Combination Effects of Organic and Mineral Fertilization on Corn (*Zea mays*) Macronutrient Concentrations and Yield

A.M.Mahdy[1]

ABSTRACT

Field experiments were conducted at the experimental farm of the soil salinity and alkalinity laboratory at Alexandria, Egypt during the growing season (May-September) in two consecutive years, i.e., 2007-2008 to assess the agronomic potential of the organic compost thus obtained for growing maize, and comparing the effect of this compost supplemented with mineral fertilizer with the conventional mineral fertilization on maize yield and on macronutrients concentrations and uptake in the plant tissues. The results of this study revealed that in all fertilizers treatments, significant increases in available macronutrients concentrations in soil were observed in the minerally and organically amended plots, and there was no significant difference between mineral and organic plots. However, the combination between mineral and organic fertilizers (T10, 25% mineral fertilizer + 75% organic fertilizer) had the highest value of available macronutrients concentrations compared to the other fertilizers treatments. It is interesting to emphasize that the highest values of macronutrients concentrations were observed with combination fertilization (T10) followed by T11(50% mineral fertilizer+ 50% organic fertilizer) and T12(75% mineral fertilizer + 25% organic fertilizer). Similarly, the highest grain and stover dry matter yields were obtained at the combination of mineral fertilizer by the rate of 25% and organic fertilizer by the rate of 75%. The increased values of grain and stover yields at the organic plots and the plots fertilized with both mineral and organic fertilizers may be associated with beneficial changes in soil N, P, K and organic matter dependent soil properties. There were significant positive relationships between N uptake, kg.ha^{-1}[R^2 (1st season) = 0.94, R^2 (2nd season) = 0.95], P uptake, kg.ha^{-1} [R^2 (1st season) = 0.95, R^2 (2nd season) = 0.97] and K uptake, kg.ha^{-1} [R^2 (1st season) = 0.96, R^2 (2nd season) = 0.95] and maize grain yield in the two years. This study demonstrated that use of combination of organic and mineral fertilizers in field experiment improved soil fertility, yields and nutrient concentration in the crops compared to mineral fertilization.

INTRODUCTION

Nowadays, the amounts of organic wastes produced by the cattle on intensive livestock farms are significant. Daberkow and Reichelderfer, (1988) suggested organic amendments as a method for 'low input agriculture' to achieve sustainability in dry land agriculture. Organic inputs are required to ensure that intensive systems do not threaten the sustainability of land use (Wopereis et al., 2006). However, small farmers are reluctant to use organic wastes or composts due to uncertainty as to their benefits and safety. The combination of the organic input and supplementary application of mineral fertilizers NPK has been proposed as a more attractive management option to solve problems of NPK deficiency in soil (McCown and Jones, 1992 and Vanlauwe et al., 1999).

Several works have shown beneficial effects of organic compost application for crop production. In this regard, Aggelides and Londra (2000) assessed the effects of compost produced from municipal solid waste (MSW) and sewage sludge on soil physical properties. Borken et al. (2002) studied the effects of compost from organic household waste on soil properties in degraded forests. The effects of composted cotton-gin trash and composted garden waste properties were examined by Bulluck et al. (2002). Debosz et al. (2002) evaluated the effects of sewage sludge and household compost on the physical, chemical and microbiological properties of soil. Vagstad et al. (2001) studied the effects of paper sludge compost on barley and wheat crops. Cuevas et al. (2003) studied the effects of various composted sewage sludge rates on a maize crop. Stamatiadis et al. (1999) applied compost from green wastes, cow manure and spoiled hay to a broccoli field, and Soumare ´ et al. (2003 b) used municipal solid waste compost on soils with a ryegrass crop. Basso and Ritchie (2005) used dairy manure compost in maize crop.

The general aim of this study was to ascertain whether the organic compost is an appropriate source of nutrients to replishment the shortage of mineral fertilizers. For answering this question, the following objectives were solved: (i) assessment of the agronomic potential of the vegetal compost thus obtained for growing maize, (ii) to compare the effect of this compost supplemented with mineral fertilizer with the conventional mineral fertilization on maize yield and on macronutrients concentrations and uptake in the plant tissues.

[1]Department of Soil and Water, College of Agriculture (Elshatby), Alexandria University, Alexandria, 21545, Egypt.
E-mail: amahdy73@ yahoo.com
Received March23, 2009, Accepted March30, 2009

MATERIALS AND METHODS

Description of Experimental Site:

Field experiments were conducted at the Experimental Farm of the Soil Salinity and Alkalinity laboratory, Alexandria, during the growing season (May-September) in two consecutive years, (2007-2008). This site lies between latitude 31^0 2" N, and longitude 29^0 6" E with an elevation of about 2.50 m below sea level. The annual rainfall averaged 200 mm and the relative humidity during daytime is about 67.30% at the experimental site. The mean maximum temperature during August and September ranged between 30.9^{o}C and 29.6 ^{o}C. The soil of the experimental fields had a clay texture with 431.67 gkg^{-1} clay, 322.33 gkg^{-1} silt and 246 gkg^{-1} sand. The soil physical and chemical properties were determined as follows:

pH and electrical conductivity (EC):In soil-paste extract (Richard, 1954);organic matter: by dichromate oxidation method (Nelson and Sommers, 1982); cation exchange capacity (CEC): by IM NaOAC method (Rhoades, 1982); particle size distribution: by the hydrometer method (Day, 1965); total calcium carbonate: by means of a calcimeter (Nelson, 1982);available P:using 0.5 M $NaHCO_3$ test (Olsen and Sommers, 1982);available nitrogen: by 2M KCl (Bremner and Mulvaney, 1982);available potassium:by 1N ammonium acetate method (Knudsen and Peterson,1982) and bulk density: by clod method (Tan,1996). The soil physical and chemical properties of the soil are presented in Table 1.

Experimental Set-up:

The experimental set-up was randomized complete block design with four replicates and twelve treatments for different fertilizers sources. Plot size was 3m x 3m. The treatments included were mineral fertilizer (urea, superphosphate and potassium sulfate), organic fertilizer (compost) and combination of mineral and organic fertilizers. The compost dose was determined by its nitrogen content, on the basis that it only releases 50 % of its organic N in the first year of cultivation (Zublena et al., 1996). The doses of compost equivalent to 0, 25%, 50%, 75% and 100% of maize requirements recommended by Ministry of Agriculture in Egypt. Characteristics of the used compost are shown in Table 2. Compost was spreaded on the soil surface and immediately raked evenly for each plot and then rototilled into the soil to a depth of about 20 cm. Likewise, mineral fertilizer was applied as a percentage of recommended rates from Ministry of Agriculture. The mineral nitrogen fertilizer was applied in two equal splits before sowing and 21 days after sowing of maize plants(*Zea mays* c.v. Single hybride 30K8, white pioneer). The phosphorus and potassium fertilizers were applied before sowing. The application of mineral and/or organic fertilizers to the soil yielded a total of twelve treatments, T1-T12:

T1: Soil + 0% NPK + 0% compost (control)

T2: Soil + 25% NPK + 0% compost

T3: Soil + 50% NPK + 0% compost

T4: Soil + 75% NPK + 0% compost

T5: Soil + 100% NPK + 0% compost

T6: Soil + 0% NPK + 25% compost

T7: Soil + 0% NPK + 50% compost

T8: Soil + 0% NPK + 75% compost

T9: Soil + 0% NPK + 100% compost

T10: Soil + 25% NPK + 75% compost

T11: Soil + 50% NPK + 50% compost

T12: Soil + 75% NPK + 25% compost

Soil Sampling and Analysis:

Composite soil sample was collected after fertilizers application before sowing and after harvesting of maize plants in first and second seasons, each sample consisted of a mixture of ten cores randomly collected with an auger (0-30cm) from each plot, air-dried, ground, then passed through a 2-mm sieve and analyzed for available macronutrients: Olsen-P (Olsen and Sommers, 1982); NH4OAC-K (Knudsen and Peterson, 1982) and available-N (Bremner and Mulvaney, 1982).

Plant Analysis:

The plants were harvested on September, 15 2007 and 2008. The grain was separated from the rest of the plant. Plants parts were triple rinsed in deionized water to remove any adhering particles. The samples were oven dried at 75 ^{0}C for 48 hr and then weighed. Plant tissues were ground in a stainless steel mill. Sub-samples of ground plant material were treated with $Mg(NO_3)_2$. 6 H_2O 50% and distilled water, heated on hotplate, dry-ashed in a muffle furnace at 450 ^{0}C for 6 h. Ash was dissolved in nitric acid (1:1), diluted to a constant volume with distilled water and analyzed for total phosphorus and total potassium. Other sub-samples were wet-ashed by sulfuric acid and hydrogen peroxide, diluted to a constant volume with distilled water and analyzed for total nitrogen (Jones, 2001).

Dry matter production and grain yield are expressed on dry weight basis. Plant nutrient uptake was calculated in first and second seasons from the concentrations in grain and Stover, grain yield and Stover yield.

Statistical Analyses

The one-way analysis of variance (ANOVA) was carried out to determine the statistical significance ofthe

Table1. The main physical and chemical characteristics of the experimental soil in 2007 (means ± SD except for pH) ‡

EC	pH	$CaCO_3$	O.M	Sand	Silt	Clay	CEC	D_b	Available –N (2M KCl)	Available-P (0.5 N $NaHCO_3$)	Available-K (1N NH_4OAc-K)
dSm^{-1}		$g.kg^{-1}$					$Cmol(+).kg^{-1}$	$Kg.m^{-3}$	$mg.kg^{-1}$		
1.37±0.15	7.80-8.00	70.04±2.56	19.46±0.96	246.00±5.29	322.33±2.52	431.67±5.69	29.94±1.69	1400±10.00	13.24±0.89	8.55±0.43	122.85±6.43

‡Data are the means of 4 samples

Table 2. Elemental analysis of the organic compost (dry weight basis †) used in the study (means ± SD except for pH) ‡

EC	pH	OC	TN	TP	TK	Av-N	N-NH_4	N-NO_3	Av-P	Av-K	DTPA-extractable metals							C/N
											Mn	Zn	Cr	Cd	Ni	Pb	Cu	
dSm^{-1}		%				$mg.kg^{-1}$												
2.59±0.18	7.48-7.60	25.85±0.39	1.98±0.13	0.55±0.03	1.49±0.06	70.17±2.00	50.93±2.57	23.46±4.16	150.35±2.56	801.12±3.61	78.10±1.91	2.97±0.15	14.40±0.78	0.76±0.06	15.21±0.57	59.96±1.61	56.72±1.34	13.07±2.97

† Humidity is 26±3%
‡ Data are the means of 4 samples

treatment effects on crop yield, extractable N, P and K, accumulation of metals, with the Fisher's least significant difference procedure at a significant level of 0.05 (SAS Institute, 1994). Regression analysis was employed to determine the relationship between metal uptake and grain yield of maize plant.

RESULTS AND DISCUSSIONS

Macronutrients in Soil:

Soil Nitrogen: In all fertilizers treatments, significant increases in Kjeldahl N content were observed in the minerally and organically amended plots, and there was no significant difference between mineral and organic plots (Table 3). However, the combination between mineral and organic fertilizers (T10, 25% mineral fertilizer + 75% organic fertilizer) had the highest value of available nitrogen compared with the other fertilizers treatments (Table 3). The mineral plots values ranged between 16.75 and 56.91 mg kg^{-1}, while for organic treatments, the available nitrogen content values ranged between 14.44 and 56.93 mg kg^{-1} (Table 3). Furthermore, The N content of mineral and organic fertilized plots (T10) is about 1.50 the N content of the mineral fertilized plots (T5) or organic fertilized plots (T9). In general, the available nitrogen concentrations significantly increased to the same extent in mineral and organic fertilized plots (Table 3). In contrast, the available nitrogen values ranged between 0.29 and 7.25 mg kg^{-1} in the mineral and organic fertilized plots after harvest of maize in the first season (Table 3). These results are in agreement with with other (Drinkwater et al., 1995 and Herencia et al., 2007). Other authors also found higher N content in soil amended with organic and mineral fertilizers than with mineral or organic fertilizer soils individually(Scheller and Raupp, 2005;Warman, 2005).

It is necessary to indicate that the N applied through the organic amendment is not immediately available for plant use. Soil organic N content may increase slightly because the N in organic amendment will not fully decompose in one single year (Sims, 1995). Therefore, the higher N contents in plots fertilized with mineral and organic fertilizers could be due in part to the nutrient supply with the composts (Tables 2 and 3). It is important to indicate that the available N before cultivation of second season showed the same trend in all treatments of organic fertilizers and plots fertilized with organic and mineral fertilizers together(T10-T12)(Table 3).

Soil Phosphorus: The available P content in the mineral fertilized plots (T2-T5) was significantly higher compared to the organic ones (T6-T9). The combination of mineral and organic fertilizers (T10-T12) to supply sufficient nutrient to the plant (100% of the recommended rate for maize in Egypt) showed the highest values of available phosphorus (32.81- 43.11 $mg.kg^{-1}$), furthermore, the T10 had the highest value 43.11 $mg.kg^{-1}$ among all fertilizer treatments (Table 3). Levels of P after harvest of maize in the organic fertilized plots showed greater fluctuations, compared with mineral plots, which reflect that the plant uptake exceeded the P fertilizer supply. Also, the same trend was found in the second season and confirmed the results (Table 3). There is considerable evidence in the literature to suggest that the application of organic material to soil may increase P solubility (Sanyal and De Datta, 1991). There are various mechanisms to explain the increase of available P in our experiments: (i) the use of organic amendments with a higher P content than those used in mineral fertilization (Table 2), and (ii) the decomposition of organic amendments could have resulted in concentrations of organic acids that effectively reduced P sorption to the soil and increase P availability (Laboski and Lamb, 2003). Tisdale et al., (1985) in a previous study showed that the OM added increased the availability of P in calcareous soils, suggesting that it is due to the increase of microbial biomass in organic plots. Microbial biomass increases when organic matter is added to the soil, increasing CO_2 release, which forms H_2CO_3 in the soil solution, resulting in the dissolution of primary P containing minerals and therefore increasing available P content. On the other hand, Tan (1998) indicated that P can be fixed in calcareous soils by forming $Ca_3 (PO_4)_2$ with Ca from $CaCO_3$; however, the organic anions from organic amendments decrease the fixation of P. Numerous studies have shown that the over-application of P in the organic form is largely responsible for soil P accumulation, at values often above crop requirements (Edmeades, 2003). That is why it is necessary to control the addition of organic amendment. However, the data of current study indicated that in slightly calcareous soils (about 7%) it seems to be more advantageous to apply these organic fertilizers combined with mineral fertilizers to reduce use of mineral fertilizers (high-cost) and improve the availability of P to plants, due to the high retention of P in this soil type.

Soil Potassium: The values of available K in the mineral plots were higher than those of the organic plots (Table 3). The available K in plots fertilized with organic and mineral fertilizers together approximately doubled when compared with control. The values in T1-T5 showed a continuous increase throughout the study in the two seasons. This result could be due to increasing the fertilization rate in the two years. It is interesting to denote that the supply of K is lower with organic fertilization than mineral fertilization (Table 3). The results obtained from plots fertilized with mineral

Table 3. Extractable macronutrients in the study soil before cultivation and after harvest of maize plants (means ± SD) ‡

Treatment	Extractable macronutrients, $mg.kg^{-1}$											
	1st Season,2007						2nd Season, 2008					
	N		P		K		N		P		K	
	before	after	before	after	before	after	before	after	before	after	before	after
T1	9.55 ^{j}±0.58	6.85 ^{de}±0.37	8.54 ^{j}±0.43	6.52 ^{de}±0.82	122.85 h±6.43	98.38 f±6.56	10.10 ^{i}±1.00	5.78 ^{cd}±0.93	8.35 ^{h}±0.40	6.68 ^{e}±0.35	119.77 ±5.54	92.64 ^{g}±5.10
T2	16.75 ^{h}±0.91	8.10 ^{cd}±1.05	18.47 ^{h}±0.69	15.21 ^{ab}±0.74	165.49 ^{g}±5.46	127.69 ^{e}±5.74	15.41 ^{h}±1.24	4.79 ^{de}±1.10	18.38 ^{f}±1.23	14.92 ^{a}±1.16	166.07 ^{g}±6.17	125.88 ^{f}±7.13
T3	27.29 ^{g}±1.02	10.09 ^{bc}±0.81	21.35 ^{g}±0.59	14.38 ^{bc}±0.47	232.23 ^{f}±10.59	173.09 ^{d}±9.79	27.47 ^{f}±0.56	7.93 ^{ab}±0.88	21.64 ^{e}±0.36	12.46 ^{c}±0.49	233.77 ^{f}±7.60	175.70 ^{e}±6.10
T4	44.39 ^{e}±0.89	16.26 ^{a}±1.33	27.72 ^{e}±0.47	16.52 ^{a}±0.46	314.78 ^{d}±5.42	233.60 ^{a}±5.03	41.13 ^{e}±1.00	8.54 ^{a}±1.00	27.91 ^{d}±0.34	13.73 ^{b}±0.31	318.10 ^{d}±10.39	232.77 ^{a}±10.48
T5	56.91 ^{d}±1.74	10.12 ^{bc}±2.11	35.48 ^{b}±1.02	13.01 ^{c}±1.43	362.61 ^{c}±10.76	243.79 ^{a}±13.03	53.40 ^{d}±2.59	3.46 ^{ef}±0.29	35.62 ^{c}±0.48	5.49 ^{f}±1.12	361.17 ^{c}±11.52	237.30 ^{a}±12.01
T6	14.44 ^{i}±0.44	7.86 ^{cd}±0.61	10.13 ^{i}±0.13	7.10 ^{d}±0.23	130.91 ^{h}±2.53	98.02 ^{f}±2.79	14.95 ^{i}±0.23	6.49 ^{bc}±0.53	10.36 ^{g}±0.76	7.59 ^{e}±0.99	131.33 ^{h}±3.48	95.35 ^{g}±2.54
T7	25.49 ^{g}±0.51	11.99 ^{b}±0.43	19.11 ^{h}±0.16	13.19 ^{c}±0.13	172.29 ^{g}±7.50	121.15 ^{e}±7.99	23.39 ^{g}±1.56	6.62 ^{bc}±1.42	19.37 ^{f}±0.27	10.25 ^{d}±0.35	172.45 ^{g}±4.04	116.19 ^{f}±3.07
T8	38.77 ^{f}±1.01	11.47 ^{b}±1.22	26.66 ^{f}±0.47	14.36 ^{bc}±0.39	278.82 ^{e}±7.62	196.79 ^{bc}±7.09	39.82 ^{e}±1.53	7.44 ^{abc}±1.45	27.42 ^{d}±0.71	10.05 ^{d}±0.67	280.79 ^{e}±8.40	189.85 ^{d}±8.13
T9	56.93 ^{d}±1.31	8.99 ^{cd}±2.26	31.73 ^{d}±0.51	5.30 ^{e}±0.90	321.43 ^{d}±3.94	190.94 ^{c}±3.70	53.24 ^{d}±0.82	2.53 ^{f}±0.13	34.86 ^{c}±0.23	1.04 ^{g}±0.79	322.82 ^{d}±6.79	193.71 ^{cd}±7.20
T10	85.49 ^{a}±2.28	0.29 ^{f}±0.10	43.11 ^{a}±0.79	1.46 ^{f}±0.65	427.53 ^{a}±8.52	234.23 ^{a}±5.94	87.59 ^{a}±2.07	2.47 ^{f}±0.88	50.63 ^{a}±1.51	1.67 ^{g}±0.23	427.89 ^{a}±8.27	233.16 ^{a}±5.87
T11	82.56 ^{b}±1.15	7.25 ^{de}±1.51	35.40 ^{b}±0.67	1.25 ^{f}±0.30	383.05 ^{b}±7.47	205.10 ^{b}±10.75	77.44 ^{b}±0.85	2.55 ^{f}±0.94	39.79 ^{b}±0.58	0.56 ^{g}±0.42	385.12 ^{b}±4.91	212.77 ^{a}±6.10
T12	68.39 ^{c}±1.07	5.30 ^{e}±1.08	32.81 ^{c}±0.55	6.34 ^{de}±1.65	365.18 ^{c}±5.57	203.95 ^{bc}±6.75	73.69 ^{c}±1.35	8.79 ^{a}±0.27	34.79 ^{c}±1.62	4.75 ^{f}±0.34	365.12 ^{c}±4.35	203.40 ^{bc}±3.38
$LSD_{0.05}$	**1.99**	**2.11**	**0.99**	**1.32**	**12.15**	**12.45**	**2.32**	**1.54**	**1.42**	**1.14**	**12.14**	**12.49**

‡ Data are the means of 4 samples

and organic fertilizers (T10, available K was 427.53 mg.kg^{-1}) indicate that the increase of available K comes both from the K released from organic amendment and increasing of K availability after addition of this organic amendment. Some authors have also shown an increase in available K after organic amendment to mineral fertilized plots (Gliessman et al., 1996; Bulluck et al., 2002; Edmeades, 2003). These results were confirmed in the second year, 2008.

Macronutrients Concentrations and Uptake by Plants

Nitrogen: The N content in the grain and stover of maize plants in the first and second seasons are shown in Table 4. Nitrogen concentrations in grains were significantly increased with increasing of mineral fertilizer application rates (T2-T5) compared with the control treatment (T1). Similarly, the N concentrations in Stover were significantly increased in mineral fertilized plots. The grain N concentrations of organic fertilized plots (T6-T9) significantly increased in a stepwise fashion and the values were close to the values of mineral fertilized plots. The combination of mineral and organic fertilizers showed the highest values of N concentrations in grains and Stover (Table 4) compared with mineral or organic fertilized plots individually. In these cases it is interesting to emphasize that generally the highest values of N were observed with combination fertilization (T10) followed by T11 and T12 (Table 4). These results were confirmed in the second season. Other authors found similar results: Phillips et al. (2002) in bean, Clark et al. (1999) and Colla et al. (2002) in tomato. Highest N uptake (340.58 kg.ha^{-1}) was measured in first season (Table 5) when also N concentrations in grains and Stover were recorded at T10, the combination of mineral fertilizer (25%) and organic fertilizer (75%) (Table 5). N uptake was significantly influenced by fertilization treatments (Table 5).

Phosphorus: Total P content of the grain and Stover of maize plants is also shown in Table 4. In general, the grain P concentration was much higher than Stover P in first and second seasons. There were significant differences in P concentration in the different parts between organic and mineral nutrition (Table 4). Phillips et al. (2002) reported no differences in P concentration of organically and conventionally fertilized crops. Colla et al. (2002) and Wszelaki et al. (2005) reported higher P content in organic than in minerally fertilized crops. However, other studies showed higher P concentration with mineral fertilization compared with organic crops (Warman, 2005). Furthermore, the values of P concentration were the highest at the treatment of 25% mineral plus 75% organic fertilizers(T10) followed by T11 and T12, respectively. The same results were found when the experiment repeated in the second season (Table 4).

Highest P uptake (166.62, 133.93 and 101.91 kg.ha^{-1}) were measured at T10, T11, and T12, respectively (Table 5). It is necessary to indicate that the highest P concentrations in grains and Stover were recorded at the same treatments. These results are in agreement with Colla et al., (2002); Wszelaki et al., (2005) and Herencia et al., (2007).

Potassium: Among the fertilizer treatments; T10 was the highest value for K concentrations in grain and stover of maize plants (Table 4). It necessary to report that the combination between mineral and organic fertilizers (T10-T12) was much higher the mineral or organic ones in K concentrations in grain and stover in each season (Table 4). Similarly, K uptake was significantly increased with increasing the application rate of mineral or organic fertilizers (Table 5), but the plots fertilized with mineral combined with organic fertilizers showed the highest values of K uptake in first and second seasons. Other authors found similar results: Haase et al.,(2007) in potato, Gil et al.,(2008) in maize and Dordas (2009) in wheat.

Dry Matter Accumulation and Partitioning

Dry matter accumulation and partitioning into different plant parts (grain and stover) were significantly different between the fertilization treatments used in this study (Fig.1). The highest value of grain dry matter (6156.67 kg.ha^{-1}) was found at the treatment of mineral (25%) and organic (75%) fertilizers in the first season (Fig.1A) and second season (Fig.1C). Similarly, the stover dry matter yield was significantly influenced by fertilization treatment and the highest values of stover dry matter yield were recorded(7713.67 and 7983.33 kg.ha^{-1}) in first and second seasons, respectively at combination of mineral fertilizer by the rate of 25% and organic fertilizer by the rate of 75%. The increased values of grain and Stover yields at the organic plots and the plots fertilized with both mineral and organic fertilizers may be associated with beneficial changes in soil N, P, K and soil organic matter and organic matter dependent soil properties (Liebhardt et al.,1989).

Figure 2 depicts macronutrients uptake versus maize grain yield as determined for treatment in 2007 and 2008. There were significant positive relationships between N uptake, kg.ha^{-1}[R^2 (1st season) = 0.94, R^2 (2nd season) = 0.95], P uptake, kg.ha^{-1} [R2 (1st season) = 0.95, R^2 (2nd season) = 0.97] and K uptake, kg.ha^{-1} [R2 (1st season) = 0.96, R^2 (2nd season) = 0.95] and maize grain yield in the two years (Fig.2). Similar results were obtained for maize in the north-central USA (Dobermann and Cassman, 2002).

Table 4. N, P and K concentrations in grains and stover of maize plants (g.kg^{-1}) as affected by fertilization (means ± SD) ‡

	1st Season,2007			2nd Season, 2008		
	N	P	K	N	P	K
			Grain			
T1	1.31 ^{k}±0.13	2.12 ^{j}±0.13	11.50 ^{l}±0.64	1.51 ^{j}±0.17	1.25 ^{k}±0.13	13.07 ^{l}±0.12
T2	4.53 ^{i}±0.09	3.50 ^{h}±0.02	16.62 ^{j}±0.35	5.16 ^{i}±0.27	3.69 ^{i}±0.37	18.35 ^{j}±1.59
T3	8.42 ^{g}±0.10	7.26 ^{f}±0.28	21.11 ^{h}±0.13	9.84 ^{g}±0.43	10.14 ^{h}±0.16	23.02 ^{h}±0.78
T4	13.59 ^{e}±0.13	11.39 ^{e}±0.55	26.90 ^{f}±0.19	15.59 ^{e}±0.13	15.35 ^{g}±0.46	28.95 ^{f}±0.13
T5	16.78 ^{d}±0.38	16.53 ^{c}±0.55	33.58 ^{d}±0.60	18.74 ^{d}±0.49	21.72 ^{d}±0.52	35.46 ^{d}±0.53
T6	2.77 ^{j}±0.48	3.62 ^{h}±0.30	15.04 ^{k}±0.10	5.10 ^{i}±0.97	2.66 ^{j}±0.46	16.07 ^{k}±0.06
T7	6.56 ^{h}±0.07	6.01 ^{g}±0.15	19.70 ^{i}±0.27	7.15 ^{h}±0.46	10.39 ^{h}±0.43	21.61 ^{i}±0.79
T8	11.52 ^{f}±0.07	12.20 ^{e}±0.28	25.37 ^{g}±0.30	12.19 ^{f}±0.49	18.20 ^{f}±0.30	27.10 ^{g}±0.27
T9	16.71 ^{d}±0.10	17.20 ^{c}±1.43	31.94 ^{e}±0.24	18.42 ^{d}±0.52	22.63 ^{c}±0.59	33.41 ^{e}±0.44
T10	26.92 ^{a}±0.34	22.96 ^{a}±0.16	44.65 ^{a}±0.46	26.51 ^{a}±0.44	28.01 ^{a}±0.25	46.72 ^{a}±0.50
T11	23.61 ^{b}±0.91	19.12 ^{b}±0.30	39.98 ^{b}±0.82	24.37 ^{b}±0.37	23.74 ^{b}±0.47	40.68 ^{b}±2.21
T12	21.37 ^{c}±0.15	15.21 ^{d}±0.09	38.19 ^{c}±0.44	20.58 ^{c}±0.44	20.39 ^{d}±0.88	38.91 ^{c}±1.13
$LSD_{0.05}$	**0.57**	**0.85**	**0.72**	**0.80**	**0.77**	**1.39**
			Stover			
T1	0.74 ^{j}±0.06	0.35 ^{g}±0.01	23.92 ^{h}±0.17	2.61 ^{i}±0.16	0.28 ^{i}±0.03	25.59 ^{h}±0.30
T2	5.44 ^{h}±0.12	0.83 ^{f}±0.07	29.80 ^{g}±0.46	7.07 ^{g}±0.45	0.91 ^{h}±0.05	30.71 ^{g}±0.54
T3	9.39 ^{f}±0.13	1.27 ^{e}±0.06	38.25 ^{e}±0.49	10.43 ^{f}±0.18	1.55 ^{f}±0.09	38.68 ^{f}±0.49
T4	13.10 ^{e}±0.45	1.83 ^{d}±0.09	45.12 ^{d}±0.17	15.42 ^{e}±0.20	2.11 ^{e}±0.05	46.78 ^{d}±0.61
T5	18.05 ^{c}±0.34	2.11 ^{c}±0.03	52.40 ^{c}±1.11	20.16 ^{c}±0.44	3.15 ^{d}±0.07	53.36 ^{c}±1.09
T6	4.57 ^{i}±0.12	0.73 ^{f}±0.04	28.76 ^{g}±0.51	5.45 ^{h}±0.12	0.83 ^{h}±0.04	30.40 ^{g}±0.53
T7	7.82 ^{g}±0.21	1.09 ^{e}±0.08	35.72 ^{f}±0.33	10.14 ^{f}±0.55	1.09 ^{g}±0.06	37.40 ^{f}±0.40
T8	12.76 ^{e}±0.38	1.85 ^{d}±0.07	44.15 ^{d}±0.99	15.11 ^{e}±0.52	2.20 ^{e}±0.08	45.07 ^{e}±0.08
T9	14.85 ^{d}±0.31	2.86 ^{b}±0.09	52.73 ^{c}±0.54	18.83 ^{d}±0.41	3.64 ^{c}±0.12	54.49 ^{c}±0.48
T10	22.01 ^{a}±0.59	3.18 ^{a}±0.11	60.15 ^{a}±1.00	23.71 ^{a}±0.38	4.42 ^{a}±0.06	61.77 ^{a}±0.68
T11	20.77 ^{b}±0.38	2.83 ^{b}±0.09	59.13 ^{a}±1.00	21.56 ^{b}±0.07	4.05 ^{b}±0.07	59.46 ^{b}±2.31
T12	18.55 ^{c}±1.08	2.27 ^{c}±0.42	57.49 ^{b}±0.55	20.16 ^{c}±0.82	3.12 ^{d}±0.10	58.75 ^{b}±0.50
$LSD_{0.05}$	**0.53**	**0.23**	**1.15**	**0.70**	**0.12**	**1.45**

‡Data are the means of 4 samples

Table 5. N, P and K uptake by maize plants ($kg.ha^{-1}$) as affected by fertilization (means ± SD) ‡

Treatment	Macronutrients uptake, $kg.ha^{-1}$					
	1st Season, 2007			2nd Season, 2008		
	N	P	K	N	P	K
T1	3.94 ^{j}±0.33	4.10 ^{h}±0.31	77.88 ^{k}±0.44	9.28 ^{j}±0.28	2.69 ^{j}±0.19	88.52 ^{l}±2.04
T2	26.60 ^{h}±0.59	9.06 ^{h}±0.35	131.19 ^{i}±2.38	34.50 ^{h}±1.29	9.85 ^{i}±0.35	140.83 ^{j}±4.53
T3	60.81 ^{f}±1.37	23.88 ^{g}±0.69	213.92 ^{g}±3.26	70.16 ^{f}±1.31	32.72 ^{h}±0.75	225.60 ^{h}±6.73
T4	104.49 ^{e}±2.40	40.84 ^{f}±0.56	304.73 ^{f}±1.66	122.39 ^{c}±1.05	52.74 ^{g}±0.46	321.31 ^{g}±1.61
T5	179.17 ^{d}±5.20	85.89 ^{e}±4.97	452.57 ^{c}±15.22	203.79 ^{d}±5.93	116.68 ^{c}±4.09	475.47 ^{c}±10.50
T6	18.34 ^{i}±0.70	8.13 ^{h}±0.66	111.58 ^{j}±2.38	25.87 ^{i}±1.21	7.10 ^{j}±0.91	123.95 ^{k}±3.77
T7	45.99 ^{g}±0.41	19.72 ^{g}±0.33	183.29 ^{h}±2.11	59.08 ^{g}±3.28	32.49 ^{h}±0.38	205.04 ^{i}±4.85
T8	101.33 ^{e}±1.38	45.20 ^{f}±0.77	308.12 ^{f}±2.99	124.18 ^{e}±5.36	65.47 ^{f}±0.52	343.76 ^{f}±5.19
T9	183.78 ^{d}±4.50	112.37 ^{c}±9.81	501.95 ^{d}±1.17	205.74 ^{d}±4.80	133.99 ^{c}±3.95	496.43 ^{d}±3.00
T10	340.78 ^{a}±8.74	166.62 ^{a}±3.11	753.19 ^{a}±15.88	340.11 ^{a}±11.10	194.50 ^{a}±7.22	758.89 ^{a}±19.59
T11	298.58 ^{b}±5.39	133.93 ^{b}±2.15	690.46 ^{b}±13.88	294.25 ^{b}±4.89	156.92 ^{b}±0.94	670.72 ^{b}±7.49
T12	252.38 ^{c}±0.68	101.91 ^{d}±4.44	625.02 ^{c}±6.23	251.59 ^{c}±6.38	125.53 ^{d}±4.67	626.98 ^{c}±11.49
$LSD_{0.05}$	**6.22**	**6.09**	**13.36**	**8.31**	**5.13**	**13.99**

‡ Data are the means of 4 samples

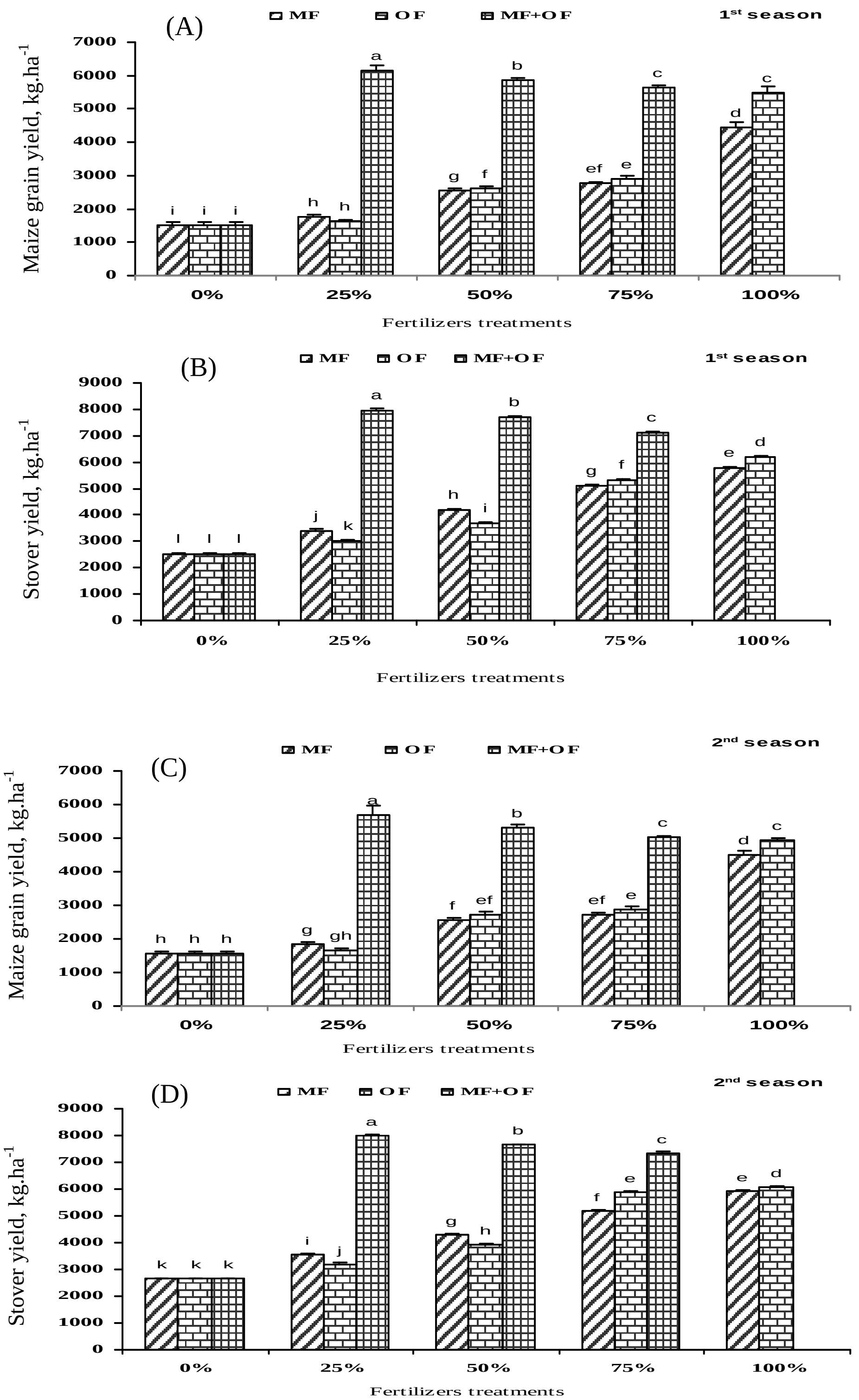

Fig. 1. Effects of mineral and organic fertilizers on grain and stover dry matter yields of maize plant in two consecutive seasons. Values followed by the same letter in the same parameter are not statistically different according to the Fisher's least significant difference procedure at a significant level of 0.05(n=4)

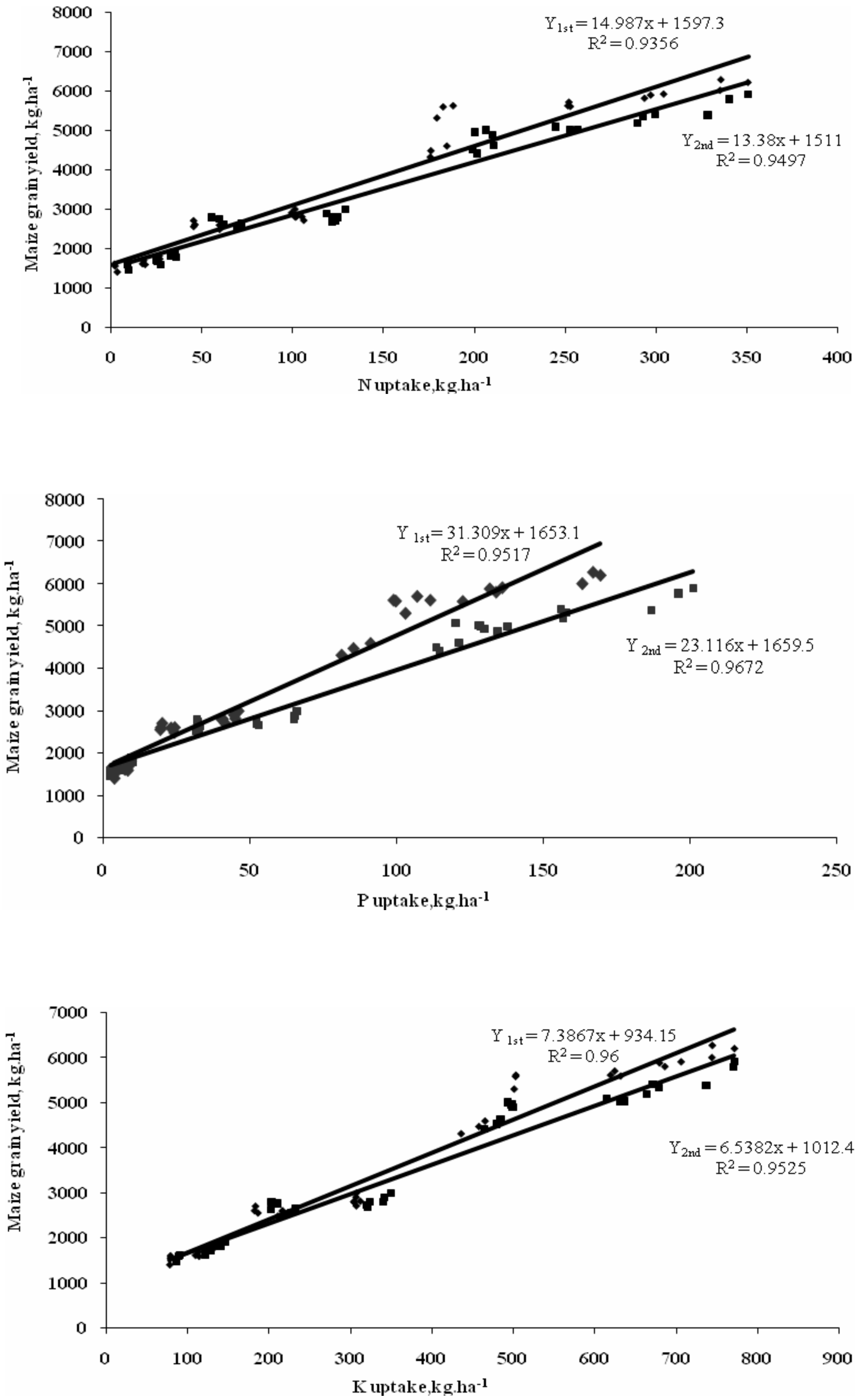

Fig. 2. Relationships between maize grain yield and plant N, P and K accumulations at harvest in the two consecutive seasons

CONCLUSION

Application of organic compost could be a mean of correcting the low organic matter content of most Egyptian agricultural soils, which would mean an improvement in their fertility. Moreover, the results confirmed that the organic compost could be a good substitute for the conventionally used basal fertilization for maize, because it was successfully applied as a fertilizer combined with additional mineral fertilizers to complete the overall needs for crops with high requirements, in this case maize. The grain and stover yields in plots fertilized with organic compost combined with mineral fertilizers were the highest values among all fertilizers treatments. Moreover, there were an increase in the N, P and K contents of the harvested grains and stover, indicating the fertilizing value of the compost. This compost, therefore, is a good basal fertilizer for maize growing. Its application improved the chemical properties and nutrient status of the soil in relation to the mineral fertilization.

We conclude that it is important to use the organic fertilizers combined with the mineral fertilizers to complete the needs of crops. Fundamentally it is more important to maintain an adequate content of organic matter in soil than the theoretical application of a pool of nutrients, because a soil rich in OM can supply the necessary nutrients to crops and provide important fertility benefits.

REFERENCES

Aggelides, S.M., and P.A. Londra (2000). Effects of compost produced from town wastes and sewage sludge on the physical properties of a loamy and a clay soil. Biores. Techno. 71: 253–259.

Basso, B., and J.T Ritchie (2005). Impact of compost, manure and inorganic fertilizer on nitrate leaching and yield for a 6-year maize-alfalfa rotation in Michigan. Agriculture, Ecosystems and Environment 108:329–341.

Borken, W., A.Muhs, and F. Neese (2002). Changes in microbial and soil properties following compost treatment of degraded temperate forest soils. Soil Biol. and Biochem. 34:403–412.

Bremner,J.M. and C.S. Mulvaney (1982). Nitrogen-Total Pp.595-623.In A.L. Page, R.H.Miller, and D.R. Keeney(eds). Methods of Soil Analysis, American Society of Agronomy, Madison, Wisconsin, USA.

Bulluck III, L.R., M. Brosius, G.K Evanylo, and J.B Ristaino (2002).Organic and synthetic fertility amendments influence soil microbial,physical and chemical properties on organic and conventional farms.Appl.Soil Ecol.19: 147-160.

Clark, M.S., W.R. Horwath, C. Shennan, K.M. Scow, W.T. Lantni,and H. Ferris.(1999). Nitrogen, weeds and water as yield-limiting factors in conventional, low input, and organic tomato systems. Agric.Ecosyst. Environ. 73:257–270.

Colla, G., J.P. Mitchell, D.D. Poudel, and S.R. Temple. (2002). Changes of tomato yield and fruit elemental composition in conventional low input, and organic systems. J. Sustain. Agric. 20:53–67.

Daberkow, S.G. , K.H. Reichelderfer.(1988). Low-input agriculture: trends, goals and prospects for input use, Am. J. Agric. Econ. 70:1159–1166.

Day, P.R. (1965). Particle Fraction and Particle Size Analysis Pp: 545-566.In A.C. Black, D.D. Evans, L.E. Ensminger, J.L. White, and F.E. Clark (eds.). Methods of soil analysis. Part I. American Society of Agronomy, Madison, Wisconsin, USA.

Debosz, K., S.O.Petersen, L.K. Kure, and P. Ambus (2002). Evaluating effects of sewage sludge and household compost on soil physical, chemical and microbiological properties. Applied Soil Ecology 19: 237–248.

Dobermann, A.and K.G., Cassman. (2002). Plant nutrient management for enhanced productivity in intensive grain production systems of the United States and Asia. Plant and Soil 247: 153–175.

Dordas,C.(2009). Dry matter, nitrogen and phosphorus accumulation, partitioning and remobilization as affected by N and P fertilization and source–sink relations. Europ. J. Agron. 30: 129–139.

Drinkwater, L.E., D.K. Leturneau, F.B. van Workneh, and A.H.C.Shennan.(1995). Fundamental difference between conventional and organic tomato agroecosystems. Calif. Ecol. Appl. 5:1098–1112.

Edmeades, D.C. (2003). The long-term effects of manures and fertilizers on soil productivity and quality: A review. Nutr. Cycling Agroecosyst. 66:165–180.

Gil, M.V., M.T. Carballo, and L.F. Calvo.(2008). Fertilization of maize with compost from cattle manure supplemented with additional mineral nutrients.Waste management,28:1432-1440.

Gliessman, S.R., M.R. Werner, S.L. Swezey, E. Caswell, J. Cochran,and F. Rosado-May. (1996). Conversion to organic strawberry management changes ecological processes. Calif. Agric. 50:24–31.

Haase,T.; C. Schuler and J.Heb.(2007). The effects of different N and K sources on tuber nutrient uptake, total and graded yield of potatoes (*Solanum tuberosum* L.) for processing. Europ. J. Agron., 26: 187-197.

Herencia, J. F. ; J. C. Ruiz-Porras; S. Melero; P. A. Garcia-Galavis; E. Morillo; and C. Maqueda.(2007). Comparison between organic and mineral fertilization for soil fertility levels, crop macronutrient concentrations, and yield.Agron.J.99:973-983.

Jones, J.B. (2001). Laboratory guide of conducting soil tests and plant analysis. CRC Press. New York, Washington, D.C.

Knudsen,D., G.A. Peterson, and P.F. Pratt (1982). Lithium,sodium and potassium.p225-245. In A.L. Page, R.H.Miller, and D.R. Keeney(eds). Methods of Soil Analysis, American Society of Agronomy, Madison, Wisconsin, USA.

Laboski, C.A.M., and J.A. Lamb. (2003). Changes in soil test phosphorus concentration after application of manure or fertilizer. Soil Sci. Soc. Am. J. 67:544–554.

Liebhardt, W.C., R.W. Andrews, M.N. Culik, R.R. Harwood, R.R. Yanke, J.K. Radke, and S.L. Rieger-Swartz. (1989). Crop production during conversion from conventional to low-input methods. Agron.J.81:150-159.

McCown, R.L.; R.K. Jones. (1992). Agriculture of semi-arid eastern Kenya: problems and possibilities .pp. 8–14. In: M.E. Probert (Ed.), Sutainable Dryland Cropping, ACIAR Proc. N 41. Canberra, Australia,

Nelson, D.W., and L.E. Sommers. (1982). Total carbon, organic carbon and organic matter. pp. 539-549. In A.L. Page, R.H. Miller, and D.R. Keeney (eds.). Methods of soil analysis, American Society of Agronomy, Madison, Wisconsin, UAS.

Nelson, R.E.(1982). Carbonate and gypsum. pp. 181-197. In A.L. Page, R.H. Miller, and D.R. Keeney (eds.). Methods of soil analysis, American Society of Agronomy, Madison, Wisconsin, USA.

Olsen, S.R. and L.E. Sommers. (1982). Phosphorus. pp:403-427. In A.L. Page, R.H. Miller, and D.R. Keeney (Eds.). Chemical and microbiological properties. 2nd edition, American Society of Agronomy, Madison, Wisconsin.

Phillips, S.B., G.L. Mullins, and S.J. Donohue. (2002). Changes in snap bean yield, nutrient composition, and soil chemical characteristics when using broiler litter as fertilizer source. J. Plant Nutr. 25:1607–1620.

Rhoades, J.D. (1982). Cation exchange capacity. pp.149-157. In A.L. Page, R.H. Miller, and D.R. Keeney (eds.). Methods of soil analysis, American Society of Agronomy, Madison, Wisconsin, USA.

Richards, L.A. (1954). Diagnosis and improvement of saline and alkaline soils. USDA. Handbook 60. US Government Printing Office, Washington, DC.

Sanyal, S.K., and S.K. De Datta.(1991). Chemistry of phosphorus transformations in soil. Adv. Soil Sci. 16:1–120.

SAS Institute. (1994). SAS/STAT User's Guide. Version 6.4th edition. SAS Inst., Cary, N.C.

Scheller, E., and J. Raupp. (2005). Amino acid and soil organic matter content of topsoil in a long term trial with farmyard manure and mineral fertilizer. Biol. Agric. Hortic. 22:379–397.

Sims, J.T. (1995). Organic wastes as alternative nitrogen sources. In P.E. Bacon (ed.) Nitrogen fertilization in the environment. Marcel Dekker, New York.

Soumare, M., F.M.G.Tack, and M.G. Verloo, (2003). Effects of a municipal solid waste compost and mineral fertilization on plant growth in two tropical agricultural soils of Mali. Bioresource Technology 86:15–20.

Stamatiadis, S., Werner, M., Buchanan, M.(1999). Field assessment of soil quality as affected by compost and fertilizer application in a broccoli field (San Benito County, California). App. Soil Eco. 12:217–225.

Tan, K.H. (1998). Anion exchange. p. 327–356. In K.H. Tan (ed.). Principles of soil chemistry. Marcel Dekker, New York.

Tan, K.H.(1996). Soil sampling, preparation, and analysis. Marcel Dekker, Inc. New York. Basel. Hong Kong.

Tisdale, S.L., W.L. Nelson, and J.D. Beaton.(1985). Soil fertility and fertilizers. 4th ed. Macmillan Publ. Co., New York.

Vagstad, N., A. Broch-Due, and I. Lyngstad (2001). Direct and residual effects of pulp and paper mill sludge on crop yield and soil mineral N. Soil Use and Management 17:173–178.

Vanlauwe, B.; J. Diels, O. Lyasse, N. Sanginga, K. Aihou, P. Hougnandan, S. Aman, B. Tossah, E. Iwuarfor, J. Omueti, S. Deckers, and R. Merckx.(1999). Annual report January 1998–December 1998 of the project balanced nutrient management systems for maize-based systems in moist savanna and humid forest zone of west-Africa (BNMS)/IITA/K.U. Leuven/ABOS.

Warman, P.R. (2005). Soil fertility, yield and nutrient contents of vegetable crops after 12 years of compost or fertilizer amendments. Biol. Agric. Hortic. 23:85–96.

Wopereis, M.C.S., A.Tame´lokpo, K. Ezui, , , D.Gnakpe´nou, B.Fofana, and H. Breman (2006). Mineral fertilizer management of maize on farmer fields differing in organic inputs in the West African savanna. Field Crops Res. 96: 355–362.

Wszelaki, A.L., J.F. Delwiche, S.D. Walker, R.E. Liggett, J.C.Scheerens, and M.D. Kleinhenz. (2005). Sensory quality and mineral and glycoalkaloid concentrations in organically and conventionally grown redskin potatoes (*Solanum tuberosum*). J. Sci. Food Agric.85:720–726.

Zublena, J.P., J.C. Barker, and D.P Wessen,.(1996). Soil Facts, dairy manure as a fertilizer source. North Carolina Cooperative Extension Service. Publication AG-439-28. March1996. (<http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-28/AG-439-28.pdf>).

الملخص العربي

تأثير الأضافة المزدوجة من التسميد العضوى والمعدنى على تركيز العناصر الكبرى وانتاجية محصول الذرة

أحمد محمد مهدى

أجريت هذة الدراسة الحقلية فى مزرعة معمل الأراضى الملحية والقلوية فى مدينة الأسكندرية خلال موسم نمو نبات الذرة(مايو– سبتمبر) فى عامين متتاليين ٢٠٠٧ و ٢٠٠٨م بهدف تقييم مقدرة الأسمدة العضوية والمعدنية والتداخل بينهما على انتاج محصول الذرة وعلى تركيز العناصر الكبرى داخل أنسجة النبات وقدرة النبات على امتصاصها. وأشارت نتائج هذة الدراسة خلال الموسمين المتتاليين الى زيادة تركيز العناصر الكبرى فى الأرض المعاملة بالأسمدة المعدنية والعضوية كلا بمفردة وأن الأضافة المزدوجة من الأسمدة المعدنية(٢٥% من احتياجات الذرة) والأسمدة العضوية(٧٥% من احتياجات الذرة) نتج عنها أعلى تركيز من الصور المتاحة للعناصر الكبرى فى الأرض وفى أجزاء النبات المختلفة (الحبوب و الحطب). ويرجع السبب فى حدوث الزيادة عند T10 الى التغيرات المفيدة التى يحدثها وجود المادة العضوية وتحسين الخواص المترتبة على وجودها فى الأرض وكذلك زيادة تركيز العناصر الكبرى (NPK) فى الأرض. وأشارت النتائج أ يضا الى وجود علاقة أرتباط موجبة ومعنوية بين أمتصاص النيتروجين ومحصول حبوب الذرة

[R^2 (1st season) = 0.94, R^2 (2nd season) = 0.95] وبين أمتصاص الفوسفور ومحصول حبوب الذرة

[R^2 (1st season) = 0.95, R^2 (2nd season) = 0.97] وبين أمتصاص البوتاسيوم و محصول حبوب الذرة

[R^2 (1st season) = 0.96, R^2 (2nd season) = 0.95] . وأثبتت هذة الدراسة أن استخدام الأضافة المزدوجة من الأسمدة العضوية والمعدنية فى تجربة حقلية أدى الى تحسين خصوبة التربة وزيادة أنتاج محصول الذرة وزيادة تركيز العناصر الكبرى فى النبات مقارنة بالتسميد المعدنى أو العضوى بمفردة.

الكلمات الكشافة: التسميد- العضوى- المعدنى- الذرة- أمتصاص- العناصر الكبرى.