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EFFECT OF USING ROTARY PLOW ON SOIL PHYSICAL PROPERTIES AND BARLEY YEILD UNDER RAINFALL CONDITIONS

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ABSTRACT

The purpose of this investigation was to study the effect of rotary plow on the soil physical properties and barely production under Libyan rainfall conditions. Four different plowing depths (5, 10, 13 and 16 cm) were applied with four different forward speeds (3.5, 4.5, 5.5 and 6.5 km.h^{-1}) at each plowing depth. The field experiments were carried out in a sandy-loam soil. The planting method was manual broadcasting and no other treatments were applied after barley seeds broadcasting. The irrigation was completely dependant upon the amount of rainfall during the experiments period. The obtained results from this investigation could be summarized as follows: The soil bulk density and the penetration resistance were much more decreased after all seed-bed preparation treatments, especially in the upper layers of the plowed soil (0-5 and 0-10 cm), since they were decreased from 1.126 g.cm^{-3} and 38.86 N.cm^{-2} to 0.832 g.cm^{-3} and 23.36 N.cm^{-2}, respectively. The soil porosity and voids ratio showed reverse trends as compared with the changes in the soil bulk density. Using the rotary plow for 10-cm depth with 4.5 forward speed gave the higher values of actual field capacity (0.338 fed.h^{-1}), higher field efficiency (83.66%), little fuel consumption (17.22 L.fed^{-1}) and required the lowest values of energy (14.48 kWh.fed^{-1}) as compared with the deeper plowing depths (13 and 16 cm) at the same forward speed. On the other hand, the obtained results at 10-cm plowing depth were almost closely to those obtained at 5-cm plowing depth. The plowing depth showed a significant effect on the number of plants per feddan (plant. fed.$^{-1}$), weight of 1000 seeds (g.) and the biological yield per feddan (grains and straw) than the effect of the forward speed.

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Generally, the plowing depth of 10-cm with all forward speeds gave the highest barely yield (grains and straw) as compared with all plowing depths with the same forward speeds.

It can be recommended that using of rotary plow at 10-cm depth with 4.5 km. h^{-1} forward speed for seed-bed barely production under the conditions of this experiment.

INTRODUCTIN

Barley represents a one of the most important crops, due to its great economical value. It is used in human feeding, in addition to its use in some industrial aspects such as: some special drinks and dried food for animals. **Moussa *et al.,* (2004)** stated that mechanizing the operations related to barley production is necessary to increase its yield.

The effect of tillage on the physical properties of the soil varies considerably with the soil type, soil moisture content at the time of operation, presence of plant residues and type of implements used (**Gooderham, 1976**). Tillage is very important because of weed control, which may save a yield loss of about to 40% (**Awady, 1986**). Tillage is one of the most fundamental and essential operations in agricultural production. It might be defined as the manipulation of soil to develop a desirable soil structure for seed-bed or root–bed to provide adequate air capacity and to establish specific surface configuration for planting operations (**Kepner *et al.,* 1987**).

The rotary plow is used for preparing a fine seed-bed in a single pass and it is considered an excellent device for mixing and distributing the organic matter or other materials throughout the tilled soils. It replaces a large number of implements, as it replaces blows, cultivators and harrows (Hanna and Morocos, 1970).

Suliman *et al.* (1993) used five different tillage treatment and they found that both the soil bulk density and the penetration resistance decreased after all the tillage treatments while, the penetration resistance increased with increasing the tillage depth. **Abo-Habaga (1994)** Using the rotary tiller at unplowed soil leaves a seed–bed with lower soil roughness than the chisel plow at plowed soil. **El-Said *et al.* (1998)** found that the value of soil penetration resistance increased by increasing plowing depth since increasing soil layer depth increased the soil compaction. **Metwalli *et al.* (2000)** found that soil bulk density decreased after tillage with mouldboard plow, chisel plow (one pass) and chisel plow (two passes) and rotary plough compared with that before tillage. They also found that mouldboard plow gave the value of soil bulk density lower than chisel plow and rotary plow. **Suliman *et al.* (2003)** recommended that the system of rotary plow followed by seed drill is the best one for seed-bed preparation and planting system of both fenugreek and mungbean crops. On other hand, the rotary plow was pulverized, crumbed the soil more and gave the lowest soil penetration resistance compared with the other seedbed preparation systems. **Abdel-Aal *et al.* (2005)** indicated that the soil bulk density and soil penetration resistance were decreased for all seedbed preparation systems, while vice versa was noticed with total porosity and void ratio. **Khadr (2000)** reported that power and energy requirements for tilling the soil increased by increasing the tilling depth. The rotary plow gives the lowest fuel consumption and energy requirements compared with the chisel plow (one pass), chisel plow (two passes) and moldboard plow followed by disc harrow, where the energy requirements were (12.28, 13.35, 23.8 and 37.87 kW. h. fed.$^{-1}$) for rotary plow, chisel plow (one pass), chisel plow (two pass) and mouldboard plow followed by disk harrow, respectively. **Khadr (2004)** concluded that the fuel consumption, the overall energy efficiency and the specific energy were increased with the increase of the agricultural operating e speed. Also, he indicated that net fuel consumption of a tractor was found to be dependent upon implement draft and plowing depth. **El-Adawy (1990)** reported that the treatment of rotary plow had the lowest value of average total cost per ton yield of bean crop followed by modified rotary plow, chisel plow (one pass), disk harrow, no tillage, modified chisel plow, chisel plow (two passes) and chisel plow (three passes). **EL-Hanafy *et al.* (1995)** stated that the use of chisel plow followed by rotary tiller can be recommended for tillage technique because it gave the best seed–bed preparation in terms of lowest value of clod mean diameter and the highest yield of barley. **Abdou (1996)** stated that using of rotary plow or disc harrow after chisel plow for preparing the seed–bed at clay–loam soil gives a higher yield of grain and straw compared with chisel plow two passes for wheat crop. On other hand, using the rotary plow at 10 cm depth increased the yield of barley (grain and straw) by 4.74% and 8.86%, respectively. **Abo-Habaga (2003)** used three tillage systems on a silt-clay soil (rotary tiller, chisel plow once followed by rotary tiller and chisel plow twice followed by wooden leveler). He recommended that the rotary tiller system recorded a lower soil roughness, lower penetration resistance and bulk density values at seed germination area, and also, obtained satisfactory crop yield in comparison with the other two systems.

Because most of Tripoli region (Libya) soils texture are sandy loams, in addition to the random use of the rotary plow by cultivators. Therefore, the purpose of this study was to use the rotary plow for preparing the seed–bed in order to investigate the effect of some operating parameters on the soil physical properties and the productivity of the barley yield under the rainfall conditions.

MATERIALS AND METHODS

This study was carried out at the High Institute of Agricultural Technologies (H. I. A. T), El-Gheran (الغيران) Tripoli - Libya in the winter season 2005-2006 (from December 2005 to May 2006) with an experimental area about 2.74 feddan. The experiments were carried out in a sandy-loam soil. Before using the rotary plow for the tillage operation directly, the average moisture content and pH of soil surface layer (0-10 cm) were determined and found to be 9.8% (d.b.) and 7.7, respectively.

A. Soil Mechanical Analysis and pH:

Three soil samples were taken in two soil layers (0-10 and 10- 20 cm) to determine the soil texture and pH. The samples were analyzed at the soil laboratory of the H. I. A. T. El-Gheran, Tripoli, Libya. The results in Table (1), indicated that the average amounts of soil fractions (%) were 78.9 sand, 13.8 silt and 7.3 clay. Thus, the soil texture was classified as a sandy-loam with an average of 7.9 pH.

Table (1): Mechanical analysis and pH of the soil.

Soil depth (cm)	Soil Fractions , (%)					Soil Texture	pH
	Sand			Silt	Clay		
	Coarse	Fine	Total				
0 - 10 0 - 20	41.10 42.10	37.00 37.60	78.10 79.70	14.00 13.60	6.90 7.70	Sandy-loam Sandy-loam	7.7 8.1
Average	41.60	37.30	78.90	13.80	7.30	Sandy-loam	7.9

B. Implements Specifications:

The specifications of the implements used in this study were summarized as shown in Table (2).

C. Experimental Procedure:

The following are the experimental details:

1.Experimental design: To fulfill the objective of this study, an experiment having an area of about 2.74 fed. Was established as a split plots in three replicates, This area divided into four main plots involved four tillage depths (5, 10, 13 and 16 cm). Each main plot include four

Table (2): Some specifications of the implements.

Implement	Specifications
Tractor	AL- Gadah 240. 35.1 kW (47 hp). The power take- off (P. T. O) shaft is 540 r. p. m.
Rotary plow	Kverneland SpL 160. Mounted with 160 cm working width. 32 rotating blades of L-shape fixed on rotative shaft in 8 groups. The all diameter of the drum (rotative shaft plus blades) is 45 cm with 10 cm clearance from the protective cover.

sub-plots, which involved four forward speeds (3.5, 4.5, 5.5 and 6.5 km. h^{-1}) resulted in a total of 48 plots, each of 240 m^2**.**

2- Tillage method: A mounted rotary plow (kverneland spL 160) having 32 L-shape blades arranged in 8 groups on a total plow width of 160 cm was used for soil tilling at four depths (5, 10, 13 and 16 cm). For each depth, the rotary plow was used at four forward speeds (3.5, 4.5, 5.5 and 6.5 km. h^{-1}).

3- Barely seeds and planting method: The barley seeds (six-rows, local type-176 Exad (إكساد)) were planted at flat land by a manual broad- casting, with a rate of 50 kg. fed $^{-1}$.

4- Fertilizing, weed control and irrigation systems: Neither fertilizers nor weed control were applied after seeds spreading. Irrigation was dependant on the amount of rainfall at the experimental location during the period of this study. The actual amounts of rainfall for Tripoli, Libya were obtained from the Tripoli Meteorological Authority (Table 3).

Table (3): Actual amounts of rainfall for Tripoli, Libya.

Month	Dec.(2005)	Jun.(2006)	Feb.(2006)	Marc.(2006)	Apr.(2006)	May(2006)
Rainfall(mm)	132	172.9	44.7	1.5	2.2	3.1

5- Harvesting: Before harvesting barley crop, three randomized samples were taken by hand from each plot using a wooden square frame (1m^2) as a simpler to determine the barley yield per feddan. Finally, the barley crop was harvested using a mounted mower and threshing by thresher.

D. Measurements:

1. Plowing depth (P.D.): The plowing depths were measured using a hand scale (ruler) at three locations in each plot. The adjacent unplowed surface was taken as a reference. The required depth was obtained by means of hydraulic system.

2. Soil moisture content (S.M.C.): It was determined using the Oven method by drying the soil samples at 105˚C for 24 h. according to ASAE (1991).

3. Soil bulk density (ρ_b): It was measured using the core sampler method according to Erbach (1987). The soil bulk density was calculated using the following equation:

$$\rho_b = M_b / V_b, (g.cm^{-3}) \quad ---------------------------------- \quad (1)$$

Where: M_b is the soil dry weight, g and V_b is the core volume, cm^3.

The relative reduction of soil bulk density (R_r. S.B.D.) was calculated as follows:

$$R_r. S.B.D. = (\rho_{b1} - \rho_{b2}) / \rho_{b1} \times 100, (\%) \quad -------------- \quad (2)$$

Where: ρ_{b1} and ρ_{b2} are the soil bulk densities before and after treatments, (g. cm^{-3}).

4. Soil porosity (S. P.): The soil porosity was calculated by using the following formula (Suliman et al., 2003):

$$S. P. = 1 - (\rho_b / \rho_s) \times 100, (\%) \quad -----------------=---- \quad (3)$$

Where: ρ_s is the real soil density, is considered 2.65 g. cm^{-3} (Landon, 1991).

5. Void ratio (V. R.): It was calculated by using the following formula:

$$V. R. = (\rho_s / \rho_b) - 1, (-) \quad ----------------------- \quad (4)$$

6. Soil penetration resistance (S. P. R.): It was measured using a handle local manufactured penetrometer at three locations for each plot at depths of 5, 10, 13 and 16 cm.

El-Saadawy *et al.* (2004) stated that the specific resistance of the soil to penetrometer is due to the weight of the falling load potential energy and the weight of both the falling load and the vertical shaft. According to this fact, the required energy (R. E.) to drive the penetrometer into the soil is expressed as follows:

$$R.E. = ((W_1 * N * H) + D * (W_1 + W_2)), \quad ------------ \quad (5)$$

Where:

W_1 and W_2 are the weights of the falling load and vertical shaft, (kg).

N is the number of impacts, (-).

H is the absolute height of the load fall, (cm).

D is the depth of penetration, (cm).

Since, the soil resistance force (F) is defined as the rate of energy change (E), with respect to the depth (D), hence:

$$F = (d (R.E) / d D) = (W1*N*H) / D + (w1 + W2) \quad -------- \quad (6)$$

Then, S. P. R. (kg. cm^{-2}) was calculated as follows:

$$S.P.R. = (F/A) = ((W_1*N*H) / AD) + ((W_1 + W_2) / A) =$$
$$(N / D) \times ((W_1*H)/A) + ((W_1+ W_2) \text{ ------------------ } (7)$$

Where: A is cross section area of the probe tip, (cm^2).

$$S.P.R. = ((N / D) \times C1) + C2, (kg.cm^{-2}) \text{ ----- } (8)$$

Where: **$C1 = (W_1*H) / A, (kg.cm^{-2})$ and $C2 = (W_1 + W_2) / A, (kg.cm^{-2})$**

From the above equation, it is clear that the number of impacts (N) is a function of the penetration depth (D).

7. Theoretical field capacity (Th.F.C.): It was calculated by using the following formula:

$$Th.F.C. = ((O.S.) \times (O.W.))/4.2, (fed.\ h^{-1}) \text{ ------------ } (9)$$

Where: O.S.: is the operating speed (km /h)

O.W.: is the operating width (m)

8. Actual field capacity (A.F.C.): It was calculated according to Suliman *et al*. (2003) as follows:

$$A.F.C. = 1/(A_t /60) , (Fed.\ h^{-1}) \text{ ----------------------- } (10)$$

here: $A_t = N_t + T_t + P_t$, h. fed.$^{-1}$.

W A_t is the total actual plowing time per fed., min. fed^{-1}.; T_t is the turning time (Time of run per min. x No. of turns per fed., min. fed.$^{-1}$ and P_t is the parasitic time, min. fed.$^{-1}$.

9. Field efficiency (F.E.): It was calculated using the following equation:

$$F.E. = ((A.F.C.) \times 100) / (Th.F.C.) , (\%) \text{ -------- } (11)$$

10. Fuel consumption (F.C.): It was determined during plowing operation by measuring the volume of fuel consumed for each treatment, ($L.h^{-1}$).

11. Energy requirements (E. R.): The energy requirement was calculated by using the following formula (Taib ,1990):

$$E.R. = (P.R.)/(A.F.C.) = (3.6 \times F.C.)/(A.F.C.),$$
$$(kW.h.fed^{-1}) \text{ --- } (12)$$

Where: P. R. is required power of engine (kW).

12. Human power:

The human power expenditure involved in the field operations can be estimated as a normal and healthy human labor supplies 0.1 hp (Chancellor, 1981). Thus, the human power can be calculated as follows:

$$\text{Human Power} = 0.1 \times 0.746 \times \text{No. of laborers} \text{ ------ } (13)$$

RESULTS AND DISCUSSIONS

The obtained were demonstrated and discussed as follows:

1. Soil moisture content: before using the rotary plow for the tillage operation directly (5 Dec., 2005), the average soil moisture content was determined in the soil surface layer of 10 cm and found to be 9.8%. After tillage operation and manual broadcasting of barely seeds, the soil moisture content was determined in the middle of every month interval at the four different tillage depths and the results are shown in Table (4). The results showed that highest soil moisture contents (10.1 to 15.8%) were measured during the months of Dec., 2005 to Feb., 2006, (First stages of barely growth), but the lowest moisture contents (5.7 to 8.9%) were measured during the months of March and April, 2006 (Final stage of barely growth). This was due to the amounts of rainfall incident on this location during these periods (See Table 3) whereas, the soil moisture contents show a parallel behavior with the amounts of incident rainfall. Generally, the soil moisture content was almost adequate for barely growth in the first stages, but it was low in the final stage of barely growth. This may be was one of the reasons which causes the decrease of the barely yield productivity.

Table (4): Soil moisture content before and after the tillage operation at different depths.

Time of determining soil moisture content	Soil moisture content , (%)			
	Tillage depth (cm)			
	0 - 5	0 - 10	0 - 13	0 - 16
5 Dec. 2005*	9.6	10.0	-	-
15 Dec. 2005	11.3	12.6	12.8	13.0
15 Jan. 2006	13.4	15.2	15.5	15.8
15 Feb. 2006	10.1	10.8	11.2	11.6
15 Mar. 2006	6.8	7.4	8.7	8.9
15 Apr. 2006	5.7	6.2	7.6	7.8

* Before plowing.

2. Effect of different seed-bed preparation treatments on some soil physical properties: Table (5) show the data obtained for the values of soil bulk density, total soil porosity and voids ratio before and after the tillage operations at various tillage depths and forward speeds of the rotary plow.

2.1. Soil bulk density: From the data in Table (5), it is clear that the values of soil bulk density were decreased after all seed-bed preparation treatments compared with those before treatments (no-tillage). The lowest values of soil bulk density (0.832 and 0.886 g.cm^{-3}) were obtained at the upper soil layers (plowing depths of 5 and 10 cm) with the highest forward speed (6.5 km. h^{-1}), while the highest values of soil bulk density (1.127 and 1.032 g.cm^{-3}) were obtained at the deeper soil layers (plowing depths of 13 and 16 cm) with the lowest forward speed (3.5 km.h^{-1}). It is clear also, that the relative reduction of the soil bulk density was much more in the two upper layers of the plowed soil (0-5 and 0-10 cm) compared with the others two deep soil layers (0-13 and 0-16 cm). The data indicated that the highest values of relative reduction of soil bulk density (26.11% and 25.04%) were obtained at plowing depths of 5 and 10 cm with the highest forward speed (6.5 km. h^{-1}), while the lowest values of soil bulk density (18.42% and 18.33%) were obtained at plowing depths of 13 and 16 cm with the lowest forward speed (3.5 km.h^{-1}). At all plowing depths, the relative reduction of soil bulk density was increased with increasing the forward speed of the rotary plow and this resulted in decreasing the soil bulk density. This due to the fact that lower forward speed of rotary plow decreased the soil mean diameter. On other hand, using rotary plow at low forward speeds stirs, pulverizes, crumbs and increases the soil distribution volume much more than using it with higher forward speeds. These results are agreed with the obtained results by Metwalli et al. (2000).

2.2. Soil porosity: The data shown in Table (5) indicated that soil porosity values increased after all seed-bed preparation treatments than those before treatments. It is clear, that the soil porosity shows a reverse behavior as compared with the changes in soil bulk density at all seed-bed preparation treatments. On the other hand, the results indicated that the soil porosity was decreased gradually with the tillage depth because the deep soil layers were more compacted than the upper soil layers. For every tillage depth, the soil porosity and its relative reduction were increased by increasing the forward speed of the rotary plow. These results are in agreement with Abdel-Aal et al. (2005).

2.3. Voids ratio: As shown in Table (5), the values of the total voids ratio are higher in all seed-bed preparation after treatments than those before treatments. The voids ratio decreased by increasing the soil depth with all forward speeds, due to the fact that increasing the soil layer depth increases the soil compaction. The values of relative reduction of voids ratio were higher in the deep plowed soil layers (0-16 cm) as compared with the corresponding values in the upper layers (0-5 and 0-10 cm). These results are in agreement with Abdel-Aal et al. (2005).

2.4. Soil penetration resistance: The soil penetration resistance has a good indication of soil physical properties. The decrease of soil penetration resistance allows the roots of plants easily to penetrate the soil and grow. The soil penetration resistance was measured after all seed-bed preparation at four plowing depths (5, 10, 13 and 16 cm) and four forward speeds (3.5, 4.5, 5.5, and 6.5 km. h^{-1}) with each plowing depth. As shown in Table (6), the soil penetration resistance was decreased after all seed-bed preparation treatments compared with that before treatment. Also, it is clear that the soil penetration resistance increased by increasing the plowing depth, since the soil compaction increased with increasing the soil layer depth. On other hand, the soil penetration resistance was increased by increasing the forward speed of rotary plow at all plowing depths. The highest values of soil penetration resistance (27.12, 35.96, 43.17 and 47.52 $N.cm^{-2}$) were obtained by using the highest forward speed (6.5 km. h^{-1}), while the lowest values of soil penetration resistance (23.36, 29.98, 39.91 and 43.60 $N.cm^{-2}$) were obtained by using the lowest forward speed (3.5 km. h^{-1}) for plowing depths of 5, 10, 13 and 16 cm, respectively. For each plowing depth, the highest value of relative reduction of soil penetration resistance was measured by using forward the lowest speed (3.5 km. h^{-1}), while the lowest value of relative reduction was obtained by using the highest forward speed (6.5 km. h^{-1}). These results are in agreement with Suliman et al. (2003) and Abdel-Aal et al. (2005).

3. Effect of different seed-bed preparation treatments on field capacity, field efficiency, fuel consumption and required energy:

Fig.(1) shows the field capacity and field efficiency for different plowing depths (5, 10, 13 and 16 cm) and forward speeds of rotary plow (3.5, 4.5, 5.5 and 6.5 km. h^{-1}) with using a manual broadcasting for barely seeds. From the results in Fig.1, it is clear that the actual field capacity decreased by increasing the plowing depth. On the other hand, it increased by increasing the forward speed of the rotary plow in all plowing depths. The highest value of actual field capacity (0.381 fed.h^{-1}) was obtained at the lowest plowing soil porosity and voids ratio of soil. depth (5cm) and highest forward speed (6.5 km. h^{-1}), while the lowest value (0.270 fed. h^{-1}) was obtained at the highest plowing depth (16 cm) and lowest forward speed (3.5 km. h^{-1}). In this study, the values of the actual field capacity were lower than the expected values and this may be due to that the use of manual broadcasting of barely seeds consumed the highest total actual time.

Fig. (1). shows that the field efficiency was decreased by increasing both plowing depth and the forward speed of the rotary plow. The highest field efficiency (87.53%) was obtained at the lowest plowing depth (5 cm) and lowest forward speed (3.5 km. h^{-1}), while the lowest field efficiency (74.20%) was obtained at the highest plowing depth (16 cm) and highest forward speed (6.5 km. h^{-1}).

Table (5): Effect of seed-bed preparation treatments on bulk density,

Before treatment			Treatment		S.B.D. (g.cm^{-3})	Relative reduction of S.B.D. (%)	Soil porosity (%)	Relative increasing of S.P. (%)	Voids ratio	Relative increasing of V.R. (%)
.D. (…m^{-3})	S.P. (%)	V.R.	Tillage depth (cm)	Forward speed (km.h^{-1})						
126	54.20	1.96	0 - 5	3.5	0.892	20.78	66.32	22.63	3.36	71.43
				4.5	0.871	22.65	69.81	28.80	3.42	74.49
				5.5	0.847	24.78	72.64	34.02	3.56	81.63
				6.5	0.832	26.11	73.20	35.06	3.61	84.18
182	52.60	1.71	0 - 10	3.5	0.936	20.81	64.12	21.90	3.12	82.46
				4.5	0.918	22.34	64.48	22.59	3.19	86.55
				5.5	0.910	23.01	65.00	23.57	3.26	90.64
				6.5	0.886	25.04	65.76	25.02	3.33	94.74
265	51.30	1.56	0 - 13	3.5	1.032	18.42	62.61	22.05	2.98	91.03
				4.5	1.019	19.45	63.10	23.00	3.11	99.35
				5.5	1.003	20.71	63.48	23.74	3.18	103.85
				6.5	0.982	22.37	63.96	24.68	3.21	105.77
380	50.80	1.47	0 - 16	3.5	1.127	18.33	61.07	20.22	2.83	92.52
				4.5	1.118	18.99	61.35	20.78	2.91	97.96
				5.5	1.109	19.63	61.92	21.89	3.08	109.52
				6.5	1.100	20.29	62.41	22.85	3.14	113.61

* S.B.D. is the soil bulk density, (g.cm^{-3}), * S.P. is the soil porosity, (%), *V.R. is the voids ratio.

Table (6): Effect of seed-bed preparation treatments on soil penetration resistance.

Before treatment	Treatment		Soil penetration resistance ($N.cm^{-2}$)	Relative reduction of *S.P.R. (%)
	Tillage depth (cm)	Forward speed ($km.h^{-1}$)		
38.86	0 - 5	3.5	23.36	39.89
		4.5	24.12	37.93
		5.5	26.38	32.12
		6.5	27.12	30.21
42.86	0 - 10	3.5	29.98	29.76
		4.5	32.07	24.86
		5.5	34.18	19.92
		6.5	35.96	15.75
48.37	0 – 13	3.5	39.91	17.49
		4.5	41.05	15.13
		5.5	42.10	12.96
		6.5	43.17	10.75
51.88	0 – 16	3.5	43.60	15.96
		4.5	45.12	13.03
		5.5	46.00	11.33
		6.5	47.52	8.40

*SP.R. is the soil penetration resistance ($N.m^{-2}$).

Fuel consumption was measured for all mechanical operations of seed-bed preparation, while energy requirements was calculated for all mechanical operations for seed-bed preparation and manual broadcasting of barely yield. Fig.(1), shows that lowest fuel consumption (14.83 L. fed^{-1}) was measured at the lower plowing depth (5 cm) with the lower forward speed (3.5 km. h^{-1}), while the highest value of fuel consumption (27.78 L. fed^{-1}) was obtained at the higher plowing depth (16 cm) with the higher forward speed (6.5 km. h^{-1}). It is clear that the fuel consumption increased by increasing both of the plowing depth and the forward speed of the rotary plow. On other hand, the fuel consumption was more affected by the plowing depth than the forward speed.

Fig.(1) shows that the required energy per feddan was increased by increasing both of the plowing depth and forward speed. The lower plowing depth (5 cm) with the lowest forward speed (3.5 km. h^{-1}) was required the lowest value of energy (12.24 kWh. $fed.^{-1}$), but the highest value of energy (20.22 kWh. $fed.^{-1}$) was required for the higher plowing depth (16 cm) with the higher forward speed (6.5 km. h^{-1}). Using Fig.,(1) it can be obtained actual field capacity, field efficiency, fuel consumption and energy requirements for each plowing depth with any forward speed of the rotary plow simultaneously, under the condition of this experiment. These results are in agreement with the results obtained by Khadr (2000) and Khadr (2004).

4. Effect of different seed-bed preparation treatments on barely yield and yield index.

In this study, barely yield includes the sum total of the following parameters: plant height, numbers of plants per feddan and weight of 1000-grain (Table 7). From the obtained results, it is clear that there is a significant effect for seed-bed preparation treatments on the grains yield. On other hand, the plowing depth was more effect on grain yield than the forward speed of the rotary plow. The values of highest grain yield (kg. fed^{-1}) were obtained at 10 cm plowing depth with all forward speeds as compared with the lower and higher plowing depths with the same forward speeds. The highest grain yield (767.68 kg $fed.^{-1}$) and highest straw yield (1497.53 kg. $fed.^{-1}$) were obtained by using forward speed of 4.5 km. h^{-1} at 10-cm plowing depth, but the lowest grains yield (488.83 kg $fed.^{-1}$) and lowest straw yield (1187.55 kg. $fed.^{-1}$) were obtained by using forward speed of 6.5 km. h^{-1} at 16-cm plowing depth. Highest grain and straw yields were obtained at 10-cm plowing depth with forward speed of 4.5 km. h^{-1} than the other forward speeds, although it gave the highest yield index (33.89 %). This means that the highest biological yield of barely (2265.21 kg. $fed.^{-1}$) was obtained by using rotary plow for10-cm plowing depth with 4.5 km. h^{-1} forward speed. Generally, it was noticed that the values of barely yield were lower than the expected values, although the use of rotary plow gave lowest values of soil penetration resistance which help the root system of plants to penetrate the soil easily. The decrease of barely yield may be due to that the use of manual broadcasting method gave un-similar distributions of seeds, crowded plants, left some seeds without covering and the local type of barely seeds used in this study. On the other hand, neither fertilizer nor weed control was applied after seeds spreading and also, the amount of rainfall at the experimental location was low in the end stages of the barely growth (April and May, 2006). Finally, the results indicated that the use of rotary plow for 10-cm plowing depth with 4.5 km. h^{-1} forward speed gave the highest values of barely yield (grain and straw).

CONCLUSION

The aim of this investigation was to study the effect of using rotary plow on physical properties and barely yield under Libyan rainfall conditions. To achieve this goal the following parameters were used and tested:

- The experiments were carried out in a sandy-loam soil under the conditions of bio-agriculture (without adding any fertilizers or herbicides)
- The rotary plow was used to plow soil at four plowing depths (5, 10, 13 and 16 cm) and four forward speeds (3.5, 4.5, 5.5, 6.5 km. h^{-1}) with each plowing depth.
- The planting method of barely was a manual broadcasting.
- The irrigation method was completely dependant upon the amount of rainfall during the period of the experiments.

The obtained results can be summarized as follows:

1. Soil bulk density was decreased after all seed-bed preparation treatments as compared with that before treatments. The lowest value of soil bulk density (0.892 g. cm^{-3}) was obtained at the lower plowing depth (5 cm) with the lower forward speed (3.5 km. h^{-1}), while the highest value (1.10 g. cm^{-3}) was obtained at the higher plowing depth (16 cm) with the higher forward speed (6.5 km. h^{-1}).

2. The soil penetration resistance takes the same trend as the soil bulk density. Both of soil bulk density and soil penetration resistance were increased with the increase of both plowing depth and forward speed.
The lowest value of soil penetration resistance (23.36N.cm^{-2}) was obtained at plowing depth of 5cm with the lower speed (3.5km. h^{-1}), while the highest value of it (47.52 N. cm^{-2}) was obtained at the higher plowing depth (16 cm) with the higher forward speed (6.5 km. h^{-1}).

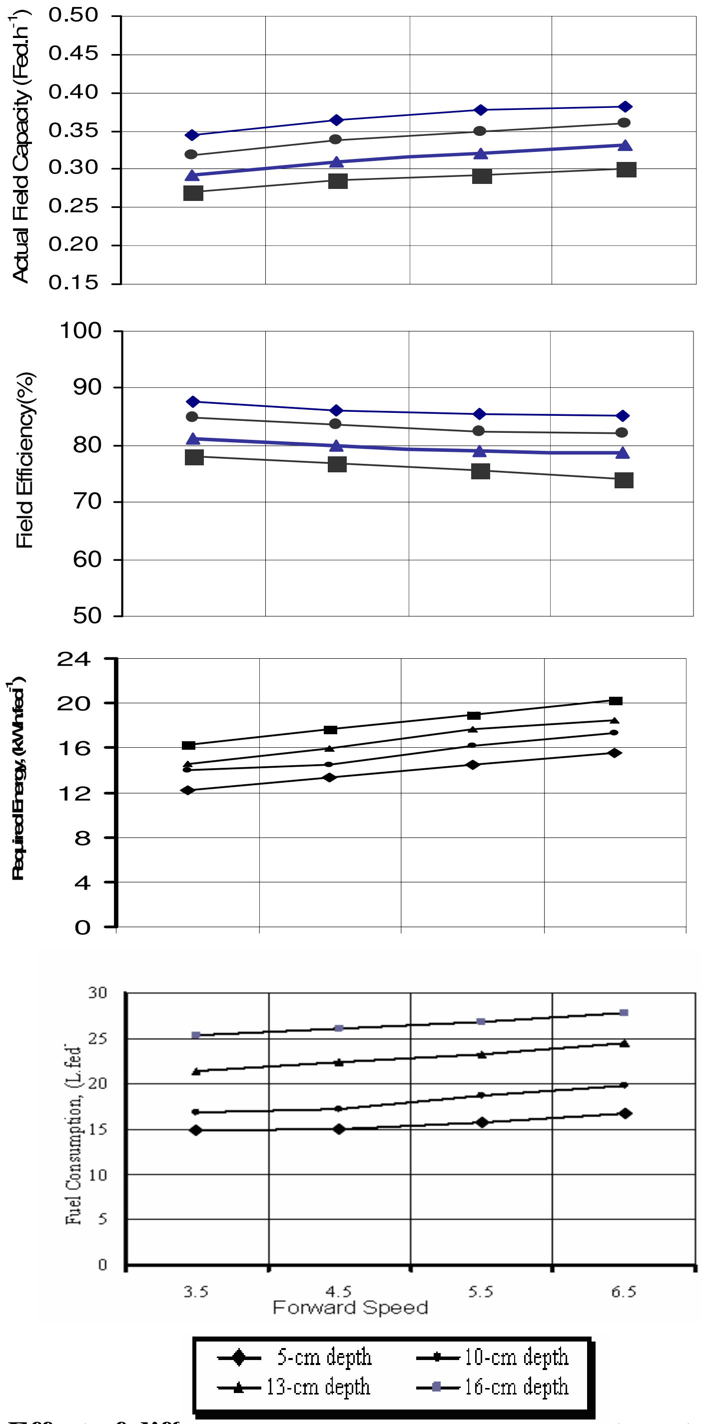

Fig. (1): Effect of different seed-bed preparation treatments on actual field capacity, field efficiency, fuel consumption and energy requirements.

Table (7): Effect of different seed-bed preparation treatments barely yield and yield Index.

ment	Aver. Plant height, (cm)	Aver. No. of plant, (plant/fed.)	Aver. weight of 1000 grain, (g)	Aver. biological Yield ($kg.fed.^{-1}$)	Aver. grain yield ($kg.fed^{-1}$)	Aver. straw yield, ($kg.fed^{-1}$)	Yield index, (%)
Forward speed, ($km.h^{-1}$)							
3.5	44.3	2395386	38.1	1725.14	534.79	1190.35	30.99
4.5	45.7	2473296	38.3	1778.83	572.96	1205.87	32.21
5.5	45.1	2177953	37.6	1510.72	484.34	1026.38	32.06
6.5	44.2	2134148	37.4	1463.45	466.12	997.34	31.85
3.5	46.5	2528738	39.2	2206.58	733.91	1472.67	33.26
4.5	49.3	2596676	42.3	2265.21	767.68	1497.53	33.89
5.5	47.6	2422062	41.1	2197.49	716.60	1480.89	32.61
6.5	46.4	2307352	39.0	2164.34	715.53	1448.81	32.06
3.5	45.7	2487662	38.7	1993.23	624.28	1368.95	31.32
4.5	48.3	2503511	40.3	2058.25	660.49	1397.76	32.09
5.5	47.1	2344230	38.6	1841.98	580.59	1261.39	31.52
6.5	46.3	2338561	37.9	1733.60	530.83	1311.17	30.62
3.5	45.6	2312522	38.3	1799.48	576.37	1223.11	32.03
4.5	46.9	2392062	39.6	1917.61	639.14	1278.47	33.33
5.5	46.6	2295132	38.7	1775.09	547.79	1227.30	30.86
6.5	45.9	2217352	37.2	1676.38	488.83	1187.55	29.16

3. The actual field capacity was decreased by increasing the plowing depth, but it was increased with the increase of forward speed at all plowing depths. Plowing depth of 5 cm with 6.5 km. h^{-1} forward speed gave the highest value of actual field capacity (0.381 fed. h^{-1}), while the lowest value of field capacity (0.270 fed. h^{-1}) was obtained at plowing depth of 16 cm with 3.5 km. h^{-1} forward speed.

4. The field efficiency was deceased by increasing both plowing depth and forward speed. Plowing depth of 5 cm with 3.5 km. h^{-1} forward speed gave the highest value of field capacity (87.53%), but the lowest value (74.20%) was obtained at plowing depth of 16 cm with 6.5 km. h^{-1} forward speed.

5. Plowing depth of 5-cm with lower forward speed (3.5 $km.h^{-1}$) consumed lowest value of fuel per hour (14.83 $L.fed^{-1}$) and required the lowest value of energy (12.24 kWh. $fed.^{-1}$), but plowing depth of 16 cm with higher forward speed (6.5 km. h^{-1}) consumed highest value of fuel (27.78 $L.fed^{-1}$) and required highest value of energy (20.22 kW. $h.fed.^{-1}$).
6. Plowing depth of 10 with all forward speeds (3.5, 4.5, 5.5 and 6.5 km. $h.^{-1}$) gave the highest values of grain yields (733.91, 767.68, 716.60 and 715.53 kg. $fed.^{-1}$) and straw yields (1472.67, 1497.53, 1480.89 and 1448.81 kg. $fed.^{-1}$), respectively as compared with the other plowing depths, although it gave the highest yield index.
7. The highest seed and straw yields (767.68 and 1497.53 kg. $fed.^{-1}$) were obtained at the plowing depth of 10 cm with the forward speed of 4.5 $km.h^{-1}$ as compared with the other forward speeds with this depth.
RCOMMENDATIONS
1. The use of rotary plow for plowing a sandy-loam soil at depth of 10-cm with forward speed of 4.5 km. $h.^{-1}$ can be recommended for seed-bed preparation and barely yield production because it consumed lowest energy and gave highest yield production under the conditions of this experiment.
2. For obtaining a higher barely yield, an auxiliary irrigation must be provided at the final stage of the crop growth (April and May moths), to maintain adequate soil moisture content required for completing the plant growth under the condition of this experiment.

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الملخص العربى

تأثير إستخدام المحراث الدورانى على الخواص الطبيعية للتربة وإنتاجية محصول الشعير تحت الظروف المطرية

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إنتشر إستخدام المحراث الدورانى فى ليبيا حديثا، حيث يعتبر من أهم أنواع المحاريث شيوعا بين المزارعين لإعداد مرقد البذرة ونظرا للإستخدام العشوائى له جاءت فكرة هذا البحث. أجرى هذا البحث بمزرعة المعهد العالى للتقنيات الزراعية بالغيران - طرابلس - ليبيا فى تربة رملية - طميية على محصول الشعير صنف محلى-167 إكساد. ويهدف هذا البحث إلى دراسة تأثير إستخدام المحراث الدورانى على الخواص الطبيعية للتربة وإنتاجية محصول الشعيرتحت ظرف الزراعة المطرية. ولتحقيق هذا الهدف أجريت المعاملات الآتية:

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• أستخدام المحراث الدورانى للحرث على أربعة اعماق مختلفة (5،10،13،16 سم) وإستخدم مع كل عمق من أعماق الحرث السابقة أربعة سرعات أمامية للجرار(3.5 - 4.5 - 5.5 - 6.5 كم/س)، وذلك لدراسة تاثير عمق وسرعة الحرث على إعداد مرقد البذرة من حيث الخواص الطبيعية للتربة وتحديد أنسب عمق للحرث مع سرعة التشغيل التى تحقق أفضل أداء تشغيلى للمحراث الدورانى بأ قل إستهلاك للوقود وأقل طاقة ممكنه وأعلا إنتاجية لمحصول الشعير.

• تمت عملية الزراعة بالنثر اليدوى لبذور الشعير تحت ظروف الزراعة الحيوية (بدون إضافة أى أسمده كيماويه أو مبيدات)، واقتصر رى الشعير على كمية الأمطار الساقطة على تلك المنطقة خلال فترة التجربة.

تتلخص النتائج التى تم الحصول عليها فيما يلى:

1. كان المحتوى الرطوبى للتربة كافيا فى المراحل الأولى لنمو الشعير(15 ديسمبر 2005 حتى نهاية فبراير 2006) ، حيث تراوح ما بين 10.1% الى 15.2% فى الطبقات السطحية للتربة (0-5 ، 0-10 سم)، بينما قل فى المراحل النهائية للنمو (مارس - مايو 2006) وذلك نتيجة لقلة كمية الأمطار الساقطة فى هذه الفتره، حيث تراوح مابين 5.7% الى 6.2% وقد إنعكس ذلك على إنتاجية محصول الشعير المطرى.

2. قلت قيم الكثافة الظاهرية للتربة عند جميع معاملات الحرث عن قيمها قبل عملية الحرث بنسب تراوحت ما بين 18.33% الى 26.11%، وكانت أقل القيم لها فى الطبقة السطحية للتربة المحروثة على عمق 10سم فأقل، حيث قلت من 1.182 جم/سم ^{3} الى 0.886 جم/سم ^{3} بنسبة 25.04%.

3 . قلت قيم مقاومة التربة للإختراق عند جميع معاملات الحرث عن قيمها قبل عملية الحرث، بنسب تراوحت ما بين 8.40% الى 29.89 % وكانت أقل القيم لها فى الطبقة السطحية للتربة المحروثة على عمق 10سم فأقل، حيث قلت من 42.86 نيوتن/سم^2 الى 29.38 نيوتن/سم^2 بنسبة 29.98%.

4. أعطى الحرث للطبقة السطحية للتربة (10سم فأقل) أقل قيم لإحتياجات الطاقة لوحده المساحة (12.24 ك.وات.ساعة/فدان) وأقل قيم لإستهلاك الوقود (14.83 لتر/فدان)، مقارنة بالحرث على الأعماق الكبيرة (13سم فأكثر(18.24 ك.وات.ساعة/فدان ، 24.52 لتر/فدان على الترتيب).

5. أعطى الحرث للطبقة السطحية للتربة (10سم فأقل) أعلا معدل أداء فعلى (0.359 فدان/ساعة) وأعلا كفاءة حقلية (84.84%) مقارنة بالأعماق الأكبر (13سم فأكثر)، حيث كانتا ما بين 0.292 فدان/ساعة الى 0.302 فدان/ساعة بالنسبة لمعدل الأداء، ما بين 74.20% الى 81.26% بالنسبة للكفاءة الحقلية.

6. كانت أعلا إنتاجية لمحصول الشعير (قش-حبوب) فى التربة المحروثة على عمق 10سم مع جميع السرعات الأمامية المستخدمة (1993.23 – 2265.21 كجم/فدان)، مقارنة بإنتاجيتة فى التربة المحروثة على أعماق أقل أو أكبر من هذا العمق عند نفس السرعا ت الامامية للحرث،

حيث تراوحت ما بين 1425.45 – 1725.14 كجم/فدان عند عمق حرث 5سم، وما بين 1676.38 – 1799.48 كجم/فدان عند عمق حرث 16سم.

7. أعطى الحرث على عمق 10سم مع سرعة أمامية 4.5 كم / س أعلى إنتاجية لمحصول الشعير (2265.21 كجم/فدان) مقارنة بالسرعات الأخرى عند نفس العمق، حيث كانتا 2197.49 كجم/فدان عند سرعة حرث 5.5 كم/ساعة، 2164.34 كجم/فدان عند سرعة حرث 6.5 كم/ساعة.

8. كان لعمق الحرث التأثير الأكبر على الخصائص الطبيعية للتربة، معدل إستهلاك الوقود، إحتياجات الطاقة وإنتاجية محصول الشعير مقارنة بتأثير السرعة الأمامية لعمليه الحرث.

التوصيات

1. يوصى بإستخدام المحراث الدورانى على عمق 10سم مع سرعة أمامية 4.5كم/ س للحصول على إعداد جيد لمرقد البذرة و أعلى أنتاجية لمحصول الشعير تحت ظروف الزراعة المطرية فى التربة الرملية-الطمية تحت ظروف هذه التجربة.

2. للحصول على أعلى إنتاجية لمحصول الشعير تحت ظروف هذه التجربة يجب تزويد التربة بالرى الإضافى أثناء فترات نمو المحصول النهائية (خلال شهرى أبريل ومايو) لإعطاء التربة الرطوبة الكافية المطلوبة لإتمام نمو المحصول.