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EFFECT OF PLOUGHING DEPTH AND MANURE ON CORN YIELD

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ABSTRACT

A field experiment was conducted to evaluate the effect of three tillage and three manure treatments on some soil physical properties, grain yield and some yield components of corn. The tillage treatments were no tillage (To), chisel plough to 10 cm (T_1), and to 20 cm (T_2) soil depth. The manure treatments were, cattle manure (M_1), rice straw (M_2), and (½ cattle manure + ½ rice straw) (M_3). Measurements of soil bulk density (Bd) and soil penetration resistance (PR) were taken to quantify the ploughing depth. Available water capacity (AWC) was calculated for all treatments. The measurements were taken twice, after ploughing and before harvest. Yield and yield components (weight of 100 grain yield (gm), weight of ear (gm), and grain yield/fed.) were obtained. The data showed that the lowest (Bd) and (PR) were obtained in the surface layer of T_2 and M_2 treatments while, the highest (AWC) was recorded in T_0 and M_2 treatments. The results also showed that the highest 100 grain weight, ear weight and grain yield were obtained with T_2 as compared with T_1 and To. However, the difference among the ploughing treatments was not significant. Application of manure showed that the highest 100 grain weight, ear weight and grain yield of corn were recorded with (M_2) comparing with (M1) and (M3) treatments. Interaction effect between ploughing depth and manure treatments influenced the grain yield, and the yield components. The combination treatment (T_2 M_2) recorded the highest 100 grain weight, ear weight and grain yield. A significant difference between (T_2M_2) and (T_2M_3) was obtained. These results concluded that the combination of soil ploughing to 20 cm depth with the application of rice straw increased corn grain yield. This increase is due to the effect of tillage and the incorporation of rice straw on the improvement of the soil physical properties.

***Key words**: corn , manure, ploughing depth, rice straw , soil bulk density, soil penetration resistance , water capacity, yield components.*

1. INTRODUCTION

Soil tillage and manuring have been reported to have a great influence on crop production. Soil tillage and manure application can change the physical conditions and can affect nutrition status of the soil. Different tillage systems can be used to maintain the optimum crop yield. Manure can be used to improve soil properties and overcome nutrient deficiencies which reduce requirements for chemical fertilizer. Therefore, choosing the most adequate tillage and manuring practice is necessary for sustaining the optimum soil physical properties and reducing chemical fertilizer addition.

Chen (1993) explained that, tillage modifies soil structure. Conventional ploughing usually yields a looser soil structure in the tilled layer than no-tillage which leaves the soil relatively intact. Motavalli *et al*. (2003) indicated that subsoil compaction may reduce the availability and uptake of water and plant nutrients, thereby lowering crop yields. Deep tillage breaks the hard layers to help the roots to extend in the deeper layers. It facilitates easy uptake of water as well as nutrients by the roots, Bongki *et al.* (1996).

Singh and Singh (1996) reported that different tillage operations may influence the physical properties such as, soil porosity, air-filled porosity, and hydraulic conductivity. Buschiazzo *et al*., (1998) indicated that soil physical properties changes affected by different soil tillage treatments could influence yield level of grown crops. Soil physical properties are connected directly and indirectly with growth of the root system of crops (Logsdon *et al*., 1987, Sidiras and Kahnt, 1988, Azooz *et al.*, 1995 and Varsa *et al.,* 1997). On the other hand, manure is a useful soil amendment that can serve as a low cost source of organic fertilizer for crop production and as a soil conditioner that may improve the physical and chemical conditions of the soil, Campbell *et al*. (1986).

Addition of the organic matter from different origins to the soil is an important practice in improving some soil physical properties, consequently increasing soil productivity, Ekwue (1990). Organic amendment increases the total porosity, moisture content, and organic matter content in the soil which improve its structure (Mbagwu, 1989). Borresen (1999) found that straw residues, on the soil surface increased maize grain yields.

The objective of this study was to evaluate the effect of different tillage depths and different manure application on some soil physical properties, yield component and grain yield of corn.

2. MATERIALS AND METHODS

The experiment was conducted at the Agricultural Experiment and Research Station, Faculty of Agriculture, Cairo University. The experiment area was 16m width and 50m length and was laid out in split plot design with three replications. Soil samples were collected to determine some soil properties before treatment application (Table, 1). The experiment was divided into three parts. The first part was the plough treatments without manure application. It consisted of three tillage treatments, no tillage (To) chisel plough to 10cm depth (T_1) and chisel plough to 20cm depth (T_2). The second part was the manure treatments which included three manure treatments; cattle manure 2.10 ton/Fed. (M_1), rice straw 2.10 ton/Fed. (M_2), and cattle manure 1.10 ton/Fed. + rice straw 1.10 ton/Fed. (M_3).Rice straw was chopped into short pieces and incorporated with the soil surface layer manually. The third part was the combination between the ploughing depths and the manure treatments. After preparing the treatments, corn seeds (*Zea mays* L.) were sown. Two corn seed s were planted per hill, 30cm apart from each other and at a distance of 70cm between each row. Half the recommended dose of NPK according to the Ministry of Agriculture (2005) was added. The plants were thinned to one plant per hill before the first irrigation. Plots were hand hoed twice to control weeds after 21 and 45 days of planting. The first irrigation was applied 21 days after planting and the following irrigation was applied at 14 day intervals. Soil samples from each treatment in the three replications were collected a day after the treatments were applied and two weeks before harvest. Bulk density was determined from oven dried undisturbed cores of 5cm diameter and 5cm height according to Klute (1986). Soil penetration resistance was measured using the penetrologger with cone type 1 cm^2 and an angle of 60^o. The bulk density and the soil penetration resistance were measured for the 0-10cm, 10-20cm, and 20-30 cm soil depths. The available water capacity was calculated as the difference between the moisture content at field capacity and the wilting point that determined at -0.33 and -15 bars according to Klute (1986) for the soil depths of 0-10 and 10-20cm. The plants were harvested at maturity, four months after planting. The studied yield parameters were weight of 100-grain (gm), weight of ear (gm), and grain yield.

3. RESULTS AND DISCUSSION

Some physical and chemical characteristics of the studied soil are presented in Table (1). The soil is loamy texture in the surface layer (0-20 cm) and clay loam in the sub surface layer (20-40 cm).

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

Soil depth (cm)	Particle size fraction (%)				Texture class	Soil pH	Ec dS/m	O.M %
	c.sand	f.sand	Silt	clay				
0 – 20	4.96	37.81	33.52	23.71	Loam	7.62	1.83	2.77
20 - 40	3.52	34.17	36.07	26.24	C.loam	7.84	2.28	2.52

3.1. Soil physical properties

3.1.1. Bulk density (Bd)

Soil bulk density of the different plough and manure treatments (after ploughing and before harvest) are presented in Table (2). The data indicate that (Bd) decreased with ploughing. The lowest (Bd) values were obtained with T_2 followed by T_1 comparing with T_0. Surface (Bd) was quite low compared to those of subsurface of T_1, T_2 and T_0. The highest (Bd) of (1.41 and 1.44 $Mg.m^{-3}$) was obtained with T_0 at 20-30 cm soil depth after ploughing and before harvest, respectively. The differences among ploughing treatments were significant at 0-10 and 10-20 cm depth for bulk density values obtained after ploughing only. Bulk density of the soil was also influenced by manure treatments. (Bd) increased with M1 and M3, while decreased with M_2 treatment at 0-10 cm depth after ploughing and before harvest. Kuchenbuch and Ingram (2004) reported that bulk densities were lowered with the incorporation of organic materials. However, the differences among manure treatments were not significant. Concerning the interaction effect of ploughing and manuring on (Bd), the data in Table (2) show that the highest bulk density was obtained with T_0 M_3 whereas, the lowest bulk density was recorded in the treatment combination of T_2 M_2.

3.1.2. Penetration resistance (PR)

Data of penetration resistance (Table 3) show that penetration resistance of the soil varied with the ploughing depth. The lowest (PR) measured after ploughing and before harvest was recorded with T_2 at 0 -10 cm depth whereas the highest (PR) value

Table (2): Effect of ploughing and manure treatments and the interaction between them on soil bulk density.

Treat.	Bulk density (Mg. m^{-3})					
	After ploughing			Before harvest		
	Depth of soil (cm)					
	0-10	10-20	20-30	0-10	10-20	20-30
Tillage practice						
T_0	1.25	1.36	1.41	1.29	1.33	1.42
T_1	1.09	1.22	1.39	1.30	1.37	1.44
T_2	1.07	1.12	1.36	1.19	1.23	1.39
L.S.D 5%	0.11	0.06	ns	ns	ns	ns
1%	0.19	0.12				
Manure treatments						
M_1	1.25	1.35	1.49	1.32	1.37	1.51
M_2	1.21	1.31	1.45	1.26	1.34	1.46
M_3	1.26	1.34	1.44	1.31	1.38	1.48
L.S.D 5%	ns	ns	ns	ns	ns	ns
Interaction between treatments						
$T_0 M_1$	1.25	1.32	1.39	1.26	1.29	1.45
$T_0 M_2$	1.18	1.30	1.35	1.23	1.24	1.42
$T_0 M_3$	1.24	1.37	1.40	1.31	1.30	1.43
$T_1 M_1$	1.06	1.24	1.37	1.25	1.33	1.42
$T_1 M_2$	0.96	1.17	1.34	1.16	1.29	1.39
$T_1 M_3$	1.08	1.19	1.38	1.20	1.34	1.44
$T_2 M_1$	1.01	1.03	1.37	1.22	1.29	1.41
$T_2 M_2$	0.95	1.12	1.35	1.18	1.26	1.38
$T_2 M_3$	0.98	1.15	1.36	1.21	1.31	1.41
L.S.D.						
5%	0.09	0.12	0.06	0.05	0.06	0.07

Table (3): Effect of ploughing and manure treatments and the interaction between them on soil penetration resistance.

Treat.	Penetration resistance (MPa)					
	After ploughing			Before harvest		
	Depth of soil (cm)					
	0-10	10-20	20-30	0-10	10-20	20-30
Tillage practice						
T_0	1.53	1.86	1.97	1.61	2.27	2.46
T_1	1.47	1.71	1.93	1.59	1.98	2.41
T_2	1..32	1.45	1.83	1.52	1.79	2.27
L.S.D 5%	ns	0.14	ns	ns	0.29	ns
1%		0.26			0.53	
Manure treatments						
M_1	1.47	1.82	2.1	1.55	1.78	2.24
M_2	1.26	1.53	1.92	1.43	1.81	2.17
M_3	1.29	1.61	1.98	1.51	1.94	2.21
L.S.D 5%	0.12	ns	ns	ns	ns	ns
1%	0.22					
Interaction between treatments						
$T_0 M_1$	1.39	1.76	1.91	1.48	1.56	2.11
$T_0 M_2$	1.26	1.59	1.89	1.42	1.54	1.97
$T_0 M_3$	1.36	1.97	1.98	1.71	1.67	2.17
$T_1 M_1$	1.21	1.63	2.13	1.33	1.41	1.92
$T_1 M_2$	1.12	1.43	1.70	1.29	1.37	1.89
$T_1 M_3$	1.23	1.51	2.18	1.36	1.49	2.21
$T_2 M_1$	0.86	1.25	1.96	1.29	1.41	2.13
$T_2 M_2$	0.73	0.93	1.64	1.26	1.45	1.97
$T_2 M_3$	1.16	1.27	2.46	1.32	1.51	2.31
L.S.D.						
5%	0.11	0.13	0.24	0.09	0.11	ns
1%	0.16	0.18	0.33	0.12	0.15	

was recorded under To at 20-30 cm soil depth. These results reveal the effect of ploughing on reducing soil penetration resistance. A significant difference among the tillage treatment is evident only at the 10-20 cm depth after ploughing and also before harvest. Manure treatments also affected (PR) values that were measured after ploughing and before harvest. The lowest (PR) was obtained with M_2 while the highest PR was obtained with M_1. Interaction effect of ploughing and manuring on (PR) is recorded (Table 3). The data show that the combination treatment ($T_2 M_2$) significantly reduced penetration resistance as compared with the other treatments. The data also show that soil penetration resistance increased with time under all treatments at the three studied depths.

3.1.3. Available water capacity (AWC)

The effects of tillage, manuring and the interaction between them on soil available water capacity (AWC) are presented in Table (4). The data calculated after tillage treatment applications show that (AWC) increased in T_0 treatment and decreased in T_1 and T_2 treatments. Kouwenhoven *et al.*(2002) reported that shallow ploughing was generally associated with high moisture content. However, the only significant difference among ploughing treatments was obtained after tillage at 10-20 cm depth. The data also show that (AWC) was increased with increasing the depth of soil. Radcliffe *et al.* (1988) reported that the greater (AWC) at the lower depth may be due to higher proportion of micro pores and more compaction compared with the upper depths. Concerning the effect of manure treatments on (AWC), it is observed that M_2 retained more water than M_1 and M_3. These results are in agreement with Kuchenbuch and Ingram (2004) as they found that the water holding capacity of the soil was increased by incorporation of organic matter, especially the rice straw. A significant difference among manure treatments was found only before harvest at 0-10 cm depth. It is also observed that the combination treatment ($T_0 M_2$) had the highest (AWC) while, the lowest was obtained with ($T_2 M_3$). Rice straw application raised up the moisture retained in the combination treatments as compared with the ploughing treatments alone.

3.2. Effect of ploughing and manuring on yield components

3.2.1. Effect on 100 – grain weight

Table (5) represents the weights of 100 grains under plough and manure treatments. The data show that the highest weight of 100 grains among tillage treatments was obtained with T_2 followed by T_1 comparing with T_0. However, the differences among T_1, T_2 and T_0 were not significant. Data of manure treatments show that M_2 increased weight of 100 grains by 14% over M_1 and by 23% over M_3 and the difference was significant between M_2 and both M_1 and M_3. Interaction effect between plough and manure treatments Table (6) shows that the highest weight of 100 grains was obtained with T_2 M_2 which increased the weight of 100 grains by 15.5% over T_2 M_1 and by 28% over T_2 M_3. The lowest 100 grains weight was obtained with T_1M_3.

The results also show that the combination between ploughing and manuring resulted in an increase of 100-grains weight when comparing with plough and manure treatments without interaction. A significant difference was only obtained between T_2 M_2 and T_2 M_3.

Table (4): Effect of ploughing and manure treatments and the interaction between them on available water capacity.

Treat.	Available water capacity (AWC %)			
	After ploughing		Before harvest	
	Depth of soil (cm)			
	0-10	10-20	0-10	10-20
Tillage practice				
T_0	22.58	23.49	22.32	23.93
T_1	20.70	23.11	23.41	23.46
T_2	19.62	20.80	23.19	24.25
L.S.D 5%	ns	2.14	ns	ns
1%		3.25		
Manure treatments				
M_1	25.93	24.19	23.61	24.51
M_2	26.13	23.96	25.82	23.93
M_3	24.42	24.13	24.54	23.72
L.S.D 5%	ns	ns	0.84	ns
1%			1.27	
Interaction between treatments				
T_0 M_1	25.72	23.71	22.96	23.28
T_0 M_2	26.15	24.17	24.97	23.94
T_0 M_3	24.87	23.82	23.64	22.69
T_1 M_1	24.27	24.51	23.62	22.71
T_1 M_2	24.62	23.73	26.14	24.93
T_1 M_3	24.19	22.91	23.48	24.19
T_2 M_1	23.68	23.91	23.79	24.41
T_2 M_2	24.91	24.29	25.15	25.72
T_2 M_3	23.26	23.48	24.13	24.73
L.S.D.				
5%	1.49	ns	1.16	1.75
1%	2.05		1.59	2.39

3.2.2. Effect on ear weight

Data presented in Table (5) show the ear weight under different plough and manure treatments. The data illustrate that the highest ear weight was obtained with T_2 comparing with T_1 and T_0. The ploughing treatment (T_2) increased ear weight by 8% and 18% over T_1 and T_0 respectively. The data also show that the manure treatment (M_2) recorded the highest ear weight; while M_3 recorded the lowest ear weight. M_2 increased ear weights by 10% and 9% over M_1 and M_3 respectively. Statistically, the difference among T_1, T_2 and T_2 and also among M_1, M_2 and M_3 was not significant.

Interaction effect between ploughing and manuring Table (6) show that the highest ear weight was recorded with T_2M_2 which increased the ear weight by about 16.5%, 19%, 5% and 20% over T_0 M_2, T_1 M_2, and T_2 M_1 respectively. A significant difference was obtained between T_2 M_2 and T_2M_3 and also between $T_2M_1$and T_2M_3.The results also illustrate that the combination treatment (T_2M_2) reflected an increase in ear weight when comparing with tillage and manure treatment alone.

Table (5): Effect of ploughing and manuring on yield components and grain yield of corn.

Treatment	100 grain weight (gm)	Ear weight (gm)	Grain yield (Kg. fed.)
Tillage practice			
T_0	38.67	201.24	3827.85
T_1	41.58	226.47	4156.24
T_2	45.09	237.26	4542.37
L.S.D 5%	ns	ns	ns
Manure practice			
M_1	40.39 a	204.66	4017.16
M_2	44.08 b	224.23	4292.23
M_3	37.52 c	205.78	3687.85
L.S.D 5%	2.99	ns	ns
1%	4.53		

Significance between a-b * b-c**

3.2.3. Effect on grain yield

The grain yield is presented in Table (5) for the plough treatments and the manure treatments. The data reveal the effect of T_2 on increasing corn yield. T_2 increased grain yield by 8% over T_0. Data of manure treatments show that the highest grain yield was recorded with M_2 followed by M_1 and M_3 respectively. M_2 increased grain yield by 5% and 19% over M_1 and M_3 respectively. Soil ploughing to 20 cm depth and incorporation of rice straw may enhance the root environment which resulted in a better growth and yield. However, the differences among the ploughing treatments and among the manure treatments were not significant. The interaction effect between ploughing and manuring treatments, Table (6), illustrates that T_2 M_2 recorded the highest grain yield among groups and increased yield by 28%, 29% over T_1M_2 and T_0 M_2 respectively. Also T_2M_2 raised grain yield over T_2M_1 and T_2M_3 treatments by 28.4% and 43% respectively. A significant difference was only obtained between T_2 M_2 and T_2M_3. The data also indicate that the combination effect between ploughing and manuring raised the grain yield by about 16% and 25% over T_2 and M_2 , respectively.

Table (6): Interaction effect of ploughing and manuring on yield components and grain yield of corn.

Treatment	Weight of		
	100-grains (gm)	Ear (gm)	Grain yield (Kg. fed.)
$T_0 M_1$	39.21	201.79	3791.43
$T_0 M_2$	43.08	215.87	4094.77
$T_0 M_3$	38.65	203.18	3183.46
L.S.D 5%	ns	ns	ns
$T_1 M_1$	38.17	205.92	3897.91
$T_1 M_2$	40.36	211.15	4140.17
$T_1 M_3$	34.52	194.99	3279.33
L.S.D 5%	ns	ns	ns
$T_2 M_1$	41.16 a	239.25 a	4105.81
$T_2 M_2$	47.55 b	251.53 b	5312.37
$T_2 M_3$	37.15 c	209.87 c	3481.17
L.S.D 5%	7.98	21.75	1414.83
1%	12.09	32.96	2143.68
a – b	6.39	12.28	1206.56
a – c	4.01	29.38*	624.64
b – c	10.4*	41.66**	1831.20*

In conclusion the response of corn varied with ploughing depth as well as the type of the applied manure. Soil ploughing to 20 cm depth provided a better environment for roots and that was reflected on increasing the corn grain yield. Application of rice straw associated with soil ploughing reduced bulk density and penetration resistance and increased available water capacity of the soil which resulted in increasing yield components and grain yield. The combination of ploughing to 20 cm depth with the application of rice straw would provide greater benefits than the ploughing or straw application alone. Application of this practice can be considered as a good management option for corn growers.

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تأثير عمق الحرث والإضافات العضوية للتربة على محصول الذرة

منال أبو المعاطى النادى
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ملخص

أجريت تجربة حقلية لدراسة تأثير كل من عمق الحرث و الإضافات العضوية المختلفة والتأثير المتداخل بينهما على بعض خواص التربة الفيزيائية و على محصول الذرة الشامية و بعض مكوناته. أجريت ثلاث معاملات للحرث (بدون حرث- حرث عمق 10سم وحرث عمق 20 سم) و ثلاث معاملات للإضافات العضوية[سماد الإسطبل و قش الأرز و(نصف كمية سماد الإسطبل+ نصف كمية قش الأرز)]. تم تقدير الكثافة الظاهرية للتربة و مقاومة التربة للإختراق مرتين الأولى بعد الحرث و الثانية قبل الحصاد مباشرة و قد تم تقدير كمية المحصول و مكوناته المختلفة (وزن 100 حبة ، وزن الكوز وكمية المحصول للفدان). أشارت النتائج الى أن وزن 100 حبة و وزن الكوز و كمية المحصول للفدان حققت أعلى قيمة فى معاملة الحرث لعمق 20 سم مقارنة بمعاملة الكنترول و معاملة الحرث لعمق 10 سم . كما دلت معاملات التسميد العضوى على تفوق معاملة قش الأرز على باقى المعاملات حيث أعطت أعلى قيمة لوزن 100 حبة و وزن الكوزاضافة الى المحصول الكلى للفدان من الحبوب. كان للتداخل بين معاملات الحرث والتسميد العضوى أثره الواضح أيضا على النتائج حيث أعطت معاملة الحرث لعمق 20 سم و معاملة التسميد بقش الارز أعلى قيمة لوزن 100 حبة ، ووزن الكوز و المحصول الكلى للفدان بالمقارنة بمعاملات التداخل الأخرى. أشار التحليل الإحصائى لنتائج التجربة الى وجود فروق معنوية فقط بين معاملة الحرث لعمق 20 سم والمسمدة بقش الأرزوالمعاملة المسمدة بنصف كمية السماد العضوى و نصف كمية قش الأرز. وقد تأثرت قيم كل من الكثافة الظاهرية و مقاومة التربة للإختراق وكمية الماء الميسر بعمق الحرث حيث كانت أقل القيم لهما فى الطبقة السطحية لمعاملة الحرث لعمق 20 سم مقارنة بمعاملة الحرث لعمق 10 سم و معاملة الكنترول. كما سجلت المعاملة بقش الارز أقل القيم لكل من الكثافة الظاهرية و مقاومة التربة للإختراق بينما سجلت أعلى قيم لكمية الماء الميسر فى التربة بالمقارنة بباقى المعاملات. و قد كان للتداخل بين كل من الحرث و الإضافات العضوية تأثيرها الواضح حيث أعطت معاملة الحرث لعمق 20 سم والمسمدة بقش الأرز أقل قيم لكل من الكثافة الظاهرية و مقاومة التربة للإختراق . دلت النتائج على أن التداخل بين معاملات الحرث والتسميد العضوى كان له أثره الواضح على إستجابة نبات الذرة وذلك نتيجة لتحسن الخصائص الطبيعية للتربة.

المجلة العلمية لكلية الزراعة – جامعة القاهرة – المجلد (59) العدد الثانى (أبريل2008):156-161.