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EFFECT OF COMPOSTED MUNICIPAL SOLID WASTE ON GROWTH, NUTRITIONAL STATUS AND FRUIT QUALITY OF APPLE TREES GROWN IN SANDY SOIL: ORGANIC FARMING

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ABSTRACT

Composted municipal solid waste (MSW) has recently received a lot of attention as a major organic fertilizer for horticulture crops grown in sandy soils. The objective of this study was to investigate the possibility of using composted municipal solid waste as the main fertilizer for apple trees (grown in sandy soil) to substitute mineral fertilizers. The study also included MSW effect on the tree nutritional status, growth and fruit quality of apples.

A field experiment at the Plant Research Department Experimental Farm, Atomic Energy Authority, using four year old apple trees (cv. Anna. grafted on Malling Merton 106 rootstock). The trees were arranged in a completely randomized block design. The soil is sandy, infertile, and almost nil in nitrogen, phosphorus and organic matter. Apple trees received MSW at two application rates, 100% and 200% of their nitrogen optimum recommended rate. This is equivalent to 72 and 144 Kg N/ha, respectively. The control treatment received mineral fertilizer (NPK) at the optimum recommended rate for apple trees.

The results obtained indicate that the application of MSW to sandy soils has improved its physical and chemical properties, provided the soil and plant with nutrients and increased the yield comparing with the control (mineral fertilizers). Significant increase in tree growth (shoot length, trunk diameter), number of buds formed, fruit set and leaf chlorophyll content occurred as a result of using MSW comparing with the control. The nutritional status of the tree (N, P, K, Ca, Mg, Fe, Mn, Zn, Cu) in the leaf and fruit has shown sufficient concentrations of macro and micro nutrients for adequate apple tree growth. Heavy metals in the leaf and fruit were far below the toxic limits comparing with the international standard. Improved fruit quality was obtained under MSW fertilization system. Composted municipal solid waste has provided apple trees with their essential nutrients. The higher MSW application rate (200% N requirement) showed higher fruit yield than the lower MSW application rate (100% N requirement) and the control.

***Key words**: bud break, chlorophyll content, fruit set, heavy metals, micro and macro-nutrients, NPK, total sugar, trunk diameter, TSS.*

1. INTRODUCTION

Outside the Nile valley and the Delta, the agricultural soils in Egypt are mainly sandy soils. Sandy soil is a characteristic of arid and semi-arid regions. In Egypt, being a semi-arid country, agriculture consumes about 90% of the available fresh water. Sandy soil is characterized by being poor in nutrients and organic matter content. Growing fruit trees in such a soil requires a lot of fertilizer input to insure high fruit production. The application of organic waste into sandy soil to improve its productivity was reported by Hornick and Parr, (1987). Municipal solid waste (MSW) is a good example of such waste that could be recycled as an organic fertilizer. It contains high organic matter and high macro and micro-nutrients which help to improve soil physical and chemical characteristics (Vogtman and Fricke,1989).

Apple tree is the most common fruit tree that is grown in cold and moderate temperature region of the world. Apple fruits in the Egyptian markets used to be imported from Europe and/or the USA. However, recently some cultivar with less chilling requirements were introduced to the sub-tropical and temperate regions, *e.g.* apple cv.Anna. In Egypt, apple cv. Anna is considered a new cultivar that was introduced to the country since 1979 (Stino, 1992). The total cultivated area of apples in Egypt is estimated to be 85,000 (acre) Feddan (1 Feddan= 4200 m^2) according to Stino (1992). This area is increasing, This area is

increasing as the demand for local consumption exceedes the supply. The apple fruit has high nutritional value, it contains sugars, nitrogen, amino acids, organic acids, vitamins (A & C), fibers, potassium, iron, calcium and volatile compounds (Stino, 1992).

Organic farming for growing fruit trees in Egypt is a new trend and an effective option for recycling of MSW. Municipal solid waste is a good substitute for mineral fertilizers which are costly. Few studies have been reported regarding the use of municipal solid waste as a fertilizer for growing apple trees. The objectives of this investigation were: 1) to study the effect of fertilization with municipal solid waste on apple tree growth, nutrition status of apple tree and fruit quality 2) to investigate the effect of fertilization with municipal solid waste on sandy soil physiochemical properties.

2. MATERIALS AND METHODS

One year old apple seedlings (Anna grafted on Malling Merton 106 rootstock) were transplanted in a field experiment at the Plant Research Department Experimental Farm, Atomic Energy Authority. The experiment started after three years from transplanting, (4 year old trees) and continued for three successive years (2002,2003 and 2004). The trees were arranged in a completely randomized block design. Each block included three treatments, and each treatment was replicated five times. The soil used is classified as being sandy soil (Typic Torripsamments) according to Soil Survey Staff (1975). This soil is virgin, infertile and poor in nitrogen, phosphorus and organic matter. Physical and chemical properties of the soil were determined and shown in Table (1).

Table (1): Physical and chemical properties of the Soil used.

Sandy soil	Unit	Value
Texture		
sand	%	95.0
silt	%	2.4
clay	%	2.6
pH		8.0
Organic matter	%	0.01
Total N	g kg^{-1}	0.03
Total P	mg kg^{-1}	9.0

The annual application rate of organic fertilizer is usually determined on the basis of the nitrogen needs of the crop. Three treatments were applied, two using MSW and the control. Apple trees received composted municipal solid waste at 100% and 200% of the apple tree nitrogen recommended rate. This is equivalent to 72 (3t/ha MSW) and 144 (6 t/ha MSW) Kg N/ha, respectively. The control treatment received mineral fertilizer (NPK) at the optimum recommended rate for apple trees (360 Kg/ha ammonium sulphate, 240 Kg/ha Super phosphate and 240 Kg/ha potassium sulfate). MSW was applied to each tree in two holes, 50 cm depth, at the limit of the root distribution area then covered by sand.

Composted MSW was obtained from the organic compost unit, Mokatum , Cairo-Egypt. The characteristics of MSW are shown in Table (2), which demonstrate that MSW is high in organic matter content, NPK and micronutrients.

Table (2): General characteristics of Municipal Solid Waste

Variables	Municipal Solid Waste
Organic matter (%)	52
Density (g/cm^3)	0.7
pH	6.6
Macro-nutrient content (%)	
Total N	2.4
Total P	0.65
Total K	1.5
Total Heavy metals (µg/g)	
Zn	800
Mn	360
Fe	5700
Cu	420
Cd	2.0
Pb	400
Cr	9.0

2.1. Determination of MSW and soil characteristics

Different parameters were measured to determine the general characteristics of MSW and the soil after three years of MSW application. The pH value was determined in a (1:2.5) soil:water suspension using pH meter (Orion), macro nutrients NPK and heavy metals were determined according to Westerman (1990). Municipal solid waste density was calculated by measuring the volume of certain weight. Organic matter content was determined according to (Klute, 1986), Water holding capacity (WHC), cation exchange capacity (CEC) and Bulk density were determined according to (Power and Dick, 2000).

2.2.Determination of apple tree growth parameters

2.2.1 Bud break

Broken flower buds of each tree in the different treatments were counted throughout the month of February and March of each year and an average number was calculated.

2.2.2. Yield

The number of fruits per tree in the different treatments was counted each year on the first week of June and the average was calculated

2.2.3. Shoot length and trunk diameter

At the end of the growing season the average length of 10 shoots (current growth) was calculated. At the same time the average trunk diameter of 10 trees of the different treatments was calculated.

Table (3): Effect of fertilization with MSW on bud break(# buds/tree)

Treat.	2002				2003				2004			
	7/2	22/2	7/3	22/3	7/2	22/2	7/3	22/3	7/2	22/2	7/3	22/3
MF (Control)	20	26	30	34	23	25	28	34	25	28	31	38
MSW 100%N	43	65	80	90	80	92	99	102	83	96	103	107
MSW 200%N	53	70	85	96	86	93	101	140	89	97	105	145
LSD 0.05	7. 3	12. 2	14.3	16.3	8.4	8.9	11.4	8.3	8.1	5.3	3.2	7.5

2.2.4. leaf chlorophyll contents

Fully expanded mature leaves representing the different treatments were used immediately after harvest to determine the chlorophyll content according to Inskeep and Bloom (1985) .

2.3. Determination of fruit quality parameters:

The percentages of total soluble solids (TSS) and total sugars contents were determined in the fruits according to A.O.A.C. (1985). Heavy metals content in the fruits was determined as described by Westerman (1990).

2.4. Determination of apple tree nutritional status

Apple tree nutritional status macro (N, P, K, Ca, Mg) and micro- nutrients (Fe, Zn, Mn, Cu) as well as heavy metals (Pb, Ni, Co, Cd, Cr) were determined in the leaves according to Westerman (1990) and analyzed by the Atomic Absorption Spectrometry (Shimadzu).

The data were subjected to ANOVA and significant differences among the treatment means were tested by the LSD test according to (Steel and Torrie, 1960) using SPSS statistical package.

3. RESULTS AND DISCUSSION

3.1. Effect of fertilization with municipal solid waste on apple tree growth

Apple tree growth was evaluated by measuring the following parameters: the number of bud break, yield (number fruit/tree), trunk diameter, shoot length and leaf chlorophyll content.

3.1.1. Bud break

Buds started to break in early February and lasted till the end of March. The number of broken buds was significantly higher under municipal solid waste application regime than the control (MF) Table (3). Relative to the control the increase in the number of broken buds, at (144 KgN/ha) MSW application rate was 2.5, 2.8 and 4.1 fold for the three successive years, respectively.

3.1.2. Yield

Yield is the main component that reflects the effect of certain treatment on tree growth and development. Data presented in Table (4) show that the yield, expressed as the number of fruits/tree, was affected by municipal solid waste application for the three successive years. The number of fruits/tree was significantly greater in trees grown in plots which received composted municipal solid waste (72 and 144 kg N/ha) than the control plots (received mineral fertilizer) for the three successive years (2002, 2003 and 2004). The increase in yield relative to the control treatment was: 300% and 338% for the first year; 286% and 357% for the second year; 226% and 274% for the third year at MSW application rate of 72 and 144 kgN/ha, respectively. The increase in yield as a result of MSW application at 100%N and 200% rates relative to the control was more pronounced than the increase in yield between 100%N and 200%N applications rates. This less increase in yield using 200% N application rates relative to 100% N could be due to the imbalance between the vegetative and the reproductive growth. At 200% N application rate the trees showed vigorous growth and more vegetative volume than the trees received 100% of N recommended rate, this is in turn was reflected on the reproductive growth (number of fruits).

Table (4): Effect of fertilization with MSW on apple tree yield (number of fruits/tree)

Treatments	2002	2003	2004
MF (Control)	65	90	95
MSW, 100%N	150	200	215
MSW, 200%N	170	250	260
LSD 0.05	12.9	24.0	10.2

3.1.3. Shoot length and trunk diameter

Shoot length, tree size and trunk diameter are good indications for tree growth. Data presented in Table (5) show an increase in shoot length and trunk diameter as a result of municipal solid waste application relative to the control. These results

held true during the three years of study. During the three years of this study shoot length was significantly higher at MSW application rate of 200% N than at MSW application rate of 100% N of the recommended rate. Trunk diameter showed

Table (5): Effect of fertilization with MSW on apple tree growth (trunk diameter and shoot length

Treatments	2002		2003		2004	
	Shoot length (cm)	Trunk diameter (cm)	Shoot length (cm)	Trunk diameter (cm)	Shoot length (cm)	Trunk diameter (cm)
MF (Control)	70.8	6.8	80.0	10.0	83.0	12.0
MSW, 100%N	86.3	11.3	88.3	14.6	90.0	16.0
MSW, 200%N	100.5	13.6	108.2	16.1	111.0	18.0
LSD 0.05	2.3	3.5	1.7	3.9	4.7	2.6

no significant differences at the second and third years of between the high and the low MSW application rates. However, significant differences in trunk diameter were maintained between the trees grown in MSW amended soil and the control throughout the study period.

3.1.4. Chlorophyll content

Total chlorophyll content significantly increased as a result of MSW application, which indicates an increase in growth and carbohydrate ynthesis (Table 6). The increase in chlorophyll content was more pronounced at the higher MSW application rate (200%N). This results held true throughout the experiment period, the three years of study. The increase in chlorophyll content could be due to high Mg and Fe supplied by MSW. The Mg content of the leaves was greater than the control by the following folds: 1.3 and 1.5 for the first year; 1.2 and 1.5 for the second year and 1.2 and 1.4 for the third year at 100% and 200% of N recommended rate, respectively. Also, the iron content was higher in the leaves under MSW application regimes than the control. The results agree with El-Motaium and Abo El-(Seoud2004) who found an increase of chlorophyll content in Fennel shoot grown in sandy soil(amended with sewage sludge paring with the control (mineral fertilizer). Magnesium and iron are required elements for chlorophyll biosynthesis (Marschner, 1986). The chlorophyll molecule contains a central Mg^{2+} ion (Hoober, 1984) which is a major component of the molecule.

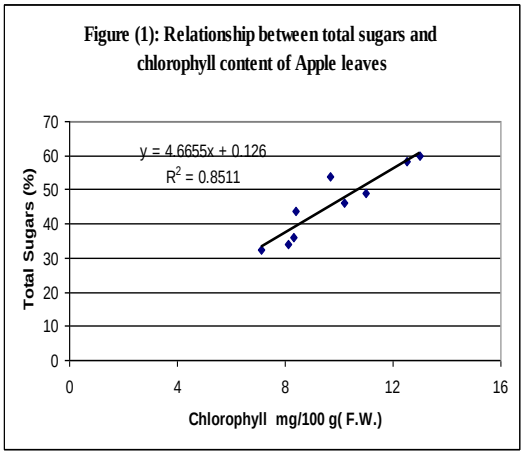
Table (6): Effect of fertilization using MSW on total chlorophyll content of Apple Leaves

Treatments	2002	2003	2004
	mg/100g (F.W.)		
MF (Control)	32.2	34.0	36.0
MSW, 100% N	43.7	46.0	49.0
MSW, 200% N	54.0	58.2	60.0
LSD 0.05	2.0	6.5	6.7

3.2. Effect of fertilization with MSW on apple fruit quality

3.2.1. Total soluble sugars and total soluble solids

The soluble sugar content was significantly higher in the plants grown in the soil amended with municipal solid waste than the control Table (7). The statistical analysis shows that, no significant differences were observed between the mineral fertilizer and MSW on total soluble solids and total sugars during the first year. Fruit total sugar content significantly increased during the second and third year as a result of MSW application at 200% N recommended rate. Total soluble solids showed progressive increase over the years under the three treatments, whereas it showed significant increase under MSW application relative to the control, at the third year only. Similar results were obtained by Pandya *et al*.,(1989) who observed an increase in protein, total soluble sugars and starch content in chickpea plants grown in soil amended with sewage sludge relative to the control (soil without sludge). The increase in fruit ugar content may result from the increase in chlorophyll content which is accompanied by an increase in leaves photosynthetic capacity. The linear regression (Fig. 1) between the chlorophyll and the sugars contents (R^2=0.85) proves the relationship between the two parameters.



Figure(1) : Relationship between total sugars and chlorophyll content of Apple leaves

3.2.2. Heavy metals

The heavy metals content of the fruits grown under organic waste application is a very important criterion to determine its quality and suitability for human consumption for health reasons. The data exhibited a slight increase in heavy metal concentrations as the years of applications increased. Cobalt and cadmium were almost nil in apple fruits. Apple fruits contained small fraction of heavy metals relative to the leaves.

Table (7): Effect of fertilization with MSW on total soluble sugars and total soluble solids of apple fruit.

Treatments	2002		2003		2004	
	Total Sugars %	TSS %	Total Sugars %	TSS %	Total Sugars %	TSS %
MF (Control)	7.1	12.5	8.1	13.5	8.3	14.0
MSW, 100% N	8.4	13.6	10.2	15.3	11.0	16.8
MSW, 200% N	9.7	14.5	12.5	16.4	13.0	15.8
LSD 0.05	2.3	2.4	3.2	2.3	2.4	4.7

During the third year of MSW application, the percentage of heavy metals in the fruits relative to those in the leaves was as follows: Pb=2.3, Ni=3.2, Co=0.83, Cd=0.82, Cr=2.5 for the mineral fertilizer treatment ; Pb=2.6, Ni=5.2, Co=0.47, Cd=0.88, Cr=8.2 for MSW at 100 N application rate treatment and Pb=4.1, Ni=5.3, Co=0.0, Cd=1.9, Cr=11.1% for MSW at 200% N application rates. The concentrations of heavy metals shown in Table (8) indicate a slight increase in heavy metals by using MSW comparing with the control. Heavy metals in the fruits under this study did not reach the excessive levels that harm plant growth or human health. After three years of application the concentrations of the studied heavy metals (Pb, Ni, Co, Cd, Cr) were far below the toxic level for fruit consumption stated by Donald (1972), which are as follows: Cd: 0.01-0.03 ppm, Pb: 0.03-0.38 ppm, Ni: 0.00-0.34 ppm. Particularly for Cd which is of major concern in food crops (Grant *et al.*, 1998). Cadmium concentration in apple fruits was 0.011 ppm after three years of MSW application. Growing apple trees for three years using MSW was safe for human consumption.

3.3. Effect of fertilization with MSW on the nutrition status of apple tree

3.3.1. Macro nutrients

Data in Table (9) show the percentage of NPK, Ca and Mg in apple leaves. The five mentioned elements were used as a tool to evaluate the nutritional status of the apple trees. Trees grown in municipal solid waste amended plots exhibited either equal or higher percentage of NPK, Ca and Mg relative to the control. The difference was more clear as the years of application advanced. This could be due to the mineralization and release of these nutrients from their organic form over the years. In general, apple leaves accumulated greater amount of macro-nutrients (N, P, K, Ca, Mg) from the soil amended with municipal solid waste than from the control (mineral fertilizer).

3.3.2. Micronutrients

Within certain concentration range, nutrient heavy metals (Fe, Mn, Zn and Cu) are essential nutrients required for plant growth and development (Marschner, 1986). Data in Table (10) show the micronutrient heavy metals content of apple leaves. Under MSW application there was a tendency for an increase in micronutrient content as the years of application advanced. Jones *et al.*, (1991) stated that the micronutrients sufficient concentration range for leaves of apple trees as follows: Fe (50-300 ppm), Mn (25-200 ppm), Zn (20-100 ppm), Cu (6-50 ppm). Municipal solid waste supplied apple trees with sufficient amount of nutrient (Fe, Mn, Zn, Cu) as mentioned by Marschner (1986) and Jones *et al.*, (1991).

Table (8): Effect of fertilization with MSW on heavy metals content of apple fruit

Treat.	2002					2003					2004				
	mg kg^{-1}														
	Pb	Ni	Co	Cd	Cr	Pb	Ni	Co	Cd	Cr	Pb	Ni	Co	Cd	Cr
MF Control	0.07	0.06	0.0	0.006	0.0	0.05	0.07	0.001	0.004	0.03	0.08	0.08	0.001	0.005	0.03
MSW 100% N	0.10	0.14	0.0	0.009	0.12	0.11	0.13	0.002	0.004	0.13	0.12	0.17	0.002	0.005	0.14
MSW 200% N	0.22	0.19	0.001	0.012	0.21	0.20	0.16	0.003	0.010	0.20	0.24	0.20	0.003	0.011	0.20
LSD 0.05	0.05	0.05	6.5×10^{-3}	0.001	0.05	0.05	0.05	0.001	0.002	0.05	0.026	0.047	0.001	0.001	0.029

Table (9): Effect of fertilization with MSW on the macronutrients content on apple leaves.

Treats	2002					2003					2004				
	%														
	N	P	K	Ca	Mg	N	P	K	Ca	Mg	N	P	K	Ca	Mg
MF Control	2.3	0.30	1.55	0.85	0.26	2.5	0.31	1.50	0.90	0.30	2.5	0.32	1.50	0.91	0.32
MSW 100%N	2.4	0.31	1.56	0.90	0.34	2.5	0.33	1.57	0.92	0.36	2.6	0.35	1.60	0.94	0.38
MSW 200%N	2.5	0.35	1.60	0.93	0.40	2.7	0.36	1.62	0.99	0.45	2.8	0.39	1.65	1.00	0.46
LSD 0.05	0.26	0.03	0.07	0.03	0.03	0.21	0.03	0.11	0.01	0.03	0.31	0.01	0.19	0.06	0.06

Table (10): Effect of fertilization with MSW on the micronutrient content of apple leaves.

Treat.	2002				2003				2004			
	mg kg^{-1}											
	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
MF Control	177	23.8	24.7	12.6	205	24.0	25.3	11.5	206	24.0	26.0	13.0
MSW 100%N	250	29.1	29.1	15.3	270	21.1	36.9	14.7	274	23.0	38.0	15.0
MSW 200%N	275	30.3	32.1	16.5	280	24.8	38.5	15.6	287	25.0	39.2	17.0
LSD 0.05	9.16	2.37	0.39	0.40	9.16	1.76	0.69	0.23	3.5	2.3	3.4	3.5

3.3.3. Heavy metals

Data in Table (11) represent the heavy metal content in apple leaves under mineral and MSW application regimes. The heavy metals were measured to study the effect of the different fertilizers on the accumulation of such metals in the leaves for three successive years. The concentrations of Pb, Ni, Co, Cd, Cr varied in response to the kind of fertilizer, application rates and duration. Most of the studied metals showed a slight increase relative to the control using MSW except cadmium. Cadmium was slightly higher in tree leaves grown using mineral fertilizer, however the increase was non-significant. Phosphate fertilizers are known as an important source of Cd (Fleischer *et al*., 1974). This could be explained by the fact that superphosphate fertilizer used in this study contains a high level of cadmium. There was an increase in leaf heavy metal concentration over the years which could be attributed to the oxidation of organic matter (resulted from high heat and aeration in sandy soil) which could release metals into more soluble form. This is explained by "the time bomb hypothesis", McBride (1995).

Heavy metals in leaf tissues were within the acceptable limits stated by Ryan and Bryndzia (1998) and are below the toxic plant concentration summarized by Chaney (1983). These toxic plant concentrations for productivity or food chain safety are as follows (Pb= 2-5 , Ni= 0.1-5, Cd=0.2-0.8 mg/kg D.W.). The reason for maintaining such low heavy metals concentrations in the leaves could be due to the distribution of such metals in the whole tree structure, dilution effect.The calculated soil Cd concentrations using MSW (Cd content = 2 mg kg^{-1}) as a fertilizer in sandy soil showed that Cd concentration was 0.0025 mg kg^{-1} and 0.0050 mg kg^{-1} under the application of 100% and 200% of N recommended rate. This concentration is very low comparing with the maximum concentration of 3 mg kg^{-1} allowed under the EU legislation (CEC, 1986) and is much lower than the Cd concentration of 20 mg kg^{-1} allowed by the EPA-503 regulation (USEPA, 1993).

3.4. Effect of fertilization with MSW on sandy soil properties

Table (12) shows the improvement in soil characteristics after three years of successive MSW application. The improvement was shown in the reduction in soil pH and bulk density and in the increase in soil organic matter, water holding capacity and cation exchange capacity relative to the control treatment. These results are in close agreement with El-Motaium and Badawy, (2002) using sewage sludge. Also, the increase in soil N,P,K at 144 Kg N/ha MSW application rate reached 12, 10, 12 fold respectively, relative to the control. The improvement in soil physical properties can play a better role in increasing crop productivity than the role of the nutrients content.

Table (11): Effect of fertilization with MSW on heavy metal contents of apple leaves

Treat.	2002					2003					2004				
	mg kg^{-1}														
	Pb	Ni	Co	Cd	Cr	Pb	Ni	Co	Cd	Cr	Pb	Ni	Co	Cd	Cr
MF Control	2.2	0.98	0.09	0.55	1.2	3.3	2.45	0.12	0.60	1.2	3.5	2.5	0.12	0.61	1.2
MSW 100%N	3.0	2.19	0.36	0.50	1.5	4.1	3.00	0.41	0.55	1.6	4.6	3.3	0.43	0.57	1.7
MSW 200%N	3.3	3.09	0.42	0.53	1.6	4.8	3.60	0.45	0.56	1.7	4.9	3.8	0.46	0.58	1.7
LSD 0.05	0.61	0.11	0.06	0.09	0.26	0.57	0.56	0.08	0.01	0.39	0.80	0.44	0.04	0.03	0.36

Table(12): Effect of fertilization with MSW on sandy soil physical and chemical characteristics and total nutrient content

Treat.	pH	Bd g.cm^{-1}	WHC %	OM gkg^{-1}	CEC meq.100g^{-1}	N %	P %	K %
Sandy soil	8.1	1.70	10.7	0.1	2.1	0.03	0.022	0.025
MSW 100%	7.8	1.50	14.8	0.6	10.9	0.24	0.112	0.154
MSW 200%	7.6	1.40	17.0	1.0	12.0	0.36	0.200	0.301

These results agree with Mays and Giordano (1989) who found that land application of MSW showed favorable effects on soil properties such as pH, increase in soil organic matter and plant nutrients. In this experiment, a reduction in sandy soil bulk density was observed under MSW application (from 1.7 to 1.4 g.cm^{-3}). Similar previous finding was reported by (Kreft, 1987) for field application of MSW compost which showed a reduction in bulk density of loamy sand soil.

4. CONCLUSION

Composted municipal solid waste could be used in sandy soil to improve soil structure, increase its water retention and cation exchange capacity and provide macro and micro-nutrients for plant growth. Apple tree growth was improved by the application of municipal solid waste. Trunk diameter, shoot length, number of bud break, fruit set and chlorophyll content were higher using MSW than the control. Apple leaf heavy metals (Pb, Cd, Co, Ni, Cr) content were very low and NPK and micronutrients was at adequate level for healthy growth. The increase in plant mineral nutrients increased the tree growth and the yield. Fruit quality has improved by showing high content of TSS and total soluble sugars. Fruits contained traces of heavy metals, *i.e.* below the toxic level for safe fruit consumption. Apple tree can grow successfully in sandy soil amended with MSW with no need for mineral fertilizer. Growing apple trees for three years using MSW was safe for human consumption.

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تأثير إستعمال مخلفات القمامة المكمورة على النمو والحالة الغذائية وجودة ثمار أشجار التفاح المزروعة فى الأراضى الرملية: الزراعة العضوية

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ملخص

تم إجراء تجربة حقليه بمزرعة قسم البحوث النباتية-هيئة الطاقة الذرية-إنشاص لدراسة إمكانية إستعمال السماد العضوى الناتج من مخلفات القمامة لتسميد أشجار التفاح المزروعه بالأراضى الرملية كبديل للأسمدة المعدنية. وشملت الدراسه تأثير هذا السماد العضوى على نمو الأشجار وحالتها الغذائية وجودة الثمار.

تم إستخدام أشجار تفاح الأنا (المطعومة على أصل مالينج ميرتون 106) عمر 4 سنوات. وإشتملت المعاملات السمادية على: المستوى الأول 100% من إحتياجات أشجار التفاح من عنصر النيتروجين و المستوى الثانى 200% من

إحتياجات أشجار التفاح من عنصر النيتروجين بالاضافه إلى معامله الكنترول بإستعمال الأسمده المعدنيه بالمعدلات المثاليه. تم ترتيب المعاملات وفقا لتصميم القطاعات كاملة العشوائية.

أشارت النتائج إلى إن إستعمال السماد العضوى الناتج من مخلفات القمامة المكمورة ، والتى تم الحصول عليها من وحده الكمر العضوى بالمقطم –القاهره-مصر ، قد أدى إلى تحسين الخواص الطبيعية والكيميائيه للأرض الرملية ، كما أدى إلى زياده نمو الأشجار وزيادة الإنتاج مقارنة بالكنترول. تبين إن التسميد العضوى قد أدى إلى توفير إحتياجات أشجار التفاح من العناصر الكبرى والصغرى (نيتروجين ، فوسفور ، بوتاسيوم ، زنك ، حديد ، منجنيز ، نحاس). وقد كان تركيز العناصر الثقيله بالثمار والأوراق أقل بكثير من الحدود المسموح بها بالمقاييس الدوليه. كما وقد تحسنت جوده ثمار التفاح من حيث كمية السكريات الكلية والمواد الصلبه الذائبه. وكانت أحسن المعاملات والتى أعطت أعلى محصول هى المعاملة 200 % من إحتياجات أشجار التفاح من عنصر النيتروجين. ويتضح من نتائج هذا البحث أنه يمكن إستعمال الأسمده العضوية الناتجه من مخلفات القمامة وإعادة إستعمالها كسماد للأراضى الرمليه بدون الحاجه للأسمدة المعدنية.

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