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IMPACT OF DITCHER PERFORMANCE ON WHEAT RESPONSE TO APPLICATION OF SOME PLANT RESIDUES USED AS ORGANIC FERTILIZERS

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ABSTRACT

This study was carried out at El-Gemmeiza Ag. Res. station, El-Gharbia Governorate, during 2007 winter season. It aimed to study the effect of the ditcher performance on wheat response to the organic fertilization. The completed conformation of cotton stalks, rice straw and corn stalks were placed into underground tunnels using ditcher at forward speeds of 1.85, 2.65, 3.45 and 4.25 km/h. The tunnels were arranged in spacing of 3.00, 5.00 and 7.00 m apart in a correspondent orientations and they were holed at 0.30, 0.45 and 0.60 m depth.

The obtained results could be summarized as follows:

1. The application of the plant residues into the underground tunnels improved the soil chemical properties and increased the wheat crop yield.
2. The application of corn stalks into the underground tunnels of 3.00 m spacing at 0.60 m depth achieved the higher soil organic carbon of 2.90%, the lower soil pH of 7.30 and the higher soil available N, P and K of 39, 15 and 392 ppm, respectively. Consequently, it achieved the higher wheat grain yield of 3.79 ton/fed.
3. To hole the underground tunnels of 3 m spacing at 0.60 m depth, the ditcher achieved the higher field capacity of 1.96 fed./h and required the lower specific energy of 68.63 MJ/fed. at forward speed of 4.25 km/h.

Finally, it is recommended to use the ditcher for placing the plant residues into underground tunnels. This practice improves the soil chemical properties which would increase the wheat response to the plant residues that use as organic fertilizers. Also, reduced the environmental pollution from agricultural wastes.

INTRODUCTION

In Egypt, wheat occupies a major rank among the other crops. The total annual wheat cultivated area is about 2.72 million fed of 2.71 ton/fed. mean productivity **(**Ministry of Agriculture and Land Reclamation, 2006). Nevertheless, wheat production stills beyond the self sufficiency and does not match with the rapid increase in population. However, agricultural policy paids a great attention to overcome or minimize the gab between wheat production and consumption. This native goal could be achieved by applying the proper agricultural practices such as the organic soil conditioners.

The excessive and continuous chemical fertilization occurs an accumulated side effects on the human and the animal health and the environment and maximizes the agricultural production cost. So, the recent world attention is directed towards utilization plant residues as organic soil conditioners.

In Egypt, an enormous amount of plant residues is remained after harvest. Utilization of these residues is largely for burning, industrial terminuses or as animal feed. On the other hand, utilization of plant residues as soil conditioners is serviceable to maintain the soil fertility through the biological process in which microorganisms decompose organic materials, consuming oxgen and producing carbon dioxide, water and heat into the soil (Hong *et al.,* 1997 and Hong *et al.,* 1998). Moreover, the natural organic materials play an important role in availability of macro and micronutrients through its active groups fulvic and humic acids which have the ability to retain such metals in complex and chelate form. The organic acids are produced during the decomposition of organic matter in the soil, influencing the soil pH, consequently, increasing the availability of macro and micronutrients (El-Abaseri *et al.* 1996, Kumar and Goh 2000, El-Fayoumy *et al.* 2000, Goh *et al.* 2001, Phongpan and Mosier 2002 and IAEA 2003).

In this study, a ditcher was used to hole underground tunnels for applying some plant residues. So, this study aimed to evaluate the effect of ditcher performance on wheat response to the organic fertilization.

MATERIALS AND METHODS

Experimental procedure:

1. Experimental site and soil characteristics:

During 2007 winter season, a field experiment of 1 fed. area was carried out at El-Gemmeiza Ag. Res. station, El-Gharbia Governorate, where the previous summer crop was maize. The soil characteristics of the experimental site are presented in Tables (1) and (2).

Table (1): Soil mechanical analysis of El-Gemmaza Ag. Res. station.

Soil depth, m	Sand, %			Silt, %	Clay, %	Soil texture class
	coarse, %	fine, %	total, %			
0 – 0.30	2.00	9.35	11.35	36.10	52.55	Silty clay loam
0.30 – 0.60	1.29	11.82	13.11	38.62	48.27	Silty clay loam

Table (2): Some soil properties of El-Gemmaza Ag. Res. station

Soil depth, m	pH, 1:2.5 (susp.)	EC, ds/cm	Organic carbon, %	Total N, %	C/N ratio	Available N, ppm	Available P, ppm	Available K, ppm
0.00–0.30	7.85	5.26	1.40	0.14	10.00	31.27	11.45	353.00
0.30–0.60	7.91	5.83	1.08	0.11	9.82	28.15	8.79	348.00

2. Instructions of agricultural practices:

a. Seed bed preparation:

The seed bed was prepared using the chisel plough in two perpendicular directions at 0.20 m depth, followed by rotary plough. Then, the soil was leveled using a hydraulic land leveler.

b. Underground tunnels holing:

A locally manufactured ditcher was used to hole underground tunnels. The ditcher was operated using a Ford-Tw 10 tractor (90 kW). Fig. (1) reveals the outlook of ditcher components.

The completed conformation of cotton stalks, rice straw and corn stalks were placed into underground tunnels of 0.60 m width with a rate of 140, 84 and 60 kg/fed. at 0.30 m depth, 255, 146 and 105 kg/fed. at 0.45 m depth and 350, 210 and 150 kg/fed. At 0.60 m depth, respectively. Then, the residues were covered with a soil layer of 0.10 m. Table (3) shows some characteristics of the used plant residues.

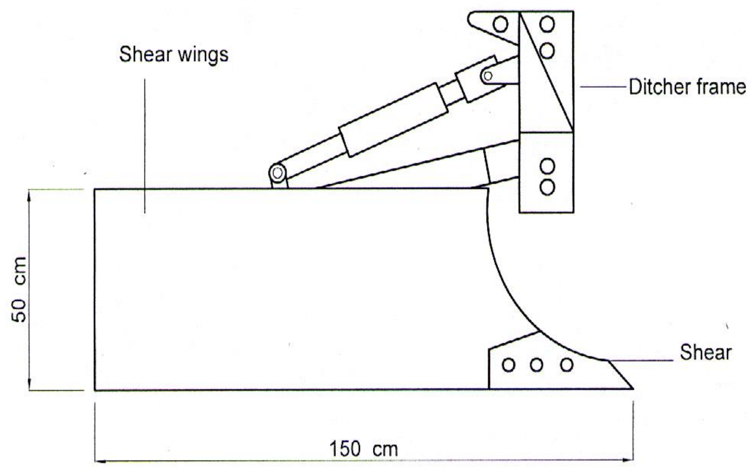

Fig. (1): Outlook of ditcher components.

Table (3): Some characteristics of the used plant residues.

Plant residues	Moisture content, %	Ash, %	Organic matter, %	Organic carbon, %	Total N, %	C/N ratio
Cotton stalks	8.84	13.29	73.87	42.01	0.478	87.88
Rice straw	9.00	17.79	75.21	43.46	0.482	90.16
Corn stalks	7.08	14.42	77.51	44.96	1.096	41.02

c. Wheat mechanical drilling:

The selected wheat seeds of Sakha 69 variety were mechanically drilled with a rate of 50 kg/fed. using a TYE type seed drill, which was operated using 45 kW Nasser tractor. Then, all the agricultural practices were applied according to the recommendations of the Wheat Res. Dep., Field Crops Inst., Ag. Res. Center, Ministry of Agriculture and Land Reclamation.

3. Treatments and statistical design:

The following treatments were tested:

1. Plant residues kind: corn stalks, rice straw and cotton stalks were applied into underground tunnels and compared with the untreated soil (control).
2. Tunnel spacing: The tunnels were arranged in correspondent orientations of 3.00, 5.00 and 7.00 m apart spacing.
3. Tunnel depth: The tunnels were holed at 0.30, 0.45 and 0.60 m depth.

The experiment was statistically designed as a split split plots design with 3 replicates. The main plots involved the plant residues kinds. While, the sub-plots involved the tunnel spacing levels and the sub-sub-plots involved the tunnel depth levels.

Measurements:

1. Soil chemical properties:

At harvest, soil samples at 0 - 0.30 m and 0.30 - 0.60 m layers were collected from each plot. These samples were air-dried, ground in a ceramic mortar and passed through 2 mm sieve and stored for chemical analysis as cited by El-Serafy and El-Ghamry (2006). The following soil chemical properties were determined:

a. Soil organic carbon:

The soil organic carbon was determined by dry combustion method.

b. Soil pH:

The soil pH was measured in soil water suspension (1:2.5).

c. Avaliable soil macronutrients concentration:

The avaliable soil N was determined by macro-Kjeldahel method, the available soil P was determined by ascorbic acid molybdenum blue method and the available soil K was determined by flame photometer method.

2. Ditcher performance:

The ditcher was operated at forward speed levels of 1.85, 2.65, 3.45 and 4.25 km/h. The ditcher performance was evaluated according to the following items:

a. Actual field capacity (*AFC*)

$$AFC = \frac{1}{ATT} \quad \text{fed./h} \tag{1}$$

Where:

ATT is the actual total time required for holing tunnels per fed.

b. Tractor wheel slip (*S*):

$$S = \frac{v_1 - v_2}{v_1} \times 100 \quad \% \tag{2}$$

Where:

v_1 is the machine forward speed without load, m/s.

v_2 is the machine forward speed with load, m/s.

c. Specific mechanical energy requirements (*SME*):

$$SME = \frac{11.41 \times FC}{AFC} \quad \text{MJ/fed.} \tag{3}$$

Where:

FC is the fuel consumption, Lit/h.

11.41 is the conversion coefficient from lit/h to MJ.

3. Crop yield:

At harvest, for each treatment, an area of 1 m^2 was taken randomly to determine the wheat crop yield (grain and straw). This procedure was replicated three times, then, the mean value was recorded and calculated on basis of 14% moisture content (d.b.).

Statistical Analysis:

Spss computer program was used to employ the analysis of variance and the LSD tests for wheat grain yield data.

Regression and Correlation Analysis:

Microsoft Office Excel computer program was used to carry out the simple regression and correlation analysis to represent the effect of the plant residues on the relation between the wheat grain yield and the tunnel depth at different tunnels spacing.

RESULTS AND DISCUSSION

1. Soil Chemical Properties:

a. Soil organic carbon:

Fig. (2) shows that applying the plant residues achieved a significant increase in the soil organic carbon content at the surface and sub-surface soil layers as compared with the control. This phenomenon could be attributed to the release of organic compounds during the mineralization of the plant residues. The application of corn stalks into underground tunnels of 3.00 m spacing at 0.60 m depth achieved the higher soil organic carbon of 2.90%.

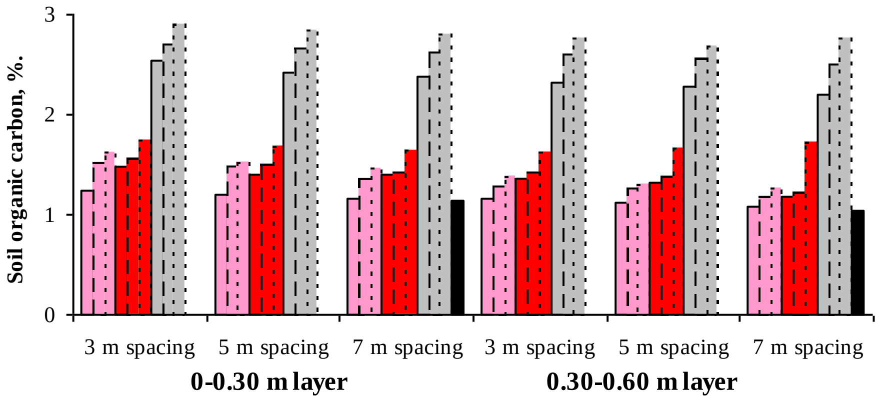

Fig. (2): Effect of some plant residues, tunnel spacing and tunnel depth on soil organic carbon.

The influence of the used plant residues on the soil organic carbon content may be arranged in the following descending order: corn stalks> rice straw> cotton stalks. This arrangement is proportional to the plant residues organic carbon content, as previously presented in Table (3).

Data reveal that applying the plant residues into the tunnels of secluded spacing decreased the soil organic carbon content. This trend could be illustrated that the soil organic matter can be trapped in the very small spaces between clay particles, making them inaccessible to the soil micro-organisms. Consequently, the rate of residues decomposition is slower as the tunnel spacing is secluded. However, the soil organic carbon content increased as applying the plant residues into the deeper tunnels. This trend is somewhat appropriate with the amount of plant residues biomass, which is proportional to the tunnel depth.

Moreover, it is clear that the soil organic carbon content at the surface soil layer is higher than that at the sub-surface layer. This finding could be attributed to the increase in the biological activity of the surface layer as a result of higher porosity, aeration and water retention.

b. Soil pH:

As shown in Fig. (3), it is obvious that applying the plant residues decreased the soil pH values, comparing with the control.

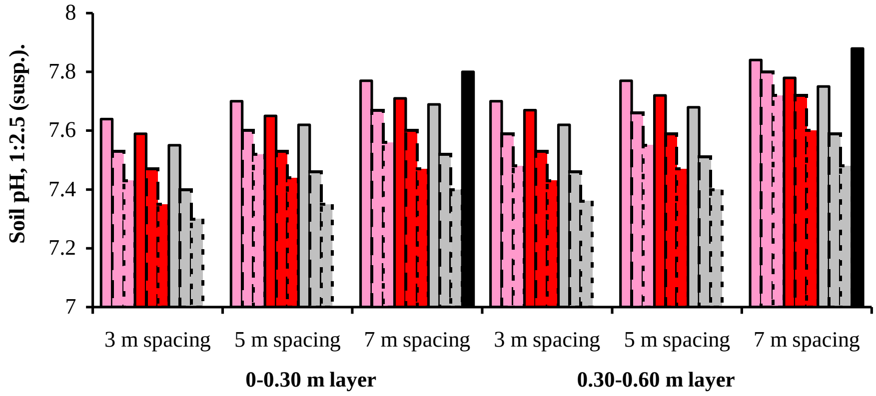

Fig. (3): Effect of some plant residues, tunnel spacing and tunnel depth on soil pH.

This observation is a contrary trend to that the effect of applying residues on the soil organic carbon. This trend is due to the decomposition of the plant residues which make the soils tend to become acidic as a result of carbon dioxide release. The corn stalks was more effective among the other residues to decrease the soil pH values at the surface and the sub-surface soil layers. The soil pH values tended to decrease as applying the plant residues into the convergent and the deeper tunnels. The application of corn stalks into underground tunnels of 3.00 m spacing at 0.60 m depth achieved the higher soil pH of 7.30.

c. Soil available macronutrients:

Figs. (4), (5) and (6) show that the available soil N, P and K values increased over that were recorded with control due to the application of different plant residues. The application of corn stalks into underground tunnels of 3.00 m spacing at 0.60 m depth achieved the higher soil available N, P and K of 39, 15 and 392 ppm, respectively. The increase in available soil

N was proportional to the available N status in plant residues during its decomposition which encourages the biological fixation of atmospheric N and its reflection on soil fertility. While, the increase in available soil P may be due to the phosphorus content of plant residues and increasing the solubility of native phosphrus by means of organic acids that produce during the plant residues decomposition. Meanwhile, the increase in available soil K is attributed to the release of K from residues and the native source as well as the retention of K by the soil organic matter against leashing.

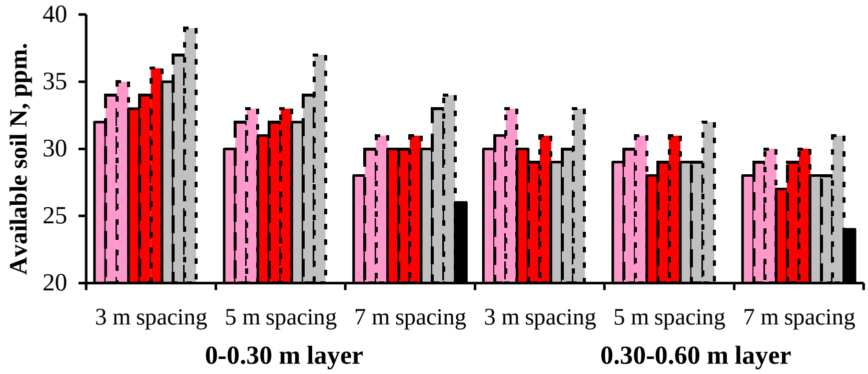

Fig. (4): Effect of some plant residues, tunnel spacing and tunnel depth on available soil N concentration.

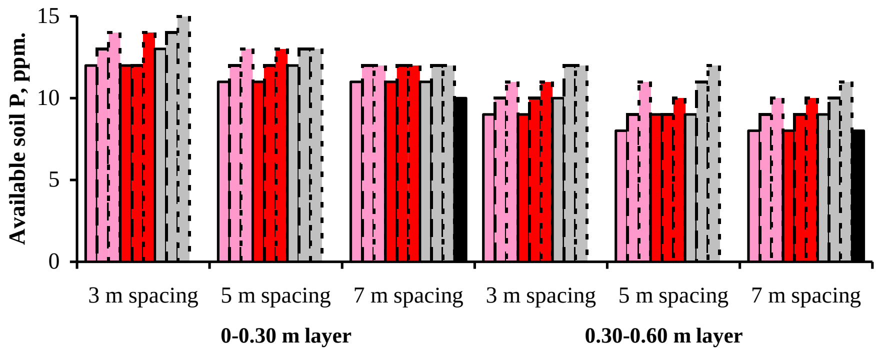

Fig. (5): Effect of some plant residues, tunnel spacing and tunnel depth on available soil P concentration.

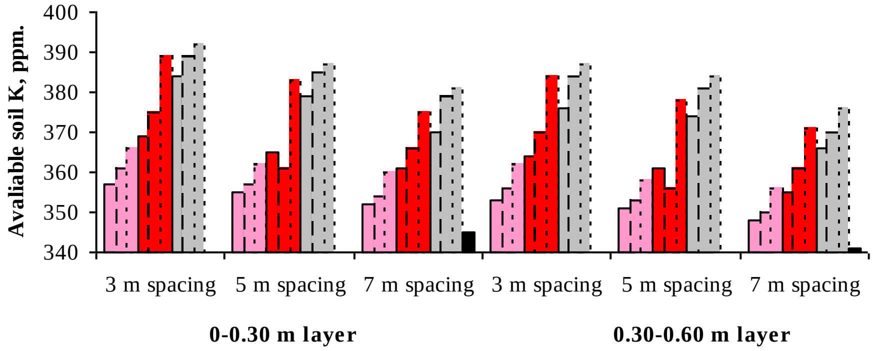

Fig. (6): Effect of some plant residues, tunnel spacing and tunnel depth on available soil K concentration.

2. Ditcher Performance:

a. Actual field capacity:

Fig. (7) demonstrates the positive relation between the ditcher forward speed and the field capacity. The higher ditcher field capacity of 6.27 fed./h was obtained using forward speed of 4.25 km/h to hole the tunnels at 7.00 m spacing and 0.30 m depth. At any holing tunnel depth, as the forward speed increased from 1.85 to 4.25 km/h, the ditcher field capacity increased by about 104, 114 and 120% at tunnel spacing of 3.00, 5.00 and 7.00 m, respectively. This trend could be illustrated that the ditcher utilizes lower operating time per unit area with the tunnel spacing. Whereas, the ditcher field capacity is inversely proportional with the holing depth. At any tunnels spacing, at the previous range of the increased forward speed, the ditcher field capacity increased by about 122, 114 and 104% at tunnel depth of 0.30, 0.45 and 0.60 m, respectively. It is may be due to the higher soil resistance against the ditcher share which utilizes more time to accomplish the work.

b. Tractor wheel slip:

Fig. (8) shows that the tractor wheel slip changed positively with the ditcher forward speed. This trend is attributed to the insufficient traction power which make the tractor wheels fail to overcome the tractive force at the higher forward speed, resulting in the higher wheel slip. As the ditcher forward speed increased from 1.85 to 4.25 km/h, the tractor wheel slip increased from 6.20, 9.20 and 13.30 to be 12.20, 15.70 and 19.80% at the tunnel holing depth levels of 0.30, 0.45 and 0.60 m, respectively. This finding is illustrated that holing the tunnels at deeper depth increases the impact action between the ditcher share and the soil, resulting in higher friction force that increases the wheel slip.

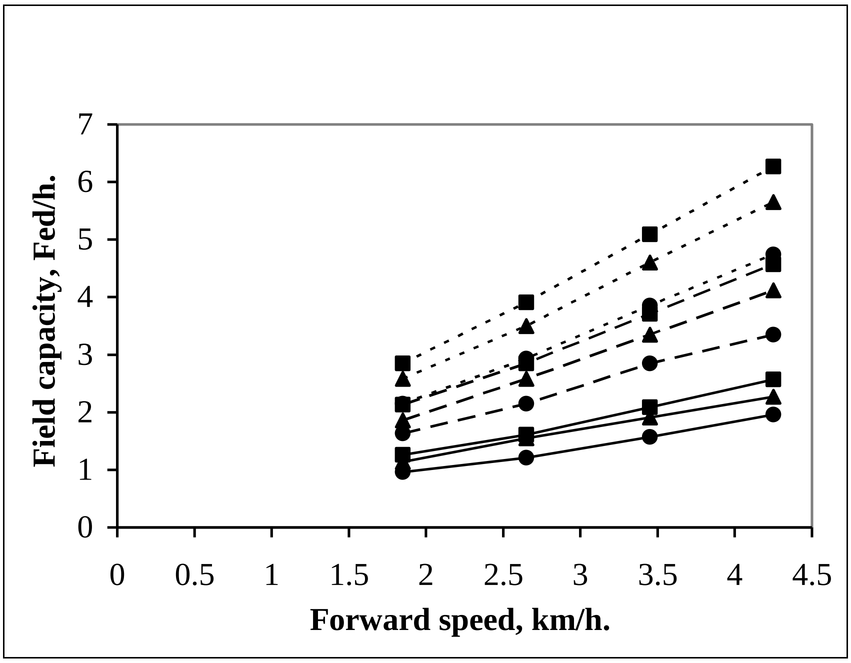

Fig. (7): Effect of ditcher forward speed on field capacity under different tunnel spacing and depth levels.

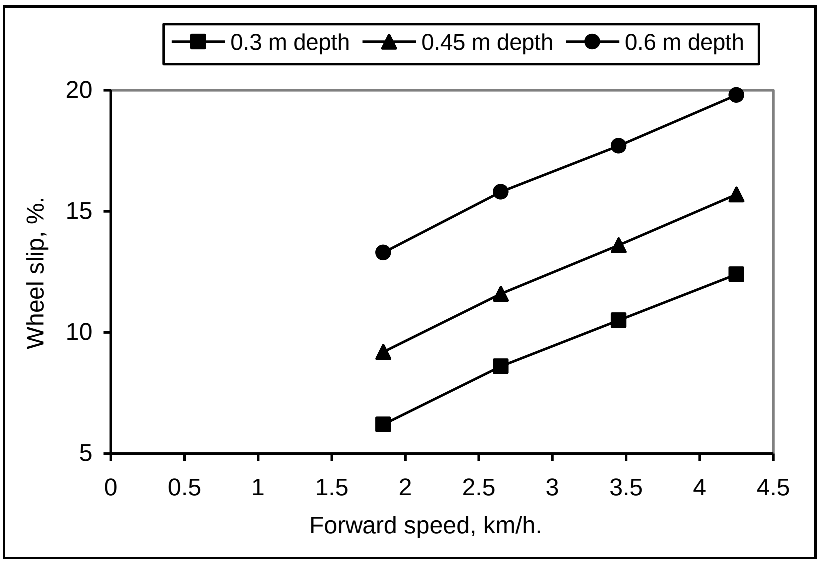

Fig. (8): Effect of ditcher forward speed on tractor wheel slip under different tunnel depth levels.

c. Specific mechanical energy:

Fig. (9) indicates that there is an apparent drop in specific required energy to hole the tunnels at distant spaces with the ditcher forward speed. At any holing tunnel depth, as the forward speed increased from 1.85 to 4.25 km/h, the specific energy requirements decreased by about 33.74, 40.08 and 48.03% at tunnel spacing of 3.00, 5.00 and 7.00 m, respectively. This observation is referred to the reverse relation between the ditcher forward speed and the rolling resistance which is required to move the tractor and the ditcher. So, there is an inversely relation between the ditcher forward speed and the required force to deflect tractor wheels to overcome the wheel and axial bearing friction, resulting in higher draft, consuming more fuel. Also, the inversely proportional of the specific required energy to the tunnel holing spacing is due to the reversible relation between the tunnel holing spacing and the ditcher field capacity. This means that the ditcher consumes lower fuel as the tunnel spacing increased.

At any tunnels spacing, at the previous range of the increased forward speed, the specific energy requirements increased by about 18.52% at each one of the tunnel depth levels of 0.30, 0.45 and 0.60 m. This trend is explained that as the tunnel holing depth increased, the higher soil resistance magnified the draft, consequently, the draw-bar pull increased, requiring more energy to hole the tunnel.

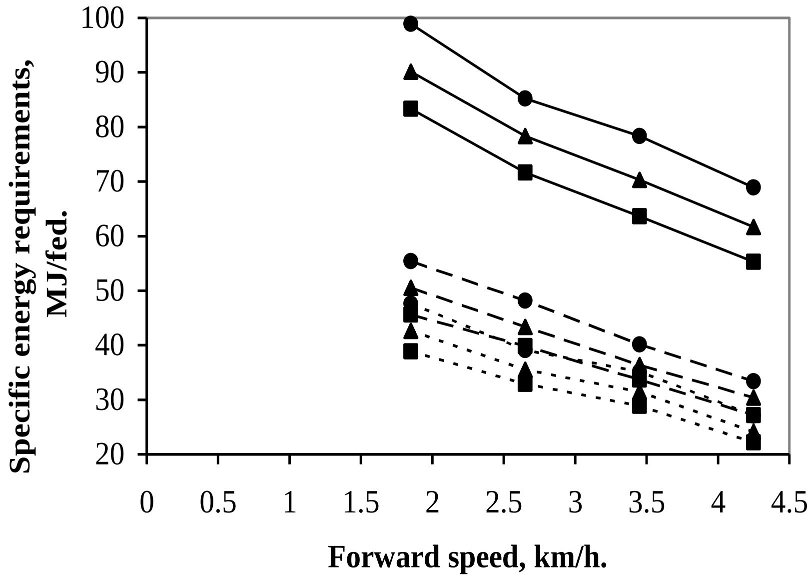

Fig. (9): Effect of ditcher forward speed on specific energy requirements under different tunnel spacing and depth levels.

3. Wheat Crop Yield:

From Fig. (10), it is clear that the application of plant residues increased wheat crop yield (grains and straw) over that was recorded with control. The application of corn stalks at tunnel of 3.00 m spacing and 0.60 m depth achieved the higher wheat crop yield of 3.79 and 3.88 ton/fed. for grains and straw, respectively.

Concerning the effect of plant residues kind on wheat crop yield, with respect to the effect of tunnel spacing on wheat crop yield, data indicate that the tunnel holing at closer spacing led to an increase in wheat crop yield. It can be observe the superiority of 3.00 m spacing since it produced the higher crop yield.

This result may be attributed to the higher rate of plant residues per unit lateral spacing which results in more residues decomposition, leading to more availability of the soil nutrients in the root growth zone. Furthermore, the tunnel holing especially at closer spacing improves the soil infiltration characteristic, consequently, the soil salinity diminishes.

Also, it has been noticed that the deeper tunnel of 0.60 m depth reached the higher wheat yield among the other tunnel depth levels. This finding may be due to the increased plant residues rate at the deeper tunnel depth which led to release higher amount of nutrients during the residues decomposition. In addition, the ditcher deeper holing breaks up the soil impediment against the plant roots in the sub-soil layer, resulting in the encourage of root growth which allows to uptake more soil available nutrients.

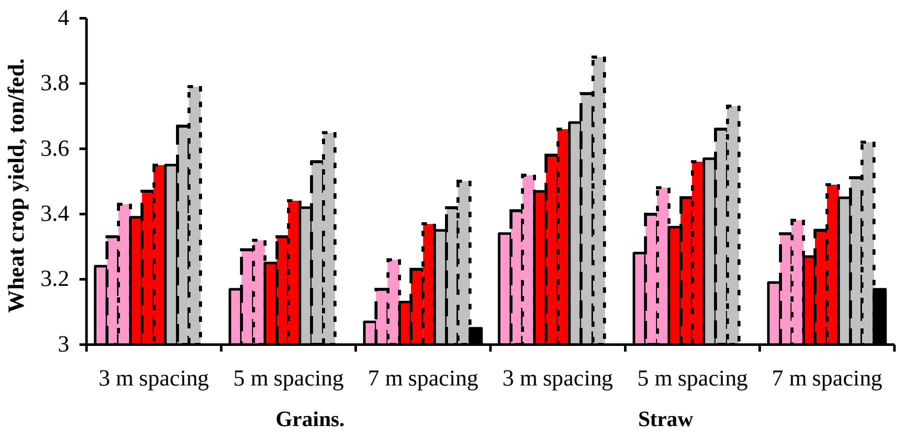

Fig. (10): Effect of some plant residues, tunnel spacing and depth on wheat crop yield.

The analysis of variance indicates that there was high significant difference in wheat grain yield due to the kind of plant residues, tunnel spacing and tunnel depth. L. S. D. test shows that application of corn stalks at 3.00 m tunnel spacing and 0.60 m tunnel depth achieved the higher wheat grain yield among the other treatments.

The obtained data of the regression and correlation analysis reveal that there was a highly significant positive correlation between wheat grain yield (y) and tunnel depth (x) at 3.00, 5.00 and 7.00 m tunnel spacing as follows:

1. 3 m tunnel spacing:

a. Corn stalks : $y = 0.155\ x + 3.088$ ($R^2 = 0.999$)
b. Rice straw : $y = 0.125\ x + 3.030$ ($R^2 = 0.958$)
c. Cotton stalks: $y = 0.090\ x + 2.970$ ($R^2 = 0.965$)

2. 5 m tunnel spacing:

a. Corn stalks : $y = 0.170\ x + 3.150$ ($R^2 = 0.989$)
b. Rice straw : $y = 0.135\ x + 3.123$ ($R^2 = 0.858$)
c. Cotton stalks: $y = 0.125\ x + 3.023$ ($R^2 = 0.917$)

3. 7 m tunnel spacing:

a. Corn stalks : $y = 0.180\ x + 3.230$ ($R^2 = 0.964$)
b. Rice straw : $y = 0.165\ x + 3.140$ ($R^2 = 0.975$)
c. Cotton stalks: $y = 0.120\ x + 3.136$ ($R^2 = 0.997$)

CONCLUSION

The previous results could be concluded as follows:

1. Using the ditcher to apply the plant residues is considered as an effective way to enhance the soil chemical properties and accordingly increasing the crop yield.
2. Holing underground tunnel at closer spacing and at deeper depth achieved the higher crop yield.

Finally, the present study recommended applying the plant residues as soil conditioners to achieve the higher crop yield and to keep the environmental safe.

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تأثير أداء آلة شق القنوات على إستجابة القمح لإستخدام بعض المخلفات النباتية كأسمدة عضوية

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معهد بحوث الهندسة الزراعية – مركز البحوث الزراعية.

أجري هذا البحث بمحطة البحوث الزراعية بالجميزة، محافظة الغربية, وذلك لدراسة تأثير أداء آلة شق القنوات على إستجابة القمح لإستخدام بعض المخلفات النباتية (حطب القطن، قش الأرز، حطب الأذرة) كأسمدة عضوية, وذلك خلال الموسم الشتوي 2007. وقد وضعت مخلفات بعض المحاصيل بكامل هيئتها في أنفاق تحت سطح الأرض تم إنشاؤها بواسطة آلة شق القنوات عند إستخدام سرعات أمامية 1,85, 2.65, 3.45, 4.25 كم/ساعة على أن تكون الأنفاق متوازية على أبعاد 3.00 ، 5.00، 7.00 متر, وعلى أعماق 0.30, 0.45, 0.60 متر, ويمكن تلخيص النتائج المتحصل عليها كالتالي:

1. أدى إستخدام المخلفات النباتية ووضعها في أنفاق تحت سطح التربة إلى تحسين الخواص الكيميائية للتربة, وبالتالي زيادة محصول القمح.
2. أدى إستخدام ووضع حطب الأذرة في أنفاق تحت الأرض تتباعد عن بعضها بمسافة 3.00 متر وعلى عمق 0.60 متر إلى الحصول على أعلى قيمة لمحتوى الكربون العضوي للتربة (2.90%), وأقل قيمة لدرجة حموضة التربة (7.30), وأعلى قيم للعناصر الغذائية الكبرى الميسرة بالتربة نيتروجين (39 جزء في المليون), فوسفور (15 جزء في المليون), بوتاسيوم (392 جزء في المليون), وأدى هذا الأمر إلى الحصول على أعلى قيمة لمحصول حبوب القمح (3.79 طن/فدان).
3. أدى إستخدام آلة شق القنوات للقيام بوضع المخلفات النباتية في أنفاق على بعد 3.00 متر وعلى عمق 0.60 متر إلى تحقيق أعلى سعة حقلية للآلة (1.96 فدان/ساعة), وأقل إحتياجات للطاقة النوعية (68.63 ميجا جول/فدان), وذلك عند إستخدام الآلة عند السرعة الأمامية 4.25 كم/ساعة.

ومما سبق, فإنه يوصى باستخدام آلة شق القنوات لإضافة مخلفات المحاصيل كأسمدة عضوية والتي تعمل على تحسين الخواص الكيميائية للتربة مما يؤدي إلى إستجابة القمح لهذه المخلفات وبالتالي زيادة المحصول. وتقليل تلوث البيئة من المخلفات الزراعية.