50	62.17 d	81.07 c	48.80 f	79.23 c
	150	69.47 b	88.43 b	61.77 b	84.40 b
	200	79.00 a	95.63 a	70.90 a	90.47 a
Mean		**66.53**	**85.11**	**56.77**	**81.64**

Data in Table (4) indicated to effect of different rates of vermicompost on fruit yield, TSS and total sugar of tomato grown on calcareous soil. Increasing vermicompost rates from 0 to 10 ton fed^{-1}increased significantly fruit yield from 8.867 to17.70 ton fed^{-1}; thus, the increment was 49.9%. As well as total sugar of tomato raised from 0.993 to 1.343 %; so the increment was 26.1 %. As well as increasing the vermicompost from 0 to 10 ton fed^{-1}increased significantly TSS of tomato fruit from 4.790 to 6.74 %; so the increment was 28.9 %.

Regarding to the effect of different rates of sulfur on fruit yield, TSS and total sugar of tomato data in Table (4) indicated that,fruit yield and total sugar of tomato grown on calcareous soil were affected significantly with increasing sulfur rates from 0 to 200 kg under without added vermicompost condition. Fruit yield was increased from8.867 to 18.30 ton fed^{-1},total sugar was increased from 0.993 to 1.447 % and TSS was increased from 3.173 to 4.790 %. Consequently, the rise was 51.4,31.4and 33.8% of fruit yield, total sugar and TSS, respectively. Kalpana *et al*., (2015) showed that increased the rate of S application enhanced tomato yield marginally recording 22.70 ton ha^{-1} with $S_{2.5}$ compared to $S_{0.}$

Data in Table (4) showed that the increase in the rate of vermicompost under different rates of sulfur led to a significant increase in fruit yield, TSS and total sugar of tomato under the conditions of calcareous soil. The high values of fruit yield, TSS and total sugar were obtained under high rate of vermicompost (10 ton fed^{-1}) and sulfur (200 kg fed^{-1}); which were 31.67 ton fed-1, 6.74 % and 2.340 %, respectively.

Table (4): Effect of vermicompost and Sulfur rates on fruit yield, TSS and total sugarof tomato plants

Vermicompost ton fed^{-1}	S Kg fed^{-1}	Fruit yield ton fed^{-1}	TSS* %	Total Sugar (%)
0	0	8.867 k	3.173 l	0.993 k
	50	12.12 i	3.777 k	1.180 ij
	150	15.20 g	4.350 j	1.380 h
	200	18.30 de	4.790 i	1.447 g
Mean		13.62	4.022	4.022
5	0	11.10 j	5.813 ef	1.153 j
	50	12.87 h	5.343 g	1.400 gh
	150	15.50 g	4.860 i	1.683 e
	200	18.77 d	4.360 j	1.940 c
Mean		14.56	5.094	5.094
7.5	0	12.72 hi	5.233 h	1.220 i
	50	16.80 f	6.197 d	1.507 f
	150	18.07 e	5.757 f	1.810 d
	200	21.23 c	6.617 b	2.180 b
Mean		17.20	5.975	5.975
10	0	17.70 e	5.403 g	1.343 h
	50	21.67 c	5.887 e	1.640 e
	150	25.87 b	6.337 c	1.970 c
	200	31.67 a	6.740 a	2.340 a
Mean		24.23	6.092	1.823

***TSS: Total Soluble Solids**

Using DRIS (Diagnosis and Recommendation Integrated system) method, nutrients indices and Nutrient Balance Index (NBI) were calculated and the results were presented in Table (*5*). Data revealed that the lowest nutrient balance index was recorded by the high rates of vermicompost (10 ton fed^{-1}) combined with 200, 150 Kg fed^{-1} of sulfur respectively. This treatment achieved high tomato yield which 31.67 and 25.87 ton fed^{-1}.The use of DRIS on concept of nutritional status of plants, this method puts the limitation of nutrients in order of plant demand, enabling the nutritional balance between the nutrients in leaf sample. With the use of dual relation on DRIS, the problem with the effect of concentration or dilution on the nutrients in plants is solved (Beaufils, 1973 and Walworth and Sumner,1987).Therefore, in order to obtain a high yield under calcareous soil conditions, we should pay attention to the nutrients of phosphorus (P index= -57.51) and then iron (Fe index = -22.50) to obtain high productivity of tomato.

Table (5): Effect of vermicompost and sulfur rates on nutrient indices and NBI in tomato leaves

Vermicompost ton fed^{-1}	S Kg fed^{-1}	Nut Nutrients indices						NBI
		N	P	K	Fe	Mn	Zn	
0	0	84.65	-86.75	29.88	-25.48	2.025	-4.311	233.11
	50	76.78	-68.26	10.47	-23.16	10.11	-5.945	194.74
	150	72.36	-70.72	4.27	-20.34	17.09	-2.659	187.44
	200	83.89	-115.1	-5.383	-14.86	26.75	24.73	270.74
5	0	80.63	-80.17	14.37	-29.35	10.07	4.452	219.04
	50	64.64	-75.48	33.85	-32.26	5.476	3.779	215.49
	150	70.29	-85.78	41.97	-33.53	4.039	3.014	238.63
	200	61.06	-42.36	-21.34	-28.43	12.40	18.67	184.25
7.5	0	76.34	-71.87	-3.900	-21.13	15.40	5.168	193.82
	50	69.30	-64.58	-9.684	-23.17	18.03	10.11	194.88
	150	63.60	-55.40	-18.40	-24.14	18.61	15.73	195.87
	200	72.06	-75.75	-5.690	-20.47	22.82	7.043	192.46
10	0	75.61	-73.03	9.325	-19.85	6.191	1.766	185.78
	50	66.56	-71.35	5.507	-20.99	14.40	5.872	184.68
	150	69.97	-57.11	-10.30	-23.82	12.62	8.648	182.47
	200	69.38	-57.51	-3.187	-22.50	7.752	6.068	166.40

Conclusion

Under calcareous soil condition, adding the vermicompost with sulfur were improved productivity and growth of tomato. As the vermicampost contains many essential nutrients in addition to natural growth regulator, which improved the growth of tomatoes and then the quantity and quality of yield in the presence of sulfur which used to improve the properties of calcareous soil.Using high rates of vermicompost(10 ton fed^{-1}) and sulfur (200 Kg fed^{-1}) gave high values of growth and yield of tomato.

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