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EFFECT OF SOIL TYPE AND SOME SOIL AMENDMENTS ON GROWTH OF 'ANNA' APPLE SEEDLINGS

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ABSTRACT: ***This study was conducted in the Orchard of the Horticulture Research Institute, Giza during the 2006 and 2007 seasons to evaluate growth of one-year-old 'Anna' apple (Malus domestica Borkh) / Malus communis seedlings in pots containing sandy (SS), loamy clay (LCS) and sandy calcareous (SCS) soils amended with either humic acid (HA), Nile Fertile (NF; a local commercial product rich in S and S-oxidizing microorganisms in addition to N, P, Ca, Mg, and Fe), or Effective Microorganisms (EM). The control soils were not amended. A split-plot system in a randomized complete block design was used. In both years, SCS had the highest significant pH, while NF gave the highest significant reduction in pH. LCS was highest in EC, while HA was the most effective amendment in reducing it. Soil N was significantly the highest in LCS and with the HA treatment. Meanwhile, soil P was significantly the highest in SS and with NF amendment, while it was significantly the lowest in SCS. Soil K was, on the other hand, significantly the highest in LCS and with the NF amendment. SS was significantly the highest in Fe, Zn, and Cu, while LCS was the highest in Mn. NF was the top treatment in soil Fe and Mn, while HA amendment was the top in soil Zn and Cu. The highest significant total microbiological counts were in LCS and when EM was applied for total bacteria and total fungi, and when NF was applied for actinomycetes. Soil type had no consistent effect on number of leaves/seedling, but NF treatment resulted in the highest number of leaves. Meanwhile, shoots were tallest in SS and with the EM treatment. Likewise, SS resulted in the largest leaf area and highest leaf chlorophyll and N leaf content, but LCS was the top in leaf P and K content. Meanwhile, the NF amendment resulted in significantly the largest leaf area and highest leaf chlorophyll and P content, while EM resulted in the highest leaf N and K content. The top foliage dry weight/seedling was obtained in SCS and with the EM treatment, while the top dry weight of main roots and secondary roots in both years was obtained in SS and with the HA treatment for main roots and EM treatment for secondary roots – a trend that was also observed in the proportion of dry matter allocated to these parts except that the proportion of dry matter allocation to secondary roots was largest in LCS. It was concluded that amending soil with HA, NF or EM, specially sandy and calcareous soil, improves growth of 'Anna'/ Malus seedlings.***

Key words: ***Apple seedling growth, Malus domestica, soil type, sandy soil, sandy calcareous soil, loamy clay soil, humic acid, Nile Fertile, EM, soil microbial count.***

INTRODUCTION

Physico-chemical properties have profound effect on plant growth and development. Mineral nutrients function as constituents of organic structures, as activators of enzyme reactions, or as charge carriers and osmoregulators, whereby the nutritional status of plants will affect growth and development (Romheld, 1997). In calcareous soil, lime content has negative effects on P and K uptake, yield of peach, and phosphorus content of soil (Szucs, 1995).

When the concentrations of N, P, K, Ca, Mg, Fe, Cu, Mn, and Zn were measured in peach flowers and leaves 60 and 120 days after full bloom, only K, Ca, and Fe were the elements whose concentrations showed the largest changes with chlorosis. The K/Ca ratio also changed with chlorosis (Belkhodja *et al.,* 1997). In California, USA, iron chlorosis represents the most serious nutrient deficiency problem in pears grown on high clay content soils. Iron is less available to the trees due to the high soil pH. Application of chelated iron was the most effective treatment in mitigating iron chlorosis in pear trees (Elkins *et al.,* 2002).

Humic fraction of cattle manure was effective than the manure itself in maintaining aggregate stability of a sandy loam soil (Fortun *et al.,* 1989). The application of HA to a soil low in organic matter gave the greatest growth response in corn seedlings. Application to a high organic matter soil gave little growth response, or even a slightly negative response, indicting that the natural soil supplied optimum amount of humic substances to the plants. Phosphorus concentration in corn seedlings increased with increasing levels of HA applied to soil. Higher Fe concentration in the plant tops and lower in roots was also observed in the treatments with HA (Lee and Bartlett, 1976). It has been claimed that HA unlock soil nutrient, improves effect of fertilizers, enhances root development, improves soil structure, improves resistance to stress, and promotes residue decomposition. Also, it improves availability of iron and other trace elements, iron and zinc uptake and their translocation, and phosphorus availability (Senn, and Kingman 1973; Russo and Berlyn, 1990). Humic substances are potentially effective as a soil conditioner in improving aggregate stability (Piccolo *et al.,* 1997; Imbufe *et al.,* 2005).

Foliar K-humate application to ‘Canino’ apricot enhanced shoot length, leaf area, leaf chlorophyll content, fruit yield, and fruit size (Eissa *et al.,* 2003). ‘Hollywood’ plum responded to soil application with Wesko plus K, which contains 56% K-humate, by increases in many foliage characters, yield components, and fruit quality attributes in addition to soil microbial count (Eissa, 2007). Humic acid treatment significantly increased root growth and

improved salinity tolerance in seedlings of 'Florda Prince' peach, 'Canino' apricot, 'Le-Conte' pear, and 'Anna' apple. (Eissa *et al.,* 2007a, 2007b, and 2007c). A liquid organic fertilizer containing a minimum of 2.9 % humic acid (i.e., Actosol) used as soil amendment and/or foliar spray improved many soil criteria and growth characters of 'Le Conte' pears and 'Canino' apricot. The combined soil and foliar application gave the highest values of each of the measured vegetative growth parameters; soil content of available NO_3; and soil and leaf content of N, P, K, Fe, Mn, and Zn (Hussien *et al.,* 2005).

The application of compost or EM, either singly or combined, increased plant available nutrients. The EM treatment also gave the maximum β-glucosidase activity in soil, which hastened the decomposition of soil organic matter (Chongpraditnum, 1996). EM or effective microorganisms is a trade name coined in 1994 by Teruo Higa of the Agricultural University, Okinawa, Japan. EM contains many types of microorganisms that fall into the categories Lactobacillus, actinomycetes, yeasts, photosynthetic bacteria, and certain fungi. Many benefits are ascribed to EM, including soil improvement and enhancement of fruit tree growing (Xu, 2000). Soil application of EM to 'Kelsey' plum trees resulted in significantly the highest count of total bacteria, actinomycetes, and fungi in rhizosphere soil; highest soil and leaf N, P, K analysis; greatest leaf area and chlorophyll reading; and largest number of fruits set/shoot and at harvest , fruit flesh thickness and total soluble solids concentration; while it resulted in the least fruit firmness and titratable acidity relative to control (Eissa, 2003).

It has been claimed that EM soil application enhances soil fertility, increases crop yield and crop quality, helps to correct nutritional and physiological crop disorders, reduces the infestation of pests and diseases, accelerates the decomposition of organic waste, reduces adverse effects of continuous cropping, enhances soil physical characteristics, increases beneficial microorganisms in the soil, and helps control pathogens by competitive exclusion (Condor-Golec *et al.,* 2007).

These experiments were, therefore, conducted in an attempt to improve top and root growth of one-year-old 'Anna' apple seedlings in different soil types, viz., sandy, loamy clay, and sandy calcareous, by the application of some soil amendments, viz., humic acid, Nile Fertile, and Effective Microorganisms.

MATERIALS AND METHODS

These experiments were conducted in the orchard of Horticulture Research Institute, Agricultural Research Center during the 2006 and 2007 seasons in an attempt to improve soil environment used for raising apple (*Malus domestica* Borkh) seedling during their early growth by the use of various soil amendments. One-year-old 'Anna' apple seedlings on *Malus communis* rootstock were planted on Feb.26, 2006 and Feb. 28, 2007 in 30-cm-wide, 40-cm-deep plastic pots filled with either sandy soil (SS), loamy

clay soil (LCS), or sandy calcareous soil (SCS). Mechanical analysis indicated that SS contained 95% sand, 3% silt and 2% clay; SCS contained 87% sand, 8% silt, and 5% clay, and it had 8% calcium carbonate to start with, while LCS had 22% sand, 44% silt, and 34% clay. Nearly 100 g of compost was thoroughly mixed with soil of each pot. Different pots of various soil types received four treatments as follows : (a) application every two weeks of 5 ml Actosol (Nile Agricultural Cooperative Society, Egypt) in ½ liter of water during April, May, and June, i.e., six applications; (b) application of 50 g Nile Fertile (Al-Giza for Manufacturing of Fertilizers, 6th October city, Egypt) once in the beginning of April; (c) treatment with Effective Microorganisms (EM, Ministry of Agriculture, Egypt), fermented with molasses, every two weeks at the rate of ½ liter per pot during April, May and June, i.e., six applications; and (d) control without any amendments.

Actosol is a product of Arctick Inc., Chentilly, VA, USA. It contains 2.9% humic acid (HA) and 10-10-10 NPK. Nile Fertile (NF) is a locally produced commercial fertilizer that contains 2.7% N, 3.5% P_2O_5, 5.0% CaO, 38% S, 2.7% MgO, and 1% Fe in addition to sulphur oxidizing microorganisms, with the objective of reducing soil pH. EM is produced by EMRO Corporation, Okinawa, Japan. It contains more than 60 selected strains of "Effective Microorganisms", viz., photosynthetic bacteria, lactic acid bacteria, yeasts, actinomycetes and various fungi. Both Actosol and NF were subjected to chemical analysis to be certain of their composition.

A split-plot system in a randomized complete block design with three replicates was used. Soil types were allocated to the main plots, while soil amendments were randomized in the sub-plots. Each experimental unit consisted of seven pots. Two pots were used for measuring destructive characters, viz., leaf area, chlorophyll content and leaf NPK analysis in mid August, and five pots were used in measuring other characters. Leaf area was measured using a CL 203 Area meter (CID, Inc. USA) based on measurements recorded on 10 leaves. Leaf chlorophyll content was measured using a SPAD 502 chlorophyll meter (Minolta Corporation, Ramsey, NJ, USA) based on readings recorded on 10 leaves as above. According to Peryea and Kammereck (1997), SPAD readings of pear leaves can also provide an unbiased quantitative measure of the severity of leaf chlorosis associated with Fe deficiency.

Leaf nutrient analysis included N by the Kjeldahl digestion method as described by Jakson (1973), P using the ammonium molybdate method as described by Trough and Mayer (1949), and K using wet digestion (Piper, 1950) and the flame photometer method according to Brown and Lilleland (1946). Leaf samples were collected for chemical analysis in late Aug. of both seasons. Each sample consisted of 5 leaves/seedling taken from the middle of shoots. Leaves were washed several times with tap water, rinsed with distilled water, and then dried at 70^{o}C to a constant weight. Dried leaves were

ground in a stainless steel rotary knife mill, screened through 20 mesh screen, and 0.5 g dried samples were taken for analysis.

The number of leaves per seedling was counted in mid-August and the total seedling length was measured in mid October.

At the end of the experiment, during November, plants were carefully removed from pots, their roots thoroughly cleaned from soil in their respective pots, and foliage separated from roots by cutting plants at soil line. Roots were separated into main and secondary roots. Foliage and main and secondary roots were each weighed fresh and after drying at 70^{o}C to constant weight. The dry weight values were used in calculating dry weight of each part as a percentage of total plant dry weight, i.e., dry matter allocation.

Soil microbial counts were made in sample soils. Small portions were used for density estimation of colony forming units (CFU) of total bacteria (TB) using the soil extract agar medium (Allen, 1953), total fungi (TF) using the rose-bengal streptomycin agar medium (Martin, 1950), and total actimycetes (TA) using Jensen's medium (Allen, 1953). This part of study was conducted at the Agricultural Microbiology Department, Soil, Water and Environment Institute, ARC.

Soil remaining in pots were also subjected to several measurements that included soil pH (1:25), soil EC and soil N, P, K, Fe, Zn, Mn and Cu analyses (Jackson, 1973). N, P, and K were determined in dry soil samples as previously mentioned for leaves. Fe, Zn, Mn, and Cu were analyzed by using an atomic absorption spectrophotometer (Pye Unican SP1900) according to Brandifeld and Spincer (1965).

Data obtained were statistically analyzed and mean separation was according to Duncan's multiple range test (Steel and Torrie, 1981).

RESULTS

Soil pH and EC :

Treatment applied exerted significant effects on both soil pH and soil EC in both years of the study (Table 1).

The highest significant soil pH was in SCS (8.6 and 8.7 in both years) and the lowest soil pH was in SS (7.7); while the most effective soil amendments in reducing soil pH was NF (pH = 7.8 in both seasons), followed by EM, then by HA. Meanwhile, control treatment was the highest in soil pH (8.4 and 8.5 in 2006 and 2007, respectively). Soil type and soil amendments interaction was also significant with the least soil pH in SS + NF (7.1 and 7.2 in the two seasons), followed by SS + EM (7.6 and 7.7 in 2006 and 2007, respectively).

Soil EC was significantly the highest in LCS (1.21 and 1.22 in both years, respectively) and the least in SCS (0.40 and 0.41 in the two seasons, respectively). The NF treatment was the highest in soil EC (1.19 and 1.33 in the two years, respectively), while the HA treatment was the least in this

respect (0.48 and 0.51 in the two seasons, respectively), though the EM treatment was not significantly different from HA treatment in 2006. Concerning interaction, the least significant soil EC was found in 2006 in both SS and SCS with or without HA or EM, and in 2007 in SCS with HA or EM.

Table (1) : Effect of soil type and amendments on soil pH and EC[z].

Treatment [y] (Soil type & amendments)	pH (1 : 2.5)		EC (mS/m)	
	2006	2007	2006	2007
SS	8.0 h	8.1 f	0.37 e	0.38 h
SS + HA	7.9 i	7.8 h	0.50 de	0.53 g
SS + NF	7.1 k	7.2 j	0.97 c	1.34 c
SS + EM	7.6 j	7.7 i	0.53 de	0.54 g
LCS	8.4 d	8.5 c	1.36 b	1.37 b
LCS + HA	8.3 f	8.2 e	0.70 cd	0.73 f
LCS + NF	8.0 h	8.0 g	1.80 a	1.82 a
LCS + EM	8.4 e	8.3 d	0.98 c	0.97 d
SCS	8.9 a	8.9 a	0.30 e	0.31 i
SCS + HA	8.8 b	8.7 b	0.24 e	0.26 j
SCS + NF	8.2 g	8.3 d	0.80 cd	0.83 e
SCS + EM	8.6 c	8.7 b	0.26 e	0.25 j
Mean Soil Type				
SS	7.7 c	7.7 c	0.59 b	0.70 b
LCS	8.3 b	8.3 b	1.21 a	1.22 a
SCS	8.6 a	8.7 a	0.40 c	0.41 c
Mean Soil Amendment				
None (Control)	8.4 a	8.5 a	0.68 b	0.69 b
HA	8.3 b	8.2 b	0.48 c	0.51 d
NF	7.8 d	7.8 c	1.19 a	1.33 a
EM	8.2 c	8.2 b	0.59 bc	0.59 c

[z] Within each group of comparable treatments in individual columns, values followed by a letter in common are not significantly different from each other at 0.05 level according to Duncan's multiple range test.

[y] SS : sandy soil; LCS : loamy clay soil; SCS : sandy calcareous soil; HA : humic acid; NF : Nile Fertile; EM : Effective Microorganisms

Soil Nutrient Analysis :

Treatments differed significantly with respect to soil content of all macro (Table 2) and micro (Table 3) elements analyzed in both years of the study.

In both years, N was significantly the highest in LCS (67.5 and 64.3 ppm, respectively), and in HA treatment (56.7 and 58.7 ppm, respectively), while it was significantly the lowest in SCS (28.8 and 32.0 ppm, respectively), and without any amendments (43.3 and 41.3 ppm, respectively). Meanwhile, the highest interaction in soil N was the LCS + EM (75.0 and 72.0 ppm, respectively), followed by LCS + HA, then by SS + EM, while the least interaction in soil N was the SCS without amendments (20.0 and 25.0 ppm, respectively, Table 2).

Table (2) : Effect of soil type and amendments on soil NPK analysis (ppm)[z].

Treatment [y] (Soil type & amendments)	N		P		K	
	2006	2007	2006	2007	2006	2007
SS	50.0 e	45.0 g	20.0 e	19.0 g	160.0 g	155.0 h
SS + HA	60.0 d	65.0 d	41.0 b	43.0 b	280.0 e	270.0 f
SS + NF	60.0 d	63.0 e	30.0 c	36.0 c	376.0 d	350.0 e
SS + EM	65.0 c	67.0 c	24.0 d	25.0 d	172.0 f	160.0 g
LCS	60.0 d	54.0 f	15.0 h	17.0 h	380.0 d	357.0 d
LCS + HA	70.0 b	68.0 b	19.0 f	24.0 e	386.0 c	377.0 c
LCS + NF	65.0 c	63.0 e	44.0 a	46.0 a	392.0 b	385.0 b
LCS + EM	75.0 a	72.0 a	18.0 g	22.0 f	616.0 a	530.0 a
SCS	20.0 i	25.0 k	12.0 k	11.0 k	112.0 j	102.0 l
SCS + HA	40.0 f	43.0 h	14.0 i	13.0 j	117.0 ij	111.0 j
SCS + NF	25.0 h	27.0 j	13.0 j	14.0 i	136.0 h	130.0 i
SCS + EM	30.0 g	33.0 i	13.0 j	13.0 j	120.0 i	109.0 k
Mean Soil Type						
SS	58.8 b	60.0 b	28.8 a	30.8 a	247.0 b	233.8 b
LCS	67.5 a	64.3 a	24.0 b	27.3 b	443.5 a	412.3 a
SCS	28.8 c	32.0 c	13.0 c	12.8 c	121.3 c	113.0 c
Mean Soil Amendment						
None (Control)	43.3 c	41.3 d	15.7 d	15.7 d	217.3 c	204.7 d
HA	56.7 a	58.7 a	24.7 b	26.7 b	261.0 b	252.7 c
NF	50.0 b	51.0 c	29.0 a	32.0 a	301.3 a	288.3 a
EM	56.7 a	57.3 b	18.3 c	20.0 c	302.7 a	266.3 b

[z] Within each group of comparable treatments in individual columns, values followed by a letter in common are not significantly different from each other at 0.05 level according to Duncan's multiple range test.

[y] SS : sandy soil; LCS : loamy clay soil; SCS : sandy calcareous soil;
HA : humic acid; NF : Nile Fertile; EM : Effective Microorganisms

Table (3) : Effect of soil type and amendments on soil Fe, Zn, Mn and Cu analysis (ppm)[z]

Treatment [y]	Fe		Zn		Mn		Cu	
(Soil type & amendments)	2006	2007	2006	2007	2006	2007		
SS	0.02 d	0.03 d	0.60 fg	0.65 f	0.58 i	0.60 f	0.02 c	0.03 f
SS + HA	0.04 d	0.05 d	6.60 a	7.00 a	0.60 i	0.61 f	9.20 a	9.80 a
SS + NF	4.60 a	4.30 a	1.10 d	1.30 d	3.80 b	4.00 b	0.18 c	0.20def
SS + EM	0.60 b	0.63 b	1.00 d	1.20 d	2.40 c	2.50 c	0.06 c	0.09 ef
LCS	0.64 b	0.65 b	0.52 g	0.60 f	0.76 gh	0.79 e	0.05 c	0.58 de
LCS + HA	0.02 d	0.03 d	4.20 b	4.50 b	2.00 d	2.50 c	4.00 b	4.50 c
LCS + NF	0.20 c	0.30 c	0.80 e	1.30 d	6.0 a	7.20 a	0.68 c	0.73 d
LCS + EM	0.02 d	0.03 d	0.68 ef	0.80 e	0.80 g	1.00 d	0.56 c	0.59 de
SCS	0.02 d	0.02 d	0.20 h	0.30 g	0.40 j	0.45 f	0.02 c	0.03 f
SCS + HA	0.02 d	0.02 d	3.40 c	3.80 c	1.00 e	1.06 d	4.00 b	5.00 b
SCS + NF	0.02 d	0.02 d	0.24 h	0.26 g	0.88 f	1.10 d	0.03 c	0.04 f
SCS + EM	0.02 d	0.02 d	0.18 h	0.20 g	0.70 h	0.80 e	0.02 c	0.03 f
Mean Soil Type								
SS	1.32 a	1.25 a	2.33 a	2.54 a	1.85 b	1.93 b	2.37 a	2.53 a
LCS	0.22 b	0.25 b	1.55 b	1.80 b	2.39 a	2.87 a	1.32 b	1.60 b
SCS	0.02 c	0.02 c	1.01 c	1.14 c	0.75 c	0.85 c	1.02 b	1.28 c
Mean Soil Amendment								
None (Control)	0.23 b	0.23 b	0.44 d	0.52 d	0.58 d	0.61 c	0.03 b	0.21 b
HA	0.03 c	0.03 c	4.73 a	5.10 a	1.20 c	1.39 b	5.73 a	6.43 a
NF	1.61 a	1.54 a	0.71 b	0.95 b	3.56 a	4.10 a	0.30 b	0.32 b
EM	0.21 b	0.23 b	0.62 c	0.73 c	1.30 b	1.43 b	0.21 b	0.24 b

[z] Within each group of comparable treatments in individual columns, values followed by a letter in common are not significantly different from each other at 0.05 level according to Duncan's multiple range test.

[y] SS : sandy soil; LCS : loamy clay soil; SCS : sandy calcareous soil;
HA : humic acid; NF : Nile Fertile; EM : Effective Microorganisms

Soil phosphorus content was in both years the highest in SS (28.8 and 30.8 ppm, respectively)and with NF amendment (29 and 32.0 ppm., respectively), while it was significantly the lowest in SCS (13.0 and 12.8 ppm, respectively) and without any amendments (15.7 ppm in both years). Meanwhile, the highest interaction in soil P was the LCS + NF (44.0 and 46.0 ppm, respectively), followed by SS + HA, then by SS + NF, while the least

interaction in soil P was the SCS without amendments (12.0 and 11.0 ppm, respectively).

In both years, K was significantly the highest in LCS (443.5 and 412.3 ppm, respectively), and with the NF treatment (301.3 and 288.3 ppm, respectively), while it was significantly the lowest in SCS (121.3 and 113.0 ppm, respectively) and without any amendments (217.3 and 204.7 ppm in 2006 and 2007, respectively). Meanwhile, the highest interaction in soil K was the LCS + EM (616.0 and 530.0 ppm, respectively), followed by LCS + NF, then by LCS + HA, while the least interaction in soil K was SCS without amendments (112.0 and 102.0 ppm, respectively, Table 2).

The highest significant soil Fe analysis was found in both years in SS (1.32 and 1.25 ppm, respectively), and with the NF treatment (1.61 and 1.54, respectively), while it was significantly the least in SCS (0.02 and 0.02 ppm, respectively) and with HA amendment (0.03 and 0.03 ppm, respectively). Meanwhile, the highest interaction in soil Fe content was SS + NF (4.6 and 4.3 ppm, respectively), followed by both SS + EM and LCS without amendment, then by LCS + NF, while all other treatment interactions were the least in soil Fe content without significant differences among them (Table 3).

Soil Zn content was in both years the highest in SS (2.33 and 2.54 ppm, respectively), and with the HA amendment (4.73 and 5.10 ppm, respectively), while it was significantly the least in SCS (1.01 and 1.14 ppm, respectively) and without any amendment (0.44 and 0.52 ppm, respectively). Meanwhile, the highest interaction in soil Zn was SS + HA (6.60 and 7.00 ppm, respectively), followed by LCS + HA (4.2 and 4.5 ppm, respectively), then by SCS + HA, while the least interaction in soil Zn was the SCS without amendments (0.20 and 0.30 ppm, respectively).

In both years, Mn was significantly the highest in LCS (2.39 and 2.87 ppm, respectively), and with the NF treatment (3.56 and 4.10 ppm, respectively), while it was significantly the lowest in SCS (0.75 and 0.85 ppm, respectively), and without any amendments (0.58 and 0.61 ppm, respectively). Meanwhile, the highest interaction in soil Mn was the LCS + NF (6.0 and 7.20 ppm, respectively), followed by SS + NF, while the least interaction in soil Mn was SCS without amendment in both years (Table 3).

The highest significant soil Cu analysis was found in both years in SS (2.37 and 2.53 ppm, respectively), and with the HA treatment (5.73 and 6.43 ppm, respectively), while it was significantly the least in SCS (1.28 ppm in 2007). The control without amendment did not differ significantly from NF or EM in soil Cu. Meanwhile, the highest interaction in soil Cu content was SS + HA (9.20 and 9.80 ppm, respectively), followed by LCS + HA in 2006 and SCS + HA in both years (Table 3).

Soil Microbial Count :

Treatments applied significantly affected soil microbial count in both years of the study (Table 4).

Table (4): Effect of soil type and amendments on the number of colony forming units (CFU) of various groups of rhizosphere microflora [z].

Treatment [y] (Soil type & amendments)	Total bacteria ($CFU \times 10^6 g^{-1}$ dry soil)		Total fungi ($CFU \times 10^3 g^{-1}$ dry soil)		Total actinomycetes ($CFU \times 10^3 g^{-1}$ dry soil)	
	2006	2007	2006	2007	2006	2007
SS	8.50 f	11.00 i	13.33 fg	16.50 fg	47.33 c	38.67 j
SS + HA	13.00 de	14.03 fg	16.00 fg	20.33 h	26.00 d	35.00 k
SS + NF	12.00 e	13.50 g	18.00 ef	23.00 g	38.33 cd	32.20 l
SS + EM	49.00 a	46.67 a	22.00 e	19.33 i	30.33 cd	41.67 i
LCS	11.33 e	12.33 h	30.00 d	29.67 e	37.67 cd	47.00 h
LCS + HA	25.00 c	23.33 d	48.67 ab	34.67 c	105.7 b	80.00 d
LCS + NF	15.00 d	16.67 e	44.00 b	39.33 b	326.7 a	226.7 a
LCS + EM	37.67 b	35.50 b	53.00 a	47.57 a	94.00 b	120.0 b
SCS	3.00 g	5.00 j	7.00 h	11.00 k	89.33 b	75.00 f
SCS + HA	13.00 de	14.67 f	12.00 gh	16.00 j	107.0 b	91.67 c
SCS + NF	11.67 e	13.33 g	28.00 d	24.00 f	107.7 b	78.33 e
SCS + EM	39.00 b	33.50 c	37.00 c	31.67 d	50.00 c	63.33 g
Mean Soil Type						
SS	20.63 b	21.30 b	17.33 c	17.79 c	35.50 c	37.13 c
LCS	22.25 a	21.96 a	43.92 a	37.81 a	141.00 a	118.40 a
SCS	16.67 c	16.63 c	21.00 b	20.67 b	88.50 b	77.08 b
Mean Soil Amendment						
None (Control)	7.61 d	9.44 d	16.78 d	19.06 d	58.11 c	53.56 d
HA	17.00 b	17.34 b	25.56 c	23.67 c	79.56 b	68.89 c
NF	12.89 c	14.50 c	30.00 b	28.78 b	157.6 a	112.7 a
EM	41.89 a	38.56 a	37.33 a	32.86 a	58.11 c	75.00 b

[z] Within each group of comparable treatments in individual columns, values followed by a letter in common are not significantly different from each other at 0.05 level according to Duncan's multiple range test.

[y] SS : sandy soil; LCS : loamy clay soil; SCS : sandy calcareous soil; HA : humic acid; NF : Nile Fertile; EM : Effective Microorganisms

In both years, total bacterial count was significantly the highest in LCS and in the EM soil amendment, while it was significantly the lowest in SCS and in the control without amendments. The highest significant interaction was that of SS + EM (49.0 and 46.67 × 10^6 g^{-1} dry soil in both years, respectively), followed by LCS + EM and SCS + EM, while it was the lowest in

SCS without amendments (30.0 and 5.0 × 10^6 g^{-1} dry soil in both years, respectively).

Total fungal count in both years was significantly the highest in LCS and in the EM amendment and significantly, the lowest in SS and in the control treatment without amendments. The highest significant interaction was LCS + EM (53.0 and 47.57 × 10^3 g^{-1} in both years, respectively), followed by LCS + HA in 2006 and LCS + NF in 2006 and 2007, while the least interaction was that of SCS without amendments (7.0 and 11.0 × 10^3 g^{-1} dry soil in both years, respectively).

In both seasons, total count of actinomycetes was significantly the highest in LCS and in the NF amendment; while it was significantly the lowest in the SS and in sub-plot treatments : EM amendment and control in 2006 and control without amendments in 2007. the top significant interaction in total count of actinomycetes was LCS + NF (326.7 and 226.7 × 10^3 g^{-1} dry soil in both years, respectively), followed by LCS + EM, which in 2006 was not significantly different from LCS + HA or SCS with or without HA or NF. The least interaction in this measurement was SS + HA (26.0 and 35.0 × 10^3 g^{-1} dry soil in both years, respectively), though in 2006 this interaction was not significantly different from SS with NF or EM and LCS without amendments (Table 4).

Number of Leaves and Shoot Length :

The effect of treatments applied on the number of leaves counted in mid-August and shoot length measured in mid-October in both years of the study are presented in Table 5.

No significant effect was observed for soil types in the number of leaves in 2006, while SCS was the top soil in the character in 2007 (145.3 leaves/seedling). Concerning soil amendments, NF was the top treatments in the number of leaves per seedling in both seasons (136.6 and 146.2 leaves/seedling, respectively). The highest significant interaction in 2006 was that of SS + NF (141.3 leaves/seedling), but it was not significantly different from LCS without amendments, LCS + NF or SCS + NF. In 2007, the top interaction was that of LCS + NF (159.0 leaves/seedling), but it was not significantly different from that of SS + EM or SCS + HA, NF, or EM.

In both seasons, shoot was significantly the tallest in SS (191.3 and 211.3 cm, respectively) and in the EM amendment (201.3 and 213.0 cm, respectively). It was significantly the shortest in the SCS and in the control treatment without amendments. The top interaction in shoot length was in both years the SS + NF, SS + EM and LCS + EM; and in 2007 these treatments were not significantly different from SS + HA. Values of the non-significant treatments ranged from 210.0 to 213.3 cm in 2006 and from 216.7 to 226.0 cm in 2007. the least interaction was that of SCS without amendments in both years (113.3 and 180.0 cm, respectively), though in 2007 this treatment was

not significantly different from SS without amendment, LCS without amendment, or LCS + NF (Table 5).

Table (5) : Effect of soil type and amendments on number of leaves in mid-August and shoot length (cm) in mid-October[z].

Treatment [y]	Number of leaves		Shoot length	
(Soil type & amendments)	2006	2007	2006	2007
SS	110.2 f	113.3 cd	145.0 d	182.7 cde
SS + HA	125.7 cde	145.7 b	196.7 b	216.7 a
SS + NF	141.3 a	124.7 c	213.3 a	220.0 a
SS + EM	120.5 de	156.7 ab	210.0 a	226.0 a
LCS	136.4 ab	106.0 d	160.0 c	175.0 e
LCS + HA	94.9 g	120.0 c	193.3 b	188.3 bcd
LCS + NF	136.5 ab	159.0 a	191.7 b	172.7 e
LCS + EM	117.0 ef	94.1 e	210.0 a	220.0 a
SCS	95.7 g	125.3 c	113.3 e	180.0 de
SCS + HA	130.0 bcd	151.8 ab	183.3 b	196.0 b
SCS + NF	132.0 abc	154.9 ab	150.0 cd	190.0 bcd
SCS + EM	128.2 bcd	149.3 ab	184.0 b	193.bc
Mean Soil Type				
SS	124.4 a	135.1 b	191.3 a	211.3 a
LCS	121.2 a	119.8 c	188.8 a	189.0 b
SCS	121.5 a	145.3 a	157.7 b	189.8 b
Mean Soil Amendment				
None (Control)	114.1 c	114.9 c	139.4 c	179.2 d
HA	116.9 bc	139.2 b	191.1 b	200.3 b
NF	136.6 a	146.2 a	185.0 b	194.2 c
EM	121.9 b	133.4 b	201.3 a	213.0 a

[z] Within each group of comparable treatments in individual columns, values followed by a letter in common are not significantly different from each other at 0.05 level according to Duncan's multiple range test.

[y] SS : sandy soil; LCS : loamy clay soil; SCS : sandy calcareous soil;
HA : humic acid; NF : Nile Fertile; EM : Effective Microorganisms

Leaf Area, Chlorophyll content, and NPK analysis :

Significant differences were found among treatments applied in leaf area, chlorophyll content, and NPK analysis in both seasons (Tables 6 and 7).

In both years, the largest significant leaf area was found in SS (35.1 and 33.5 cm^2, respectively) and with the NF amendment (33.1 and 34.0 cm^2, respectively), though in 2006 the NF treatment was not significantly different in leaf area from the HA treatment. The top interaction was that of SCS + NF (38.1 and 38.7 cm^2, respectively), though in 2006 it was not significantly different from that of SS with or without any of the soil amendments. The least interaction treatment in leaf area was SCS + EM (25.7 and 27.0 cm^2, respectively), though this treatment was not significantly different in this character in 2006 from LCS with or without any of the soil amendments and in 2007 from LCS with or without NF (Table 6).

Chlorophyll content as SPAD reading was significantly the highest in both years in SS (49.4 and 51.3, respectively) and with NF amendment. However, the latter treatment was not significantly different in leaf chlorophyll content in 2006 from HA or EM treatments. The best interaction in both years was by far, SS + EM (51.2 and 53.5, respectively) and SS + NF (51.1 and 52.7, respectively), though these treatments were in 2006 not significantly different from SS with or without HA, LCS + EM and SCS + HA or NF. The remaining interactions were in 2006 the least in leaf chlorophyll content without significant differences among them, while in 2007 SCS without amendment was significantly the least (42.4) in this character (Table 6).

The top treatments in leaf N content were in both years, EM (2.54 and 2.47%, respectively) and SS (2.13 and 2.17%, respectively) though SS was not significantly different in this character in 2007 from LCS. The control treatment (without soil amendments) was the least in N content in both years (1.47 and 1.64%, respectively). The highest significant interaction in leaf N content was SS + EM (2.78 and 2.60%, respectively), while the least was SCS without amendments (1.32 and 1.4%, respectively, Table 7).

LCS was also the top in both leaf P content (0.36 and 0.38% in both years, respectively) and K content (1.89 and 1.96%, respectively) in both years. Likewise, EM was the top amendment in leaf K content (1.81 and 1.85%, respectively), but NF was the top amendment in leaf P content (0.34 and 0.36%, respectively) in both years (Table 7).

The top interaction in leaf P content in both seasons was LCS + NF (0.51 and 0.53%, respectively), while the top interaction in leaf K content was LCS + EM (2.08 and 2.20%, respectively). Meanwhile, the least interaction was SCS without amendment in leaf P content (0.15 and 0.14%, respectively) and leaf K content (1.42 and 1.45%, respectively), though this treatment was not significantly different in leaf P and K content from SS without amendments and from SCS + NF in leaf K content in both years. Many other treatments were not significantly different from the above treatments in leaf K content in 2007, including all treatments of SS and SCS with any of the amendments not mentioned above (Table 7).

Table (6) : Effect of soil type and amendments on leaf area and chlorophyll content[z].

Treatment [y] (Soil type & amendments)	Leaf area (cm^2)		Chlorophyll (SPAD reading)	
	2006	2007	2006	2007
SS	34.5 ab	32.0 cde	47.1 abc	48.0 e
SS + HA	35.7 ab	33.3 bcd	48.3 abc	50.8 c
SS + NF	35.3 ab	34.7 b	51.1 a	52.7 ab
SS + EM	34.8 ab	34.0 bc	51.2 a	53.5 a
LCS	24.5 c	27.0 g	44.2 c	49.4 d
LCS + HA	27.5 c	31.3 de	45.1 bc	46.8 f
LCS + NF	26.1 c	28.6 fg	45.3 bc	51.1 c
LCS + EM	27.6 c	30.7 ef	48.5 abc	49.3 d
SCS	23.8 c	22.0 h	32.0 d	42.4 g
SCS + HA	31.9 b	33.7 bc	48.6 abc	51.5 c
SCS + NF	38.1 a	38.7 a	46.8 abc	51.8 bc
SCS + EM	25.7 c	27.0 g	48.9 ab	47.4 ef
Mean Soil Type				
SS	35.1 a	33.5 a	49.4 a	51.3 a
LCS	26.4 c	29.4 b	45.8 b	49.1 b
SCS	29.9 b	30.3 b	44.1 b	48.3 c
Mean Soil Amendment				
None (Control)	27.6 b	27.0 d	41.1 b	46.6 c
HA	31.7 a	32.8 b	47.3 a	49.7 b
NF	33.1 a	34.0 a	47.7 a	51.9 a
EM	29.4 b	30.6 c	49.5 a	50.1 b

[z] Within each group of comparable treatments in individual columns, values followed by a letter in common are not significantly different from each other at 0.05 level according to Duncan's multiple range test.

[y] SS : sandy soil; LCS : loamy clay soil; SCS : sandy calcareous soil;
HA : humic acid; NF : Nile Fertile; EM : Effective Microorganisms

Table (7) : Effect of soil type and amendments on leaf NPK analysis (%)[z].

Treatment [y] (Soil type & amendments)	N		P		K	
	2006	2007	2006	2007	2006	2007
SS	1.39 k	1.62 f	0.16 gh	0.15 i	1.50 g	1.60 cd
SS + HA	1.91 h	2.10 cd	0.21 f	0.23 e	1.60 f	1.65 cd
SS + NF	2.42 c	2.35 b	0.31 d	0.34 c	1.65 ef	1.70 bcd
SS + EM	2.78 a	2.60 a	0.23 e	0.28 d	1.70 de	1.68 bcd
LCS	1.70 j	1.90 e	0.17 gh	0.19 g	1.75 d	1.80 bc
LCS + HA	2.05 f	2.30 b	0.34 c	0.35 c	1.82 c	1.84 bc
LCS + NF	1.94 g	2.07 cd	0.51 a	0.53 a	1.90 b	2.00 ab
LCS + EM	2.61 b	2.50 a	0.41 b	0.44 b	2.08 a	2.20 a
SCS	1.32 l	1.40 g	0.15 h	0.14 i	1.42 h	1.45 d
SCS + HA	2.40 d	2.20 bc	0.18 g	0.17 h	1.50 g	1.60 cd
SCS + NF	1.85 i	1.96 de	0.21 f	0.22 ef	1.52 g	1.64 cd
SCS + EM	2.22 e	2.30 b	0.20 f	0.21 f	1.65 ef	1.66 cd
Mean Soil Type						
SS	2.13 a	2.17 a	0.23 b	0.25 b	1.61 b	1.66 b
LCS	2.08 b	2.19 a	0.36 a	0.38 a	1.89 a	1.96 a
SCS	1.95 c	1.97 b	0.19 c	0.19 c	1.52 c	1.59 b
Mean Soil Amendment						
None (Control)	1.47 d	1.64 c	0.16 d	0.16 d	1.56 d	1.62 b
HA	2.12 b	2.20 b	0.24 c	0.25 c	1.64 c	1.70 ab
NF	2.07 c	2.13 b	0.34 a	0.36 a	1.69 b	1.78 ab
EM	2.54 a	2.47 a	0.28 b	0.31 b	1.81 a	1.85 a

[z] Within each group of comparable treatments in individual columns, values followed by a letter in common are not significantly different from each other at 0.05 level according to Duncan's multiple range test.

[y] SS : sandy soil; LCS : loamy clay soil; SCS : sandy calcareous soil;
HA : humic acid; NF : Nile Fertile; EM : Effective Microorganisms

Dry Weight of Various Plant Parts :

Foliage, main root, and secondary roots dry weight and dry matter allocation to different plant parts were significantly affected by treatments applied in both seasons of the study (Tables 8 and 9).

Table (8) : Effect of soil type and amendments on dry weight of foliage, main root and secondary roots (g/seedling)[z] .

Treatment [y] (Soil type & amendments)	Foliage		Main roots		Secondary roots	
	2006	2007	2006	2007	2006	2007
SS	51.2 cd	58.3 bc	46.9 b	54.5 bcd	9.3 b	7.1 ab
SS + HA	41.0 de	45.3 de	62.9 a	55.0 abcd	9.1 b	8.5 ab
SS + NF	46.0 de	50.3 cd	72.3 a	66.9 a	6.6 cde	7.3 ab
SS + EM	60.8 bc	64.8 ab	46.1 b	57.1 abc	12.1 a	9.2 ab
LCS	39.8 de	35.9 e	39.6 b	33.9 f	5.8 e	5.5 b
LCS + HA	38.2 e	47.2 d	63.1 a	60.0 abc	6.1 de	6.1 b
LCS + NF	73.7 a	65.0 ab	61.6 a	65.0 ab	7.2 cde	5.1 b
LCS + EM	50.3 cd	45.6 de	42.4 b	44.7 def	7.9 bcd	8.1 ab
SCS	59.9 bc	70.4 a	37.9 b	41.6 ef	6.4 de	5.5 b
SCS + HA	62.7 b	69.9 a	48.2 b	61.6 abc	8.0 bcd	9.5 ab
SCS + NF	38.5 e	45.4 de	41.6 b	45.0 def	7.0 cde	7.8 ab
SCS + EM	75.7 a	70.3 a	44.7 b	49.7 cde	8.4 bc	11.4 a
Mean Soil Type						
SS	49.8 b	54.7 b	57.0 a	58.4 a	9.2 a	8.0 ab
LCS	50.5 b	48.4 c	51.7 b	50.9 b	6.8 b	6.2 b
SCS	59.2 a	64.0 a	43.1 c	49.5 b	7.4 b	8.5 a
Mean Soil Amendment						
None (Control)	50.3 b	54.9 ab	41.5 b	43.3 c	7.2 b	6.0 b
HA	47.3 b	54.1 b	58.1 a	58.9 a	7.7 b	8.0 ab
NF	52.7 b	53.6 b	58.5 a	59.0 a	6.9 b	6.7 b
EM	62.3 a	60.2 a	44.4 b	50.5 b	9.5 a	9.6 a

[z] Within each group of comparable treatments in individual columns, values followed by a letter in common are not significantly different from each other at 0.05 level according to Duncan's multiple range test.

[y] SS : sandy soil; LCS : loamy clay soil; SCS : sandy calcareous soil;
HA : humic acid; NF : Nile Fertile; EM : Effective Microorganisms

Table (9) : Effect of soil type and amendments on dry weight of foliage, main and secondary roots, and total root system as percentages of total dry seedlings weight (%)[z]

Treatment [y] (Soil type & amendments)	Foliage		Main roots		Secondary roots		Total root system	
	2006	2007	2006	2007	2006	2007		
SS	43.0 b	43.7 bc	51.1 c	49.7 bc	5.9 c	6.6 h	57.0 d	56.3 bc
SS + HA	38.0 c	42.6bcd	53.2 c	49.9 bc	8.8 abc	7.5 f	62.0 bc	57.4 ab
SS + NF	36.3 c	38.6 d	57.6 a	53.9 a	6.1 e	7.2 g	63.7abc	61.4 a
SS + EM	52.2 a	52.6 a	38.1 g	38.9 e	9.7 a	8.5 c	47.8 f	47.4 d
LCS	34.5 c	40.7 cd	59.0 a	51.4 ab	6.5 de	7.9 e	65.5 a	59.3 ab
LCS + HA	35.2 c	38.6 d	58.2 a	53.3 ab	6.8 de	8.1 d	64.8 ab	61.4 a
LCS + NF	52.4 a	52.2 a	41.0 f	39.8 e	6.7 de	8.0 de	47.6 f	47.8 d
LCS + EM	53.3 a	54.6 a	38.7 fg	36.7 e	8.1abcd	8.7 b	46.7 f	45.4 d
SCS	53.8 a	55.3 a	39.9 fg	38.9 e	6.2 e	5.8 i	46.2 f	44.7 d
SCS + HA	46.2 b	46.8 b	44.8 e	45.7 d	9.0 ab	7.5 f	53.8 e	53.2 c
SCS + NF	44.7 b	46.7 b	48.1 d	46.9 cd	7.2 cde	6.3 h	55.3 de	53.3 c
SCS + EM	38.2 c	39.7 cd	54.3 b	50.8 ab	7.5bcde	9.2 a	61.8 c	60.3 a
Mean Soil Type								
SS	42.4 b	44.4 b	49.1 a	48.1 a	7.6 a	7.4 b	57.6 a	55.6 a
LCS	43.8 b	46.5 ab	49.2 a	45.3 b	7.0 a	8.2 a	56.2 b	53.5 b
SCS	45.8 a	47.2 a	46.8 b	45.6 b	7.5 a	7.2 c	54.2 c	52.9 b
Mean Soil Amendment								
None (Control)	43.8 b	46.6 ab	50.0 ab	46.7 b	6.2 b	6.7 d	56.2 b	53.4 b
HA	39.8 c	42.7 c	50.9 a	49.6 a	8.2 a	7.7 b	60.2 a	57.3 a
NF	44.5 b	45.8 b	48.9 b	46.9 b	6.7 b	7.2 c	55.5 b	54.2 b
EM	47.9 a	49.0 a	43.7 c	42.1 c	8.4 a	8.8 a	52.1 c	51.0 c

[z] Within each group of comparable treatments in individual columns, values followed by a letter in common are not significantly different from each other at 0.05 level according to Duncan's multiple range test.

[y] SS : sandy soil; LCS : loamy clay soil; SCS : sandy calcareous soil;
HA : humic acid; NF : Nile Fertile; EM : Effective Microorg

The top seedling foliage dry weight was obtained in both years in SCS (59.2 and 64.0 g, respectively) and with the EM treatment (62.3 and 60.2 g, respectively), while the least foliage weight was in LCS (50.5 and 48.4 g, respectively) without significant differences in top weight from SS in 2006. There were no significant differences in top weight among control and each

of HA and NF amendments in both years. The top significant interaction treatment in foliage weight was LCS + NF (73.7 and 65.0 g, respectively) and SCS + EM (75.7 and 70.3 g, respectively) in both years and SCS with or without HA in 2007 only (70.4 and 69.9 g, respectively). The least interaction treatments in foliage dry weight were in both years, SS + HA, LCS without amendments, and SCS + NF (Table 8).

Main roots and secondary roots dry weights were significantly the highest in SS in both years (respectively, 57.0 and 58.4 g for main roots and 9.2 and 8.0 g for secondary roots) and with HA amendment for main roots (58.1 and 58.9 g, respectively) and EM amendment for secondary roots (9.5 and 9.6 g, respectively). The top significant interaction in main roots dry weight was SS + NF, but this treatment was not significantly different, in both years, from LCS + HA or NF. The least interaction treatment in main roots dry weight in both years was LCS without amendment (39.6 and 33.9 g, respectively), but this treatment was not significantly different, in both years, from LCS + EM and SCS with or without NF. The top interaction treatments in secondary roots dry weight were SS + EM in 2006 (12.1 g) and SS with or without any amendment, LCS + EM, and SCS + any amendment in 2007 (a range of 7.1 to 11.4 g). The least interaction treatment in secondary roots dry weight were LCS without amendments in 2006 (5.8 g) and all other treatments not mentioned above in 2007 (a range from 5.1 to 6.1 g). Additionally, in 2006, the LCS without amendment interaction was not significantly different in secondary root dry weight from SS + NF, LCS + HA or NF, and SCS with or without NF (a range from 6.1 to 7.2 g) (Table 8).

Treatments applied exerted in both years of the study significant effect on the dry matter allocation to different plant parts, i.e. foliage main roots, secondary roots and total root system dry weights as percentages of total plant dry weight (Table 9).

Foliage received in both years the greatest proportion of dry matter in SCS (45.8 and 47.2%, respectively) and with the EM amendment (47.9 and 49.0%, respectively), while it received the least proportion in the remaining soil types (a range from 42.4 to 43.8% and from 44.4 to 46.5%, in both years, respectively) and with HA amendment (39.8 and 42.7%, respectively). The top interaction treatment in foliage dry weight as a percentage of total plant dry weight was in both years SS + EM, LCS + NF or EM, and SCS without amendments (a range from 52.2 to 53.8% and from 52.2 to 55.3%, in both years, respectively). The least interaction treatments in this character in both years were SS + HA or NF, LCS with or without HA, and SCS + EM (Table 9).

Concerning roots, the main and total root systems had the largest proportion of dry matter allocation in both years in SS, while secondary roots had the largest proportion in both years in LCS. Also, main and total root system had the largest proportion in both years with the HA amendment, while secondary roots were largest with the EM treatment, which induced the least dry matter allocation to main roots and total root system. The top

significant interaction treatment in dry matter allocation to main roots were in both years SS + NF (57.6 and 53.9%, respectively), LCS without amendments (59.0 and 51.4%, respectively), and LCS + HA (58.2 and 53.3%, respectively). These same treatments were also among the top in total root system dry matter allocation. Secondary root dry matter allocation differed in its response to treatments, as the top interaction treatments were in 2006 SS + EM (9.7%) and SCS + HA (9.0%) and in 2007 SCS + EM (9.2%). The least significant interaction in secondary root dry weight as percentage of total dry weight in both years was SS + NF (6.1 and 7.2%, respectively), but this treatment was not significantly different from several other treatments in 2006 (Table 9).

DISCUSSION AND CONCLUSION

NF, which contains sulfur-oxidizing microorganisms, resulted in the least soil pH in both years (7.8 in both years relative to 8.4 and 8.5 in the control in 2006 and 2007, respectively). This effect was particularly evident in SS. Soil EC was generally low irrespective of soil type or treatment applied, but it was highest in LCS and with the NF treatment and lowest in the SCS with the EM treatment (Table 1). It is known that HA ameliorates salinity tolerance in plants (Senn and Kingman, 1973; Russo and Berlyn, 1990; Eissa *et al.,* 2007a, 2007b, and 2007c). The high content of NF of each of P and Fe was reflected in the high soil content of these two elements (Tables 2 and 3).

The beneficial effects obtained in the present study with the application of EM and/or HA on various soil attributes and plant characters measured is in harmony with many previous studies (Senn and Kingman, 1973; Russo and Berlyn, 1990; Chongpraditnum, 1996; Lee and Bartlett, 1996; Xu, 2000; Eissa, 2003; Eissa *et al.,* 2003; Hussien *et al.,* 2005; Condor-Golec *et al.,* 2007; Eissa, 2007; Eissa *et al.,* 2007a, 2007b, 2007c).

HA has been shown to contain many types of nitrogen compounds. Its content of polyamines putrescine, spermidine, and spermine ranged in different sources of HA between 1.54-7.00, 0.39-3.88, 0.48-4.79 nMg^{-1}, respectively. Polyamines may explain the hormone-like activity of humic substances (Young and Chen, 1997). Evidence has been previously presented that the effect of humic substances (HS) on plant growth depends on the source concentration and molecular weight of the humic fraction. A low molecular size (< 3500 Da) fraction easily reaches the plasmalemma of higher plant cells and, in part, is taken up into them and positively influence the uptake of some nutrients in particular, that of nitrate HS exhibit stimulatory effects on plant cell growth and development (Nardi *et al.,* 2002).

In accordance with results obtained in the present study, EM applied to soil with an organic fertilizer was shown to promote sweet corn root growth and activity, and to enhance photosynthetic efficiency and capacity, which resulted in increased grain yield. This was attributed largely to a higher level of nutrient availability facilitated by EM application over time (Xu, 2000). Also,

soil EM application improved tomato fruit quality and yield in presence of organic fertilizers (Xu et al., 2000). It is well-established that organic residues, bacteria, and polysaccharides stabilize microaggregates (Tisdall, 1994). EM has been used with considerable success to improve soil quality and the growth and yield of crops (Xu, 2000). It is well established that EM application to soil increases soil microbial biomass (Cao *et al.,* 2000).

The principle of activity of the EM is by increasing the biodiversity of soil microflora which influences crop yield. Photosynthetic bacteria are the backbone of the EM, working synergistically with other microorganisms to provide the nutritional requirement to the plant and also reduce the disease problem. There are primarily 5 types of bacteria used to prepare EM solution. Photosynthetic bacteria (Phototrophic bacteria) are independent self supporting microorganisms. These bacteria synthesize amino acids, nucleic acid, bioactive substances and sugar, substances from secretions of roots, and organic matter (carbon) by using sunlight and the heat of soil as sources of energy. They can use the energy from infrared band of solar radiation from 700 nm to 1200 nm to produce the organic matter, while plants cannot. So the efficiency of plants is increased. These metabolites are absorbed into plants directly and also act as substrates for bacteria increasing the biodiversity of the microflora. Adding photosynthetic bacteria in the soil enhances other effective microorganisms. It suppresses harmful microorganisms and increases rapid decomposition of organic matter. Moreover, lactic acid bacteria enhances the breakdown of organic matter such as lignin and cellulose, and ferment these materials which normally take plenty of time. Yeasts synthesize antimicrobial and useful substances for plant growth from amino acids and sugars secreted by photosynthetic bacteria, organic matter and plant roots. Bioactive substances such as hormones and enzymes produced by yeasts promote active cell and root division. Their secretions are useful substrates for effective microorganisms such as lactic acid bacteria and actinomycetes. Actinomycetes produce antimicrobial substances from amino acids secreted by photosynthetic bacteria and organic matter. These antimicrobial substances suppress harmful fungi and bacteria. Actinomycetes can coexist with photosynthetic bacteria. Thus, both species enhance the quality of the soil environment, by increasing the antimicrobial activity of the soil (Condor-Golec *et al.,* 2007).

The beneficial effects of treatments applied to different soil types on various soil attributes and characters measured in 'Anna' apple seedlings were interrelated. Activity of soil microflora improved soil environment and positively affected soil macro and micronutrients availability, which, in turn, affected leaf NPK analysis and various top and root growth parameters measure. Treatments applied had a profound effect on seedling root growth, which in turn, affected vegetative growth parameters.

In conclusion, it is recommended for growth improvement of one-year-old 'Anna' apple seedlings, specially in sandy and calcareous soil, to apply to

each seedling either 6 applications of humic acid at the rate of 5ml Actosol (10-10-10 NPK) in ½ liter of water (every 15 days during April, May and June), 50 g Nile Fertile once in the beginning of April, or 6 applications of ½ liter EM fermented with molasses (every 15 days during April, May, June).

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تأثير نوع التربة وبعض محسناتها علي نمو شتلات التفاح 'أنا'

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الملخص العربي

أجريت هذه الدراسة في حديقة معهد بحوث البساتين بالجيزة خلال موسمي ٢٠٠٦ ، ٢٠٠٧ لتقييم نمو شتلات التفاح (*Malus domestica*) صنف 'أنا' المطعوم على أصل مالص فى أصص مملوءة بتربة رملية ، أو طميية طينية ، أو رملية جيرية مضاف إليها محسنات التربة: حامض هيوميك أو النيل فرتيل (وهو منتج غنى بالكبريت والكائنات الدقيقة المؤكسدة له ، بالإضافة إلي النيتروجين والكالسيوم والمغنيسيوم والحديد) ، أو الـ إي إم (EM ، وهو منتج تجاري يحتوي على أكثر من ٦٠ نوع من البكتيريا والأكتينوميسيتات والفطريات) وتركت أصص المقارنة دون محسنات. استخدم في هذه الدراسة نظام القطع المنشقة في تصميم القطع الكاملة العشوائية.

وجد فى عامي الدراسة أن التربة الرملية الجيرية كانت هي الأعلى معنوياً فى الـ pH ، بينما أعطت معاملة النيل فرتيل أكبر خفض معنوي فى الـ pH . كانت التربة الطميية الطينية هي الأعلى في درجة التوصيل الكهربي لمستخلص التربة ، بينما كانت معاملة حامض الهيوميك هي الأكثر فاعلية في خفض تلك الخاصية . كانت التربة الطميية الطينية هي الأعلى في محتوى النيتروجين وكذلك عند المعاملة بحامض الهيوميك ، هذا بينما كانت التربة الرملية هي الأعلى معنوياً في محتوى الفوسفور ، الذي ازداد كذلك عند المعاملة بالنيل فرتيل ، في الوقت الذي كان فيه الفوسفور الأقل معنوياً في التربة الرملية الجيرية. أما البوتاسيوم فقد كان أعلى معنوياً في التربة الطميية الطينية ومع معاملة النيل فرتيل. كذلك كانت التربة الرملية هي الأعلى معنوياً في كل من الحديد والزنك والنحاس ، بينما كانت التربة الطميية الطينية هي الأعلى معنوياً في المنجنيز. وبالنسبة لمحسنات التربة كانت معاملة النيل فرتيل هي الأعلى معنوياً في محتوى التربة من الحديد والمنجنيز ، بينما كانت معاملة حامض الهيوميك هي الأعلى في الزنك

والنحاس. ومن حيث بيولوجي التربة .. حصل على أكبر الأعداد الكلية من البكتيريا والفطريات والأكتينوميسيتات في التربة الطميية الطينية وكذلك عند المعاملة بالـ إي إم . وبينما لم يكن لنوع التربة تأثيرا معنويا ثابتا في سنتي الدراسة على عدد الأوراق بالشتلة ، فإن معاملة النيل فرتيل أعطت أكبر عدد من الأوراق. هذا بينما حصل على النباتات الأكثر طولاً في التربة الرملية ومع معاملة الـ إي إم . كذلك أعطت التربة الرملية أكبر مساحة للورقة وأعلى محتوي ورقي من الكلوروفيل والنيتروجين ، إلا أن التربة الطميية الطينية كانت هي الأعلى في كل من الفوسفور والبوتاسيوم بالأوراق ، هذا في الوقت الذي أعطت فيه معاملة النيل فرتيل أكبر مساحة للورقة وأعلى محتوى ورقي من الكلوروفيل والفوسفور ، بينما أعطت معاملة الـ إي إم أعلى محتوى ورقي من النيتروجين والبوتاسيوم. كان أكبر وزن جاف للنمو الخضري في التربة الرملية الجيرية وكذلك عند المعاملة بالـ إي إم بينما كان أعلى وزن جاف للجذور الرئيسية والثانوية في التربة الرملية ومع معاملة حامض الهيوميك بالنسبة للجذور الرئيسية وبالـ إي إم بالنسبة للجذور الثانوية ، وكان هذا الإتجاه واضحا كذلك في نسبة توزيع المادة الجافة على تلك الأجزاء النباتية فيما عدا أن أعلى نسبة توزيع للمادة الجافة في الجذور الثانوية حصل عليها في التربة الرملية الجيرية.

وقد أوصي لأجل تحسين نمو شتلات التفاح 'أنا' –خاصة في الأراضي الرملية والرملية الجيرية – بمعاملة التربة بأي من ستة إضافات من حامض الهيوميك بمعدل ٥ مل أكتوسول (١٠ –١٠ – ١٠ / ن–فو–بو) في نصف لتر ماء كل ١٥ يوماً خلال إبريل ومايو و يونيو ، أو ٥٠ جم نايل فرتيل مرة واحدة في أوائل إبريل ، أو ست إضافات بمعدل نصف لتر إي إم مخمر مع المولاس كل ١٥ يوماً خلال إبريل ومايو ويونيو وذلك لكل نبات على حدة.