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Effect of some Cultural Treatments, Elemental Sulfur Application and N-fertilization Levels on the Productivity of Maize and Fertility of Calcareous Sandy Soil

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Abstract

The aim of the present investigation was to improve the productivity of calcareous sandy soil of Arab El-Awammer Experimental Station, Assiut governorate, Egypt. For this purpose a field experiment under minimum soil tillage conditions in summer season of 2010 was conducted in split split plot design with three replicates to detect the production of maize and soil fertility as influenced by previous and immediately some soil cultural treatments in main plot, levels of powder elemental S (zero and 300 kg S/fed) in the sub plots and mineral nitrogen fertilization levels (120 and 180 kg N/fed) in the sub sub plots. The four soil cultural treatments in main plots were two different crop sequences with crop residues completely removed (-CR) or with crop residues incorporated in soil surface layer 0-25 cm (+CR). The different two crop sequences (depend on it's inclusions from legume crop) were:-

Year	2009	2010	legume crop%
Sequence 1 =	wheat – maize –	wheat – <u>maize</u>	(0%)
Sequence 2 =	wheat – maize –	clover – <u>maize</u>	(25%)

The obtained results from the maize crop cultivated in season four of this study show that, crop residues applied in legume cereal cropping systems (25% legume crops) resulted in higher maize growth, yields, yields components, NP uptake by maize plants and improved soil fertility (soil organic matter content, soil total N, soil available P and soil pH). Powdered elemental S applied seasonally at a level of 300 kg S/fed and N-fertilizer at the high levels (180 kg N/fed) were also efficient in improving maize productivity and improving fertility status of calcareous sandy soil. The study recommends that seasonally application of crop residues in legume cereal cropping systems with seasonally application of powdered elemental S at a level of 300 kg S/fed and N-fertilizer at the height levels (180 kg N/fed) is the best treatment for producing high production of maize crop and improving fertility status of calcareous sandy soil.

***Keywords**: Crop sequence, Crop residues, Elemental sulfur, N-fertilization, Maize productivity, Sandy calcareous soil.*

Introduction

In Egypt, the calcareous soils constitute about 25-30% of the total area (Abo-Elela, 2002). The following approaches are often applied for conservation agriculture as well as improving calcareous soil physico-chemical characteristics, plant growth and productivity of planted crops: (1) Use minimum tillage (2) Use of good crop rotation or crop sequences (2) Application of organic materials or crop residues (3) Supplementation and management of nitrogen and other nutrients (4) Application of sulfur or other acidifiers for partially neutralizing the $CaCO_3$ present in soil (Ali, 2008; Dendooven *et al*., 2012).

Abd El-Halim *et al.* (2001) reported that productivity of peanut, soybean, maize and pearlmillet in summer season were much higher following clover or lentil than after wheat or barley.

Crop residues are the parts of plants left in the field after crops have been harvested and threshed. The total yield of agricultural residues in Egypt has been as much as 24 millions tons per year, which is equivalent to 120 million kg N, 130 millions kg P, and 1,300 million kg K. of the used crop residues in the field which not only enhanced the content of organic matter in soil and increased the crop production, but also decreased the total amounts of chemical fertilizer consumption, as well as the environmental concerns (Safwat *et al*., 2003).

Elemental S is the most effective soil acidifier; and finely ground elemental S is converted quickly to H_2SO_4 in the soil through microbial action (Imas and Sheva, 2000). So, Many investigators (Attia and El-Dsouky, 1996; Heydarnezhad *et al.* 2012) reported changes produced by addition of elemental sulfur to calcareous soils as it decreased soil pH and increased availability of P, Fe, Mn, Zn and Cu.

On sandy soil, Hassanein *et al.* (2007) reported that the highest nitrogen level (180 kg/fed) applied to the maize hybrid Single Cross 10 gave the significantly highest grain yield, straw yield and biological yield.

The objective of this study was to examine the impact effect of crop sequence & crop residues as a soil cultural treatment, S-application and N-fertilizer levels on the productivity of maize crop grown on sandy calcareous soil.

Materials and Methods

Site and experimental description

Field experiment in summer season of 2010 in split spit plot design with thee replicates was conducted under minimum soil tillage conditions at Arab El-Awammer Research Station, Agric Res. Center (ARC)., Assiut Governorate, Egypt to detect the production of maize and soil fertility as influenced by previous and immediately soil cultural treatments in main plot, levels of powder elemental S (zero and 300 kg S/fed) in the sub plots and mineral nitrogen fertilization levels (120 and 180 kg N/fed) in the sub sub plots. The four soil cultural treatments in main plot were two different crop sequences with crop residues completely removed (-CR) or with crop residues incorporated in soil surface layer 0-25 cm (+CR). The different two sequences (depend on it's inclusions from legume crop) were:-

Year	2009	2010	legume crop%
Sequence 1 = wheat –	maize – wheat –	<u>maize</u>	(0%)
Sequence 2 = wheat –	maize – clover –	<u>maize</u>	(25%)

The soil of the experimental site is calcareous sandy and it is classified as typic torripsamments. The important physical and chemical characteristics of representative soil samples from the surface (0-25 cm) layers of the field experimental site are shown in Table (1).

Treatments description

Under sprinkler irrigation system on fallow soil, two field experimental seasons in 2009 (winter and summer seasons) was carried out in split plot design (4 × 2 factorial) with three replicates to test the response of crops to soil cultural treatments (integration between crop sequence and crop residues) and sulfur application. But in the third and fourth seasons, two N-fertilizer levels were applied as a new factor in sub sub plots. Hence the experimental design was split split plot design (4 × 2 × 2 factorial) with three replicates area of each was1/350 feddan (3m × 4m = 12m^2). At harvest the aboveground residues of all crops were completely removed from the experimental plots and chopped into short pieces (approximatily 3-8 cm pieces). Soil was ploughed by chisel plough (minimum tillage) then divided into experimental plots and before cultivating the next crop in crop sequences by 14 to 18 day, the chopped crop residues of the previous crop was spreader on the plots and incorporated with the surface layer manually (+ CR) or not (-CR).

Table 1. Physical and chemical characteristics of representative soil samples from the field experimental site of the surface layer (0-25 cm).

Soil Properties	Unit	Values*
Particle size distribution		
Sand	(%)	91.10
Silt	(%)	5.65
Clay	(%)	3.25
Texture grade		Sandy
Physical properties		
Saturation	% (w/w)	22.9
Field capacity	% (w/w)	10.6
Wilting point	% (w/w)	4.3
Organic matter	(%)	0.57
Total $CaCO_3$	(%)	31.9
Chemical properties		
pH (1 : 1 water suspension)**		8.35
EC (1 : 1 extract)	dS/m	0.53
Total nitrogen	(%)	0.013
Available-P	(mg/kg)	8.50
Available-K	(meq/100g soil)	0.13

*Each value represents the mean of three replications
**Each value of pH (negative logarithmic value) converts to the original value by antilog equation to estimate the mean of three replications and converts again to pH value.

The experimental soil was irrigated by small quantity of irrigation water every 3 days until cultivating the next crop. The chopped crop residues were applied at rates of 3.4, 3.6 and 1.8 ton fed^{-1} from wheat, maize and Egyptian clover (fourth cut) straw residues respectively.

In the sub plots; elemental S at tested levels (zero and 300 kg powder

S/fed) were broadcasted and thoroughly mixed with the surface soil layer (0-25cm) every season before cultivating the next crop. In the sub sub plots nitrogen fertilizer as ammonium nitrate (33.5% N) at tested levels (low and high) was used. The low N fertilizer for the different crops were 60, 120 and 15 kg N/fed while the high N fertilizer were 120, 180 and 45 kg N/ fed for wheat, maize and clover, respectively.

Maize cultivated in summer season of 2010

The chopped crop residues of the previous crop were spreaded over the plots and manually incorporated with the surface layer of the soil (+ CR) to be compared with plots without crop residues (-CR). Before sowing maize granular superphosphate (15.5% P_2O_5) at a rate of 200 kg/fed, and elemental S at the tested level (zero and 300 kg powder S/fed) were broadcasted and thoroughly mixed with soil surface layer (0 - 25cm). Maize seeds (*Zea mays* L. cv. single hybrid 10) were planted in 29th May by drilling 2 - 4 seeds in each hill 4-5 cm deep, 20 cm apart and 60 cm distance between rows. After two weeks from sowing; seedlings were thinned to 2 plants /hill and after three weeks seedlings were thinned to 1 plants /hill. Ammonium nitrate (33.5 %N) was added at the tested levels (120 and 180 kg N/fed), 8 kg N/fed was broadcasted after 4 days from sowing and the rest of N fertilizer was added in six equal doses, after 14 - 28 - 35 - 42, 49 and 54 days from sowing. Potassium sulfate (48% K_2O) was, added at a rate of 50 kg /fed in two equal doses after 42 and 54 days from sowing. Chelated Fe, Mn and Zn in liquid solution, containing 200 ppm of each was used as foliar spray at a rate of 300 L/fed, sprayed twice after 30 and 50 days from sowing.

Plant sampling for growth measurements

Three random plant samples were taken from each plot at blooming start in 62 days after sowing. Plants height (cm), shoot fresh weights were immediately determined, then plants were dried at 70 $^{\circ}$C and their dry weights were determined.

Measurements of yield and yield components

At harvest (after 115 days from sowing), total yield of each plot was manually harvested, dried for 2 weeks and weighted. After threshing grain weights were determined, then total grain, straw yields per feddan and seed index were calculated. Samples of grains were taken from each plot for chemical analysis.

Soil sampling

After harvesting; soil of each plot was sampled. From each plot, 2 random soil cores were taken (0 - 25 cm depth). Soil cores were thoroughly mixed, air-dried and ground to pass a 2-mm sieve and stored for analysis.

Soil analysis

At the beginning of the study, soil mechanical analysis was carried out using pipette method according to Klute (1986). Water saturation, field capacity and wilting point were determined according to Klute (1986). Organic matter content, total $CaCO_3$, soil pH, electrical conductivity, total nitrogen, available phosphorus and potassium were determined according to Jackson (1973).

Analysis of plants and crop residues

Plant samples and crop residues were digested according to Parkinson and Allen, 1975. The digested materials were subjected to analysis for the determinations of total N by micro-kjeldahl procedure, total P was determined coloremetrically by the stannous chloride phosphomolybdic-sulfuric acid method and total K was determined by the flame photometric method according to Jackson (1973).

The results of chemical analysis of the residues of wheat, clover and maize are shown in Table (2).

Table 2. Chemical analyses of crop residues for wheat, clover and maize that was used in the experiment.

Properties of Crop Residue	Values*		
	Wheat residues	Clover residues	Maize residues
Organic matter (%)	60.3	68.1	63.6
Organic carbon (%)	35.0	39.5	36.9
Total N (%)	0.36	1.77	0.58
C/ N ratio	97.2	22.4	63.6
Total P (%)	0.07	0.16	0.08
Total K (%)	1.89	1.81	1.90

*Each value represents the mean of crop residues analyses of different seasons

Statistical analysis

All obtained data were subjected to statistical analysis of variance and treatment means were compared for significant differences using the LSD at $p = 0.05$**.** The MSTAT-C computer program was used to perform all the analysis of variance in agreement with the procedure outlined by Steel and Torrie (1982).

Results and Discussion

The data obtained on maize growth at 62 days, yield and yield components are shown in Tables (3, 4 and 5). Also, the data obtained on soil properties after harvesting maize 2010 are shown in Table (6).

Maize growth parameters

Maize plant fresh and dry weights (g)

Data illustrated in Table (3) show that maize fresh and dry weights obtained from the plant samples at plant bloom (62 days from sowing) were increased significantly due to different soil cultural treatments.

Table 3. Effect of soil cultural treatment, sulfur application and N-fertilizer levels on maize growth at bloom day in summer season of 2010.

Soil Cultural and Sulfur Treatments		**Average Fresh Weights of 3 Plants(g)**			**Average Dry Weights of 3 Plants(g)**			**Average Heights of 3 Plants (cm)**		
Soil Cultural	Sulfur kg/fed	N kg/fed		Mean	N kg/fed		Mean	N kg/fed		Mean
		120	180		120	180		120	180	
Sequence 1	0	621	673	647	107.6	108.7	108.2	214	222	218
	300	614	705	659	109.7	112.4	111.1	230	229	230
Mean		617	689	653	108.7	110.6	109.6	222	226	224
Sequence 1 + CR	0	754	785	770	121.6	130.3	125.9	224	231	228
	300	823	903	863	144.4	148.6	146.5	241	239	240
Mean		788	844	816	133.0	139.4	136.2	233	235	234
Sequence 2	0	679	629	654	106.2	114.6	110.4	224	224	224
	300	664	784	724	118.7	134.3	126.5	238	236	237
Mean		672	707	689	112.4	124.5	118.5	231	230	231
Sequence 2 + CR	0	751	961	856	127.4	168.3	147.8	253	255	254
	300	855	1011	933	148.7	168.5	158.6	253	254	254
Mean		803	986	895	138.0	168.4	153.2	253	254	254
Mean S × N	0	701	762	732	115.7	130.5	123.1	229	233	231
	300	739	851	795	130.4	140.9	135.6	241	240	240
Mean		720	806	763	123.0	135.7	129.4	235	236	236
LSD 0.05	**C**	35.3			10.76			15.4		
	S	31.9			4.33			n.s		
	C×S	n.s			8.67			n.s		
	N	52.1			6.96			n.s		
	C×N	n.s			13.92			n.s		
	S×N	n.s			n.s			n.s		
	C×S×N	n.s			n.s			n.s		

Sequence 1 = continuous cereal crops (wheat and maize), Sequence 2 = three seasons cereal crops followed by one season legume crop (clover), +CR = every season crop residues of previous crop incorporated in surface soil layer.

The plant fresh and dry weights varied between 653 and 109.6g, respectively in sequence 1 to 895 and 153.2g, respectively in sequence 2 + CR (Table 3). Moreover, there were significant increases in plant fresh and dry weights at plant bloom as a result of crop residues incorporated in soil surface layer in crop sequence 1 and 2 as compared with the same treatment but with crop residues completely removed (crop sequence 1 and 2 respectively).

The results of this field experiment are in agreement with those of other investigators indicating the positive effects of crop residues on plant growth and yield of many crops especially under newly reclaimed soil conditions (kumar and Prasad 2014; Monsefi *et al.*, 2014; Sepahvand and Mehranzadeh, 2013; Soleymani *et al.,* 2016).

On the other hand, calculating the average of two crop sequences regardless crop residues effect, the obtained data indicated that, cultivating 25% from crops by legume crop improvement maize plant growth as compared with continues cereal crops (Table 3).

Sulfur application seasonally, at the rate of 300 kg/fed, induced significant improvement in maize growth parameters (plant fresh and dry weights). Increasing N–fertilization levels from 120 to 180 kg N/fed caused significant increases in maize growth parameters (plant fresh and dry weights).

The results presented in Table (3) show two significant interactions on maize plant dry weight at plants bloom, the first interaction between soil cultural treatments & S-application, and the second interaction between soil cultural treatments and N-fertilizer levels. In this respect Attia and El-Dsouky, (1996) reported that the best synergetic effect for wheat plants grown on sandy calcareous soil was obtained by combined of those treatment, 30 m^3 organic manure +1 ton S with inoculation + 120 kg N/fed.

Maize plant height (cm)

Maize plant height obtained from the plant samples at plant bloom (62 days from sowing) was increased significantly due to different soil cultural treatments. The plant height varied from 224 cm in sequence 1 to 254 cm in sequence 2 + CR (Table 3). This agrees with the results obtained by Rahman (2004); Verma and Pandey (2013). They reported that crop residues have positive effect on wheat yield and plant height.

Maize grain yield, straw yield and biological yield (kg/fed)

Data illustrated in Table (4) show that maize yield and yield components (grain yield, straw yield and biological yield) were increased significantly due to different soil cultural treatments.

The results in Table (4) reflect great differences in response of maize yield to the soil cultural treatments. The obtained values of maize yield components could be descendingly ranked in the following older; The sequence 2 + crop residues came in the first rank recording the highest maize grain yield, straw yield and biological yield while sequence 1 + crop residues was the second. The contentious cereal crop sequence came in the last rank. Also, treatment (sequence 2 + crop residues) resulted in significant percent increases in grain yield, straw yield and biological yield estimated by 24.3%, 24.7% and 24.5%, as compared with the control (contentious cereal crop sequence). While treatment (sequence 1 + crop residues) resulted in significant increases in grain yield, straw yield and biological yield estimated by 13.5%, 15.9% and 14.9% respectively as compared with control. Also, the increase in maize yield and yield components of treatment sequence 2 + crop residues was significant as compared by treatment sequence 1 + crop residues.

Furthermore, crop residues incorporated with soil resulted in 19.9%, 18.6% and 19.1% increases in grain yield, straw yield and biological yield of maize, respectively as compared with averages of crop residues completely removed. This probably happened due to more nutrients released from crop residues. These findings are in agreement with those of Javadianfar and Siadat (2013); Kravchenko and Thelen (2007); Soleymani *et al.* (2016).

On the other hand crop sequences had little effect on maize yield and yield components. Averages of crop sequence 1 were 2371, 3257 and 5628 kg/fed for grain, straw and biological yields, respectively. While averages of crop sequence 2 were 2471, 3434 and 5905 kg/fed for grain, straw and biological yields, respectively. This estimated number means that, crop sequence 2 resulted only in 4.2%, 5.4% and 4.9% increases in grain, straw and biological yields, respectively compared with sequence1 without legume crops.

Sulfur application, at the rate of 300 kg/fed seasonally, induced significant improvement on maize yield and yield components parameters (grain, straw and biological yield) as compared with the zero S.

Table 4. Effect of soil cultural treatments, sulfur application and N-fertilizer levels on maize yield and yield components (2010).

Soil cultural and Sulfur Treatments		**Grain Yield kg/fed**			**Straw Yield kg/fed**			**Biological Yield (kg/fed)**			**Seed Index (100 Grains/g)**		
Soil Cultural	Sulfur kg/fed	N kg/fed		Mean	N kg/fed		Mean	N kg/fed		Mean	N kg/fed		Mean
		120	180		120	180		120	180		120	180	
Sequence 1	0	1824	2198	2011	2427	3031	2729	4251	5229	4740	23.93	25.51	24.72
	300	2364	2497	2431	3166	3445	3305	5530	5943	5736	25.99	26.03	26.01
Mean		2094	2348	2221	2796	3238	3017	4891	5586	5238	24.96	25.77	25.36
Sequence 1 + CR	0	1962	2471	2216	2746	3432	3089	4708	5902	5305	25.22	27.13	26.18
	300	2800	2854	2827	3785	4025	3905	6584	6880	6732	28.91	29.56	29.24
Mean		2381	2663	2522	3265	3729	3497	5646	6391	6019	27.07	28.35	27.71
Sequence 2	0	1857	2277	2067	2670	3185	2928	4527	5461	4994	23.32	27.20	25.26
	300	2270	2326	2298	3224	3342	3283	5495	5668	5582	25.73	26.17	25.95
Mean		2064	2301	2183	2947	3263	3105	5011	5565	5288	24.52	26.69	25.61
Sequence 2 + CR	0	2084	2916	2500	3099	4045	3572	5183	6961	6072	25.06	28.26	26.66
	300	3018	3021	3020	3852	4056	3954	6870	7077	6974	29.85	29.43	29.64
Mean		2551	2969	2760	3475	4050	3763	6026	7019	6523	27.45	28.84	28.15
Mean S × N	0	1932	2465	2199	2736	3423	3079	4667	5888	5278	24.38	27.03	25.70
	300	2613	2675	2644	3507	3717	3612	6120	6392	6256	27.62	27.80	27.71
Mean		2272	2570	2421	3121	3570	3346	5394	6140	5767	26.00	27.41	26.71
LSD 0.05	**C**	229.3			208.0			412.2			2.19		
	S	120.2			146.5			249.5			0.66		
	C×S	n.s			n.s			n.s			1.33		
	N	104.1			158.4			241.0			1.01		
	C×N	n.s			n.s			n.s			n.s		
	S×N	147.3			316.8			340.9			1.42		
	C×S×N	n.s			n.s			n.s			n.s		

Sequence 1 = continuous cereal crops (wheat and maize), Sequence 2 = three seasons cereal crops followed by one season legume crop (clover). + CR = every season crop residues of previous crop were incorporated in surface soil layer.

The results of this field experiment are in agreement with those of other investigators indicating that S-application to soil, especially in powdered form or small sized particles is beneficial for enhancing plant growth as well as being good amendment for improving soil properties and productivity (Ali, 2008; Attia and El-Dsouky, 1996).

Also, N levels at the rate of 180 kg N/fed, induced significant improvement in all maize yield parameters as compared with 120 kg N/fed (Table 4). Compared with 120 kg N/fed the increases in grain, straw and biological yields were 13.1% 14.4% and 13.8% respectively due to the higher rate of nitrogen (180 kg N/fed). Results of this field experiment are in accordance with those of other investigators confirming the stimulative effect of increasing N-fertilization, especially on newly cultivated soils with low O.M. for improvement of growth and yield of maize and wheat (Abd El-Qahar and Ahmad, 2016; El- Afandy *et al*., 2007; Hassanein *et al.*, 2007).

Results presented in Table (4) show significant dual interactions between S-application and N-fertilizer levels on maize grain yield, straw yield and biological yield. These results are similar to those reported by other investigators recording the synergetic improvements in maize yield observed by the combined application of S with N-fertilizer (Jaliya *et al.,* 2016; Ray and Spider, 2000).

Seed index (g)

Data obtained regarding to seed index at harvest as influenced by soil cultural treatments (Table 4) indicated that, seed index (100 grains weight) was increased significantly due to different soil cultural treatments. The 100 grains weights varied from 25.4 g sequence 1 without crop residues to 28.2 g in sequence 2 with crop residues (Table 4).

Seasonally sulfur application, at the rate of 300 kg/fed induced significant improvement in maize seed index at harvesting as compared with the zero S (Table 4). These results are in agreement with Ali, (2008).

On the other hand, N-fertilizer level, at the rate of 180 kg N/fed induced significant increases in maize seed index at harvesting as compared with the 120 kg N/fed (Table 4).

The data also suggested that there are two significant interactions, the first between soil cultural treatments & S-application, while the second significant interaction was between S-application and N-fertilizer levels on maize seed index at final harvesting. This finding is agreed with Attia and El-Dsouky, 1996.

N and P uptake by maize grains (kg/fed)

It could be deduced form the data presented in Table (5) that N and P uptake by maize grain yield were significantly increased due to different soil cultural treatments. Nitrogen uptake by maize grain yield was almost similar with a value of 34.8 kg/fed in sequence 1 or sequence 2 without crop residues. Mean N uptake was increased to 45.0 kg/fed in sequence 2 with crop residues. In the same time P uptake by maize grain yield varied from 8.1 kg/fed in sequence 2 without crop residues to 11.1 kg/fed in sequence 2 with crop residues incorporated in soil surface layer.

Table 5. Effect of soil cultural treatments, sulfur application and N-fertilizer levels on N & P uptake by maize grain yield in summer season of 2010.

Soil Cultural and Sulfur Treatments		**N uptake by Grains (kg/fed)**			**P uptake by Grains (kg/fed)**		
Soil Cultural Treatments	Sulfur (kg/fed)	N (kg/fed)		Mean	N (kg/fed)		Mean
		120	180		120	180	
Sequence 1	0	27.41	34.69	31.05	6.70	8.86	7.78
	300	37.26	39.79	38.52	8.68	10.14	9.41
Mean		32.34	37.24	34.79	7.69	9.50	8.60
Sequence 1 + CR	0	29.50	39.55	34.52	7.70	11.19	9.44
	300	43.52	47.11	45.32	11.72	12.98	12.35
Mean		36.51	43.33	39.92	9.71	12.08	10.90
Sequence 2	0	29.09	36.69	32.89	6.63	8.45	7.54
	300	35.62	37.80	36.71	8.31	9.00	8.66
Mean		32.35	37.24	34.80	7.47	8.73	8.10
Sequence 2 + CR	0	33.62	47.40	40.51	7.98	11.79	9.89
	300	48.59	50.21	49.40	11.89	12.74	12.32
Mean		41.11	48.81	44.96	9.94	12.27	11.10
Mean **S × N**	0	29.91	39.58	34.74	7.25	10.07	8.66
	300	41.25	43.73	42.49	10.15	11.22	10.68
Mean		35.58	41.65	38.62	8.70	10.64	9.67
LSD 0.05	**C**	2.85			0.41		
	S	1.11			0.44		
	C×S	2.22			0.88		
	N	1.76			0.44		
	C×N	n.s			n.s		
	S×N	2.49			0.62		
	C×S×N	n.s			n.s		

Sequence 1 = continuous cereal crops (wheat and maize), Sequence 2 = three seasons cereal crops followed by one season legume crop (clover), + CR = every season crop residues of previous crop were incorporated in surface soil layer.

Furthermore, significant increases in N and P uptake by maize grain yield were obtained as a result of crop residues incorporated in soil surface layer in crop sequence 1 and 2 as compared with its values with crop residues completely removed. Also, crop residues incorporated in the soil resulted in 22.0%, and 31.8% increases in N and P grain uptake. This probably happened due to the increases in nutrient availability in the soil as well as to the nutrients released from crop residues after decomposition. This finding is in agreement with those obtained by Mohammad *et al.,* 2012; Zhang *et al.,* 2016. They found that organic residues have been considered as the preferable nutrient source to improve fertilizer use efficiency. Combining N fertilizer with medium quality residues has the potential to change N transformations through a negative interactive effect on mineral N. Similarly, straw incorporation, in the soil resulted in an increase in microbial biomass and N mineralization (Singh, 1995), Furthermore Mohammad *et al.,* 2010 and Safwat *et al.,* 2003 reported that the possible reason for improvement N uptake by plant in no tillage with crop residues retained treatment might be due to lower soil surface temperature and water evaporation that might have helped to reduce the N-losses from fertilizer.

Sulfur application, at the rate of 300 kg S/fed, induced significant improvement and resulted in 22.31% and 23.33% increases in N and P uptake by maize grains as compared with the zero S (Table 5). These findings are in line with those of Ali, (2008) who observed that the N and P uptake by maize grains were affected significantly by S-application and N-fertilizer level. Also, Eisa *et al.* (2003) recorded that sulfur application exhibited a relatively high content of N, P and K in maize grains and straw in calcareous soil.

Increasing N–fertilizer level from 120 to 180 kg N/fed caused significant increases in N and P uptake by maize grain yield. These findings are in agreement with those obtained by Hassanein *et al*., 2007.

The results in Table (5) show two significant interactions, the first interaction between soil cultural treatments & sulfur application and the second interaction was between sulfur application & N-fertilizer levels on N and P uptake by maize grains. This may be due to the increase in available N and P in soil under regaining crop residues with S-application and under high N-fertilizer level with S-application. In this respect Attia and El- Dsouky, 1996 reported that the best synergetic effect for N uptake by wheat grown on sandy calcareous soil was obtained by combined of those treatments, 30 m^3 organic manure +1 ton S with inoculation + the height fertilizer level of N, 120 kg N/fed.

Soil properties after maize 2010 harvesting

It is worth to mention that soil properties after maize yield of 2010 harvesting (soil organic content, soil total N, soil available P and soil pH) were improvement significantly due to different soil cultural treatments (Table 6).

Generally, incorporated of crop residues as soil cultural treatments with any crop sequences for many seasons before maize 2010 cultivated resulted in significant increases in soil organic content, soil total N and soil available P as compared with treatments cultivated with crop residues completely removed. Averages of this increases in soil organic content (%), soil total N (ppm) and soil available P (ppm) were 0.16%, 122 and 3.24 ppm, respectively (Table 6). This probably happened due to more nutrients release from crop residues.

This finding is agreed with Ailincai *et al.,* (2010); Ghimire *et al*., (2016).

On the other hand soil cultural treatments resulted in significant decreases in soil pH after maize 2010 harvesting. The best treatment in decreasing soil pH was sequence 2 + crop residues which resulted in significant decreases between it and other treatments with crop residues completely removed. In this respect Huang *et al.* (2004); Millar and Baggs (2004), reported that, organic wastes can influence soil pH through accumulation of CO_2 and organic acids during their decomposition in the soils.

Seasonally S-application at the rate of 300 kg/fed to soil affected soil properties as shown from the results presents in Table (6), in addition to inducing significant reduction in soil pH, it resulted in significant increase in soil total N and soil available P at harvesting maize of 2010. Elemental sulfur can be oxidized by many soil microorganisms and forming sulfuric acid, consequently it react with soil $CaCO_3$ resulting in $CaSO_4$. The latter can be lonized to Ca^{2+} and $SO4^{2-}$, then Ca^{2+} can be improved soil aggregation and permeability and SO_4^{-2} reduced soil pH. Theses results are in agreement with those by Awadalla *et al.* (2003).

This probably happened due to more nutrients availability as a result of decreasing pH of sandy calcareous soil. This finding is agreed with Abdo *et al.,* (2010); Heydarnezhad *et al.* (2012).

Data presented in (table 6) show that nitrogen fertilizer level at the rate of 180 kg N/fed, induced significant increase in soil total N. This finding is agreed with Khadr *et al.,* (2004). Also, Nitrogen fertilizer level at the rate of 180 kg N/fed induced significant decreases in soil pH as compared with 120 kg N/fed level.

Table 6. Soil properties changes of maize crop as influenced by soil cultural treatments, sulfur application and N-fertilizer levels during summer season of 2010

Soil Cultural and Sulfur Treatments		**Soil Organic Matter (%)**			**Soil Total N (ppm)**			**Available P (ppm)**			**pH in (1:1) soil suspension**		
Soil Cultural	Sulfur kg/fed	N kg/fed		Mean	N kg/fed		Mean	N kg/fed		Mean	N kg/fed		Mean
		120	180		120	180		120	180		120	180	
Sequence 1	0	0.87	0.85	0.86	470	497	484	7.81	8.40	8.10	8.15	8.07	8.11
	300	0.87	0.87	0.87	503	513	508	8.99	9.47	9.23	7.97	7.82	7.90
Mean		0.87	0.86	0.86	486	505	496	8.40	8.93	8.67	8.06	7.95	8.00
Sequence 1 + CR	0	1.00	1.05	1.02	569	609	589	10.96	11.54	11.25	8.07	8.01	8.04
	300	1.01	1.04	1.02	619	647	633	12.00	12.94	12.47	7.72	7.66	7.69
Mean		1.00	1.05	1.02	594	628	611	11.48	12.24	11.86	7.89	7.84	7.87
Sequence 2	0	0.84	0.85	0.84	489	502	495	7.30	7.46	7.38	8.11	8.02	8.07
	300	0.86	0.82	0.84	512	542	527	7.97	8.57	8.27	7.86	7.68	7.77
	Mean	0.85	0.84	0.84	501	522	511	7.64	8.02	7.83	7.98	7.85	7.92
Sequence 2 + CR	0	1.00	1.01	1.01	603	631	617	10.04	10.61	10.33	7.97	7.85	7.91
	300	0.96	1.00	0.98	610	638	624	11.49	12.34	11.92	7.74	7.66	7.70
Mean		0.98	1.01	0.99	606	634	620	10.77	11.47	11.12	7.85	7.75	7.80
Mean **S × N**	0	0.92	0.94	0.93	533	560	546	9.03	9.50	9.26	8.07	7.99	8.03
	300	0.93	0.93	0.93	561	585	573	10.11	10.83	10.47	7.82	7.71	7.76
Mean		0.93	0.94	0.93	547	572	560	9.57	10.17	9.87	7.95	7.85	7.90
LSD 0.05	**C**	0.05			36.1			2.34			0.07		
	S	n.s			18.3			0.73			0.08		
	C×S	n.s			n.s			n.s			n.s		
	N	n.s			18.4			n.s			0.07		
	C×N	n.s			n.s			n.s			n.s		
	S×N	n.s			n.s			n.s			n.s		
	C×S×N	n.s			n.s			n.s			n.s		

Sequence 1 = continuous cereal crops (wheat and maize), Sequence 2 = three seasons cereal crops followed by one season legume crop (clover), +CR = every season crop residues of previous crop incorporated in surface soil layer.

This may be due to the effect of ammonium fertilizer on lowering the soil pH during nitrification because protons are released in this process ($2NH_4^+ + 3O_2 \longrightarrow 2NO_3^- + 8H^+$).This finding is in accordance with those obtained by Imas and Sheva (2000).

The results presented in Table (6) show that there were no significant interactions between soil cultural treatments, S-application and N-fertilization levels on soil properties after summer maize of 2010 harvested.

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تأثير بعض المعاملات الزراعية، إضافة الكبريت العنصري والتسميد النيتروجينى على إنتاجية الذرة الشامية وخصوبة الأراضي الرملية الجيرية

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الملخص

استهدفت هذه الدراسة تحسين إنتاجية الأراضي الرملية الجيرية بمحطة بحوث عرب العوامر الزراعية بمحافظة أسيوط، لذلك صممت تجربة بالموسم الصيفي لسنة ٢٠١٠ تحت ظروف معدل الحراثه المنخفض في تصميم قطع منشقة مرتان بثلاث مكررات، لدراسة التأثير السابق والحالي لكلاً من بعض المعاملات الزراعية في القطع الرئيسية، إضافة الكبريت الناعم (صفر – ٣٠٠ كجم/فدان) في القطع المنشقة مرة واحدة والتسميد النيتروجينى (١٢٠ – ١٨٠ كجم نيتروجين/ فدان) في القطع المنشقة مرتين على إنتاجية الذرة الشامة وخصوبة التربة. وكانت بعض المعاملات الزراعية في القطع الرئيسية عبارة عن عدم إضافة المخلف الزراعي و إضافة المخلف الزراعي لكل محصول قبل زراعة المحصول التالي في التعاقب المحصولي طبقا لاثنين من التعاقبات المحصولية كالتالي:-

لسنة	٢٠٠٩	٢٠١٠	نسبة المحصول البقولي
التعاقب الأول :-	قمح – ذرة شامية –	قمح – ذرة شامية	(٠% محاصيل بقوليه)
التعاقب الثاني:-	قمح – ذرة شامية –	برسيم – ذرة شامية	(٢٥% محاصيل بقوليه)

أظهرت النتائج أن استخدام معاملة التعاقب المحصولي الثاني (قمح – ذرة شامية – برسيم – ذرة شامية) مع قلب المخلف الزراعي أدت إلى الحصول على اعلي زيادات في نمو الذرة الشامية عند الأزهار، محصول الذرة الشامية ومكوناته، النيتروجين والفوسفور الممتصين بواسطة حبوب الذرة وتحسين خصوبة التربة (النسبة المئوية للمادة العضوية، النيتروجين الكلى في التربة، الفوسفور الميسر و pH التربة)، كذلك فعلت معاملة إضافة الكبريت الناعم بمعدل ٣٠٠ كجم للفدان كل موسم وكذلك معاملة ١٨٠ كجم أزوت للفدان. لذلك يمكن التوصية بأن معاملة التعاقب المحصولي الثاني (قمح – ذرة شامية – برسيم – ذرة شامية) مع قلب المخلف الزراعي بالإضافة إلى الكبريت الناعم بمعدل ٣٠٠ كجم للفدان كل موسم مع معاملة ١٨٠ كجم أزوت للفدان أدت إلى الحصول على اعلي إنتاجية للذرة الشامية وتحسين خصوبة التربة الرملية الجيرية.

الكلمات الدالة: التعاقب المحصولي، مخلفات المحاصيل، الكبريت العنصري، التسميد النيتروجينى، إنتاج الذرة الشامية، الأراضي الرملية الجيرية.