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Effect of Crop Sequences, Crop Residues, Sulfur Application and N-Fertilizer on Wheat Crop Grown on Sandy Calcareous Soils

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Abstract:

Under minimum soil tillage conditions a field experiment for four seasons (2009 and 2010) was conducted to detect the effect of integration between crop sequences and crop residues application as a soil management strategies, S-application and N- fertilizer levels on some crops grown on the sandy calcareous soil of Arab El-Awamer Experimental Station, Assiut governorate. Egypt. At the fifth growth season, during the winter of 2010/2011 the field experiment was completed and wheat field experiment with 3 replications in a split split plot design was designed to study the response of wheat crop to the previous and continued eight soil management treatments in main plots, rates of powder elemental S (zero and 300 kg S/fed every season) in the sub plots and mineral nitrogen fertilizer levels (60 and 120 kg N/fed) in the sub sub plots. The eight soil management treatments in main plot were four different crop sequences with crop residues completely removed (-CR) or with crop residues incorporated in soil surface layer 0-25 cm (+CR). The different four sequences (depend on it's inclusions from legume crops) were:-

Sequence 1 = wheat - maize - wheat - maize - wheat (0% legume crops)
Sequence 2 = wheat - maize - clover - maize - wheat (25% legume crops)
Sequence 3 = wheat - maize - clover - peanut - wheat (50% legume crops)
Sequence 4 = wheat - peanut - clover - peanut - wheat (75% legume crops)

The obtained results showed that wheat growth, NP uptake at spiking expulsion, yield and yield components were increased significantly due to different soil managements strategies (different crop sequences with or without crop residues) as compared with continuous cereal crop sequence with crop residues completely removed. Also, the treatment sequence 4 + CR caused increases in grain, straw and biological yield of wheat estimated by 78.8%, 55.1% and 63.0%, respectively. While, treatment sequence 3 + CR caused increases in grain, straw and biological yield estimated by 69.1%, 49.7% and 56.2%, respectively as compared with continues cereal crop sequence 1 (control). Furthermore, the increase was recorded in wheat grain yield of treatment sequence 4 + CR was significant as compared with treatment sequence 3 + CR.

Sulfur application, at the rate of 300 kg/fed seasonally, induced significant improvement on wheat growth, NP uptakes at spiking expulsion, yield and yield components as compared with the zero S.

Nitrogen fertilizer levels at the rate of 120 kg N/fed, induced significant improvement on wheat growth, NP uptake at spiking expulsion, yield and yield components as compared with 60 kg N/fed. Furthermore, the increases in grain yield, straw yield and biological yield were 12.2% 13.6% and 13.1%, respectively due to the rate of 120 kg N/ fed.

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In summary, crop residues applied in legume cereal cropping system especially highly legume crop sequence (75 % legume crops) resulted in higher yield and yield components of wheat crop as well as powdered S-application at 300 kg S/fed seasonally and N-fertilizer level at 120 kg N/fed. But the question, Is the crop sequence including 75% legume crops will be suitable for all other crops (clover, maize and peanut.

Keywords: crop sequence, crop residues, S-application, N-fertilizer levels and sandy calcareous soil.

Introduction:

Wheat is an exhaustive crop, which not only depletes soil fertility but also degrades soil physical properties (Akhtar *et al.,* 2014). In Egypt the cultivated wheat area was 3.33 million fed with total production of 8.7 million tons with average yield of 2613 kg fed^{-1} during 2013-2014 (Hamza and Beillard, 2014). On the other hand, the demand for wheat production is increasing with increasing population of Egypt day by day and the present production of wheat is not sufficient to meet the requirements of population. So to meet the population demand for wheat production, it is a must to increase yield per unit area or bringing more area under cultivation will be required.

Most of newly reclaimed soil was sandy or sandy calcareous soils that's naturally occur in arid and semi-arid regions if their parent materials are rich in $CaCO_3$ and when the parent material is relativity young and has undergone little weathering (Brody and Weil, 1999). In Egypt, the calcareous soils constitute about 25-30% of the total area (Abou-Elela, 2002). The main problems in land utilization of calcareous soils in agriculture are: crusting of soil surface, cemented condition of the subsoil layers, poor physical characteristics, poor water retention, the high pH level results in low availability of nutrients especially nitrogen, phosphorus, essential micronutrients, and rapid nutrients fixation if added to the soil (Kadry, 1973).

The following approaches are often applied for improving calcareous soil physico-chemical characteristics, plant growth and productivity of planted crops: (1) Use of a good crop rotation or crop sequences (2) Application of organic materials or crop residues (3) Application of sulfur or other acidifiers for partially neutralization of the $CaCO_3$ present in soil (4) Supplementation and management of nitrogen.

Crop rotation is a series of different crops planted in the same field to improve soil quality. Monoculture on the other hand is the repeated planting of the same crop in the same field year after year (Thierfelder and Wall, 2011). The principal advantages of crop rotations could be summarized in the next: (1) increases in yield and yield components (2) maintenance and improving soil fertility (3) controlling weeds, pests and diseases (Thierfelder and Wall, 2011).

Crop residues are the parts of plants left in the field after the crops have been harvested and thrashed. It's a good source of plant nutrients, organic material added to the soil and are important components for the stability of agricultural ecosystems.

About 25% of nitrogen (N) and phosphorus (P), 50% of sulfur (S), and 75% of potassium (K) uptake by cereal crops are retained in crop residues, making them valuable nutrient sources (Singh and Singh, 2001).

Rahman (2004) reported that the highest wheat grain and straw yields were observed in the treatment of minimum tillage with crop residues of rice straw at 3 tonnes ha^{-1} and the lowest was observed in the minimum tillage without crop residues. Treatments can be ranked as follows: minimum tillage with crop residues > conventional tillage with crop residues > conventional tillage without crop residues > minimum tillage without crop residues.

Elemental sulfur is the most effective soil acidifier; and finely ground elemental S is converted quickly to H_2SO_4 in the soil through microbial action. So, many investgators reported that the soil acidulates especially elemental sulfur can improve nutrient availability in calcareous soils by decreasing soil pH. (Imas and Sheva, 2000).

Nitrogen requirements by wheat crop in Egypt were quite known as highly requirements. Zeidan *et al.* (2005) reported that N-fertilization up to 120 kg N/fed significantly increased dry weight of plants, flag leaf area and grain yield. Also, Ali *et al.* (2008) reported that application of 125 kg/fed ammonium nitrate in 8 splits along with FYM increased wheat grain and straw yields.

Attia and El-Dousuky 1996 concluded that the best synergistic effect for wheat plants was obtained by combination between these treatments; 30 m^3 organic manure + 1 ton S with microbial inoculation + 120 kg N/fed rather than their separate application

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

Materials and Methods:

Site description

Field experiments was designed at Arab El-Awammer Research Station, Agric Res. Center (A.R.C)., Assiut Governorate, Egypt. Daily maximum temperatures can reach up to 43 °C in June and July, while minimum temperatures can drop to 4 °C in December and January. The relative humidity varied between 37% and 47% during winter seasons (November-April) and summer seasons (May-October), respectively while the mean annual precipitation is approximately zero. Hence, summers are warm and dry, whereas winters are cold and dry. The soil of the experimental site is sandy calcareous and it is classified as typic torripsamments. The important physical and chemical characteristics of representative soil samples from the surface (0-25 cm) layer of the field experimental site are shown in Table (1).

Experimental description

After four growth seasons (2009 and 2010) from beginning the field experiment, a field experiment was designed in split split plot design with 3 replications to test the response of wheat crop to previous and recently eight soil management treatments in main plot, powder elemental S rates (zero and 300 kg powder S/fed every season) in the sub plots and levels of mineral nitrogen fertilization (60 and 120 kg N/fed as ammonium nitrate 33.5% N) in the sub sub plot. Area of each plot in sub sub plot was 3m × 4m = 12 m^2 = 1/350 fed.

The eight soil management strategies in main plots were four different crop sequences with crop residues completely removed (-CR) or with crop residue incorporated in soil surface layer 0-25 cm (+CR). The different four sequences (depends on it's inclusions from legume crops) were:-

Sequence 1 = wheat - maize - wheat - maize - wheat (0% legume crops)

Sequence 2 = wheat - maize - clover - maize - wheat (25% legume crops)

Sequence 3 = wheat - maize - clover - peanut - wheat (50% legume crops)

Sequence 4 = wheat - peanut - clover - peanut - wheat (75% legume crops)

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 $CaCO_3$	(%)	31.89
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

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 (8 × 2 factorial) with three replicates to test the response of crops to soil management strategies (integration between crop sequence and crop residues) and sulfur application. In the third, fourth and fifth seasons, two N- fertilizer levels were applied as a new factor in sub sub plot. 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). When soil samples were taken from each plot; the experimental soil was irrigated and after 3 to 5 days; soil was ploughed by chisel plough (minimum tillage), and divided into experimental plots. 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). The experimental soil was irrigated every 3 days until cultivating the next crop. The chopped crop residues were applied at rates of 3.4, 3.6, 1.8 and 2.4 ton fed^{-1} from wheat, maize, Egyptian clover (fourth cut) and peanut 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) each 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, 15 and 15 kg N/fed while the high N fertilizer were 120, 180, 45 and 45 kg N/ fed for wheat, maize, clover and peanut, respectively.

Wheat cultivation

The wheat field experiment was conducted during the winter growth season of 2010/2011. Crop residues were applied as described before. Granular superphosphate (15.5% P_2O_5) at a rate of 200 kg/fed, and elemental S at the tested levels (zero and 300 kg powder S/fed) were broadcasted and thoroughly mixed with soil surface layer (0 - 25cm) before sowing wheat seeds. Wheat grains (*Triticum aestivum L.* cv. Sids1) were sown by broadcasting at a rate of 85 kg/fed. Ammonium nitrate (33.5 %N) at the tested levels (60 and 120 kg N/fed) was applied in doses as follows: 8 kg N/fed was broadcasted after 4 days from sowing while the rest of N fertilizer quantity was added in six equal doses, after 14 - 28 - 42 - 56, 70 and 82 days from planting. Potassium sulfate (48% K_2O) was, added at a rate of 50 kg /fed in two equal doses after 42 and 70 days from sowing. Chelated Fe, Mn and Zn in liquid solution, containing 100 ppm of each was used as a foliar spray at rate of 0.57 L /plot (200 L/fed), sprayed twice after 65 and 95 days from planting.

Plant sampling for growth measurements:

Ten random plants were taken from each plot at start of spiking expulsion at 92 days after sowing. Shoot fresh weight was immediately determined, then plants were washed with tap water, followed by distilled water and dried at 70 °C and their dry weights were determined. Plant content of N and P (%) were determined in plant samples and plant uptake was calculated.

Measurements of yield and yield components:

Before wheat harvesting, plant heights (cm) of ten random plants were determined in each plot. After harvesting, total yield of six square meters from the center of each plot were manually harvested, dried for 10 days and weighted. After threshing, grain yield was determined, then total grain and straw yields per feddan and seed index were calculated. Spike average weights of ten random plants were determined.

Soil analysis

At the beginning of the study, soil mechanical analysis was carried out using pipette method according to Klute (1986). Saturation, field capacity and wilting point were determined according to Klute (1986). Organic matter content, total $CaCO_3$, soil pH, electric 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 for the residues of wheat, clover, maize and peanut are shown in Table (2).

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

Properties of Crop Residue	Values*			
	Wheat residues	Clover residues	maize residues	Peanut residues
Organic matter (%)	60.3	68.1	63.6	66.6
Organic carbon (%)	35.0	39.5	36.9	38.6
Total N (%)	0.36	1.77	0.58	1.33
C/ N ratio	97.2	22.4	63.6	29.0
Total P (%)	0.07	0.16	0.08	0.12
Total K (%)	1.89	1.81	1.90	2.08

*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 (version 2.10) 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:

Wheat growth parameters

Wheat plant fresh and dry weights at spiking expulsion (92 days from sowing) were increased significantly due to different management strategies (different crop sequences with or without crop residues) as compared with continuous cereal crop sequence with crop residues completely removed. The plant average fresh and dry weights varied from 7.99 and 2.57g, respectively in sequence 1 to 12.29 and 3.27g, respectively in sequence 4 + CR (Table 3).

Data in Table (3) show that mean averages of wheat plant fresh and dry weights were significantly increased with crop residues application as well as with increasing legumes crops percentage (Table 3). The increments in plant growth may be due to the enhancement effect of organic matter of crop residue or crop sequence which improved the physo-chemical and biological properties of soil. This may increase soil exchange capacity, available nutrients and this in turn, may result in stimulating plant growth. These results are similar to those of Miglierina *et al* 2000 and Akbari Moghaddam *et al*. 2011.

Sulfur application, at the rate of 300 kg/fed seasonally, induced significant improvement in all growth parameters of wheat during the vegetative stage (Table 3). Also, N levels at the rate of 120 kg N/fed, induced significant improvement in all growth parameters of wheat during the vegetative stage as compared with 60 kg N/fed (Table 3). This agrees with results obtained by Ali (2008)

The data also suggested that there is significant interaction between S-application and N fertilizer levels on plant fresh weight at spiking expulsion (Table 3). The high correlation between N-fertilization rates and sulfur supply on plant nutrition and protein synthesis are known to be interdependent (Daigger and Fox, 1971; Ray and Spider, 2000). When the crop had no S deficiency; the positive interaction between N and S was reflected on higher N use efficiency (Salvagiotti and Miralles, 2008).

N and P uptake by wheat plants at spiking expulsion

Data presented in Table (4) show that, wheat N and P uptake at spiking expulsion (92 days from sowing) was increased significantly due to the different management treatments. Wheat plant NP uptake varied from 33.4 and 4.19 mg, respectively in sequence 1 to 49.7 and 6.35 mg, respectively in sequence 4 + CR (Table 4). Also, there were significant increases in NP uptake by wheat plants at spiking expulsion as a result of crop residues incorporated in soil surface layer in crop sequence 1, 2, 3 and 4 as compared with the same treatments but with crop residues completely removed (crop sequence 1, 2, 3 and 4 respectively), except one case in P uptake between crop sequence 4 and crop sequence 4 + CR where the increase was insignificant. This probably happened due to the increase in residue decomposition, organic NP mineralization and the availability of NP for plant use. This finding is agreed with Akhtar *et al*., 2014.

Table (3): Wheat growth in field as affected by soil management treatments, sulfur application and N-fertilizer levels (2011).

Management and Sulfur Treatments		Plant Fresh Weight (average of 10 plants-g)			Plant Dry Weight (average of 10 plants-g)		
Soil Management	**Sulfur kg/fed**	**N kg/fed 60**	**N kg/fed 120**	**Mean**	**N kg/fed 60**	**N kg/fed 120**	**Mean**
Sequence 1	0	6.32	8.32	7.32	2.21	2.50	2.35
	300	7.61	9.70	8.66	2.65	2.92	2.79
Mean		6.97	9.01	**7.99**	2.43	2.71	**2.57**
Sequence 1 + CR	0	8.25	8.72	8.48	2.67	2.75	2.71
	300	8.36	10.37	9.37	2.67	2.97	2.82
Mean		8.31	9.54	**8.93**	2.67	2.86	**2.76**
Sequence 2	0	9.16	9.53	9.35	2.74	2.76	2.75
	300	9.37	10.95	10.16	2.80	3.12	2.96
Mean		9.26	10.24	**9.75**	2.77	2.94	**2.86**
Sequence 2 + CR	0	9.89	11.31	10.60	2.77	2.96	2.86
	300	10.18	11.78	10.98	2.85	3.13	2.99
Mean		10.03	11.55	**10.79**	2.81	3.05	**2.93**
Sequence 3	0	9.60	10.15	9.88	2.84	2.88	2.86
	300	9.58	10.61	10.10	2.85	2.99	2.92
Mean		9.59	10.38	**9.99**	2.84	2.94	**2.89**
Sequence 3 + CR	0	10.79	12.37	11.58	3.09	3.26	3.17
	300	10.70	12.53	11.61	3.09	3.31	3.20
Mean		10.74	12.45	**11.60**	3.09	3.28	**3.18**
Sequence 4	0	9.82	10.88	10.35	2.91	3.05	2.98
	300	11.28	12.61	11.95	3.34	3.46	3.40
Mean		10.55	11.74	**11.15**	3.13	3.26	**3.19**
Sequence 4 + CR	0	10.64	11.93	11.29	3.04	3.05	3.04
	300	12.27	14.33	13.30	3.34	3.65	3.49
Mean		11.45	13.13	**12.29**	3.19	3.35	**3.27**
Mean S × N	0	9.31	10.40	**9.86**	2.78	2.90	**2.84**
	300	9.92	11.61	**10.76**	2.95	3.19	**3.07**
Mean		**9.61**	**11.01**	10.31	**2.87**	**3.05**	2.96
LSD 0.05	**M**	1.042			0.200		
	S	0.420			0.096		
	M×S	n.s			n.s		
	N	0.295			0.081		
	M×N	n.s			n.s		
	S×N	0.418			n.s		
	M×S×N	n.s			n.s		

Sequence 1 = continuous sequence of cereal crops (wheat and maize), **Sequence 2** = three seasons cereal crops followed by one season legume crop (clover), **Sequence 3** = two seasons cereal crops, followed by two seasons legume crops (clover and peanut), **Sequence 4** = one season cereal crop (wheat) followed by three seasons legume crops. **CR** = crop residues of previous crop incorporated in surface soil.

Table (4): Effect of soil management treatments, sulfur application and N-levels on NP uptake by wheat shoots at spiking expulsion during (2011).

Management and Sulfur Treatments		N Uptake- mg/Plant (average of 10 plants)			P Uptake- mg/Plant (average of 10 plants)		
Soil Management	**Sulfur kg/fed**	**N kg/fed 60**	**N kg/fed 120**	**Mean**	**N kg/fed 60**	**N kg/fed 120**	Mean
Sequence 1	0	26.0	33.0	29.5	3.01	4.17	3.59
	300	30.9	43.5	37.2	3.84	5.76	4.80
Mean		28.5	38.3	**33.4**	3.43	4.96	**4.19**
Sequence 1 + CR	0	35.6	41.2	38.4	4.63	5.52	5.08
	300	35.8	46.9	41.3	4.95	5.84	5.40
Mean		35.7	44.0	**39.9**	4.79	5.68	**5.24**
Sequence 2	0	33.2	38.8	36.0	4.63	4.66	4.64
	300	34.6	46.8	40.7	5.08	5.40	5.24
Mean		33.9	42.8	**38.4**	4.86	5.03	**4.94**
Sequence 2 + CR	0	36.9	43.9	40.4	5.31	5.74	5.52
	300	40.4	49.3	44.9	5.83	6.16	6.00
Mean		38.7	46.6	**42.6**	5.57	5.95	**5.76**
Sequence 3	0	33.9	43.5	38.7	4.83	4.85	4.84
	300	35.9	45.0	40.5	4.88	5.12	5.00
Mean		34.9	44.3	**39.6**	4.85	4.99	**4.92**
Sequence 3 + CR	0	41.2	49.0	45.1	5.76	6.07	5.91
	300	43.7	49.4	46.6	5.95	6.29	6.12
Mean		42.4	49.2	**45.8**	5.85	6.18	**6.02**
Sequence 4	0	36.7	43.8	40.3	5.18	5.62	5.40
	300	42.3	52.8	47.5	6.51	7.12	6.82
Mean		39.5	48.3	**43.9**	5.85	6.37	**6.11**
Sequence 4 + CR	0	41.6	48.0	44.8	5.64	5.82	5.73
	300	46.9	62.3	54.6	6.15	7.78	6.96
Mean		44.3	55.2	**49.7**	5.90	6.80	**6.35**
Mean S × N	0	35.7	42.7	**39.2**	4.87	5.31	**5.09**
	300	38.8	49.5	**44.2**	5.40	6.18	**5.79**
Mean		**37.2**	**46.1**	41.7	**5.14**	**5.74**	5.44
LSD 0.05	**M**	4.19			0.33		
	S	1.51			0.22		
	M×S	n.s			0.63		
	N	1.34			0.21		
	M×N	3.78			0.60		
	S×N	n.s			n.s		
	M×S×N	n.s			n.s		

Sequence 1 = continuous sequence of cereal crops (wheat and maize), **Sequence 2** = three seasons cereal crops followed by one season legume crop (clover), **Sequence 3** = two seasons cereal crops, followed by two seasons legume crops (clover and peanut), **Sequence 4** = one season cereal crop (wheat) followed by three seasons legume crops. **CR** = crop residues of previous crop incorporated in surface soil.

On the other hand, calculating the average of different crop sequences regardless crop residue effect, it is observed that increasing legume crops percentage in crop sequences through four seasons before cultivation of wheat in (2011) from zero (sequence 1) up to 75% (sequence 4) resulted in additive increases in NP uptakes by wheat plants at 92 days age from sowing.

Sulfur application, seasonally, at the rate of 300 kg/fed induced significant improvement in NP uptake by wheat plants at spiking expulsion as compared with zero S-application (Table 4). Also, N levels at the rate of 120 kg N/fed, significanting improvement NP uptake by wheat plants during the vegetative stage growth as compared with 60 kg N/fed (Table 4). This probably due to more nutrients available in soil followed by more nutrient absorption by plants. This finding is in agreement with Ali, 2008, and Abou Basha*, et al*., 2013.

The data also suggested that there is significant interaction between soil management strategies and S-application on P uptake. This may be attributed to the continuous supply of suitable digestable carbon sources that stimulated the heterotrophic S-oxidizing microbes, this may result in increasing available P (and probably other nutrients) and consequent increases on plant growth and nutrient uptake especially P. Stimulating S-oxidation by organic matter application to soil was reported by other investigators (Cifuentes and Lindemann, 1993; Gallardo-Lara *et al.,* 1990).

On the other hand, another significant interaction was observed between soil management strategies and N-fertilizer levels on NP uptake by wheat plants at spiking expulsion. This may be due to more available NP in soil from crop residues decomposition and more available N from N-fertilizer. All of this followed by more NP absorption by wheat at wheat expulsion at 92 days from sowing. Similar results were mentioned by Usman *et al.,* 2014.

Wheat yield and yield components;

Wheat grain, straw and biological yields (kg/fed)

Data illustrated in Tables (5 and 6) show that, wheat grain yield, straw yield and biological yield were increased significantly due to different cultural management treatments as compared with sequences 1 (cultivated with continuous cereal crops; wheat and maize). Generally, the obtained values of wheat yield components could be descendingly ranked in the following older: The treatment (sequence 4 + crop residues) came in the first rank recording the highest wheat grain, straw and biological yields while (sequence 3 + CR) was the second. The continuous cereal crop + CR came in the seventh rank and contentious cereal crop in last rank. Furthermore, the treatment (sequence 4 + CR) resulted in significant increases in grain, straw and biological yields estimated by 78.8%, 55.1% and 63.0% respectively compared with sequences. while treatment (sequence 3 + CR) resulted in significant increases in grain, straw and biological yields estimated by 69.1%, 49.7% and 56.2% respectively as compared with continues cereal crops sequence 1 (control). Wheat grain yield of treatment sequence 4 + CR was significant as compared by treatment sequence 3 + CR. These results are similar to those obtained by Varennes *et al*., (2007). They investigated soil conservation under oat-oat and lupine-oat rotations when roots or roots plus aboveground residues were retained. The indicated results show that oat biomass was greater after lupine than after oat due to differences in supply of N from these residues. Buried residues of both crops appeared to decompose faster than when left on the soil surface and lupine residues decomposed faster than oat residues. Also, Feizabady, 2013 reported that in the short-term, benefit of crop rotation is increased crop yield, which would likely increase crop profitability, but in the long-term, rotations with high residue-producing crops increase the total soil C and N concentrations over time, which may further improve soil productivity.

Data in (Tables 5 and 6) indicated, also that, there were significant increases in wheat grain yield, straw and biological yields as a result of crop residues incorporated in soil surface layer in crop sequences 1, 2, 3 and 4 as compared with its counterpart sequences but with crop residue completely removed. The increase in yield and yield components may be due to benefits of crop residus incorporated in soil surface layer. In this respect and under Egypt condition El-Nady (2008) reported that the combination treatment between chisel plough to 20 cm and rice straw (rice straw 2.10 ton/fed was chopped into short pieces and incorporated with the soil surface manually) recorded the highest corn 100 grain weight, ear weight and grain yield of wheat grown on loam soil. These increases are due to the effect of tillage and the incorporation of rice straw on the improvement of soil physical properties.

Table (5): Wheat grain and straw yields as influenced by cultural management treatments, sulfur application and N-fertilizer levels (2011).

Management and Sulfur Treatments		Grain Yield (kg/fed)			Straw Yield (kg/fed)		
Soil Management	**Sulfur kg/fed**	**N kg/fed 60**	**N kg/fed 120**	**Mean**	**N kg/fed 60**	**N kg/fed 120**	**Mean**
Sequence 1	0	1008	1225	1117	2092	2222	2157
	300	1083	1384	1233	2210	2834	2522
Mean		1046	1304	**1175**	2151	2528	**2339**
Sequence 1 + CR	0	1080	1322	1201	2352	2832	2592
	300	1222	1391	1307	2629	2942	2785
Mean		1151	1357	**1254**	2491	2887	**2689**
Sequence 2	0	1514	1777	1645	2676	3236	2956
	300	1604	1859	1732	2879	3362	3120
Mean		1559	1818	**1689**	2777	3299	**3038**
Sequence 2 + CR	0	1701	1875	1788	3199	3819	3509
	300	1804	2026	1915	3528	3862	3695
Mean		1753	1950	**1851**	3363	3841	**3602**
Sequence 3	0	1691	1941	1816	2998	3446	3222
	300	1797	1978	1888	3116	3447	3282
Mean		1744	1960	**1852**	3057	3446	**3252**
Sequence 3 + CR	0	1851	2022	1936	3268	3491	3379
	300	1957	2119	2038	3421	3832	3627
Mean		1904	2071	**1987**	3345	3662	**3503**
Sequence 4	0	1819	1947	1883	3175	3600	3387
	300	1956	2092	2024	3215	3608	3412
Mean		1887	2019	**1953**	3195	3604	**3399**
Sequence 4 + CR	0	1954	2141	2047	3361	3758	3559
	300	2095	2213	2154	3549	3843	3696
Mean		2024	2177	**2101**	3455	3800	**3628**
Mean **S × N**	0	1577	1781	**1679**	2890	3300	**3095**
	300	1690	1883	**1786**	3068	3466	**3267**
Mean		**1633**	**1832**	1733	**2979**	**3383**	3181
LSD 0.05	**M**	96.0			175.4		
	S	77.5			139.8		
	M×S	n.s			n.s		
	N	37.3			82.0		
	M×N	n.s			n.s		
	S×N	n.s			n.s		
	M×S×N	n.s			n.s		

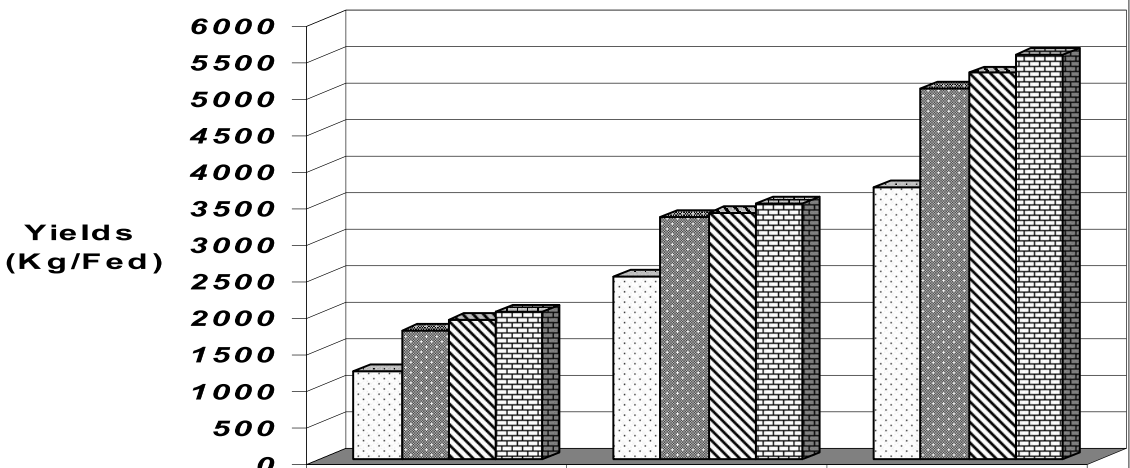
Sequence 1 = continuous sequence of cereal crops (wheat and maize), **Sequence 2** = three seasons cereal crops followed by one season legume crop (clover), **Sequence 3** = two seasons cereal crops, followed by two seasons legume crops (clover and peanut), **Sequence 4** = one season cereal crop (wheat) followed by three seasons legume crops. **CR** = crop residues of previous crop incorporated in surface soil.

Table (6): Biological wheat yield and plant height as influenced by soil management treatments, sulfur application and N-fertilizer levels (2011).

Management and Sulfur Treatments		Biological Yield (kg/fed)			Plant Height (cm)		
Soil Management	Sulfur kg/fed	N kg/fed		Mean	N kg/fed		Mean
		60	120		60	120	
Sequence 1	0	3100	3447	3274	80.7	83.6	82.2
	300	3293	4218	3755	82.1	87.1	84.6
Mean		3196	3832	**3514**	81.4	85.4	**83.4**
Sequence 1 + CR	0	3432	4153	3793	89.3	93.0	91.2
	300	3850	4334	4092	94.7	96.2	95.4
Mean		3641	4244	**3942**	92.0	94.6	**93.3**
Sequence 2	0	4189	5013	4601	91.5	95.0	93.3
	300	4483	5221	4852	93.9	94.5	94.2
Mean		4336	5117	**4727**	92.7	94.7	**93.7**
Sequence 2 + CR	0	4900	5694	5297	98.2	101.5	99.8
	300	5332	5887	5610	99.3	101.8	100.5
Mean		5116	5791	**5453**	98.8	101.6	**100.2**
Sequence 3	0	4688	5387	5038	95.9	96.0	96.0
	300	4914	5425	5169	94.6	95.7	95.2
Mean		4801	5406	**5103**	95.3	95.9	**95.6**
Sequence 3 + CR	0	5119	5513	5316	99.8	100.8	100.3
	300	5378	5952	5665	100.0	101.8	100.9
Mean		5249	5732	**5490**	99.9	101.3	**100.6**
Sequence 4	0	4993	5546	5270	95.7	96.5	96.1
	300	5171	5700	5435	96.4	97.8	97.1
Mean		5082	5623	**5353**	96.1	97.1	**96.6**
Sequence 4 + CR	0	5314	5899	5607	100.3	100.7	100.5
	300	5644	6055	5850	101.5	102.4	101.9
Mean		5479	5977	**5728**	100.9	101.5	**101.2**
Mean S × N	0	4467	5082	**4774**	93.9	95.9	**94.9**
	300	4758	5349	**5054**	95.3	97.2	**96.2**
Mean		**4613**	**5215**	4914	**94.6**	**96.5**	95.6
LSD 0.05	**M**	257.6			2.69		
	S	210.5			1.15		
	M×S	n.s			n.s		
	N	114.3			0.85		
	M×N	n.s			n.s		
	S×N	n.s			n.s		
	M×S×N	n.s			n.s		

Sequence 1 = continuous sequence of cereal crops (wheat and maize), **Sequence 2** = three seasons cereal crops followed by one season legume crop (clover), **Sequence 3** = two seasons cereal crops, followed by two seasons legume crops (clover and peanut), **Sequence 4** = one season cereal crop (wheat) followed by three seasons legume crops. **CR** = crop residues of previous crop incorporated in surface soil.

Data in figure (1) show the effect of different crop sequences regardless to crop residues effects on wheat grain, straw and biological yields. The Data in this figure indicated that, increasing leguminous crops percentage in crop sequences before cultivating wheat of 2011 from zero (sequence 1) up to 75% (sequence 4) resulted in additive increases in grain yield, straw yield and biological yield of wheat. In this respect Thierfelder and Wall, 2011 showed that, many crops may have positive effects on succeeding crops in the rotation, leading to greater production overall. Also, rotations may also give benefits in terms of improved soil quality (more or deeper roots; root exudates), better distribution of nutrients in the soil profile (deep-rooted crops bring up nutrients from below) and to increase biological activity. Furthermore, Feizabady 2013 showed that the growth characteristics and yield of wheat were significantly enhanced in crop rotation compared with wheat monoculture. This might be due to increasing weeds, pests and diseases in wheat monoculture compared with other crop rotations. Therefore, continuous wheat often increased herbichemical requirement and decreased soil organic carbon and physical and chemical soil characteristics compared with other crop rotations.



	Seed	Straw	Biological
Sequence 1	1214	2514	3728
Sequence 2	1770	3320	5090
Sequence 3	1920	3377	5297
Sequence 4	2027	3513	5540

Figure (1):- Effect of crop sequences on wheat seed yield, straw yield and biological yield during winter season of 2011

Sulfur application, at the rate of 300 kg/fed seasonally, induced significant improvement on wheat grain, straw and biological yields as compared with the zero S (Tables 5 and 6). This probably may due to the oxidation of elemental sulfur to SO_4^{--} by microorganisms, which in turn lowers the soil pH. This may consequently increased the availability of nutrients and improved physical and chemical properties of the soil. 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 crops yield and yield components as well as being good amendment for improving soil properties and productivity (Ali, 2008, Attia & El-Dosuky, 1996 and Heydarnezhad *et al.* 2012).

Nitrogen fertilizer at the rate of 120 kg N/fed, induced significant improvements on wheat grain, straw and biological yields as compared with 60 kg N/fed. The increases in grain straw and biological yields were 12.2% 13.6% and 13.1% respectively due to the rate of 120 kg N/ fed (Table 5 and 6). These increases may be attributed to that, nitrogen increases photosynthetic area and consequently increased photosynthates in wheat plants without harmful shading effect on sandy calcareous soil which have lower N-content. The 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 organic matter. for improvement of wheat growth and yield (Abou Basha, *et al*., 2013; El- Afandy *et al.,* 2007; Gheith *et al*., 2013 and Zeidan *et al.,* 2005).

Interactions between cultural management treatments, S-application and N-fertilizer levels on wheat grain yield, straw yield and biological yields, were not significant (Tables 5 and 6).

Plant height (cm)

Data presented in Table (6) show that wheat plant height was significantly increased due to different cultural treatments as compared with sequence 1 (continuous cereal crops, wheat and maize). The plant height varied from 83.4 cm in sequence 1 to 101.2 cm in sequence 4 + CR. Also, there were significant increases on wheat plant height at final harvest as a result of crop residues incorporated in soil surface layer in crop sequence 1, 2, 3 and 4 as compared with its counterpart sequences but with crop residues completely removed. These results are similar to those mentioned by Feizabady, 2013; Rahman, 2004 on wheat plants.

On the other hand, calculating the average of different crop sequences regardless crop residues effects, data show that, increasing of leguminous crops percentage in crop sequences before cultivating of wheat of 2011 from zero (sequence 1) up to 75% (sequence 4) resulted in additive increases on wheat plant height at final harvest. These results are similar to those mentioned by Feizabady, 2013.

The main effect of sulfur application at the rate of 300 kg/fed seasonally and nitrogen fertilizer levels at the rate of 120 kg N/fed induced significant improvement on wheat plant height at final harvesting as compared with zero S-application and 60 kg N/fed, respectively. The obtained results are in accordance with those reported by Ali, 2008.

The results in Table (6) show no significant interaction between the tested factors on wheat plant height.

Average Spike weight (g)

The results obtained in this field experiment show that, average of spike weight was increased significantly due to different cultural management treatments. Average of plant spike weight varied from 1.70 g cm in sequence 1 without crop residues to 2.28 g in sequence 4 + CR. (Table 7). Obtained results are in accordance with those reported by Jan *et al*., 2012.

N levels at the rate of 120 kg N/fed, induced significant improvement on wheat plant spike average as compared with 60 kg N/fed (Table 7). Obtained results are in accordance with those reported by El- Afandy *et al*., 2007 and Gheith *et al*., 2013. On the other hand, there were no significant interactions between treatments on spike average.

Seed index (g)

Data regarding seed index at harvest as influenced by soil management treatments (Table 7) indicated that, seed index (1000 grains weight) was increased significantly due to different soil management treatments. The 1000 grains weight varied from 45.0 g in sequence 1 without crop residues to 49.7 g in sequence 4 +CR (Table 7). The results of this field experiment are in accordance with those obtained by other investigators confirming the stimulative effect of crop residues and crop rotation, especially on newly cultivated soils with low organic matter for improvement of wheat growth and yield components (Feizabady 2013; Jan *et al*., 2012; Usman *et al*. 2014).

S-application at the rate of 300 kg/fed seasonally induced significant improvement on wheat seed index at final harvesting as compared with the zero S-application (Table 7), the increments in wheat seed index scored by S-application in the present investigation are in agreement with those obtained by Ali, 2008.

Nitrogen fertilizer levels at the rate of 120 kg/fed induced significant improvement on wheat seed index at final harvesting as compared with 60 kg N/fed (Table 7), The increments in wheat seed index scored by height N-fertilizer level in the present investigation are in agreement with those obtained by other investigators (El-Afandy *et al*., 2007 and Gheith *et al.* 2013).

The data also suggested that there is one significant interaction between cultural management treatments and S-application on wheat seed index at final harvesting. This may be attributed to supplying of suitable digestable carbon sources that stimulates the heterotrophic S-oxidizing microbes, thus resulting in increasing available nutrients. The stimulated S-oxidation by organic matter application to soil was reported by other investigators (Cifuentes and Lindemann, 1993; Gallardo-Lara *et al.,* 1990).

Table (7): Effect of soil management treatments, sulfur application and N-fertilizer levels on wheat spike average weights and seed index (2011).

Management and Sulfur Treatments		Average of 10 Spikes (g)			Seed Index (1000 Grains /g)		
Soil Management	**Sulfur kg/fed**	**N kg/fed**		**Mean**	**N kg/fed**		**Mean**
		60	**120**		**60**	**120**	
Sequence 1	0	1.56	1.71	1.63	43.6	44.4	44.0
	300	1.72	1.80	1.76	45.6	46.3	45.9
Mean		1.64	1.75	**1.70**	44.6	45.3	**45.0**
Sequence 1 + CR	0	1.64	1.79	1.72	44.2	46.5	45.3
	300	1.71	1.84	1.77	46.1	47.5	46.8
Mean		1.68	1.81	**1.74**	45.1	47.0	**46.1**
Sequence 2	0	2.04	2.18	2.11	46.6	46.9	46.8
	300	1.93	2.14	2.03	49.2	49.5	49.4
Mean		1.99	2.16	**2.07**	47.9	48.2	**48.1**
Sequence 2 + CR	0	2.12	2.21	2.16	47.6	48.5	48.1
	300	2.14	2.20	2.17	48.0	49.8	48.9
Mean		2.13	2.20	**2.17**	47.8	49.2	**48.5**
Sequence 3	0	2.12	2.28	2.20	46.7	47.2	46.9
	300	2.19	2.18	2.19	49.4	49.9	49.6
Mean		2.16	2.23	**2.19**	48.0	48.5	**48.3**
Sequence 3 + CR	0	2.14	2.21	2.18	48.9	49.6	49.2
	300	2.24	2.24	2.24	49.2	49.9	49.6
Mean		2.19	2.23	**2.21**	49.1	49.7	**49.4**
Sequence 4	0	2.16	2.20	2.18	47.9	48.0	48.0
	300	2.11	2.20	2.16	49.5	50.0	49.8
Mean		2.13	2.20	**2.17**	48.7	49.0	**48.9**
Sequence 4 + CR	0	2.25	2.31	2.28	49.5	49.7	49.6
	300	2.26	2.32	2.29	49.6	50.1	49.8
Mean		2.25	2.31	**2.28**	49.5	49.9	**49.7**
Mean **S × N**	0	2.00	2.11	**2.06**	46.9	47.6	**47.2**
	300	2.04	2.12	**2.08**	48.3	49.1	**48.7**
Mean		**2.02**	**2.11**	2.07	**47.6**	**48.4**	48.0
LSD 0.05	**M**	0.05			1.13		
	S	n.s			0.42		
	M×S	n.s			1.19		
	N	0.03			0.45		
	M×N	n.s			n.s		
	S×N	n.s			n.s		
	M×S×N	n.s			n.s		

Sequence 1 = continuous sequence of cereal crops (wheat and maize), **Sequence 2** = three seasons cereal crops followed by one season legume crop (clover), **Sequence 3** = two seasons cereal crops, followed by two seasons legume crops (clover and peanut), **Sequence 4** = one season cereal crop (wheat) followed by three seasons legume crops. **CR** = crop residues of previous crop incorporated in surface soil.

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تأثير التعاقب المحصولي، مخلفات المحاصيل، إضافة الكبريت الزراعي والتسميد النيتروجيني على محصول القمح النامي بالأراضي الرملية الجيرية

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الملخص:

تحت ظروف معدل خدمة التربه المنخفض تم إجراء تجربة زراعية قصيرة الموسم لمدة أربع مواسم (٢٠٠٩ و ٢٠١٠) لدراسة سياسات إدارة التربة من التكامل بين التعاقب المحصولي ومخلفات المحاصيل المزروعة، إضافة الكبريت الزراعي الناعم والتسميد الأزوتي على بعض المحاصيل النامية بالأراضي الرملية الجيرية بمحطة بحوث عرب العوامر الزراعية بأسيوط – مصر. وعند الموسم الخامس خلال الموسم الشتوي ٢٠١٠/٢٠١١م استكملت التجربة بزراعة القمح في تصميم القطع المنشقة مرتان مع ثلاث مكررات لدراسة استجابة نمو النباتات، محصول القمح ومكوناته للتأثيرات السابقة والحالية لثمانية سياسات مختلفة لإدارة التربة في القطع الرئيسية، الكبريت الزراعي الناعم (صفر و ٣٠٠ كجم كبريت زراعي ناعم كل موسم) في القطع المنشقة ومستويين من التسميد الأزوتي (٦٠ و ١٢٠ كجم أزوت للفدان من سماد نترات النشادر ٣٣,٥% أزوت) في القطع المنشقة مرتان. إن السياسات الثمانية المختلفة لإدارة التربة كانت عبارة عن عدم إضافة المخلف الزراعي و إضافة المخلف الزراعي لكل محصول قبل زراعة المحصول التالي في التعاقب المحصولي طبقا لأربع تعاقبات محصولية مختلفة مقسمة حسب نسبة احتوائها على المحاصيل البقولية كالتالي:-

التعاقب الأول:- قمح – ذرة شامية – قمح – ذرة شامية – قمح (٠% محاصيل بقوليه)
التعاقب الثاني:- قمح – ذرة شامية – برسيم – ذرة شامية – قمح (٢٥% محاصيل بقوليه)
التعاقب الثالث:- قمح – ذرة شامية – برسيم – فول سوداني – قمح (٥٠% محاصيل بقوليه)
التعاقب الرابع:- قمح – فول سوداني – برسيم – فول سوداني – قمح (٧٥% محاصيل بقوليه)

وأظهرت النتائج حدوث زيادة معنوية في كلا من نمو نباتات القمح عند طرد السنابل، النيتروجين والفوسفور الممتصين عند طرد السنابل ، محصول القمح ومكوناته نتيجة استخدام سياسات أدارة تربة مختلفة بالمقارنة بالتعاقب المحصولي النجيلي المستمر (قمح – ذرة شامية) مع عدم إضافة المخلف الزراعي، كذلك فأن معاملة التعاقب المحصولي الرابع + المخلف الزراعي أدت إلى زيادة في محصول الحبوب، محصول القش والمحصول الكلى قدرت بـ ٧٨,٨% ٥٥,١% ٦٣,٠% على التوالي بينما معاملة التعاقب المحصولي الثالث + المخلف الزراعي أدت إلى زيادة في محصول الحبوب، محصول القش والمحصول الكلى قدرت بى ٦٩,١% ٤٩,٧% ٥٦,٢% على التوالي وذلك بالمقارنة بمعاملة التعاقب المحصولي الأول (الكنترول). علاوة على ذلك فأن الزيادة في محصول الحبوب نتيجة استخدام معاملة التعاقب المحصولي الرابع + المخلف الزراعي أدت إلى زيادة معنوية في محصول الحبوب بالمقارنة بمعاملة التعاقب المحصولي الثالث + المخلف الزراعي.

أدت معاملة إضافة الكبريت الزراعي الناعم بمعدل ٣٠٠ كجم للفدان كل موسم إلى حدوث زيادة معنوية في كلا من نمو نباتات القمح عند طرد السنابل، النيتروجين و الفوسفور الممتصين عند طرد السنابل ، محصول القمح ومكوناته وذلك بالمقارنة بمعاملة صفر كبريت زراعي للفدان.

أدت معاملة التسميد الأزوتي بمعدل ١٢٠ كجم أزوت للفدان إلى حدوث زيادة معنوية في كلا من نمو نباتات القمح عند طرد السنابل، النيتروجين و الفوسفور الممتصين عند طرد السنابل، محصول القمح ومكوناته وذلك بالمقارنة بمعاملة ٦٠ كجم أزوت للفدان. علاوة على ذلك فأن الزيادات في محصول الحبوب، محصول القش والمحصول الكلى كانت ١٢,٢%، ١٣,٦% و ١٣,١% على التوالي.

أيضا أظهرت النتائج تداخلات ثنائية فقط بين عوامل الدراسة على نمو القمح ووزن ألاف حبه.

التوصية:- أدى استخدام التعاقب المحصولي قمح – فول سوداني – برسيم – فول سوداني – قمح + إضافة مخلفات المحاصيل إلى الحصول على أعلى نمو نباتات للقمح عند طرد السنابل، النيتروجين و الفوسفور الممتصين عند طرد السنابل ، محصول القمح ومكوناته. كذلك فعلت معاملة إضافة الكبريت الزراعي الناعم بمعدل ٣٠٠ كجم للفدان وكذلك معاملة ١٢٠ كجم أزوت للفدان. ولكن السؤال هل التعاقب المحصولي المثالي للقمح سيكون مثالي أيضا لباقي المحاصيل (البرسيم ، الذرة الشامية والفول السوداني) في التعاقب أم لا ؟