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RESPONSE OF CHICKPEA AND MAIZE CROPS PLANTS GROWN IN A CLAYEY SOIL TO SURFACE AND SUBSURFACE DRIP IRRIGATION, BIOSOLID AND MINERAL NPK FERTILIZERS

Omar, E. H.; M. A. Abd El-Aziz; M. M. Ragab and M. M. Saied
Soil, Water and Environment Research Institute, ARC

ABSTRACT

Two field experiments were conducted during winter season 2006/2007 and summer season 2007 at the Farm of Sakha Agricultural Research Station, Kafr El-Sheikh Governorate to study the response of chickpea (*Cicer arietinum*) and maize (*Zea mayes)* crops to biosolids with different rates of mineral NPK fertilizers under surface drip and subsurface drip irrigation systems The design of the experiment was split plot with four replicates. Main plots were assigned to irrigation systems while subplots were assigned to biosolids (20 ton/fed.), zero, 50 ,75 and 100 % of the recommended mineral NPK fertilizers (R D).

The obtained results revealed that irrigation methods , biosolid , mineral fertilizers and their interactions have high significant effects on the grain yield and yield components of chickpea and maize crops. Surface drip irrigation produced the higher grain yields, 587.63 and 3872.6 kg/fed of chickpea and maize crops, respectively. Application of biosolid compost with 75 % NPK of (R D) resulted in the highest grain yield and yield components of chickpea and maize crops while surface drip gave higher grain N and K contents for the two crops while subsurface drip gave higher grain P content. The combination between biosolid and 100 % NPK of (R D) under surface drip irrigation result in the highest NPK contents 5.13, 0.63 and 10.74 ppm in grains of chickpea, respectively and 2.64, 0.71 and 3.93 ppm in grains of maize, respectively. The combination between biosolid and 100 % NPK of (R D) under surface drip irrigation result in the highest Co, Pb and Ni contents 0.05, 0.06 and 0.19 ppm, respectively in grains of chickpea, respectively and 0.16, 1.52 and 0.45 ppm in grains of maize, respectively.Increasing the application rate of mineral fertilizers from 50 to 100% of (R D) with biosolid compost caused an increase in soil available NPK and available heavy metals under surface and subsurface drip irrigation. Application of biosolid compost increased soil available heavy metals, soil salinity and organic matter under the two irrigation systems. Soil salinity values under subsurface irrigation were higher than those under surface drip irrigation. The amounts of water applied to chickpea and maize under surface drip irrigation (1126.60 and 2088.86 m^3 /fed.), respectively were higher than the amounts applied (1058.36 and 2025.54 m^3 / fed.) , respectively under subsurface irrigation. Application of compost with 75 % NPK of (R D) under subsurface drip irrigation resulted in the highest values of field water use efficiency for chickpea and maize (0.72 and 2.23 kg/m^3), respectively. The periodic application of biosolid compost with a rate of 20 ton /fed. could save about 25 % of the mineral NPK fertilizers , maintain soil fertility and productivity level and a best means to recycling farm and human wastes for a clean environment.

Keywords: Chickpea, maize, drip irrigations, biosolids, compost, mineral NPK fertilizers, heavy metals.

INTRODUCTION

Food security is one of the most important aims facing Egypt today's. This can be achieved by raising the efficiency of the present irrigation system and the productivity of the cultivated soils. Water is considered the important factor for any policy to increase agriculture productivity, since the supply of water is seemed to be constant with time. Water demand is augmenting to face the increasing in population. Thus, it was necessary to control and manage the available water supply to face overuse problem and minimize water losses to improve irrigation efficiency, (Badawy *et al*., 2001).

Drip irrigation becomes a very popular method for irrigating orchards and vegetables in new lands in Egypt. Some field trials were carried out to investigate the applicability of drip irrigation in clay soil of the old land and to compare it with flood irrigation for vegetable and field crops, (Ansary 1994, Abdel-Baky, 1995 and Marazky1996). It could save much irrigation water, which could be used to reclaim and cultivate more desert lands by changing the traditional irrigation to surface drip and subsurface drip irrigation methods. Abo Soliman *et al.* (2005) concluded that maize grains yield was higher under surface drip irrigation than that under subsurface drip one. They also added that sprinkler , drip and gated pipes irrigation methods saved 21.8, 31.9 and 11.9 % of the applied water, respectively compared to conventional irrigation method. Hanson and Petterson (1974) showed that water use efficiencies were superior with drip and sprinkler systems compared to furrow and subsurface systems with maize crop. Kumar and Sivanappan (1980) and Bielorai (1985) showed that soil salinity around plant root zone in the wetted areas maintained at the lowest levels and salts were pushed to the outer periphery of the moisture zone. Also, Singh *et al.* (1985) found that maximum salt accumulation lays in-between two emission points, where the wetting fronts join each other along the laterals. Sivanappan *et al.* (1987) recommended that drip irrigation in place of furrow irrigation due to the reduction in water use as little as 15.3 % water used without any loss of yield. The yield of okra increased by about 40 % under drip irrigation over that with furrow irrigation.

Interest in subsurface drip irrigation (SDI) has increased during the last two decades primarily due to increased pressure to conserve water resources and the availability of reliable system components. While interest in this technology has existed in the USA for over 40 years. Discussions of subsurface drip irrigation was included in several reviews of drip irrigation (Bucks *et al*., 1982; and Bucks and Davis, 1986). Jorgenson and Norum (1992) presented an overview of SDI (Surface drip irrigation) theory and various applications. Camp (1998) found that yields for subsurface drip irrigated crops were equal to or greater than yields from other methods of irrigation. He also found that the water requirement for SDI systems was generally similar to or slightly less than any efficient, well-managed irrigation system and irrigation water requirements was 40% less than that with other irrigation methods .Compared to conventional surface drip systems, accumulation of salts on or near the surface causing reduction of germination and other problems tends to be reduced under properly designed and managed SDI systems. Ayars *et al.*, 1995 concluded that salinity may still be a problem with SDI in arid and semi-arid areas since any leaching above the tubing occurs only as the result of rain. Thus, salts tend to accumulate in this area during the season as the plants extract water and leave the salts behind. High salt concentrations exceeding 10 dS /m have been found in the top 6-10 cm of the soil profile. Salinity distribution measurements have shown that salts were moved to below the plant row when the laterals were placed under the furrows rather than under the beds.

The best means of maintaining soil fertility and productivity level could be achieved through periodic addition of proper organic fertilizer in combination with mineral fertilizer. The use of sewage sludge in agriculture practice may reduce the applied amounts of inorganic NPK fertilizers. When sewage sludge applied at rates up to 50 ton /ha induced marked effects of maize and soybean yield potential (Reddy *et al.*, 1989). El-Shebiny et al. (2002) showed that the fruit, fresh and dry weights of tomato significantly increased with increasing sludge application from 1.0 to 8.0 % of the soil. Shoots and fruit content of Fe, Zn, Mn, Cd and Ni, significantly increased with sludge application rate. Daoud (2005) reported that application of sewage sludge mixed with inorganic N at ratio 1: 1 resulted in increasing maize and stover yields by 17.8 % and 26 %, respectively .Also he added that increasing inorganic N rates from 200 and 300 kg N / ha-1 markedly increased maize grain yield from 14.3 to19.4 % 1.Application of sewage sludge with increasing inorganic N rate increased the soil and grain content of N, P and heavy metals. Businelli *et al* (1990) showed that grain yield/plant was increased with increasing waste rate but was greater with the optimum NPK compared with waste. Grain DM yield was higher (98.5 g/plant) with optimum NPK fertilizer + 10 ton waste. Total plant weight was highest (182.1 g DM) with optimum NPK fertilizer + 90 t town waste. Blaga *et al.* (1991) concluded that maize grain yields were 2.60 t/ha with 80 t sludge, 3.22 t with 120 t/ha sludge and 2.23 t/ha with 150 kg N + 80 kg P2O5 + 60 kg K2O in subsequent years. . Coker (1966b), and Coker (1966c) observed that 24 to 46 percent of the sludge N was ultilized by barley and clover when 100 kg N/ha as sludge was applied.. Kelling *et al.* (1 977c) reported in their experiments that 50 percent of the applied organic N was mineralized within 3 weeks. Stewart *et a.* (1975a) reported that 3 to 12 percent of the total N applied as sewage sludge was removed by maize plants. King and Morris (1972c) observed that, as total applied N increased, percentages of applied N removed by crops decreased.Granato *et al.* (2004) revealed that biosolids application increased Cd and Zn concentrations in grain compared with unamended fields (0.01 to 0.10 mg kg-1 for Cd and 23 to 28 mg kg-1 for Zn) but had no effect on grain Ni concentration. Inyang *et al.* (1984) found that metals in plant tissues were, in most cases, at lower concentrations, than that found in the soil. Metal levels found in the maize grain and tomatoes were generally lower than those found in the maize leaves. Due to this relatively low uptake of metals from the soil, tomatoes and maize were considered well suited for cultivation on sludge amended soil..Rappaport *et al.* (1988)showed that maximum DTPA-extractable metal levels in the soils due to sludge applications were 0.6 mg Cd, 150 mg Cu, 4.0 mg Ni, and 75 mg Zn kg-1. The order of DTPA-extractable metal concentrations in the soils, Cu>Zn>Ni>Cd, paralleled the amounts of metals applied via sludge application.Kiemnec *et al.*(1990) found that leaf Cd and Zn concn were higher in maize fertilized with sludge than with ammonium sulphate.Oyedele *et al.* (2006) found that the Cd, Pb, and Hg contents of the soil were increased significantly with the addition of the single superphosphate fertilizer by 14 – 60% over the control.

The objective of the present study was to evaluate the effect of applying biosolid with different rates of mineral NPK fertilizers under surface and subsurface drip irrigation on yield of chickpea and maize, plant elemental content, soil salinity and water use efficiency.

MATERIALS AND METHODS

Two field experiments were conducted during two successive growing seasons 2006 and 2007, in Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate, to study the responses of chickpea (*Cicer arietinum*) and maize *(Zea mayes)* crops to application of biosolid with different rates of mineral NPK fertilizers under surface drip and subsurface drip irrigation systems. The first crop; chickpea (variety Giza 3) was sown at the first of November, 2006 and harvested at the end of April, 2007. The second crop maize (Triple hybrid 314 cultivar) was sown at the middle of May and harvested on the late of August, 2007. All agronomic practices recommended by ministry of Agriculture and Land Reclamation (MALR) in the area were done. The design of the experiment was split plot with four replicates.

Main plots:

1) Surface drip irrigation, the distance between laterals is 60 cm.
2)Subsurface drip irrigation, buried below surface by 25 cm.

Sub plots:

1) Biosoilds at a rate of 20 ton/fed. (compost of sewage sludge with rice straw (B)).
2) Mineral NPK fertilizers (the recommended dose: M).
3) B + 50 % M.
4) B + 75 % M.
5) B + 100 % M.

Biosolid { sewage sludge} was collected from Kafr El-Sheikh Sewage Treatment Plant , mixed with rice straw by ratio 1 : 1 and composted during the summer season. Some chemical properties of the biosolid are illustrated in Table (1).

Table (1): Some chemical properties of the biosolid :

EC* (dS/m)	pH*	$CaCO_3$ (%)	O.M (%)	Total N (%)	Available (ppm)		Total heavy metals (ppm)			Available heavy metals (ppm)		
					P	K	Co	Pb	Ni	Co	Pb	Ni
4.52	7.02	3.56	22.41	0.18	346	380	33.56	291.3	44.2	3.7	5.6	9.25

* Measured in 1 : 2.5 soil water suspension
** Measured in soil saturated water extract.

Table (2a): Some physical and chemical properties of the experimental soil.

Soil depth cm	Particle size distribution %			Texture class	Total Carbonate %	O.M %	PH* 1:2.5	ECe** dS/m	SAR
	Sand	Silt	Clay						
0 – 30	18.8	32.7	48.5	Clayey	2.46	1.58	7.78	1.75	4.71
30 – 60	١٦,٦	33.2	50.2	Clayey	2.38	1.51	7.93	1.63	5.83
60 – 90	14.9	37.2	47.9	Clayey	2.10	1.17	8.42	2.27	7.11

* Measured in 1 : 2.5 soil water suspension
** Measured in soil saturated water extract.

Table (2b): Moisture characteristics of the experimental soil:

Soil depth cm	Field capacity (%)	Wilting point (%)	Available soil moisture (%)	Bulk density (g/cm^3)
0 – 15	43.9	23.96	20.04	1.24
15 – 30	39.0	21.2	17.80	1.36
30 – 45	37.0	20.11	16.89	1.39
45 – 60	36.2	19.67	16.53	1.47

The recommended doses of NPK mineral fertilizers for chickpea were added by fertigation at the rate of 30 kg N/fed. , 15.5 kg P_2O_5 /fed. and 24 kg K_2O /fed. While the recommended doses of NPK mineral fertilizers for maize were 120 kg N/fed. , 15.5 kg P_2O_5 /fed. and 24 kg K_2O /fed. .

Water relations

1. Total Available Water (TAW),mm = FC – CEW [1].

Where:

FC is field capacity , mm.

CEW is crop extractable water , mm.

2. Frequency of irrigation (I_{fr}) = AM_{40} / Et_{mgs} [3].

Where: Et_{mgs} is the evapo-transpiration at the midpoint of the growing season. The quantity of water applied was estimated using the class A pan evaporation equation:

$$ET_P = K_P\, E_{pan} \quad [4].$$

Where:

ET_P = Evapo-transpiration of grass reference crop, mm/d

K_P = pan coefficient (0.8 – 1.0).

E_{pan} = pan evaporation, mm/d.

The irrigation water was calculated on 100% ET_P basis and 100% water application efficiency, due to the even distribution of water within the strips and non-water losses, as a result to precision land leveling by laser technology on the following basis:

1. The measured evaporation from the A pan between irrigation rounds.
2. A Pan coefficient = 0.8 for dry regions.

3. Average crop coefficient = 1 for all stages of growth.
4. Potential evapo-transpiration (ET_P) = 100%

$$\text{Field water use efficiency} = \frac{Y}{WR} \quad [5]$$

Where:-

Y = Grain Yield (kg/Feddan).

WR = The total amount of water applied in the field (m^3/fed.).

Soil analysis:

Soil samples (0-30 cm) were taken before and after harvesting and chemically analyzed for ECe and N,P and K as well as some pollutant elements (Ni, Co and Pb).

Total soluble salts (TSS) were measured as ECe (dS/m) electrical conductivity apparatus in the saturated soil paste extract; soluble ions and organic matter were determined according to Page *et al.* (1982). Available nitrogen was extracted by K_2SO_4 (1%) and determined by macro-Kjeldahl method. Available phosphorus was extracted with 0.5 N sodium bicarbonate and determined by spectrophotometer according to *Olsen et al., (1954).* Available potassium was extracted by ammonium acetate 1 N and determined photometrical according to Page *et al.* (1982). Available micro-elements were extracted using diethyl triamine penta acetic acid (DTPA) according to Lindsay and Norvell (1978) and determined spectrophotometrically using Atomic absorption technique.

Plant analysis:

Plant grain samples were taken at late season and subjected to analysis for NPK and some pollutant elements (Co, Pb and Ni) using acid ashing technique as described by Chapman and Partt (1961). An acid mixture made from 3:1 sulphuric and perchloric acids were used for chemical determination. Total nitrogen was determined in the acid digest solution of plant by semi micro – Kjeldahl as described by Cotteine *et al.*, (1982). Total phosphorus was determined using ascorbic acid method according to Murphy and Riley (1962). Total potassium was determined using flame photometer. The total heavy metals (Co, Pb and Ni) were determined using atomic absorption spectrophotometer according to Cotteine *et al.*, (1982). The data represent experiments of two successive seasons were subjected to the analysis of variance and LSD using the microcomputer statistical analysis package {Irristat}.

RESULTS AND DISSCUSSIONS

1-Yield and yield components of chickpea and maize:

Table (3) revealed that irrigation methods, biosolids and fertilizers rate and the interaction have high significant effects on the grains yield and yield components of chickpea and maize crops. Surface drip irrigation produced the highest values of grain yield (587.63 and 3872.6 kg/fed.), plant height (56.37 and 237.22 cm), weight of 100 grain (21.11 and 38.97 gm) for chickpea and maize, respectively. Also, the highest values of chickpea pods weight/plant (44.49 g); maize ear length (16.91cm); ear diameters (16.33 cm) and rows number (13.71) were given under surface drip irrigation compared to subsurface irrigation method. These results are in accordance with those of Camp (1998) and Abo Soliman *et al.* (2005).

Table (3): Values of yield and yield components of chickpea and maize as influenced by irrigation methods, biosoilds and mineral NPK fertilizers.

Treatments	Chickpea (first crop)				Maize (second crop)					
	Grains yield (kg / fed.)	Plant height (cm)	Pods weight / plant (g)	Weight of 100 grains (g)	Grains yield (kg /fed.)	Plant height (cm)	Ear length (cm)	Ear diameter (cm)	Rows number	Weight of 100 grain (g)
Irrigation method (I)										
Surface drip	587.63	56.37	44.49	21.11	3872.6	237.22	16.91	16.33	13.71	38.97
Subsurface drip	578.09	55.59	44.15	20.84	3802	236.45	16.55	16.13	13.61	38.86
F Test	**	**	**	**	**	**	**	**	**	**
L.S.D 0.01	0.374	0.018	0.02	0.009	0.156	0.196	0.081	0.029	0.051	0.053
L.S.D 0.05	0.253	0.013	0.014	0.006	0.106	0.133	0.014	0.02	0.024	0.036
Biosolid+ Mineral. NPK										
Minerak(M)	522.49	56.25	44.54	20.56	4062.9	234.96	17.1	16.04	13.74	38.42
Biosoilds(BI	411.45	52.4	41.25	19.35	3149.7	231.91	15.19	15.89	13.19	37.4
B+M 50%	540.25	54.25	42.06	20.75	3446.5	236.98	16.55	16.1	13.45	37.77
B +M 75%	764.02	61.49	47.69	22.45	4594.8	241.44	18.05	16.65	14.22	41.7
B +M100%	676.08	55.5	45.49	21.75	3932.4	238.91	16.75	16.45	13.69	39.29
F. Test	**	**	**	**	**	**	**	**	**	**
L.S.D 0.01	0.699	0.023	0.022	0.021	0.23	0.188	0.006	0.02	0.061	0.062
L.S.D 0.05	0.526	0.017	0.017	0.016	0.173	0.141	0.005	0.015	0.046	0.046
Interaction9 (IxB+ M)	**	**	**	**	**	**	**	**	**	**

I:Irrigation methods B:Biosolid M: Mineral fertilizers

Regarding the effect of biosolids and the different rates of mineral NPK fertilizers data in Table (3) showed that application of biosolids and increasing the rate of mineral NPK fertilizers up to 75 % of the recommended NPK increased the yield and yield components of either chickpea and maize crops. Application of biosolid and 75 % of mineral NPK (B + 75 % M) produced the highest values of grains yield (764.02 and 4594.8 kg/fed.) , plant height (61.49 and 241.44 cm)and weight of 100 grains (22.45 and 41.7 g) for chickpea and maize, respectively. Also the highest values of maize ear length (18.05 cm), ear diameter (16.65 cm) and rows number (14.22) were obtained under B+ 75 % M treatment. It is clear, therefore, that application of biosolid alone produced low grains yields for chickpea and maize comparing with the full dose of mineral NPK fertilizers. While the combination between them was beneficial for the grain yields of the two crops. The obtained results are in agreement with those of Reddy *et al.*, (1989), Blaga *et al.* (1991) and Daoud (2005).

2- Mineral contents in grains:

Table (4) revealed that N and K contents in chickpea grains N K contents were higher than those in maize grains. In contrast P content in grains was higher in maize than in chickpea. Table (4) also indicated that maize grains contain higher concentrations of Co, Pb and Ni than chickpea grains.This trend is similar to that observed by Furr *et al.* (1980).

The average values of N and K contents in grains of the two crops were higher with surface drip irrigation than with subsurface irrigation. Phosphorus grains contents were higher in the two crops with subsurface drip irrigation than that with surface drip irrigation.

Increasing the mineral fertilizer rates with constant rate of biosolid led to an increase in grains NPK and heavy metals contents for chickpea and maize. The combination between biosolid and full recommended mineral NPK produced the highest NPK contents (5.13, 0.63 and 10.74 ppm) in grains of chickpea and in grains of maize (2.64, 0.71 and 3.93 ppm) with surface drip irrigation. The corresponding values under subsurface drip irrigation were 5.26, 0.65 and 11.52 ppm in grains of chickpea and 2.94, 0.58 and 4.19 ppm in grains of maize. These results are in agreement with those found by Coker (1966b) and Coker (1966c).

The combination between biosolid and the recommended rate of mineral fertilizers with surface drip irrigation produced the highest values of Co, Pb and Ni in chickpea grains (0.05, 0.06 and 0.19 ppm, respectively) and in maize grains (0.16, 1.52 and 0.45 ppm, respectively). It is clear from Table (4) that Cd and Ni reached the highest values (average of1.16 and 0.36 ppm) in the maize grains . The obtained results are in agreement with those given by Reddy *et al.* (1989), El-Shebiny *et al.* (2002), Daoud (2005) and Oyedele *et al.* (2006)

Table (4): Values of N, P and K (%) and heavy metals (ppm) contents in grains of chickpea and maize as influenced by irrigation methods, biosoild and mineral NPK fertilizers.

Irrigation method	Fertilizer rate	Chickpea						Maize					
		N	P	K	Co	Pb	Ni	N	P	K	Co	Pb	Ni
Surface drip irrigation	Mineral(M)	2.71	0.51	6.32	0.004	0.02	0.13	1.81	0.57	3.15	0.11	0.32	0.24
	Biosoilds(Bl	2.32	0.31	5.96	0.005	0.03	0.15	1.25	0.32	1.03	0.15	1.11	0.33
	B+M 50%	3.56	0.46	8.15	0.01	0.03	0.16	1.68	0.54	2.41	0.15	1.41	0.35
	B +M 75%	4.21	0.54	9.31	0.03	0.04	0.18	2.03	0.58	3.29	0.16	1.44	0.41
	B +M100%	5.13	0.63	10.74	0.05	0.06	0.19	2.64	0.71	3.93	0.16	1.52	0.45
	Average	3.59	0.49	8.1	0.02	0.03	0.16	1.88	0.54	2.76	0.15	1.16	0.36
Subsurface drip irrigation	Mineral(M)	2.77	0.59	6.25	0.004	0.02	0.12	1.96	0.53	3.88	0.12	0.33	0.25
	Biosoilds(Bl	2.32	0.32	6.05	0.005	0.03	0.13	1.11	0.37	1.55	0.14	1.21	0.29
	B+M 50%	3.64	0.47	8.82	0.01	0.03	0.15	1.98	0.41	2.33	0.15	1.35	0.31
	B +M 75%	4.12	0.06	9.36	0.02	0.04	0.16	2.41	0.46	3.31	0.16	1.38	0.35
	B +M100%	5.26	0.65	11.52	0.04	0.05	0.17	2.94	0.58	4.19	0.16	1.41	0.38
	Average	3.62	0.42	8.4	0.02	0.04	0.12	2.08	0.47	3.05	0.15	1.14	0.32

3- Elemental contents in soil:

Table (5) indicated that the amounts of available N and K and heavy metals in soil were slightly higher with subsurface drip irrigation than with surface irrigation while phosphorus was found to be higher with surface drip irrigation. The reduction of available N and K with surface drip irrigation could be attribute to leaching and movement of N and K from the surface layer to the subsurface one. In contrast, soil available P was higher with surface drip irrigation than that under subsurface one due to low mobility of P in soil. Application of biosolid increased soil available NPK and heavy metals as compared with application of the full-recommended mineral NPK fertilizer. Increasing the application rate of mineral NPK fertilizers from 50 to 100% with the biosolid increased soil available NPK and heavy metals with surface and subsurface drip irrigation, also it is clear that available NPK and heavy metals were higher after chickpea than those after maize which could be due to higher uptake of maize for nutrients than chickpea.

The highest values of available N and K after chickpea(63.3and 287 ppm) and after maize (62 and 279 ppm), were recorded with B + 100 % M treatment with subsurface drip irrigation. The highest values of P after chickpea and maize (11.4 and 11.2 ppm), were obtained with B + 100 % M treatment with surface drip irrigation. The highest concentrations of soil available Co, Pb and Ni after chickpea (0.21, 1.9 and 0.72 ppm), and after maize (0.19, 1.6 and 0.58 ppm), were found in the soil treated with biosolid and the recommended rate of mineral fertilizers with subsurface drip irrigation. Concentrations of heavy metals (Co, Pb and Ni) found in the biosolid, soil, and in plants were below the critical limits for agricultural use. Thus, it seems to be safe for utilizing biosolid without major risks to the environment. The obtained results are in agreement with those of Reddy et al. (1989), El-Shebiny et al. (2002), Daoud (2005) and Oyedele et al. (2006)

Table (5): Values of soil available N, P and K and heavy metals (ppm) in soil after harvesting chickpea and maize as influenced by irrigation methods, biosolid and mineral NPK fertilizers.

Irrigation method	Fertilizer rate	Chickpea						Maize					
		N	P	K	Co	Pb	Ni	N	P	K	Co	Pb	Ni
Surface drip irrigation	Initial	20.1	3.6	104	0.02	0.9	0.26	20.1	3.6	104	0.02	0.9	0.25
	Mineral(M)	29.4	4.8	145	0.07	1.2	0.32	31	5.1	136	0.07	1.2	0.32
	Biosoilds(BI	36.8	6.9	83	0.11	1.3	0.39	35	6.2	76	0.09	1.1	0.31
	B+M 50%	46.2	9.3	236	0.12	1.5	0.52	39	8.5	223	0.11	1.3	0.51
	B +M 75%	52.8	10.7	267	0.14	1.7	0.61	44	10.1	243	0.13	1.5	0.58
	B +M100%	63.1	11.4	282	0.19	1.8	0.66	51	11.2	268	0.16	1.7	0.64
	Average	45.7	8.6	202.6	0.13	1.5	0.5	40	8.2	189.2	0.11	1.36	0.47
Subsurface drip irrigation	Mineral(M)	29.3	4.5	148	0.07	1.3	0.35	28	4.3	145	0.07	1.2	0.35
	Biosoilds(BI	43.6	6.7	84	0.13	1.4	0.38	41	6.6	75	0.12	1.2	0.35
	B+M 50%	52.6	8.5	241	0.16	1.6	0.54	49	8.4	228	0.14	1.4	0.51
	B +M 75%	60.4	9.6	266	0.18	1.7	0.63	55	8.9	252	0.16	1.5	0.6
	B +M100%	68.3	10.8	287	0.21	1.9	0.72	62	9.1	279	0.19	1.6	0.58
	Average	50.8	8	205.2	0.15	1.58	0.52	47	7.5	195.8	0.14	1.38	0.48

4. Soil salinity and organic matter contents:

Table (6) showed that application of biosolid compost to the soil led in increasing soil salinity and organic matter with the two irrigation systems. Soil salinity values with subsurface irrigation were higher than those with surface drip irrigation due to the upward movement of water by capillary rise and evaporation of water remaining salts in the top soil. Slight increase in soil salinity was detected with increasing the mineral fertilizer rate with biosolid compost. Soil salinity with surface drip irrigation after the second crop was less than after the first crop in the biosolid treated soil. While with subsurface drip irrigation soil salinity was higher after maize than after the chickpea which could be attribute to the cumulative salinity buildup. The highest values of soil salinity after chickpea and maize (3.2and 3.5 dS/m), respectively were recorded with the combination of subsurface drip irrigation, biosolid compost and 100 % NPK of (R D) These results are in agreement with those obtained by Ayars *et al.*, 1995.

Organic matter content was higher with surface drip system than that with subsurface drip one and that may be due to continuous wetting of the soil surface layer under the surface drip system which decreased the decomposition rate of the organic matter. Application of biosolid compost increased soil organic matter content from 1.3 to2.8 %.. Increasing the rate of mineral fertilizer increased the organic matter content which could be due to the low mineralization rate in the presence of mineral fertilizers. Data also show that soil organic matter content are higher after the first season and decreased after the second season. These results are in harmony with those obtained by Kelling *et al.* (1977c)

Table (6): Values of soil salinity and organic matter content after chickpea and maize crops as influenced by irrigation methods , biosoild and mineral NPK fertilizers.

Irrigation method	Fertilizer rate	Chickpea		Maize	
		ECe, S/m	O.M,%	ECe,dS/m	O.M, %
Surface drip irrigation	Initial	1.3	1.03	1.3	1.03
	Mineral(M)	1.8	1.18	1.9	1.06
	Biosoilds(BI	2.4	1.75	2.2	1.56
	B+M 50%	2.5	1.83	2.2	1.64
	B +M 75%	2.5	1.94	2.3	1.71
	B +M100%	2.8	2.12	2.6	1.77
	Average	2.4	1.76	2.2	1.55
Subsurface drip irrigation	Mineral(M)	2.1	1.15	2.3	1.01
	Biosoilds(BI	2.8	1.77	2.9	1.46
	B+M 50%	2.9	1.87	3.1	1.52
	B +M 75%	3.1	1.91	3.3	1.63
	B +M100%	3.2	1.96	3.5	1.68
	Average	2.82	1.73	3.0	1.46

5. Water applied and field water use efficiency:

Table (7) showed that the amount of water applied to chickpea and maize with surface drip irrigation (1126.60 and 2088.86 m^3 /fed.), respectively were higher than the amounts (1058.36 and 2025.54 m^3 / fed.) , applied with subsurface irrigation. The high amount of water applied with surface drip system could be attributed to water losses by evaporation from soil surface which was higher than that with subsurface drip system. On the other hand, the water applied to maize crop was higher than that applied to chickpea one.

The field water use efficiency data demonstrated that the high average values for chickpea and maize (0.55 and 1.88 kg/m^3), were obtained with subsurface drip irrigation system. Increasing the mineral fertilizer rate up to 75 % of (R D) increased the field water use efficiency of the two crops under the different irrigation methods. The highest values of field water use efficiency for chickpea and maize (0.72 and 2.23 kg/m^3), were resulted by application of B + 75 % M with subsurface drip irrigation method. The obtained results are in agreement with those of Hanson and Petterson (1974) and Abo Soliman *et al.* (2006) .

Table (7): Values of the amount of water applied and field water use efficiency for chickpea and maize as affected by biosolid and mineral NPK fertilizers under surface and subsurface drip irrigation:

Treatments		Chickpea			Maize		
Irrigation methods	Fertilization treatment	Grain yield (kg/fed.)	Amount of water applied (m^3/fed.)	Field water use efficiency kg/m^3	Grain yield (kg/fed.)	Amount of water applied (m3/fed.)	Field water use efficiency kg/m^3
Surface drip irrigation	Mineral(M)	529.54	1126.60	0.47	4089.43	2088.86	1.96
	Biosoilds(B)	415.54	1126.60	0.37	3160.49	2088.86	1.51
	B+M 50%	543.94	1126.60	0.48	3475.44	2088.86	1.66
	B +M 75	766.60	1126.60	0.68	4667.91	2088.86	2.23
	B +M100	682.53	1126.60	0.61	3969.53	2088.86	1.90
	Average	587.63	1126.60	0.52	3872.56	2088.86	1.85
Sub surface drip irrigation	Mineral(M)	515.45	1058.36	0.49	4036.36	2025.54	1.99
	Biosoilds(B)	407.36	1058.36	0.38	3139.00	2025.54	1.55
	B+M 50%	536.56	1058.36	0.51	3417.50	2025.54	1.69
	B +M 75	761.44	1058.36	0.72	4521.70	2025.54	2.23
	B +M100	669.63	1058.36	0.63	3895.34	2025.54	1.92
	Average	578.09	1058.36	0.55	3801.98	2025.54	1.88

Conclusion:

The periodic application of biosolid and rice straw compost with rate of 20 ton /fed. could save about 25 % of the mineral fertilizers Meantime soil fertility and productivity are improved. This recommend the means for recycling farm and domestic wastes for a clean and safe environment.

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استجابة محصولي الحمص و الذرة النامية في ارض طينية إلى التسميد بالمخلفات الحيوية الصلبة و التسميد المعدني تحت نظم الري بالتنقيط السطحي و تحت السطحي

السعيد حماد عمر، محمد احمد عبد العزيز، محمد مصطفى صالح رجب و محمود محمد سعيد
معهد بحوث الأراضي و المياه و البيئة- مركز البحوث الزراعية

أقيمت تجربتان حقليتان خلال الموسم الشتوي ٢٠٠٦/ ٢٠٠٧ و الموسم الصيفي ٢٠٠٧ بمزرعة محطة البحوث الزراعية بسخا.و ذلك لدراسة استجابة محصولي الحمص (Cicer arietinum) و الذرة (Zea mayes) لإضافة السماد العضوي الصناعي من المخلفات الحيوية الصلبة و قش الأرز مع معدلات من السماد المعدني تحت نظامي الري بالتنقيط السطحي و تحت السطحي .صممت التجربة في قطع منشقة في أربعة مكررات. وزعت معاملات الري بالتنقيط السطحي و تحت السطحي في القطع الرئيسية بينما وزعت معاملات التسميد العضوي و المعدني في القطع المنشقة.و تشتمل معاملات التسميد المعدني الموصى بة , تسميد عضوي, تسميد عضوي + ٥٠ % معدني, تسميد عضوي + ٧٥ % معدني, تسميد عضوي + ١٠٠ % معدني.

أوضحت النتائج المتحصل عليها:

أن استجابة محصولي الحمص و الذرة كنت عالية المعنوية لمعاملات الري و التسميد العضوي و المعدني و التفاعلات بينهم. أدى الري بالتنقيط السطحي إلى أعلى إنتاجية ٥٨٧,٦٣ و ٣٨٧٢,٦٠ كجم/ فدان لمحصولي الحمص و الذرة على الترتيب. أدت إضافة ٢٠ طن/ فدان مكمورة مخلفات صلبة مع إضافة ٧٥ % من التسميد المعنى الموصى به إلى أعلى إنتاج حبوب لمحصولي الحمص و الذرة.أدى الري بالتنقيط السطحي إلى أعلى محتوى للحبوب من النتروجين و البوتاسيوم لمحصولي الحمص و الذرة بينما أدى الري بالتنقيط تحت السطحي إلى أعلى محتوى للحبوب من الفوسفور . أدى التفاعل بين سماد المخلفات الصلبة و ١٠٠ % من التسميد المعدني الموصى بة تحت نظام الري بالتنقيط السطحي إلى أعلى محتوى من النتروجين و الفسفور و البوتاسيوم ٥,١٣ , ٠,٦٣ و ١٠,٧٣ جزء في المليون على الترتيب في حبوب الحمص و ٢,٦٤ ,٠,٧١ و ٣,٩٣ جزء في المليون على الترتيب في حبوب الذرة. أدى التفاعل بين سماد المخلفات الصلبة و ١٠٠ % من التسميد المعدني الموصى بة تحت نظام الري بالتنقيط السطحي إلى أعلى محتوى للكوبالت و الرصاص و النيكل ٠,٠٥, ٠,٠٦ و ٠,١٩ جزء في المليون على الترتيب في حبوب الحمص و ٠,١٦،١,٥٢ و ٠,٤٥ جزء في المليون على الترتيب في حبوب الذرة. زيادة معدل إضافة السماد المعدني من ٥٠ % إلى ١٠٠% من الموصى به مع التسميد العضوي أدى إلى زيادة تركيز النتروجين و الفوسفور و البوتاسيوم الميسر بالتربة و كذلك المعادن الثقيلة الميسرة تحت نظام الري بالتنقيط السطحي و تحت السطحي. إضافة سماد المخلفات الحيوية الصلبة أدى إلى زيادة المحتوى الميسر في التربة من المعادن الثقيلة التربة ملوحة التربة و محتواها من المادة العضوية تحت نظامي الري. قيم ملوحة التربة كنت اكبر تحت نظام الري بالتنقيط تحت السطحي عنها تحت نظام الري بالتنقيط السطحي. كمية مياه الري المضافة بنظام الري بالتنقيط السطحي ١١٢٦,٦٠ و ٢٠٨٨,٨٦ م٣/ فدان كانت أعلى منها ١٠٥٨,٣٦ و ٢٠٢٥,٢٤ تحت نظام الري بالتنقيط تحت السطحي لمحصولي الحمص و الذرة على الترتيب.أدت إضافة سماد المخلفات الحيوية الصلبة مع إضافة ٧٥ % من التسميد المعنى الموصى بة تحت نظام الري بالتنقيط السطحي ا إلى تحقيق أعلى كفاءة ري ٠,٧٢ و٢,٢٣ كجم / م٣ لمحصولي الحمص و الذرة على الترتيب.

الإضافة الدورية لمكمورة المخلفات الحيوية الصلبة مع قش الأرز للتربة هي انسب وسيلة للحفاظ على خصوبة وإنتاجية التربة و التخلص الأمن للمخافت الزراعية و الآدمية للمحافظة على بيئة نظيفة و الذي يمكن أن يوفر ٢٥ % من الأسمدة المعدنية.