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DIRECT AND RESIDUAL EFFECTS OF MIXING THE ADDED COMPOST TO A CALCAREOUS SOIL WITH SULPHUR AND PHOSPHORUS:
1- ON CROP YIELDS AND SOME SOIL PROPERTIES

Rehan, M.G.; A.H. El-Sayed; M. M. Hassan and M. A. Negm
Soil, Water and Environ. Res. Instit., Agric. Res. Centre, Giza, Misr (Egypt)

ABSTRACT

A field experiment was conducted at the Experimental Farm of Nunaria Agric. Res. Station, Egypt, during two successive growing seasons on a calcareous sandy clay loam soil to study the direct effect of compost, sulphur and phosphorus on yields of faba bean and their residual effect on succeeding maize crop as well as soil physical and chemical properties. Two kinds of composts (compost A&B) both at two levels (0 and 4 ton/fed) were applied in combination with two levels of sulphur (0 & 200 kg S /fed) and /or two levels of phosphorus (0 & 13.5 kg P/fed). Application of compost in combination with S or P resulted in a significant increase in seed yield of faba bean compared with the control ($C_0 + S_0 + P_0$) treatment or that received compost A or B alone. A further insignificant (P>0.05) increase was occurred as a result of application of S and P with the compost. Maize grain yield, as an indicator of the residual effect, showed a similar trend. A small but consistent improvement in soil properties (pH, Organic carbon, total-N and saturation percent) and a noticeable increase in available nutrient (P, Fe, Mn and Zn) contents of the soil were detected as a result of the applied materials.. Maize grain yield was positively to correlated with OC (P<0.05), total-N (P<0.01), available P(P<0.01) ,available Zn(P<0.05) and inversely related to soil pH (P<0.10). Generally, the best treatment to improve and sustain calcareous soil properties as well as increasing productivity of faba bean and maize yields was the combined treatment of compost A or B each at 4 ton + 200 kg S + 13.5 kg P per feddan.

Keywords: Calcareous soil properties, compost, sulphur, phosphorus, faba bean and maize.

INTRODUCTION

In view of the current world food crisis, the considerable increase in price of mineral fertilizers and their adverse impact on environment, there is a renewed interest in organic recycling to improve soil fertility and productivity. The direct effects of organic manure on soil productivity are related to retention and release of plant nutrients, absorption of organic components of humus, which influence favorable plant metabolism, and release of carbon dioxide. The microbial fixation of N, solubility of P, the slowing down of N release from added fertilizers, improvement in the physical, chemical and biological properties of the soil, and moisture and ion retention capacities are among the several important indirect effects (Vidyarthy and Misra, 1978).

The amounts of farmyard manures available to the Egyptian farms are not only insufficient but also decreasing with the increasing tendency towards the mechanization of agriculture. An alternative way to meet the growing needs for organic manure is by composting plant and animal residues (Abdel Ghaffar, 1978).

Efforts should be directed towards a balanced use of organic combined with mineral fertilizers to give optimum conditions for sustained soil fertility (Hauck, 1978). In this point of view, many studies have been done to improve the beneficial effects of fresh or composted organic materials through addition of P fertilizer (Waasif *et al.*,1988; and Genaidy, 1994), or S (El-Maghraby *et al.*, 1997; Hashem *et al.*, 1997; and Negm *et al.*, 2001&2002a &2002b).

Little information is available on the effect of the added compost to a calcareous soil in combination with both sulphur and phosphorus on soil productivity. We hypothesized that this triplex combination could further increase the beneficial effect of compost added with S or P. Therefore, the objective was to study the direct and residual effects of two kinds of compost, sulphur and phosphorus added to a calcareous soil on yield, soil physical and chemical properties and nutritive status of the soil using faba bean as an indicator crop in the winter season and maize in the following summer season.

MATERIALS AND METHODS

A field study was conducted at the Experimental Farm of Nubaria Agriculture Research Station. Northern Tahrir, Beheira Governorate, Egypt during 11 months starting of Nov.2001 till Oct. 2002 on a sandy clay loam soil. The main soil characteristics are shown in Table 1. The obtained composts were commercial one (comp. A) and the another was suggested and prepared by Soil, Water and Environ. Research Institute, Giza (comp. B) the chemical analysis of the composts are shown in Table 2.

Table (1): Some chemical and physical characteristics of the studied soil.

Soil depth cm	pH (1:2.5) susp.	SP %	EC• (dS/m)	Soluble cations (meq/100g soil)				Soluble anions (meq/100		
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{--}
0-20	8.00	48.00	2.60	0.42	0.43	0.58	0.03	0.19	0.45	0.76
20-40	8.08	48.60	2.52	0.36	0.39	0.55	0.03	0.21	0.36	0.74

Soil depth cm	Total N %	Available nutrients (ppm)					OM %	$CaCO_3$ %	Mechanical analysis (%)				Soil texture Class
		P	K	Fe	Mn	Zn			Coarse sand	Fine sand	Silt	Clay	
0-20	0.042	8.32	500	3.20	3.0	1.34	0.62	23.11	15.31	37.46	20.13	27.10	
20-40	0.037	7.70	447	2.75	2.8	2.80	0.57	25.21	13.95	37.52	23.80	24.73	SCL

† In saturation soil paste extract

± SCl = Sandy clay loam.

Table (2). Some main characteristics of the used composts.

Compost type	Moisture %	pH (1:10) susp.	EC dS/m	OC %	Total N %	C/N ratio	Total P %	Total K %	Total Fe %	Total Mn (mg/kg)	Total Zn (mg/kg)
A	12.6	7.81	3.60	18.77	1.99	9.42	0.99	1.30	1.05	500	140
B	33.0	6.20	5.00	27.50	1.30	21.15	1.10	0.98	0.80	284	167

The experimental design was a split-plot with four replicates and included twelve treatments representing all the factorial combinations of different applied composts (0, comp.A and Comp. B each at 4 ton/fed rate), two sulphur levels (0 and 200 kg S /fed, as elemental S) and two phosphorus levels (0 and 13.5 kg/fed, as calcium superphosphate). The compost treatments were assigned to the main plots while those of S and P were randomly assigned to the sub plots (3.5 x 6 m^2). The composts were thorough mixed with the soil tilth layer one week before sowing faba bean.

On the 7^{th} of November 2001, seeds of faba bean (*ficia faba* c.v.Noubaria 1) inoculated with special strain of Rhyzobia produced by SWERI were planted. After harvesting faba bean, on the 26^{th} of May 2002 the same treated plots were prepared for the following crop without any addition of neither compost, sulphur nor phosphorus treatment and grain of maize (Zea *mays* L. c.v. Hybrid 310) were sown on the 3^{rd} of June 2002.

Two doses of mineral fertilizer each of 8.0, 7.5 and 12.5 kg N, P_2O_5 and K_2O as ammonium nitrate, calcium superphosphate and potassium sulphate, respectively, were added after 3 and 6 weeks of planting to each plot in both seasons. The local common cultivation practices were executed for both crops. Maize was harvested on the 4^{th} of October 2002. Seed yields were recorded and harvest index [(seed yield /biological yield) x 100] (Jolliff *et al.*,1993) were calculated for each crop.

Soil samples were taken from each plot to represent the 0-20 and 20-40 cm soil layers at the end of each season. The soil samples were prepared and analyzed for saturation percentage (SP), EC_e, soluble cations and anions, pH, cation exchange capacity(CEC), organic carbon(OC%), total nitrogen and available P, K, Fe, Mn and Zn according to the standard methods (Black *et al.*, 1965; Lindsay and Norvell,1978 and Page *et al.*, 1982).

The obtained data were statistically analyzed according the method described for split-plot in randomized complete block design by Snedecor and Cochran (1971). Correlation between maize grain yield and some soil properties were calculated using mean values; averaged across replications (n=12).

RESULTS AND DISCUSSION

1- General characterization:-

a-The soil: Physical and chemical analysis of the soil (experimental site) prior to initiation of the experiment (Table 1) indicates that the soil had a light texture, was alkaline in reaction, contained an excess of calcium carbonate and deficient in some macro and micronutrients (N,P and Fe).

b-Composts: Compost A was a mixture of bentonite mud, farm residues and peanut pod husks inoculated with special bio-decomposer strains of bacteria, fungi and actinomyses under aerobic condition. Compost B, on the other hand, was a mixture of animal and chicken manures, by-products of meat and fish industries, straw of sesame, lentil and peanut inoculated with special bio-decomposer strains of bacteria and fungi.

The chemical analyses of both composts (Table 2) show that compost B had a relatively higher C/N ratio, soluble salts, and total P than compost A, while compost A contained a higher content of total Fe and Mn. Data reveal also that compost A was slightly alkaline, whereas compost B was acidic in reaction.

2-Grain yield and harvest index:-

Direct and residual effects of the studied treatments on grain yields and harvest indexes are shown in Table 3.

Table (3): Effect of compost, sulphur and phosphorus on yield in ard/fed and harvest index (%) of faba bean and maize.

Compost	Sulphur	Faba bean						Maize					
		Seed yield			Harvest index			Grain yield			Harvest index		
		Phosphorus											
		P_0	P_1	mean	P_0	P_1	mean	P_0	P_1	mean	P_0	P_1	mean
0	S_0	3.30	3.95	3.63	46.12	45.18	45.65	13.50	11.12	12.31	44.93	46.01	45.47
	S_1	4.26	4.49	4.38	45.67	45.35	45.51	12.10	13.20	12.65	45.57	46.64	46.11
	mean	3.78	4.22	4.22	45.90	45.27	45.58	12.80	12.16	12.48	45.25	46.33	45.79
A	S_0	5.05	5.67	5.36	45.89	42.78	44.34	13.95	14.06	14.00	46.78	46.03	46.41
	S_1	5.69	6.13	5.91	46.12	45.08	45.60	13.28	15.70	14.90	43.68	45.07	44.38
	mean	5.37	5.90	5.64	46.01	43.93	44.97	13.62	14.88	14.45	45.23	45.55	45.37
B	S_0	5.67	6.00	5.84	45.06	44.89	44.98	12.79	15.00	13.90	49.94	43.67	46.80
	S_1	5.84	7.29	6.57	44.81	44.44	44.63	13.52	16.07	14.80	46.30	46.63	46.33
	mean	5.76	6.65	6.20	44.94	44.67	44.80	13.16	15.54	14.35	48.12	45.15	46.57
Mean	S_0	4.67	5.21	4.94	45.69	44.29	44.99	13.41	13.39	13.40	47.21	45.24	46.23
	S_1	5.26	5.97	5.62	45.53	44.96	45.24	13.00	14.99	13.99	45.18	46.03	45.61
	mean	4.97	5.59		45.61	44.63		13.21	14.06		46.20	45.67	
L.S.D (0.05)													
C		1.05			NS			NS			NS		
S		0.45			NS			NS			NS		
P		0.45			NS			0.70			NS		
C x S		NS			NS			NS			NS		
C xP		NS			NS			NS			NS		
S x P		NS			NS			NS			NS		
C x S x P		1.52			NS			2.08			NS		
cv %		17.25			15.01			10.47			6.80		

0 = no addition; A, B= 4ton/fed of compost A and B
S_0, P_0: not added, S_1 and P_1: 200 and 13.5 kg S and P /fed. respectively.

The faba bean seed yield increased significantly due to application of composts (P=0.016), sulphur (P=0.025), or phosphourus (P=0.016). The interaction between compost, sulphur and phosphorus was also significant. Application of either A or B compost increased faba bean seed yield by about 53 and 72% over the control treatment ($C_0S_0P_0$). Further increase in seed yield was occurred when the applied compost was mixed with both sulphur and phosphorus. The increase in seed yield of faba bean due to the (comp. A + S_1 + P_1) treatment was about 21% over the (comp. A + S_0 +P_0) treatment and about 8% over either (comp. A + S_0 + P_1) or (comp. A + S_1 + P_0) treatment. Similar trends were observed with compost B (Table 3). Statistical analysis showed that there was no significant difference between treatments of (comp. A + S_1 + P_1) and (comp. B + S_1 + P_1) The statistical analysis showed also that there were no significant differences between (comp. A + S_1 + P_1) and both of the (comp. A + S_1 + P_0) and (comp. A + S_0 + P_1) treatments. The same was observed with compost B. As for residual effect, data in Table 3 show that the main effects of compost (P=0.075) and phosphorus (P=0.022) on maize grain yield were significant. However, the response of grain yield to the previously added compost or phosphorus was dependent on sulphur application, as the compost x suluphur x phosphorus interaction effect was significant (P=0.031). The highest yield of maize grain was recorded in the plots treated with (comp.B + S_1 + P_1) followed by (comp. A + S_1 +P_1) which were significantly greater than that of (comp. B + S_0 + P_0) or (comp. A + S_0 + P_0) treatment. Theses results are in agreement with those of Wassif *et al.* (1988); Genadiy (1994); Varavipour *et al.* (1999); Negm *et al.* (2002 a & b; 2003) who found that application of compost alone or in combination with S or P improved the growth and yields of the treated crops. They attributed that to the improvement in soil water relation, soil organic matter and availability of N, P and S.

Harvest index of faba bean and maize were not affected significantly by nither direct nor residual effect of the studied treatments (Table 3). These results indicated that under the studied conditions, compost, sulphur and /or phosphorus did not alter significantly the ratio in which faba bean or maize plants allocated the photosynthates into reproductive and vegetative growth. These results are in harmony with those of Negm *et al.* (2002b & 2003).

3. Soil characteristics.

3. a. physical and chemical properties.

Organic carbon content(OC) of both surface and subsurface soil layers increased considerably at the end of the first season (after faba bean) due to application of compost, sulphur and phosphorus either individually or in combination. The increase in surface layer was higher than in subsurface ones (Table 4). A similar increase, but in a lesser magnitude was observed after harvesting maize crop.

Averaged across sulphur and phosphorus treatments, the increase in OC content in the surface soil layer at the end of first season were 26 and 19% due to application of compost. A and B compared with the control, respectively. The corresponding values for the tow composts at the end of the second season were 18 and 10%, respectively. Application of sulphur and / or phosphorus increased the positive effect of compost. This may be due to the high content of OC in the applied composts in addition to the role of the applied materials (composts, sulphur and phosphorus) in increasing the plant growth (especially root mass) and consequently, remaind more plant residues after harvest (Draz *et al.*, 1996 and Hasham *et al.*, 1997). Total N content of the surface layer also increased due to application of composts either alone or in combination with sulphur and phosphorus at the end of the first season, whereas the increase in total N at the end of the second season was rather less. This may be due to the enhancement of plant growth and consequently, consumption of more nitrogen (Negm *et al.*, 2002a) and /or due to the increase in soil nitrogen gained from nitrogen fixation and photosynthesis by faba bean as a leguminous crop (Rizk,1968). In both seasons, the total N in subsurface soil layer was slightly affected. As a result of these changes in both OC and total N, the C/N ratio showed a slight increase at the end of the first season and became wider at the end of the second one (Table 4). These results are in agreement with those of Negm *et al.* (2002 a & b).

Table (4): Effect of compost, sulphur and phosphorus on some soil characteristic after harvesting faba bean and maize.

Com-post	Sul-phur (S)	Phos-phorus	OC %		Total N %		C/N ratio		CEC (meq/100g)		pH (1:2.5 susp.)	
			Soil depth (cm)									
			0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
After faba bean												
0	S_0	P_0	0.36	0.33	0.045	0.038	8.00	8.68	14.85	14.90	8.01	8.00
		P_1	0.37	0.34	0.044	0.040	8.40	8.50	14.88	14.90	7.98	7.99
	S_1	P_0	0.36	0.34	0.045	0.041	8.00	8.29	14.85	14.89	7.95	7.96
		P_1	0.37	0.34	0.045	0.042	8.22	8.10	14.90	14.89	7.94	7.96
A	S_0	P_0	0.51	0.48	0.049	0.043	10.63	11.16	15.00	15.20	7.99	7.99
		P_1	0.46	0.38	0.048	0.048	9.57	7.92	15.00	15.10	7.97	7.98
	S_1	P_0	0.39	0.40	0.045	0.047	8.67	8.51	14.95	15.00	7.94	7.96
		P_1	0.48	0.40	0.050	0.048	9.60	8.33	15.00	15.05	7.92	7.95
B	S_0	P_0	0.46	0.40	0.050	0.048	9.20	8.00	15.20	14.60	7.96	7.97
		P_1	0.45	0.40	0.050	0.047	9.00	8.50	15.15	15.20	7.94	7.96
	S_1	P_0	0.40	0.39	0.050	0.049	8.00	8.13	15.20	15.25	7.92	7.95
		P_1	0.43	0.41	0.051	0.047	8.43	8.72	15.20	15.25	7.90	7.94
After maize												
0	S_0	P_0	0.45	0.44	0.035	0.033	12.86	13.33	15.20	15.00	8.02	8.00
		P_1	0.46	0.31	0.038	0.036	12.10	8.61	15.25	15.15	7.98	8.00
	S_1	P_0	0.48	0.42	0.041	0.043	11.11	9.77	15.20	15.00	7.93	7.94
		P_1	0.37	0.29	0.040	0.039	9.25	7.44	15.25	15.02	7.92	7.95
A	S_0	P_0	0.60	0.58	0.060	0.050	10.00	11.60	15.30	15.15	7.97	7.98
		P_1	0.46	0.44	0.047	0.048	9.79	9.17	15.25	15.20	7.97	7.98
	S_1	P_0	0.50	0.48	0.048	0.045	10.42	10.67	15.30	15.20	7.90	7.95
		P_1	0.52	0.43	0.050	0.049	10.40	8.78	15.35	15.20	7.89	7.94
B	S_0	P_0	0.40	0.36	0.045	0.041	8.89	8.78	15.40	15.15	7.95	7.96
		P_1	0.55	0.45	0.051	0.048	10.78	9.38	15.45	15.25	7.94	7.96
	S_1	P_0	0.53	0.34	0.049	0.046	10.82	7.39	15.45	15.25	7.89	7.94
		P_1	0.46	0.39	0.048	0.043	9.58	9.07	15.45	15.20	7.88	7.93

0 = no addition; A, B= 4ton/fed of compost A and B
S_0, P_0: not added, S_1 and P_1: 200 and 13.5 kg S and P /fed. respectively.

Cation exchange capacity, CEC, and water holding capacity estimated as water saturation percentage, SP, of the studied soil showed a minor but consistent increase due to application of composts, whereas the changes in these two parameters due to sulphur or phosphorus application were negligible (Table 4). The increase was more pronounced after the second season than after the first one. Contrary to EC_e and SP, soil pH decreased consistently as a result of compost, sulphur and phosphorus application (Table 4). The treatments of (comp.A + S_1 + P_1) and (comp. B + S_1 +P_1) were the most effective treatments in reducing soil pH either in the surface or subsurface soil layers after each of the growing seasons. The decrease in soil pH was from 8.01 for the control (C_0 + S_0+P_0) to 7.92 and 7.90 for the two treatments, respectively in the surface soil layer at the end of the first season. The corresponding values for the subsurface soil layers were from 8.00 to 7.95 and 7.94, respectively. A further decrease in soil pH was occurred at the end of the second season. However, all the figures fluctuated within a limited range which was between 7.88 and 8.02; this may be due to the high buffering capacity of the studied soil because of the presence of appreciable amounts of $CaCO_3$. Similar results were reported by Hashem *et al.*,1997 and Negm *et al.*,2003

Total soluble salts represented by EC_e and soluble ions of the saturated soil paste extract reflected the composition of the added composts and the effect of the added sulphur (Table 5). While EC values of the plots treated with compost B (which had considerable higher salt content than compost A (Table 2) was increased, it showed a slight effect by compost A application. Sulphur applied alone or in combination with phosphorus, increased soil salinity which may be due to gypsum formation in the soil (El-Fayoumi, 1996 and Abd El-Halim, 2001). The variations in soil salinity due to phosphorus application were negligible.

Table (5a): Effect of compost, sulphur and phosphorus on soluble salts in soil after faba bean.

Com-post	Sul-phur (S)	Phos-phorus	Depth (cm)	SP	EC dS/m	Anions (meq/100g soil)			Cations (meq/100g soil)			
						HCO_3^-	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+	K^+
0	S_0	P_0	0-20	48.5	2.62	0.18	0.46	0.77	0.43	0.35	0.59	0.03
			20-40	48.0	2.53	0.22	0.37	0.74	0.45	0.30	0.56	0.03
		P_1	0-20	48.0	2.44	0.19	0.36	0.74	0.42	0.27	0.56	0.03
			20-40	48.5	2.51	0.20	0.32	0.76	0.45	0.23	0.57	0.03
	S_1	P_0	0-20	48.5	3.25	0.18	0.41	0.97	0.56	0.34	0.61	0.05
			20-40	48.5	3.04	0.19	0.41	0.89	0.51	0.32	0.64	0.03
		P_1	0-20	49.0	3.91	0.23	0.51	1.17	0.71	0.52	0.59	0.05
			20-40	49.0	3.84	0.20	0.51	1.06	0.62	0.39	0.68	0.04
A	S_0	P_0	0-20	48.5	2.85	0.18	0.37	1.08	0.54	0.45	0.62	0.06
			20-40	48.0	2.11	0.22	0.33	0.65	0.34	0.35	0.51	0.04
		P_1	0-20	48.5	2.95	0.23	0.44	1.03	0.62	0.45	0.77	0.06
			20-40	48.5	2.15	0.37	0.39	0.93	0.53	0.62	0.99	0.05
	S_1	P_0	0-20	49.0	2.85	0.18	0.37	1.08	0.54	0.37	0.62	0.06
			20-40	49.5	3.33	0.16	0.42	1.05	0.55	0.37	0.67	0.04
		P_1	0-20	48.5	2.95	0.23	0.44	1.03	0.62	0.45	0.77	0.06
			20-40	49.0	3.59	0.21	0.52	1.05	0.68	0.51	0.55	0.04
B	S_0	P_0	0-20	50.5	3.71	0.23	0.58	1.07	0.66	0.50	0.67	0.06
			20-40	51.0	3.82	0.26	0.58	1.08	0.69	0.45	0.71	0.05
		P_1	0-20	50.0	3.05	0.21	0.43	0.99	0.59	0.46	0.56	0.03
			20-40	50.5	3.11	0.23	0.51	1.16	0.66	0.45	0.73	0.06
	S_1	P_0	0-20	49.5	3.59	0.21	0.52	1.05	0.68	0.55	0.55	0.04
			20-40	50.0	2.89	0.20	0.39	1.01	0.55	0.40	0.61	0.04
		P_1	0-20	50.5	3.44	0.18	0.51	1.12	0.62	0.44	0.59	0.06
			20-40	51.0	4.00	0.24	0.50	1.26	0.66	0.57	0.71	0.06

0 = no addition; A, B= 4ton/fed of compost A and B
S_0, P_0: not added, S_1 and P_1: 200 and 13.5 kg S and P /fed. respectively.

Table (5b): Effect of compost, sulphur and phosphorus on soluble salts in soil after maize.

Com-post	Sul-phur (S)	Phos-phorus	Depth (cm)	SP	EC dS/m	Anions (meq/100g soil)			Cations (meq/100g soil)			
						HCO_3^-	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+	K^+
0	S_0	P_0	0-20	48.5	3.17	0.21	0.42	0.95	0.58	0.41	0.54	0.03
			20-40	49.0	3.41	0.23	0.48	1.02	0.67	0.47	0.56	0.03
		P_1	0-20	49.0	2.67	0.23	0.37	1.03	0.59	0.42	0.59	0.03
			20-40	48.5	2.59	0.23	0.39	0.97	0.53	0.39	0.63	0.03
	S_1	P_0	0-20	48.5	3.48	0.21	0.45	1.05	0.60	0.47	0.61	0.04
			20-40	49.0	4.06	0.22	0.47	1.27	0.63	0.55	0.75	0.03
		P_1	0-20	49.0	2.16	0.20	0.36	0.71	0.36	0.33	0.51	0.03
			20-40	49.5	2.86	0.23	0.38	1.19	0.54	0.45	0.77	0.04
A	S_0	P_0	0-20	48.5	2.38	0.24	0.37	0.74	0.41	0.37	0.52	0.05
			20-40	49.0	2.14	0.20	0.33	0.68	0.36	0.26	0.55	0.05
		P_1	0-20	48.5	2.83	0.24	0.47	0.69	0.44	0.36	.0.56	0.04
			20-40	49.0	3.01	0.22	0.42	0.83	0.49	0.34	0.61	0.04
	S_1	P_0	0-20	49.0	3.91	0.23	0.51	1.17	0.71	0.52	0.59	0.05
			20-40	49.5	2.60	0.12	0.28	1.15	0.67	0.37	0.50	0.03
		P_1	0-20	48.5	4.00	0.24	0.50	1.26	0.66	0.57	0.71	0.06
			20-40	49.0	2.91	0.24	0.37	1.07	0.67	0.39	0.60	0.03
B	S_0	P_0	0-20	48.5	3.05	0.21	0.43	0.99	0.59	0.46	0.56	0.03
			20-40	50.0	3.63	0.25	0.59	0.93	0.66	0.37	0.70	0.05
		P_1	0-20	49.0	2.39	0.23	0.44	0.94	0.57	0.45	0.55	0.03
			20-40	50.0	2.95	0.23	0.45	0.98	0.60	0.45	0.58	0.04
	S_1	P_0	0-20	50.0	2.91	0.21	039	1.00	0.62	0.46	0.49	0.04
			20-40	49.5	2.98	0.23	0.40	1.00	0.62	0.45	0.53	0.03
		P_1	0-20	50.0	3.05	0.21	0.43	0.99	0.59	0.46	0.56	0.03
			20-40	50.0	2.19	0.15	0.29	1.02	0.49	0.44	0.51	0.02

0 = no addition; A, B= 4ton/fed of compost A and B
S_0, P_0: not added, S_1 and P_1: 200 and 13.5 kg S and P /fed. respectively.

3. b. Availability of plant nutrients:

Application of composts increased, in different magnitudes, the available nutrient contents (P, Fe, Mn and Zn) of both surface and subsurface soil layers after each of the growing seasons (Table 6). A further increase in compost effects was occurred due to application of sulphur or phosphorus or both of them. Available K content showed a similsr trend to those of P, Fe, Mn and Zn after the first seasons, but a noticeable decrease in its content was detected after the second season. In all cases, the plots treated with compost A or B in combination with sulphur and phosphorus,i.e. (comp.A +

S_1 + P_1) or (comp. B + S_1+ P_1), exhibited the highest values of available nutrient contents.

Table (6): Effect of compost, sulphur and phosphorus on availability of some macro and micro nutrients after harvesting faba bean and maize.

Com-post	Sulphur (S)	Phos-phorus	P		K		Fe		Mn		Zn	
			Soil depth (cm)									
			0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
After faba bean												
0	S_0	P_0	8.00	7.65	489	440	3.14	2.73	2.98	2.79	1.32	0.95
		P_1	11.48	8.10	547	469	3.17	2.74	3.03	2.80	1.32	0.96
	S_1	P_0	8.83	7.92	532	508	3.84	2.90	3.45	2.84	1.44	0.98
		P_1	12.00	7.95	501	761	3.78	2.80	3.48	2.83	1.44	0.97
A	S_0	P_0	11.48	7.98	516	461	4.92	3.18	3.26	2.84	1.50	1.00
		P_1	15.27	8.20	579	516	4.96	3.16	3.30	2.83	1.50	1.01
	S_1	P_0	12.98	8.10	571	532	5.86	3.21	3.75	2.88	1.57	1.03
		P_1	17.40	9.05	626	600	6.15	3.22	3.80	2.87	1.56	1.03
B	S_0	P_0	13.45	8.10	501	516	3.84	3.90	3.15	2.82	1.60	1.08
		P_1	16.50	8.50	545	532	3.04	2.92	3.19	2.81	1.60	1.07
	S_1	P_0	15.81	9.30	461	469	4.57	2.95	3.63	2.86	1.64	1.10
		P_1	18.20	10.30	579	567	4.56	2.94	3.67	2.86	1.63	1.11
After maize												
0	S_0	P_0	7.65	7.00	477	444	2.09	2.71	2.97	2.97	1.30	0.95
		P_1	9.50	7.50	426	434	3.17	2.95	3.06	2.80	1.31	0.95
	S_1	P_0	8.00	7.30	470	461	3.78	3.00	3.54	2.86	1.42	1.00
		P_1	10.00	7.80	475	497	3.71	2.80	3.57	2.85	1.42	0.99
A	S_0	P_0	17.50	7.98	474	442	6.07	3.20	3.39	2.85	1.52	1.02
		P_1	21.70	8.20	418	399	6.16	3.19	3.46	2.86	1.53	1.02
	S_1	P_0	20.30	9.20	418	383	7.49	3.24	4.01	2.89	1.59	1.04
		P_1	22.30	9.90	420	407	6.95	3.25	4.05	2.90	1.58	1.04
B	S_0	P_0	15.45	8.20	470	441	4.27	2.96	3.23	2.83	1.62	1.10
		P_1	17.00	9.00	403	427	4.30	2.97	3.30	2.82	1.63	1.08
	S_1	P_0	17.30	10.00	403	352	5.34	2.99	3.81	2.89	1.66	1.12
		P_1	20.10	10.50	446	434	5.30	2.97	3.85	2.88	1.67	1.05

0 = no addition; A, B= 4ton/fed of compost A and B
S_0, P_0: not added, S_1 and P_1: 200 and 13.5 kg S and P /fed. respectively.

4. Maize grain yield vs. soil properties

In order to expose the nature and magnitude of the association between maize grain yield and soil properties prior to the initiation of the second season to expound the behavior of the residual effect, correlation coefficients were calculated (Table 7). Results indicated that maize grain yield appeared to be positively and significantly correlated with OC, total nitrogen, available P, Zn contents through the two soil layers and available K content of the sub surface soil layer. The correlation between grain yield and available Fe or Mn was positive but week. Data revealed also that a negative linear relationship between maize grain yield and soil pH was found. These data reflected the beneficial residual effect of the applied materials on soil properties and productivity.

Table(7): Simple correlation coefficients (*r*) and associated probabilities (*P*) between maize grain yield and some properties of the two soil layers at the end of the first season (after faba bean crop).

Soil properties	0 -20 cm		20 - 40 cm	
	r	*P*	*r*	*P*
EC	0.135	0.676	0.310	0.324
PH	-0.520	0.081	-0.527	0.076
OC	0.573	0.049	0.661	0.018
Total-N	0.735	0.006	0.540	0.068
Available P	0.734	0.006	0.670	0.016
Available K	0.378	0.223	0.623	0.028
Available Fe	0.319	0.309	0.462	0.128
Available Mn	0.477	0.120	0.412	0.181
Available Zn	0.601	0.037	0.551	0.061

In summary, results of these studies show that the beneficial direct and residual effects of the applied composts on crop yields and soil properties and productivity were significantly improved by the addition of S or P. A further improvement was achieved by the addition of both S and P with the applied composts. However, the differences were not significant. Maize grain yield, as an indicator of the residual effects of the applied materials, was positively and significantly correlated with soil OC, total N, available P and Zn and negatively with soil pH. The best treatment to improve and sustain calcareous soil properties as well as increasing productivity of faba bean and maize was the combined treatment of compost A or B each at 4 ton + 200 kg S + 13.5 P/fed.

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التأثير المباشر والمتبقى لخلط المكمور المضاف للأرض الجيرية بالكبريت والفوسفور :
١- على ناتج المحاصيل و بعض خواص التربة

محمد جلال الدين ريحان، عبد اللة حسين السيد، مصطفى محمد حسن، محمد عبد السلام نجم
معهد بحوث الاراضى والمياه والبيئة- مركز البحوث الزراعية- الجيزة- مصر

اقيمت تجربة حقلية بالمزرعة التجريبية لمحطة البحوث الزراعية بالنوبارية بمصر خلال موسمين زراعيين متتاليين على أرض جيرية ذات قوام طمييى طينى رملى لدراسة التأثير المباشر والمتبقى للمكمور والكبريت والفوسفور على محاصيل الفول البلدى والذرة وكذلك على الصفات الطبيعية والكيماوية للارض، وقد صممت التجربة على توافيق ثلاث معاملات للمكمور (عدم اضافة مكمور أو مكمور أ أو مكمور ب بمعدل ٤ طن من أى منهما للفدان) فى وجود أو عدم وجود ٢٠٠كجم كب أو ١٣,٥ كجم فو / فدان.

وقد دلت النتائج المتحصل عليها على أن اضافة المكمور مصاحبا للكبريت أو الفوسفور تزيد محصول بذور الفول البلدى معنويا كدليل على وضوح الاثر المباشر لهذه المواد بالقياس بمعاملة المقارنة التى لم يضف اليها أى من المكمور أو الكبريت أو الفوسفور أو تلك التى أضيفت فيها مكمور أ أو ب بمفرديهما وقد أعطى محصول حبوب الذرة الشامية نفس الاتجاه كدليل على وجود أثر متبق لكن بدرجة وقد أدت اضافة المكمور مع الكبريت والفوسفور معا الى زيادة أخرى فى محصول كل من الفول والقمح مقارنة بالمعاملة المضاف اليها المكمور مع الكبريت أو تلك المضاف اليها المكمور مع الفوسفور، لكن هذه الزيادة لم تكن معنوية.

وقد رصد تحسن مستمر طفيف فى صفات الارض (تركيز أيون ألايدروجين والكربون العضوى والنيتروجينن الكلى والسعة النشبعية) وزيادة فى صلاحية العناصر الغذائية (الفوسفور والحديد والمنجنيز والخارصين) كنتيجة لاضافات المكمور والكبريت والفوسفور، وقد ارتبط محصول حبوب الذرة الشامية كمستفيد بالاثر المتبقى لهذه الاضافات طرديا بمحتوى الارض من الكربون العضوى والنيتروجين الكلى والميسر من الفوسفور والخارصين وعكسيا بقيم تركيز أيون الايدروجين.

وعموما فقد كانت أفضل معاملة لتحسين صفات الارض الجيرية واستدامة خصوبتها ورفع انتاجيتها من محصولى الفول البلدى والذرة الشامية هى اشتراك أى من مكمورى أ أو ب بمعدل ٤ طن/فدان مع ٢٠٠ كجم كب ، ١٣,٥ كجم فو/ فدان.