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EFFECT OF DIFFERENT TYPES AND RATES OF COMPOSTED SEWAGE SLUDGE ON YIELD AND COMPOSITION OF TWO STRAWBERRY CULTIVARS

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ABSTRACT

A field experiment was carried out during 2000/2001-growth season at the Experimental Farm of the Faculty of Agriculture**,** Suez Canal University. The aim of the present work is to evaluate two strawberry (*Fragaria x aananssa*) cultivars (Camarosa and Chandler) yields response and compositions to varying rates (0, 40 and 60 m^3 ha^{-1}) of different composted sewage sludge**,** plant residues and cement kiln dust (5:5:0**,** 5:5:0.4**,** 5:5:0.8 and 5:5:1.6 v/v).

Fresh and dry weights, NPK contents and uptakes of shoot and fruit of strawberry were significantly increased as result of applying different compost mixtures to the soil as compared with untreated soil. Also, Fe, Mn, Zn, Cu and Ni contents of shoot and fruit of strawberry were significantly increased (but they were still in safe concentrations, often do not build-up to phytotoxic levels) as result of applying different compost mixtures to the soil as compared with untreated soil. All measured parameters were also increased with increasing compost application rates. There are different responses for the two strawberry cultivars in yield, metal contents and uptakes as result of applying of different compost mixtures and rates. Generally, although fresh weights of shoot, fruit, and total yield and dry weights of shoot and total yield of Chandler cultivar were more significantly higher in the compost untreated soil, they more responded to the application of the compost to the soil in Camarosa cultivar.

Keywords: strawberry cultivars, yield, sewage sludge, cement kiln dust, plant residues, compost, sandy soil, heavy metals

INTRODUCTION

Most of the soils used for horticultural production in Suez Canal region are coarse-textured. These soils are characterized by low organic matter and low cation exchange capacities resulting in limited nutrient and water holding capacity (Wittneben, 1986). Large and increasing volumes of composted agricultural/municipal/other organics are being generated which have the potential to improve the quality of these soils for horticultural production. Large volumes of compostable materials are produced from sewage sludge, generated especially from wastewater treatment plants, cement kiln dust as by-bass from cement industry factories, and agricultural farm wastes (Zayed et al., 2001). Treated sewage sludge is a potentially valuable resource for essential macro- and micro-nutrients, and may also serve as a good natural soil conditioner due to its content of organic matter. Newly reclaimed desert lands are very poor in their physical, chemical, biological properties and fertility, which may be improved by the addition of sewage sludge (Rabie et al., 1997).

All users of composted municipal wastes require knowledge of its value in order to determine its nutrient availability, and its influence on heavy metal uptake and the nutrient content of crops. Since composted municipal wastes are a relatively new soil amendment, there are relatively few studies, which provide a compost user with the necessary information to determine its effectiveness (Warman, 1998).

Albregts and Howard, (1979) found that heat-dried sewage sludge and a 1:1 combination of sludge and NH_4NO_3 consistently produced strawberry yields above those with Osmocote ([N-P_2O_5-$K_2$0] 16-8-12) treatments over two seasons. In both seasons 100% relative yields resulted from plants with the sludge treatment compared to 98 and 87% relative yields with the NH_4NO_3/sludge treatment, and 96 and 85% relative yields with the Osmocote treatment.

Also, Albregts and Howard (1984) found that plants fertilized with sludge and sludge/urea-formaldehyde 1:1 (UFA) treatments yielded 30 to 60% more strawberries compared to UFA- and organiform-fertilized (leather tankage bonded with methylene urea) subplots.

The objective of the present work is to study the effect of different sewage sludge**,** cement kiln dust and plant residues composts with different application rates on yield and composition of two strawberry cultivars grown on a sandy soil.

MATERIALS AND METHODS

A field experiment was carried out during 2000/2001-growth season at the Experimental Farm of the Faculty of Agriculture, Suez Canal University. The aim of the present work is to evaluate two strawberry (*Fragaria x aananssa*) cultivars (Camarosa and Chandler) yields response and compositions to varying rates of different composted sewage sludge, cement kiln dust and plant residues. Strawberry plants were grown on a sandy soil (93.8% sand, 3.5 silt, 2.7% clay; organic matter 0.07%, $CaCO_3$ 3.15%, EC 1.2 dSm^{-1} and pH 7.52) treated with 4 composted sewage sludge, cement kiln dust and plant residues at different rates (0, 40 and 60 m^3ha^{-1}). Table (1) indicated volume ratios of the components and some characteristics of the composts.

Table (1): Some chemical characteristics of the composts used.

*Compost	ph	EC (dSm^{-1})	Organic matter %	C/N ratio	N	P	K	Fe	Mn	Cu	Zn	Ni
					%			(mg kg^{-1})				
1	7.19	3.97	48.08	20.74	1.344	0.127	1.212	141.15	94.43	32.73	56.65	7.74
2	7.20	4.77	44.28	20.52	1.260	0.147	1.413	147.26	98.85	37.93	59.28	8.32
3	7.48	5.20	42.90	25.75	0.966	0.160	1.521	151.50	101.35	52.23	60.65	8.49
4	7.49	6.73	40.56	26.49	0.888	0.165	1.622	158.14	106.75	54.60	63.58	9.50

*Compost	Volume ratios of compost components		
	Sewage sludge	Farm wastes	Cement kiln dust
1	5	5	0
2	5	5	0.4
3	5	5	0.8
4	5	5	1.6

Soil was treated with the different composts 7 days before transplanting. The strawberry was transplanted on September 25th, in furrows 5 m in length, 50 cm apart and 25 cm spacing within the furrows.

Total yield was that accumulated throughout the harvesting season which was determined by the end of May 2001. Samples of shoot and fruit were harvested from each treatment in April 15, 2001 for the different analyses. Plant samples were oven dried at 70 ^{o}C, ground, digested and analyzed for N, P, K, Fe, Mn, Zn, Cu and Ni according to Chapman and Pratt (1961). Soil and composted sewage sludge were prepared and analyzed according to Page *et al.* (1982). Split-split plot design with three replicates was used and Plabstat version 2D computer program was used for statistical analysis.

RESULTS AND DISCUSSION

Data obtained on the effect of different compost mixtures and application rates on fresh and dry weights of shoot and fruit of both Chandler and Camarosa strawberry cultivars are presented in Table (2). Fresh and dry weights of shoots, fruits, and total yield of strawberry were significantly increased as result of applying different compost mixtures to the soil as compared with untreated soil. Increasing cement kiln dust (CKD) volume ratio from 0 to 1.6 in different compost mixtures significantly decreased fresh and dry weights of strawberry shoots, fruits and total. Several workers obtained similar results on the effect of sewage sludge or its compost on plant dry weight. Amending soil with sludge or composted waste has resulted in increasing yield of some vegetable crops including strawberry (Albergts and Howard, 1979), tomato and cabbage (Sterrett *et al*., 1983a), carrot (Harrison, 1986), cucumber (Harrison and Staub, 1986), cranberry (Bugbee and Frink, 1989), and pepper (Roe *et al*., 1997).

With regard to the effect of the compost application rate, fresh and dry weights of shoots, fruits, and total yield were significantly increased with increasing the compost application rate to the soil. Rabie *et al.* (1997) found that shoot and root dry weights of sorghum were significantly increased by increasing sewage sludge application rate to the sandy soil up to 5%. Dahdoh and Hassan (1997) reported a significant increase of broad bean yield when sewage sludge applied up to 2% in calcareous soil. Generally, although fresh weights of shoot, fruit, and total yield and dry weights of shoot and total yield of Chandler cultivar were more significantly higher in the compost untreated soil, they more responded to the application of the compost to the soil in Camarosa cultivar. The increase means in fresh weight of shoot, fruit and total yield were 2.0**,** 2.6, and 2.3 times for Chandler and 2.1, 2.9 and 2.5 times for Camarosa grown on compost treated soil as compared with the untreated soil.

Table (2): Effect of different compost mixtures and rates on fresh and dry weights of shoot, fruit and total yield of Chandler and Camarosa strawberry cultivars.

*Treatments	Rate $m^3\ ha^{-1}$	Fresh weight kg ha^{-1} Shoot	Fruit	Total	Dry weight kg ha^{-1} Shoot	Fruit	Total
Chandler cultivar							
Control		3000	3120	6120	1125	430	1555
1	40	7750	9380	17130	2600	1080	3680
	60	8065	9770	17835	2695	1340	4035
Mean		7908	9575	17483	2648	1210	3858
2	40	6000	7435	13435	2030	1070	3100
	60	6875	9375	16250	2535	1260	3795
Mean		6438	8405	14843	2283	1165	3448
3	40	4765	7025	11790	1615	880	2495
	60	5065	8340	13405	1870	1130	3000
Mean		4915	7683	12598	1743	1005	2748
4	40	3940	5990	9930	1365	760	2125
	60	4315	6305	10620	1620	1105	2725
Mean		4128	6148	10275	1493	933	2425
Camarosa cultivar							
Control		2940	3035	5975	1080	455	1535
1	40	7915	10125	18040	2770	1235	4005
	60	8590	10385	18975	2840	1530	4370
Mean		8253	10255	18508	2805	1383	4188
2	40	7190	10075	17265	2595	1090	3685
	60	8375	10370	18745	2685	1425	4110
Mean		7783	10223	18005	2640	1258	3898
3	40	3815	7115	10930	1490	875	2365
	60	8065	9580	17645	2355	1410	3765
Mean		5940	9348	14288	1923	1143	3065
4	40	3090	5225	8315	1140	785	1925
	60	3165	5570	8735	1245	1380	2625
Mean		3128	5398	8525	1193	1083	2275
$LSD_{0.05}$ for							
Treatments		221	66	193	47	61	56
Rate		741	1001	1741	219	268	485
Cultivar		1562	1339	225	53	122	175

*Treatments	Volume ratios of compost components Sewage sludge	Farm wastes	Cement kiln dust
1	5	5	0
2	5	5	0.4
3	5	5	0.8
4	5	5	1.6

Results of NPK contents for shoot and fruit are presented in Table (3) and computed uptakes of NPK for shoot, fruit and total yield for both Chandler and Camarosa strawberry cultivars as affected by different compost mixtures and their application rates are shown in Table (4). Shoot N content was significantly increased as result of applying different compost mixtures to the soil as compared with untreated soil. Also, increasing the compost application rate from 40 to 60 m^3 ha^{-1} shoot N content was significantly increased. Increasing cement kiln dust volume ratio from 0 to 1.6 in different compost mixtures significantly decreased N shoot content in both strawberry cultivars. This may be due to the low compost N content by increasing cement kiln dust and decreasing Sewage sludge and plant residues volume ratios in compost mixtures (Table 2). Generally, the increase in Camarosa shoot N content was significantly responded as compared with those in Chandler.

There are no significant differences in Fruit N content between the two strawberry cultivars as affecting by the application of the different compost mixtures. But significant differences as result of compost application rates were found. Since increasing the rate of application from 40 to 60 m^3 ha^{-1} increased fruit N content of strawberry. Mean values of fruit N content were 1.32 and 1.56% for Chandler and 1.30 and 1.49% for Camarosa at 40 and 60 m^3 ha^{-1}, respectively. The same trend of shoot, fruit and total N uptakes was found as previously mentioned for shoot N content as result of different compost treatments, their application rates and strawberry cultivar (Table 4).

Addition of the different compost mixtures to the soil resulted in increasing P and K contents in strawberry shoot and fruit. In opposite of N content, increasing CKD volume ratio P and K contents in shoot and fruit were significantly increased. This may be due to the high compost P and K contents by increasing CKD and decreasing Sewage sludge and plant residues volume ratios in compost mixtures (Table 2). Increasing compost application rate was significantly increased P and K contents in shoot and K content in fruit of strawberry plant. There is no significant effect for the compost application rate on fruit P content. Shoot K content was significantly higher in Camarosa than in Chandler while fruit P content was significantly higher in Chandler than in Camarosa. There are no differences in shoot P and fruit K contents as result of strawberry cultivar effect.

Generally, Shoot, Fruit and total P and K uptakes were increased as result of applying different compost mixtures to the soil as compared with untreated soil. Also, increasing compost application rate, Shoot, Fruit and total P and K uptakes were increased. With exception of fruit P uptake, there are significant differences in fruit K, shoot and total PK contents as result of treating the soil with composts consisting of different volume ratios of sewage sludge, cement kiln dust and plant residues. This means that, although PK contents in the different strawberry tissues increased by increasing CKD volume ratio in the compost, their uptakes decreased in the same manner. This refers to the increase in strawberry dry matter yield by decreasing CKD volume ratio, consequently strawberry PK uptakes increased. There are no significant differences between cultivars in shoot, fruit, total P and fruit K uptakes. Mean values of shoot and total K uptake in Camarosa were significantly higher than in Chandler.

Table (3): Effect of different compost mixtures and rates on shoot and fruit NPK contents of Chandler and Camarosa strawberry cultivars.

*Treatments	Rate M^3 ha^{-1}	Shoot % N	Shoot % P	Shoot % K	Fruit % N	Fruit % P	Fruit % K
Chandler cultivar							
Control		1.79	0.29	1.25	1.26	0.14	1.03
1	40	1.96	0.35	1.30	1.34	0.15	1.05
	60	2.35	0.36	1.53	1.71	0.16	1.23
Mean		2.16	0.36	1.42	1.53	0.16	1.14
2	40	1.85	0.35	1.34	1.32	0.16	1.06
	60	2.30	0.38	1.57	1.64	0.17	1.32
Mean		2.08	0.37	1.46	1.50	0.17	1.19
3	40	1.82	0.36	1.38	1.32	0.17	1.08
	60	2.18	0.39	1.61	1.54	0.18	1.37
Mean		2.00	0.38	1.50	1.43	0.18	1.23
4	40	1.80	0.38	1.48	1.30	0.18	1.12
	60	2.13	0.40	1.65	1.40	0.19	1.39
Mean		1.97	0.39	1.57	1.35	0.19	1.23
Camarosa cultivar							
Control		1.96	0.30	1.38	1.29	0.12	1.01
1	40	2.18	0.32	1.42	1.32	0.13	1.03
	60	2.25	0.35	1.55	1.57	0.14	1.14
Mean		2.22	0.34	1.49	1.45	0.14	1.09
2	40	2.16	0.33	1.49	1.30	0.14	1.05
	60	2.30	0.36	1.57	1.48	0.16	1.17
Mean		2.23	0.35	1.53	1.39	0.15	1.11
3	40	2.10	0.35	1.50	1.30	0.14	1.14
	60	2.24	0.38	1.61	1.46	0.16	1.16
Mean		2.17	0.37	1.56	1.38	0.15	1.15
4	40	2.02	0.35	1.55	1.29	0.16	1.19
	60	2.24	0.40	1.77	1.43	0.17	1.25
Mean		2.13	0.38	1.66	1.36	0.17	1.22
$LSD_{0.05}$ for							
Treatments		0.09	0.02	0.07	Ns	0.05	0.09
Rate		0.36	0.03	0.11	0.07	Ns	0.13
Cultivar		0.16	Ns	0.24	Ns	0.11	Ns

*Treatments	Volume ratios of compost components: Sewage sludge	Farm wastes	Cement kiln dust
1	5	5	0
2	5	5	0.4
3	5	5	0.8
4	5	5	1.6

Table (4): Effect of different compost mixtures and rates on shoot, fruit and total NPK uptakes of Chandler and Camarosa strawberry cultivars.

*Treatments	Rate m^3 ha^{-1}	N Shoot	N Fruit	N Total	P Shoot	P Fruit	P Total	K Shoot	K Fruit	K Total
		kg ha^{-1}								
Schandler cultivar										
Control		20.14	5.42	25.56	3.26	0.60	3.86	14.06	4.43	18.49
1	40	50.96	14.47	65.43	7.10	0.16	9.26	33.80	11.34	45.14
	60	63.33	22.91	86.24	9.70	2.14	11.84	41.23	16.48	57.71
Mean		57.15	18.69	75.84	9.40	1.15	10.55	37.52	13.91	51.42
2	40	37.56	14.12	51.68	7.11	1.71	8.82	27.20	11.34	38.54
	60	58.31	20.66	78.97	9.63	2.14	11.77	39.80	16.63	56.43
Mean		47.94	17.39	65.33	8.37	1.93	10.30	33.50	13.99	47.49
3	40	29.39	11.62	41.01	5.81	1.50	7.31	22.29	9.50	31.79
	60	40.77	17.40	58.17	7.29	2.03	9.32	30.11	15.48	45.59
Mean		35.08	14.51	49.59	6.55	1.77	8.32	26.20	12.49	38.69
4	40	24.57	9.88	34.45	5.19	1.37	6.56	20.20	8.51	28.71
	60	14.51	15.47	49.98	6.48	2.10	8.58	26.73	15.36	42.09
Mean		29.54	12.68	42.22	5.84	1.74	7.57	23.47	11.94	35.40
Camarosa cultivar										
Control		21.18	5.87	27.05	3.24	0.55	3.79	14.90	4.80	19.50
1	40	60.39	16.30	76.69	8.86	1.61	10.47	39.33	12.72	52.05
	60	63.90	24.02	87.92	9.94	2.14	12.08	44.02	7.44	51.46
Mean		62.15	20.16	82.31	9.40	1.88	11.28	41.68	15.08	51.76
2	40	56.05	14.17	70.22	8.56	1.53	10.09	38.67	11.45	50.12
	60	61.76	21.09	82.85	9.67	2.28	11.95	42.15	16.67	58.82
Mean		58.91	17.63	76.54	9.12	1.91	11.02	40.41	14.06	54.47
3	40	31.29	11.38	42.67	5.22	1.23	6.45	22.35	9.98	32.33
	60	52.75	20.59	73.34	8.95	2.26	11.21	37.92	16.36	54.28
Mean		42.02	15.99	58.01	7.09	1.75	8.83	30.14	13.17	43.31
4	40	23.03	10.13	33.16	3.99	1.26	5.25	17.67	9.34	27.01
	60	27.89	19.73	47.62	4.98	2.35	7.33	22.04	17.25	39.29
Mean		25.46	14.93	40.39	4.49	1.81	6.29	19.86	13.30	33.15
$LSD_{0.05}$ for										
Treatments		5.73	1.73	6.48	1.11	Ns	1.11	2.12	1.11	1.72
Rate		16.47	5.63	22.10	2.74	0.39	2.74	7.63	7.01	14.08
Cultivar		2.60	6.83	9.43	Ns	Ns	Ns	7.65	Ns	15.33

*Treatments	Volume ratios of compost components		
	Sewage sludge	Farm wastes	Cement kiln dust
1	5	5	0
2	5	5	0.4
3	5	5	0.8
4	5	5	1.6

Increasing plant NPK contents and uptakes by applying sewage sludge or its compost to the soil were reported by several workers (Albergts and Howard, 1979; Sterrett et al., 1983b; Harrison, 1986; Harrison and Staub, 1986; Bugbee and Frink, 1989).

Data obtained on the effect of different compost mixtures and their application rates on Fe, Mn, Zn, Cu and Ni contents in strawberry plant are presented in Tables (5). With the exception of shoot and fruit Ni contents, there are significant increases in metal contents in both strawberry shoot and fruit in compost-treated soil as compared with untreated soil. Often increasing cement kiln dust volume ratio in the compost, metal contents of plant tissues were increased. Also, Fe, Mn, Zn, Cu and Ni contents in both shoot and fruit increased with increasing compost application rate to the soil.

Table (5). Effect of different compost mixtures and rates on shoot, fruit and total Fe, Mn, Zn, Cu and Ni contents of Chandler and Camarosa strawberry cultivars.

*Treatments	Rate	Shoot					Fruit				
	$m^3\ ha^{-1}$	mg kg^{-1}									
		Fe	Mn	Zn	Cu	Ni	Fe	Mn	Zn	Cu	Ni
Chandler cultivar											
Control		79.8	42.5	38.3	7.8	0.21	49.4	26.2	23.6	3.8	0.14
1	40	95.0	50.7	45.6	8.1	0.25	53.2	28.8	25.3	4.5	0.15
	60	123.5	64.6	58.5	8.8	0.33	67.5	35.6	28.0	5.9	0.18
Mean		109.3	57.7	52.1	8.5	0.30	60.4	32.2	26.7	4.7	0.17
2	40	108.3	57.2	51.5	8.2	0.29	55.1	29.4	26.5	5.8	0.16
	60	131.1	69.7	62.1	9.1	0.35	70.3	37.6	32.1	6.4	0.19
Mean		119.7	63.5	56.8	8.7	0.32	62.7	33.5	29.3	6.1	0.18
3	40	112.1	59.7	53.7	8.4	0.30	58.9	31.1	28.0	6.1	0.18
	60	136.8	71.5	64.8	9.7	0.36	76.1	40.1	36.1	6.5	0.20
Mean		124.5	65.6	59.3	9.05	0.33	67.5	35.6	32.1	6.3	0.19
4	40	121.6	61.3	62.1	9.1	0.32	67.5	35.6	30.2	7.5	0.20
	60	157.7	83.4	74.8	10.3	0.42	85.5	45.8	37.8	8.4	0.23
Mean		139.7	72.4	68.5	9.7	0.37	76.5	40.7	34.0	8.0	0.22
Camarosa cultivar											
Control		119.7	63.8	56.7	7.7	0.31	39.9	21.7	19.1	5.1	0.11
1	40	126.6	70.3	59.9	8.2	0.33	53.2	24.8	22.1	5.2	0.12
	60	148.2	78.5	70.7	8.8	0.39	59.9	30.7	27.1	6.5	0.15
Mean		137.4	74.4	65.3	8.5	0.36	56.6	27.8	24.6	5.9	0.14
2	40	133.4	77.7	69.8	8.4	0.38	51.3	28.9	25.1	5.5	0.14
	60	152.0	80.1	72.0	9.1	0.40	60.8	31.9	28.6	7.0	0.16
Mean		142.7	78.9	70.9	8.8	0.39	56.1	30.4	26.9	6.3	0.15
3	40	146.3	78.5	70.7	8.4	0.40	55.1	29.4	22.8	5.8	0.14
	60	188.1	99.8	89.8	9.1	0.51	62.1	32.7	28.8	7.1	0.16
Mean		167.2	89.2	80.3	8.8	0.46	58.6	31.1	25.8	6.5	0.15
4	40	151.1	80.1	72.5	8.8	0.49	57.0	30.7	26.5	6.5	0.15
	60	198.3	106.3	83.4	9.7	0.53	64.6	34.3	30.6	8.2	0.17
Mean		174.7	93.2	78.0	9.3	0.51	60.8	32.5	28.6	7.4	0.16
$LSD_{0.05}$ for											
Treatments		**8.6**	**4.2**	**9.1**	**Ns**	**0.05**	**7.2**	**2.9**	**1.9**	**0.8**	**Ns**
Rate		6.5	7.6	8.2	1.52	0.08	3.3	8.5	1.9	1.6	0.02
Cultivar		41.0	11.5	6.9	Ns	0.17	24.9	2.7	12.5	3.8	0.05

***Treatments**	**Volume ratios of compost components**		
	Sewage sludge	**Farm wastes**	**Cement kiln dust**
1	5	5	0
2	5	5	0.4
3	5	5	0.8
4	5	5	1.6

6

6cont

Generally, there are significant differences in metal contents between the two strawberry cultivars. Higher shoot metal content was found in Camarosa while higher fruit metal content was observed in Chandler. Shoot, fruit and total metal uptakes were usually dry matter yield and metal content dependent (Tables 2, 5 and 6). This means that, the increase in both dry matter yield and metal content associated with the increase in metal uptake.

Although there are significant differences in shoot metal uptake, fruit metal uptake not significantly affected by the compost type. Increasing compost application rate to the soil resulted in significant increases in shoot, fruit and total Fe, Mn, Zn, Cu and Ni uptakes. There are no significant differences between the two strawberry cultivars in fruit Fe, Zn and shoot Cu uptakes. Shoot and total Fe, Mn, Zn, Ni and fruit and total Cu uptakes were higher in Camarosa while fruit Mn and Ni uptakes were higher in Chandler. Generally, the levels of determined elements are much less than the recorded toxic limits for plant as given by Cottenie *et al.* (1976).

In waste-amended soils, heavy metal concentrations often do not build-up to phytotoxic levels (Sterrett *et al*., 1983a). In addition, it has been observed for cucumber, tomato, muskmelon and cabbage that amending the growing media with sludge containing low concentrations of metals resulted in very low concentrations of these metals in the edible portions of the plants (Ozores-Hampton *et al*. 1994; Falahi-Ardakani *et al*., 1988; Sterrett *et al*., 1983b).

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تأثير أنواع ومعدلات مختلفة من مكمورة حمأة المجارى على إنتاجية وتركيب صنفين من الفراولة

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أجريت تجربة حقلية خلال موسم ٢٠٠٠ /٢٠٠١ فى المزرعة التجريبية لجامعة قناة السويس فى محاولة لدراسة تأثير أنواع ومعدلات مختلفة من مكمورة حمأة المجارى على إنتاجية وتركيب صنفين من الفراولة (شاندلر – كماروزا). حيث كانت أنواع المكمورات على النحو التالى:

1- حمأة مجارى + مخلفات نباتية + تراب الأسمنت (٥ : ٥ : صفر حجما)
2- حمأة مجارى + مخلفات نباتية + تراب الأسمنت (٥ : ٥ : ٠,٤ حجما)
3- حمأة مجارى + مخلفات نباتية + تراب الأسمنت (٥ : ٥ : ٠,٨ حجما)
4- حمأة مجارى + مخلفات نباتية + تراب الأسمنت (٥ : ٥ : ١,٦ حجما)

وقد أضيفت تلك الأنواع بمعدلات صفر ، ٤٠ ، ٦٠ م^{٣}/هكتار

أشارت النتائج الى:

1- زيادة الوزن الطازج والجاف لكل من المجموع الخضرى والثمار المحصول الكلى بإضافة الأنواع المختلفة للمكمورة وزيادة معدل إضافتها بالمقارنة بالأرض غير المعاملة.
2- زاد محتوى وامتصاص النتروجين والفوسفور والبوتاسيوم لكل من المجموع الخضرى والثمار بإضافة الأنواع المختلفة للمكمورة وزيادة معدل إضافتها بالمقارنة بالأرض غير المعاملة.
3- زاد محتوى وامتصاص الحديد والمنجنيز والزنك والنحاس والنيكل لكل من المجموع الخضرى والثمار بإضافة الأنواع المختلفة للمكمورة وزيادة معدل إضافتها بالمقارنة بالأرض غير المعاملة ، ولكن محتوى تلك العناصر ظهر بمستويات آمنة وفى الحدود المسموح بها.
4- كانت استجابة صنفى الفراولة للتسميد بالأنواع المختلفة من المكمورة مختلفة من حيث الوزن الطازج والجاف لكل من المجموع الخضرى والثمار والمحصول الكلى وكذلك محتوياتها من العناصر المدروسة.
5- على الرغم أن الأوزان الطازجة للمجموع الخضرى ومحصول الثمار كانت أعلى لصنف شاندلر فى الأرض الغير معاملة بمكمورة المخلفات إلا أن استجابة صنف الكاماروزا لإضافة المكمورة كانت أعلى.

J. Agric. Sci. Mansoura Univ., 26 (11): 7381 - 7393, 2001.

Table (6). Effect of different compost mixtures and rates on shoot, fruit and total Fe, Mn, Zn, Cu and Ni uptakes of Chandler and Camarosa strawberry cultivars.

*Treatments	Rate M^3 ha^{-1}	Fe			Mn			Zn g ha^{-1}			Cu			Ni		
		Shoot	Fruit	Total	Shoot	Fruit	Total	Shoot	Fruit	Total	Shoot	Fruit	Total	Shoot	Fruit	Total
Chandler cultivar																
Control		89.73	21.24	111.0	47.8	11.27	59.1	142.1	10.15	53.1	8.78	1.63	10.41	0.236	0.060	0.296
1	40	247.0	57.46	304.5	131.8	31.10	162.9	118.6	27.32	145.9	21.06	4.86	25.92	0.650	0.162	0.812
	60	332.8	90.45	423.3	174.1	47.70	221.8	157.7	37.52	195.2	23.72	7.91	31.63	0.889	0.241	1.132
Mean		289.9	73.96	363.9	153.0	39.40	192.4	138.1	32.42	170.5	22.39	6.39	28.78	0.770	0.202	0.972
2	40	219.9	58.96	278.8	116.1	31.46	147.6	104.6	28.36	132.9	16.65	6.21	22.86	0.589	0.171	0.760
	60	332.3	88.58	420.9	176.7	47.38	224.1	157.4	40.45	197.9	23.07	8.06	31.13	0.887	0.239	1.126
Mean		276.1	73.77	349.9	146.4	39.42	185.8	131.0	34.41	165.4	19.86	7.14	27.00	0.738	0.205	0.943
3	40	181.0	51.83	232.9	96.4	27.37	123.8	86.7	24.64	111.4	13.57	5.37	18.94	0.485	0.158	0.643
	60	255.8	85.99	341.8	133.7	45.31	179.0	121.2	40.79	162.0	18.14	7.35	25.49	0.673	0.226	0.899
Mean		218.4	68.91	287.3	115.1	36.34	151.4	104.0	32.72	136.7	15.86	6.36	22.22	0.579	0.192	0.771
4	40	166.0	51.30	217.3	83.7	27.06	110.7	84.8	22.95	107.7	12.42	5.70	18.12	0.437	0.152	0.589
	60	255.5	94.48	350.0	135.1	50.61	185.7	121.2	41.77	163.0	16.69	9.28	25.97	0.389	0.254	0.643
Mean		210.7	72.89	283.6	109.4	38.84	148.2	103.0	32.36	135.3	14.56	7.49	22.05	0.413	0.203	0.616

*Treatments	Volume ratios of compost components		
	Sewage sludge	Farm wastes	Cement kiln dust
1	5	5	0
2	5	5	0.4
3	5	5	0.8
4	5	5	1.6

Table (6). Continued.

*Treatments	Rate M^3 ha^{-1}	Fe Shoot	Fe Fruit	Fe Total	Mn Shoot	Mn Fruit	Mn Total	Zn Shoot	Zn Fruit	Zn Total	Cu Shoot	Cu Fruit	Cu Total	Ni Shoot	Ni Fruit	Ni Total
		g ha^{-1}														
Camarosa cultivar																
Control		129.3	18.16	147.4	68.9	9.87	178.8	61.2	8.69	69.9	8.32	2.32	10.64	0.335	0.050	0.385
1	40	350.7	66.07	416.8	194.7	30.63	225.4	165.9	27.29	193.2	22.71	6.42	29.13	0.914	0.148	1.112
	60	420.9	91.04	511.9	222.9	46.97	269.9	200.8	41.46	242.3	24.99	9.95	34.94	1.108	0.230	1.338
Mean		385.8	78.56	464.3	208.8	38.80	247.6	183.4	34.38	217.7	23.85	8.19	32.04	1.011	0.189	1.225
2	40	346.2	55.92	402.1	201.6	31.50	233.1	181.1	27.36	208.5	21.80	5.10	26.90	0.986	0.153	1.139
	60	408.1	86.64	494.8	215.1	45.46	260.5	193.3	40.76	234.1	24.43	9.98	34.41	1.074	0.228	1.302
Mean		377.2	71.28	448.4	208.4	38.48	246.8	187.2	34.06	221.3	23.12	7.54	30.67	1.030	0.191	1.221
3	40	218.0	48.21	266.2	117.0	25.73	142.7	105.3	19.95	125.3	12.52	5.08	17.60	0.596	0.123	0.719
	60	443.0	87.56	530.5	235.0	46.11	281.1	211.5	40.61	252.1	21.43	10.01	31.44	1.201	0.226	1.427
Mean		330.5	67.89	398.4	176.0	35.92	211.9	158.4	30.28	188.7	16.98	7.55	24.52	0.899	0.175	1.073
4	40	172.3	44.75	217.0	91.3	24.10	115.4	82.7	20.80	103.5	10.03	5.10	15.13	0.559	0.118	0.677
	60	246.9	89.15	336.0	132.3	47.33	179.7	103.8	42.23	146.1	12.08	11.32	23.40	0.660	0.235	0.895
Mean		209.6	66.95	276.5	111.8	35.72	147.5	93.2	31.52	124.8	11.06	8.21	19.27	0.610	0.177	0.786
LSD$_{0.05}$ for																
Treatments		**11.19**	**Ns**	**16.26**	**7.53**	**Ns**	**7.23**	**27.55**	**Ns**	**28.33**	**2.40**	**Ns**	**1.69**	**0.13**	**Ns**	**0.14**
Rate		50.08	23.17	69.70	47.24	22.22	47.24	29.54	12.55	38.94	3.75	1.99	4.87	0.32	0.08	0.39
Cultivar		93.14	Ns	128.30	5.44	1.39	5.44	23.33	Ns	13.33	Ns	3.07	5.01	0.14	0.06	0.20