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SOIL PROPERTIES AND PLANT GROWTH OF PEANUT AS AFFECTED BY PLANT RESIDUES MANAGEMENT

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ABSTRACT

Afield experiment was conducted in summer season 2009 to evaluate the effect of broad bean and wheat straw plant residues on some soil physical, chemical properties and plant growth of peanut (*Arachis hypogaea*, Giza 5) in the farm of Faculty Agriculture, Al-Azhar University, Nasr City, Cairo. Also, the residual effect of plant residues on growth of wheat plant (*Triticm aestivum L*) during winter season of 2010 was studied. Three treatments were conducted; namely 1) the control treatment i.e. without adding plant residues (NR), 2) surface mixing residues (SR) at 10 cm depth and 3) subsurface incorporated residues at a depth of 40 cm (SSR). The plant residues were mixed by feldspar. The results could be summarized as follows:

1. The values of soil bulk density and hydraulic conductivity decreased as a result of surface and deep management of plant residues compared with the control.
2. Soil total porosity increased, pore size distribution improved and values of water holding pores increased due to the used treatments.
3. The values of mean weight diameter, soil organic matter and cation exchange capacity increased due to the treatments.
4. The mean values of plant height and number of pods in plant increased with plant residues management treatments. The yield of pods for the subsurface incorporated plant residues (SSR) treatment increased by 77.3 %, while the yield of foliage increased by 49.94 % compared to the control.
5. The treatments under investigation gave higher percentage values of NPK in seeds and foliages of peanut plants compared to the control.

6. There were obvious beneficial effect of plant residues management on wheat production and NPK content of straw and grains.

Key words: residues management, pore size distribution, peanut plant

INTRODUCTION

Agricultural residues include sugarcane bagasse, sugar beet pulp, wheat and broad bean straw, rice hulls, corn stover and essentially any material remained after processing of crop for food. Although, some of these materials are used for animal feeding, yet they are used also as soil conditioners to improve soil physical and fertility properties as well. Thus, agricultural residues are a largely untapped biomass resource for conversion of products (Peterson, 2006).

Conservation tillage practices and the management of crop residues are of generating increasing interest. Under conservation tillage practices, plowing results in mixing of the soil profile and the burial accumulates on the soil surface as mulch. These differences in soil disturbance and residue placement and their effects on soil physical and chemical properties can influence the growth and productivity of plants. Management practices that conserve organic matter are important to develop porous soil with high infiltrability. Possible beneficial effects on the soil physical environment when manures and crop residues are applied (Edward et al., 1988). The lower bulk density of deep residue management was the partial incorporation of crop residues into the surface soil and the undisturbed organic debris of pervious crops root systems. They built up soil organic matter content and on elaborate channel structure with a wide range of capillaries and pore sizes (Dick et al., 1991; Dao, 1996).

Pikul and Zuzel (1994) found that increased biomass input to loamy sand soil increased aggregate stability and water infiltration. They found that porosity of the surface upon residues burned thereon was 12 % greater than upon no residue management. Unger (1992) found that mean weight diameter (MWD) and organic matter concentration increased for tillage treatment with residue left in place.

Management practices that enhanced soil organic matter and microbial conditions also, improved soil stable aggregation (Bissonnette et al., 2001). Meanwhile, the increased accumulation of organic matter that has high water retention capacity and the observed greater porosity would contribute to gains in stored water. Virto et al.

(2007) indicated that the role of burnt plant residues in organic matter accumulation and soil physical properties is of major important. Organic matter levels in the soil surface were higher in both watersheds after conservation tillage was implemented, likely caused by increased plant residues accumulation and limited soil mixing. Limon-Ortega et al. (2006) indicated that soil aggregates are greater in size and more stable for conventional tilled-bed with all plant residues incorporated compared to other treatments.

Srisaard (2007) showed that crop residue derived from roots of both sunflower and soybean plants had their significant inhibition effects of allelopathic substances on plant height, root dry weight, top growth dry weight and total dry weight of both plant crops (sunflower and soybean). Yuan et al. (2009) showed that organic matter levels in the soil surface were higher in both watersheds after conservation tillage was implemented, likely caused by increased plant residue accumulation and limited soil mixing.

Many investigators stated that plant residue are often used to improve the soil physical and chemical properties of soil and meet the slowly release of nutrient requirements of annual crops. Nutrient release from residues can be regulated by altering or manipulating the factors that influence the mineralization of nutrients; such as residue quality, environmental factors and management factors, Srinivas and Sridevi (2007) showed that N use efficiency can be maximized by strategic conjunctive use of plant residues and chemical fertilizers in appropriate proportion and at appropriate time during crop growth. Also, Garnier et al. (2008) –in a field study on soil and plant residue incubation- showed that larger residues decomposed more slowly because it provides less surface area in contact with the soil.

Ahmed and Osman (2003) found that the application of organo-mineral fertilizer derived from sugarcane industry wastes increased the yield, yield components, seed oil and protein content of groundnuts.

The variation in tillage depth and intensity influence the decomposition rate of crop residues and their location within the soil profile (Balesdent et al., 1990). The crop species and the amount and type of manure applied influence the quantities of C and N added to soil (Paustian et al. 1990). The objective of this study was to evaluate the effect of some plant residues management on some soil physical, chemical properties and plant growth of peanut (*Arachis hypogaea* *sp*.) and examine the residual effect of plant residues management on growth of wheat plant (*Triticm aestivum L*).

MATERIALS AND METHODS

The current investigation aims of studying the effect of broad bean and wheat plant residues management on some soil physical, chemical properties and growth of peanut plant (*Arachis hypogaea*, Giza 5). A field experiment was set up at the farm of Faculty of Agriculture, Al-Azhar University, Nasr City, Cairo, during the summer season of 2009. The soil is sandy loam (55.82 % coarse sand, 20.43 % fine sand, 12.11 % silt and 11.64 % clay), containing 0.9 % organic matter, its soil bulk and particle densities are 1.35 and 2.6 Mg. M^{-3} respectively, and its total porosity was 48.07 %).

The experiment was conducted in a randomized complete block design with three replicates. The treatments were 1) the control i.e. without adding any residues (NR), 2) surface applied and mixed plant residues at 10 cm depth (SR) and 3) subsurface incorporated plant residues at 40 cm depth (SSR). The plant residues applied at a rate of 4 t/ f. were mixed by feldspar at a rate 200 kg/f. where chemical composition was 68 %, 17 %, 2.5 %, 0.1 % 0.4 %, 11.99 % and 0.01 % from SiO_2, Al_2O_3, Fe_2O_3 MgO, CaO, K_2O and P_2O_5 respectively). Peanut plant (*Arachis hypogaea*, Giza 5, at rate of 20 Kg pods/ fed) was grown in 15 May 2009 after one month from adding plant residues. Wheat plant (*Triticm aestivum L*) is cultivated at 1 November, 2009 to study the residual effect of plant residues on growth of wheat plant.

Soil sampling and analysis:-

Surface (0-20 cm) and subsurface samples (20-40 cm) of the treated soil were collected, air dried, ground and passed through a 2 and 8 mm sieve. These samples were prepared for the determination of physical (i.e. bulk density, total porosity, pore size distribution, hydraulic conductivity and mean weight diameter, according to Klute, 1986) and chemical properties of the soil (i.e. EC, pH, organic matter, soluble cations, soluble anions and cation exchange capacity, according to Page et al., 1982) to detect the changes that might take place in soil characteristics.

Plant sampling and analysis:-

At harvesting stage (15 October, 2009), plant samples of the treatments were collected and the following parameters were determined; plant height in cm, number of pods in plant, yield of pods in kg/fed, yield of foliage in kg/fed and NPK content in plant (according to Page et al., 1982). Also, after harvesting of wheat (1April 2010), plant samples of the treatments were collected to determine dry matter and NPK content in straw and grains.

RESULTS AND DISCUSSION

a. Soil physical properties:

Data in Table 1 show the important soil physical properties as affected by the used types of plant residues and depth of its application. The data reveal that soil bulk density, total porosity, pore size distribution, hydraulic conductivity and mean weight diameter were improved owing to the used plant residues. The effect of the subsurface application of the used (SSR) was more obvious more than the surface residue management (SR). Concerning the effect of treatment on soil bulk density, the values were significantly decreased by 14 % and 12 % with (SSR) and (SR) managements, respectively, as compared with the control. On contrary, the mean values of total porosities were increased due to the aforementioned treatments by the same percentages, respectively. The pore size distribution results showed that water holding pores (WHP) significantly increased due to the (SSR) and (SR) treatments. In other words, quickly drainable pores (QDP) decreased after treatments. So, the values of hydraulic conductivity significantly decreased, and soil order according to hydraulic conductivity values (cm h^{-1}) changed from rapid to moderately rapid compared with the control. Also, the data showed that the values of mean weight diameter significantly increased by 39 % and 26 % with subsurface and surface residue management, respectively, compared with the control. These results are in agreement with those of Doran and Smith (1987); who stated that practices such as cultivation, crop rotation, residue management and fertilization regulate soil microbial biomass and enhance pore size distribution. Also, Bordovsky et al. (1999) found that surface soil bulk density under the tillage with residues application were lower than with the conventional tillage without residues application. On the other hand, the values of hydraulic conductivity have the opposite trend.

Table1. Soil physical properties as affected by the used treatments.

Treatments	Depth cm	BD Mg. m-3	E %	QDP %	SDP %	WHP %	NSP %	K cm. h-1	MWD Mm
NR	0- 20	1.30	49.02	16.18	13.73	10.29	8.82	14.5	0.572
	20- 40	1.34	47.45	15.66	13.28	9.97	8.54	14.3	0.165
SR	0- 20	1.15	54.90	14.27	14.83	15.37	10.43	13.6	0.725
	20- 40	1.27	50.20	13.05	13.55	14.06	9.54	13.3	0.773
SSR	0- 20	1.12	56.08	13.46	14.02	19.63	8.97	12.2	0.765
	20- 40	1.16	54.51	13.08	13.63	19.08	9.72	12.4	0.793
LSD at 0.05	0- 20	0.01	0.01	0.01	0.003	0.012	0.012	0.19	0.012
LSD at 0.05	20- 40	0.01	0.01	0.01	0.003	0.010	0.010	0.15	0.010

BD = soil bulk density, E = total porosity, QDP = quickly drainable pores, SDP = slowly drainable pores, WHP = water holding pores, NSP = nun-useful pores, K = hydraulic conductivity, MWD = mean weight diameter

b. Soil chemical properties:

Data in Table 2 show that some soil chemical properties were affected by the applied plant residues, where the values of organic matter, cation exchange capacity, soluble Ca, Mg, and K increased with (SSR) management followed by surface residue (SR) management relative to the control treatment. In this respect, Moyin-Jesu (2007) showed that the application of 6 t ha^{-1} of plant residues increased the soil N, P, K, Ca, Mg, and soil organic matter; pod content N, P, K, Mg and pod yield of okra. Also, Auler et al. (2008) showed a significant increment in organic matter content in the conventional and strip tillage with maintenance of the remaining of plant residues compared to the other treatments under study. On the other hand, the pH values decreased with soil depth due to residues management relative to the control treatment. This remark can of course induce nutrients solubility and availability.

Table 2. Soil chemical properties as affected by the used treatments.

Treatments	Depth Cm	EC $dS\ m^{-1}$	pH	OM %	CEC meq/100 g soil	Cations meq l^{-1}				Anions Meq l^{-1}		
						Ca	Mg	Na	K	Cl	SO_4	HCO_3
NR	0- 20	0.88	8.01	1.00	17.4	1.50	1.30	3.38	1.00	2.13	2.91	2.38
	20- 40	0.90	8.01	0.95	17.3	1.052	1.33	3.39	1.01	2.15	2.92	2.28
SR	0- 20	0.77	7.92	1.25	19.6	1.51	1.30	3.28	1.12	2.14	2.85	2.22
	20- 40	0.80	7.89	1.11	18.3	1.52	1.32	3.32	1.12	2.16	2.88	2.26
SSR	0- 20	0.76	7.93	1.35	20.2	1.53	1.30	3.27	1.10	2.10	2.80	2.24
	20- 40	0.80	7.90	1.29	19.5	1.56	1.36	3.31	1.13	2.10	2.85	2.27

C. Peanut plant growth parameters:

Peanut plant growth parameters i.e. plant height in cm, number of pods / plant, yield of pods in kg/f and yield of foliage in kg/f are shown in Table 3. Compared with the control, the subsurface residues management (SSR) gave the highest values of these parameters followed by the surface residues management (SR). The data indicated that the subsurface plant residues management (SSR) significantly increased the abovementioned parameters compared with the control by 23 %, 165 %, 60 % and 45%, respectively. These results are supposed to be due to beneficial effects of treatments on physical, chemical and biological properties of the soil, which in turn increased plant growth and production. The inducing effects of subsurface management (SSR) on plant growth go in line with those reported by Fayez (2006); who reported that the combined effects of soil cultivation and crop residue play a significant role in changing the nutrient balance and availability in soils with conventional agricultural practices, and consequently crop productivity.

d. NPK content in plant:

The results of nitrogen, phosphorus and potassium percentages in seeds and foliage of peanut plant at the end of experiment are given in Table 3. The data reveal that N percentage significantly increased in seeds and foliage by 73 % and 52 %, respectively, for the subsurface residues management (SSR) compared with the control. Likewise, the corresponding P percentage increased by 5 % and 112 %, respectively. Also, K percentage increased by 33 % and 16 %, respectively. These increases in NPK contents in soil and subsequently in plant may be attributed to the decomposition of plant residues as well as the supply of potassium by the applied feldspar. The decrease in pH values of soil, on the other hand, is a final product at of the acid formed upon decomposition of the applied plant residues. Besides, the CO_2 released due to exhalation of the organic matter decomposer dissolve in water forming H_2CO_3 acid which contribute to reduction of soil pH. This is in agreement with those of Zai et al. (2008); who stated that the composts of pea residue with chicken manure and chicken manure plus rapeseed residue enriched soil with NPK and other nutrients, and increased nutrient accumulation

Table 3. Growth parameters and NPK contents of peanut plant as affected by the used treatments.

Treatments	Plant height cm	No. of pods/ plant	Yield of pods kg/ f	Yield of foliage kg/ f	N %		P %		K %	
					seed	foliage	seed	Foliage	seed	foliage
NR	56	17	1139	7284	4.82	1.64	0.471	0.102	2.53	0.58
SR	66	28	1548	7552	6.11	1.98	0.484	0.176	3.10	0.65
SSR	69	45	1820	10548	8.32	2.49	0.493	0.216	3.35	0.75
LSD at 0.05	1.30	5.23	0.65	27.20	0.022	0.022	0.007	0.001	0.71	0.022

e. The residual effect on wheat growth and NPK content.

Data in Table 4 reveal that the dry matter yield and NPK content in wheat plants were significantly affected by residual management of plant residues. The highest values of dry matter yield were recorded with (SSR) management i.e. by incorporating the residues in the subsurface layer of soil, and then surface management (SR) compared with the control. Also, data in the same Table show that the highest values of NPK content were obtained at owing to the (SSR) management than the surface management (SR) and finally the control. This may be due to the improved soil fertility caused by the applied plant residues. This finding is in agreement with those of Skuodiene and Daugeliene (2008); who found that the amounts of plant residues left in the soil give back obviously amount of NPK. Also, they stated that the mineralization of legume residues gradually released N exerted a positive effect on the yield forming elements of winter cereals.

Concerning the effect of residual management on weight of 100 grains for wheat, data show that the value of 100 grains of wheat was

3.88 g obtained with control treatment, and increased to 4.18 and 4.92 g for surface and subsurface residues management, respectively.

Table 4. The residual effect of plant residues on wheat growth and NPK content.

Treatments	**Dry weight kg / f**	N %	P %	K %
	Shoots of wheat			
NR	2625	3.92	0.37	3.45
SR	2972	4.13	0.41	3.54
SSR	3231	4.26	0.42	3.62
LSD at 0.05	3.46	0.12	0.022	0.07
	Grains of wheat			
NR	1312	2.84	0.35	2.91
SR	1486	3.11	0.36	3.24
SSR	1615	3.17	0.37	3.07
LSD at 0.05	6.54	0.007	0.007	0.07

Generally, it could be concluded that, the best management for improving soil properties under study and increasing growth of peanut and wheat plants grown thereon was the subsurface residues management (SSR) i.e. by incorporating the residues in the soil at a depth of about 40 cm.

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تأثير خدمة بقايا النباتات على خواص التربة ونمو نبات الفول السودانى

على محمد عبد الوهاب مشهور ، عماد سعيد السيد عبد الهادى ، أحمد حمدى رزق

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أقيمت تجربة حقلية فى صيف موسم 2009 لدراسة تأثير اضافة مخلفات النباتات(الفول البلدى والقمح) على بعض خواص التربة الطبيعية والكيميائية ونمو نبات الفول السودانى فى مزرعة كلية الزراعة، جامعة الأزهر، مدينة نصر، القاهرة. ثم تم دراسة التأثير المتبقى لخدمة بقايا النباتات على محصول القمح فى الموسم الشتوى 2010 وقد شملت معاملات التجربة 1) معاملة الكنترول : الزراعة بدون إضافة أى بقايا نباتية ، 2) الخدمة السطحية: الزراعة مع خلط البقايا النباتية على عمق 10 سم من سطح التربة ، 3) الخدمة تحت السطحية : الزراعة مع دفن أو تقليب البقايا النباتية على عمق 40 سم من سطح التربة. وقد أضيف البقايا النباتية بمعدل 4 طن/ فدان مع الفلسبار(خام البوتاسيوم) بمعدل 200 كيلوجرام /فدان.

ويمكن تلخيص أهم النتائج التى أمكن الحصول عليها فيما يلى:.

1- انخفضت قيم الكثافة الظاهرية للتربة والتوصيل الهيدروليكى كنتيجة لمعاملتى الخدمة السطحية والتحت سطحية لبقايا النباتات.

2- زادت قيم المسامية الكلية للتربة وحدث تحسن ملحوظ فى التوزيع الحجمى للمسام، حيث زادت قيم المسام الحافظة للرطوبة كنتيجة لاضافة بقايا النباتات.

3- زادت قيم المتوسط الموزون للتجمعات وزادت التجمعات الكبرى كنتيجة للمعاملات سالفة الذكر كما زادت أيضا قيم المادة العضوية للتربة والسعة التبادلية الكاتيونية .

4- زاد طول النبات وعدد القرون فى النبات نتيجة المعاملة ببقايا النباتات، كما زاد محصول الفول السودانى فى معاملة الخدمة التحت سطحية بـ 77.3 % مقارنة بمعاملة الكنترول بينما زاد محصول العروش بـ 49.94 %.

5- أعطت المعاملات تحت الدراسة أعلى القيم لمحتوى النبات من عناصر النيتروجين – الفوسفور والبوتاسيوم.

6- بالنسبة للتأثير المتبقى للمعاملات، أوضحت النتائج وجود تأثيرات مفيدة لخدمة بقايا النباتات على انتاج نبات القمح ومحتواه من عناصر النيتروجين، الفوسفور والبوتاسيوم فى القش والحبوب.