Agricultural engineering programs as related to employment requirements: 467 - 480

STUDY THE EFFECT OF DIFFERENT TYPES OF REAR ROLLERS ATTACHED TO THE VERTICAL ROTARY TILLER ON THE SANDY LOAM SOIL

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ABSTRACT

This study was conducted on the developed Kuhn model rotary power harrow, which originally designed mainly for secondary tillage of sugar beet cultivate, to be makes cropping more rational and the soil easier to cultivate. The aim of this work is to study and choose a suitable rear roller that attached rotary power harrow to be maximizing exploitation by Egyptian investments in new reclaimed land. The equipment was tested under different operating conditions, at depth of rear roller (3, 5 and 7 cm), tractor forward speed (2.8, 3.9, and 4.6 km/h) and four types of rear roller (cage, spike, packer and helical). The results showed that the optimum forward speed is 4.6 km/h, depth of rear roller was 7 cm and the suitable type of rear roller packer, respectively due to its ability to level plough furrows, crushing clods and reconsolidate the soil.

INTRODUCTION

In Egypt most exporting rotary power harrow needed more study for choosing the suitable rear roller. The Egyptian investments in new reclaimed land was needy the rear roller that attached rotary power harrow for suitable its soil bed preparation for sugar beet crop (shallow cultivate), improving soil structure and give desired roots of sugar beet. Consequently, the production of sugar beet root and sucrose percentage increased. So, this study aimed to choosing the suitable rear roller, while secondary tillage operation in order to offer the time, effort and cost. Allam et al. (1988) showed that, sugar beet is considered as one of the most important crops not only for sugar production but also for producing fodder and organic matter for the soil. It extends to the use of its products in producing untraditional animal feed.

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Therefore government is planning to increase the growing area of sugar beet and improving the technique of agricultural processes. The prospective of mechanical growing of sugar beet in Egypt are very promising and can be adapted in the old valley farms and the newly reclaimed areas. Raininko (1990) found that the best depth to planting mono-germ sugar beet coated seed is from 1 to 3 cm. he also, indicated that the growth of sugar beet root go deep to 75 cm. Abdalla (1999) indicated that, the sowing process is considered one of the most agricultural operations. The art of planting seeds in the soil to obtain high germination ratio and healthy plants is the most important objective to achieve highest yield. Abo-Habaga (1987) reported that using rotary tiller as a secondary tillage implement leaves a satisfactory level surface with a low degree of soil roughness for a sufficiently tilled seed-bed. Abo-El-Ees (1985) Reported that the rotary tiller is one of the active machines used in seed-bed preparation, where basic movement of working elements is rotation around a stationary axes. The use of rotary tillers has recently become widespread in Egypt due to its suitability and feasibility for small acreages. Kosutic et al. (1997) found that the best combination with respect to minimum energy requirement and highest rate of work for a rotary tiller was 4.87 km/h. working speed, 12 cm depth of tillage and 5.91 m/s peripheral tine velocity. Rotary tillers prepare the seed bed fundamentally different than the conventional method of plowing. The soil is pulverized by the cutting and chopping action of a number of blades that receive energy from the engine of the prime mover. It was reported that the performance of the transplanted lowered when the soil was not sufficiently soft and leveled after pudding. As far as the quality of the seedbed is concerned, one pass of the rotary tiller is equivalent to several conventional tillage operations Mandang et al. (1993). Shibusawa (1993) found that the reverse-rotary tiller cuts and throws the soil backwards in the form of large sliced soil clods.

MATERIALS AND METHODS

The actual field experiments were conducted at the Salihea sector- Al-Sharkea Governorate. The field experiments were carried out in a sandy loam soil during seed – bed preparation before planting sugar beet in winter season of 2010-2011. The chemical and mechanical properties of the experimental soil are summarized in table (1).

Table (1): The chemical and mechanical analysis of the experimental field soil.

[redacted]				Soil texture	PH	$CaCo_3$ (%)	Soil bulk density gm/cm^3
Clay	Silt	Fine sand	Coarse sand				
6.4	3.8	16.1	71.52	sandy loam	8.1	2.18	1.4
[redacted]							

Materials:

The utilized rotary power harrow machine:

The numerous rotary power harrow Kuhn vertical rotary type existent in Salihea sector within the French product. They are obtained secondary tillage on soil, that suitable Egyptian condition and requirement to study. The Kuhn vertical rotary power harrow has two units front tines units and rear roller unit consists of group of parts attached frame bar hitching by three points with hydraulic system, as shown in fig. (1).

Table (2): Specifications of studied rotary power harrow

[redacted]	
Tractor HP Required	140-180 Hp
Length, mm	2000
Width, mm	4000
Height, mm	1200
Weight, Kg	1900

The experimental field was prepared by soil bed preparation machines, moldboard plow at 40 cm plowing depth) , followed by vertical rotary plow (10 cm depth and working width about 4 m.) attached with rear roller. This study was conducted to comparative between performance of four different types of rollers, to study the effect of each one on seed – bed preparation and soil constructer before planting sugar beet seeds to obtain optimum seedbed preparation in sandy loam soil, to good germination, vigorous young plants and maximized yield.

Source of power:-

A New Holland tractor 180 Hp was used in field experiments as the power source. As shown in fig. (1), Tractor and vertical rotary plow attached with rear roller at working width 4 m.

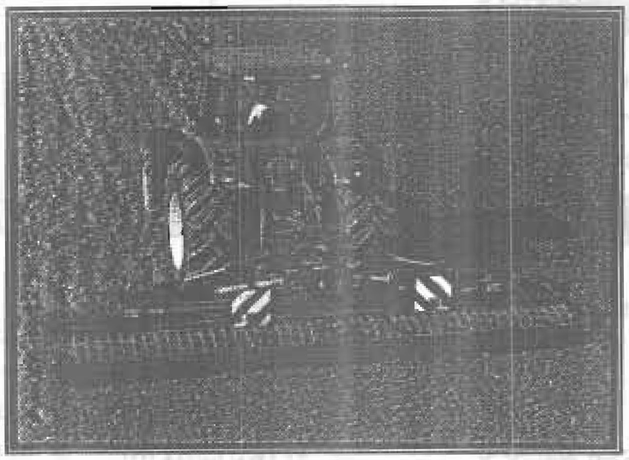

Fig. (1) : Rotary power harrow while working

To evaluate the performance of affecting each roller attached vertical rotary plow, there were many factors and measurements under study.

Scope of factors:-

The main factors used in field experiments were as follows:-

1-Type of Rollers: four types of rollers treatments with different shapes and weights were taken in this study as shown in fig.s (2 and 3) [(**R_1**) Cage roller – (**R_2**) Spike roller – (**R_3**) Packer roller – (**R_4**) Helical roller.]

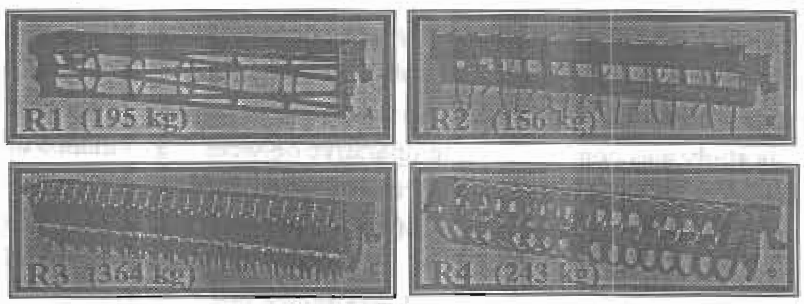

Fig. (2): Types of rear rollers with weight of each one

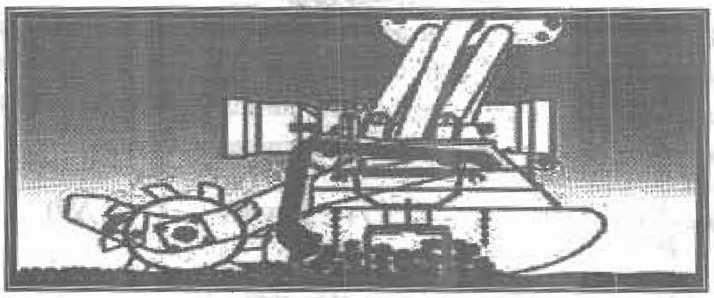

Fig. (3): Side view schematic diagram for vertical rotary power harrow attached with rear roller

2-Forward Speed: (Fs_1 = 2.8) & (Fs_2 = 3.9) & (Fs_3 = 4.6) km/h

3-Working Depth of Rollers (d_1 = 3) & (d_2 = 5) & (d_3 = 7) cm

Experimental measurements

There were four measurements were calculated as follows:

1- Soil penetration resistance:

The penetration resistance of soil is important to characterise the soils in terms of crop growing ability and to determine the resistance to seedling emergence and sugar beet root penetration. The soil penetration resistance was measured at the same mentioned working depths of the rollers by using cone pentrometer. Measuring points were selected at random samples (10 points for each one). The values were converted into N/cm^2 units as the penetration resistance (N) divided by the cone base area (one cm^2). The soil penetration resistance was measured ten days after sowing and first irrigation. The mean value of penetration resistance are shown in table (3)

2- Determination of soil clods diameters:

Soil physical properties were measured, namely soil clod diameter. Clod diameters were measured using crumb structure measuring device. It consisted of seven sieves having different mesh sizes. The diameter of each sieve is 20 cm and the mesh sizes are 100, 50, 30, 20, 10, 5 and 2 mm. After finishing secondary tillage by rotary power harrow attached rear roller, soil samples were randomly taken from five different places of each plot and were air dried. The sieve apparatus containing the soil samples is put into motion in a semi-circular fashion for one minute. After sieving all the individual fractions, were weighed and converted as a percentage of total sample weight. The formula of (Rnan, 1983) was used to determine the mean weight clod diameter as follows:

$$MWD = \frac{1}{W}(A + 3.5B + 7.5C + 15D + 25E + 40F + 75G + NJ)$$

Where:

M.W.D = Mean weight soil clod diameter, mm.

W = Total weight of soil samples.

A, B, C, ...G = Weight of soil in each sieve.

N = Mean of measured diameter of soil clods retained on the largest sieve, mm.

J = Mean of measured diameter of soil clods retained on the smallest sieve, mm.

3- Soil bulk density (Bd) :

The soil bulk density was assessed to **Jakson (1958).** Soil bulk density has been determined using a metallic cylinder (10 days after the first irrigation) at the same working three depths treatments 0-3, 3-5 and 5-7 cm, after each type of roller passing up the soil . It was pressed into the desired soil depth and carefully withdraws in order to maintain a known sample volume. The sample was dried at 105°C for 24 hours and weighed.

$$\text{(Soil bulk density) } Bd = \frac{Ws}{V}\ gram / cm^3$$

Where:

Ws = the ovens dry mass of the sample (gm).

V = Soil sample volume in cm^3.

4- The emergence ratio (E.R):

It was calculated after three weeks from sowing and irrigation, by using the following formula:

$$ER. = \frac{PN}{SN} \times 100$$

Where:

PN = Average plant number per one square meter.

SN = Average number of delivered seeds per one square meter. This value was calculated during seeder calibration (13 sugar beet seeds).

RESULTS AND DISCUSSION

This experiments was conducted in the field in order to evaluate a performance of four types of rear rollers attached vertical rotary plow .

The obtained results of this study could be explained as following:-

1- Soil penetration resistance:

Table (3) show that, the highest soil penetration resistance (44.2 N/cm^2) obtained at Packer roller (R_3) at the highest depth (d_3 = 7 cm) and the lowest forward speed (F_{S1} = 2.8 km/h). the lowest soil penetration resistance (28.9 N/cm^2) obtained at spike roller (R_2) at the lowest depth (d_1 = 3 cm) and the highest forward speed (F_{S3} = 4.6 km/h) one can notice that, the highest soil penetration resistance means decreasing porosity of soil led to cohesion of particles achieved good contracture of sandy loam soil that give good penetration of sugar beet roots.

Table (3) : The soil penetration resistance (N/cm^2) for the different treatments under study

The main factors		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Fs_1=2.8km/h	33.4	32.3	34.7	33.1
	Fs_2=3.9km/h	32.5	29.8	33.4	31.7
	Fs_3=4.6km/h	31.2	28.9	32	32.8
[illegible]	Fs_1=2.8km/h	38.1	37.2	41.1	38.9
	Fs_2=3.9km/h	37.2	35.1	40.8	37.8
	Fs_3=4.6km/h	35.2	34.3	39.3	36.3
[illegible]	Fs_1=2.8km/h	40.1	39.3	44.2	41.8
	Fs_2=3.9km/h	39.8	38.1	42	41.1
	Fs_3=4.6km/h	39	36.8	41.4	40.6

2- Determination of soil clods diameters:

Figs. (4-a through 4-i) shows the variation in each range of clod size and soil mean diameter due to the different reaction of each roller on the soil clods constructer. The analyses of the obtained data indicate that, there is a significant difference between the mean weight clod diameter for different four rear rollers under study. It also can be seen that, using vertical rotary plow followed by Packer roller (R_3) at the lowest depth (d1 = 3 cm) and the highest forward speed (F_{S3} = 4.6 km/h) obtained the lowest value of mean weight clod diameter (MWD = 24.2), but using vertical rotary plow followed by Spike roller (R_2) at the big depth (d3 = 7 cm) and the lowest forward speed (F_{S1} = 2.8 km/h) achieved the highest value (MWD = 50.16). that is may be due to increasing of tractor forward speed and weight of rear roller (Packer type) caused increasing rotational speed of rear roller caused cracking of clods at shallow depth.

Soil clods diameters

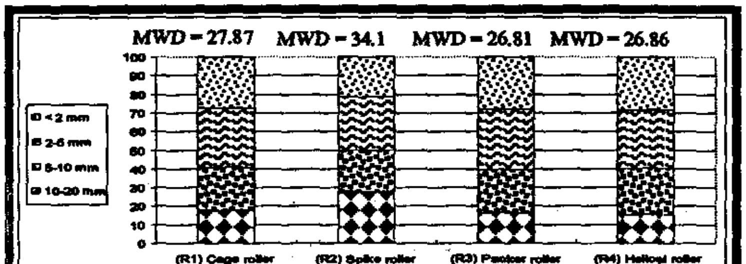

Fig (4-a): Clod size distributions and mean weight diameter for four rear rollers under study at d1 Fs1

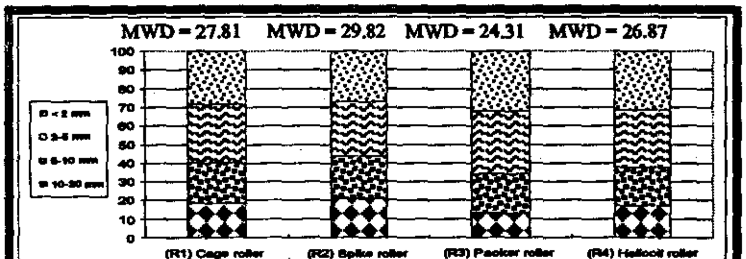

Fig (4-b): Clod size distributions and mean weight diameter for four rear rollers under study at d1 Fs2

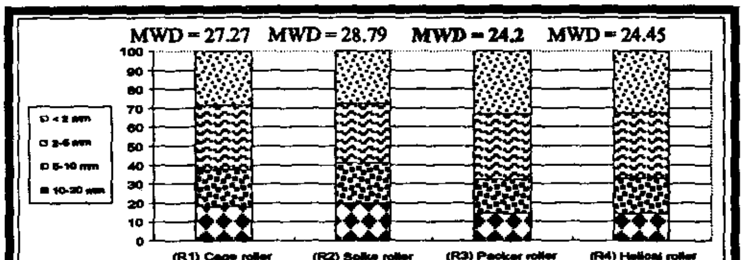

Fig (4-c): Clod size distributions and mean weight diameter for four rear rollers under study at d1 Fs3

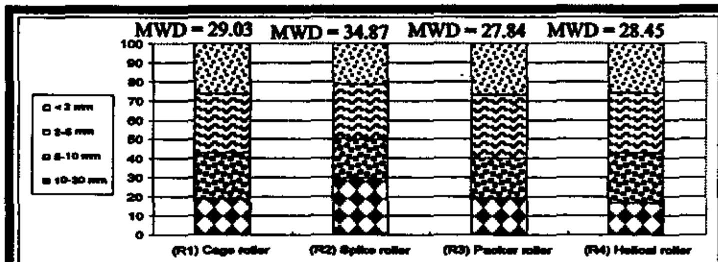

Fig (4-d) : Clod size distributions and mean weight diameter for four rear rollers under study at d2 Fs1

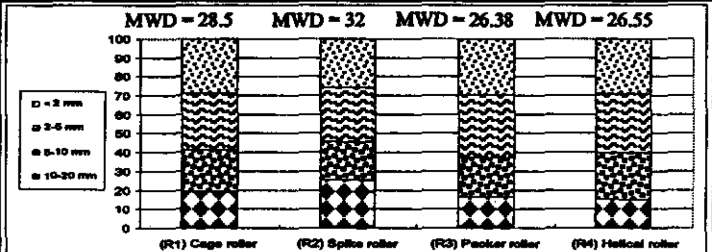

Fig (4-e) : Clod size distributions and mean weight diameter for four rear rollers under study at d2 Fs2

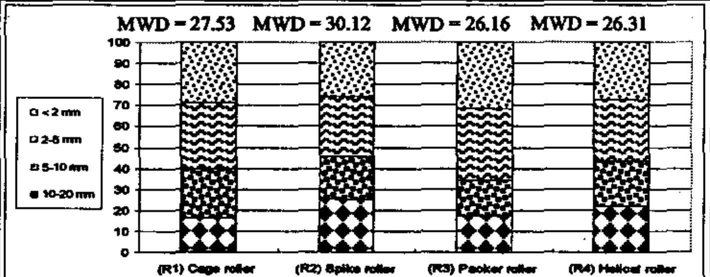

Fig (4-f) : Clod size distributions and mean weight diameter for four rear rollers under study at d2 Fs3

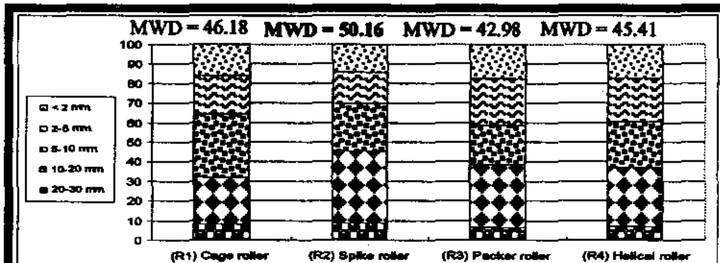

Fig (4-g) : Clod size distributions and mean weight diameter for four rear rollers under study at d3Fs1

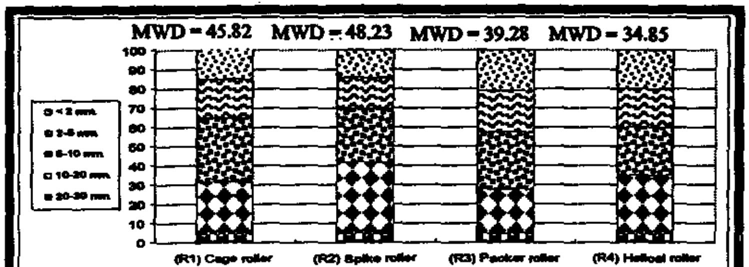

Fig (4-h) : Clod size distributions and mean weight diameter for four rear rollers under study at d3Fs2

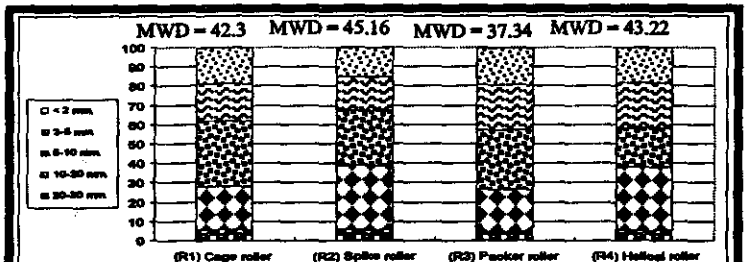

Fig (4-i) : Clod size distributions and mean weight diameter for four rear rollers under study at d3Fs3

3- Soil bulk density (Bd) :

Fig.s (5-a through 5-c) show that, the highest value of the soil bulk density (1.52 gram/cm^3) obtained at Packer roller (R_3) at the highest depth (d_3 = 7 cm) and the lowest forward speed (F_{S1} = 2.8 km/h), the lowest soil bulk density (1.41 gram/cm^3) obtained at spike roller (R_2) at the lowest depth (d_1 = 3 cm) and the highest forward speed (F_{S3} = 4.6 km/h) we can say that, the highest soil bulk density means reduce the spacing and arrangement granular quality of sandy soils and increase of mass per unit volume.

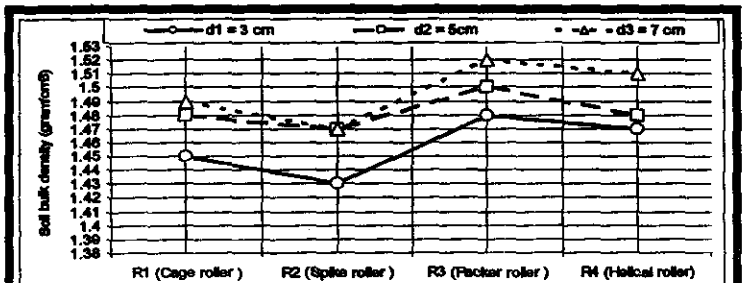

Fig. (5-a): Soil bulk density (Bd) at four types of rollers and Fs1 with different depths d.

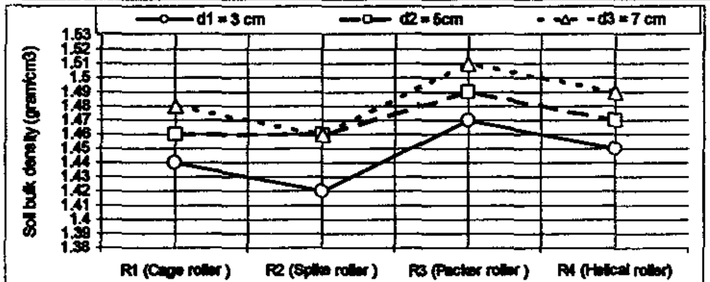

Fig. (5-b): Soil bulk density (Bd) at four types of rollers and Fs2 with different depths d.

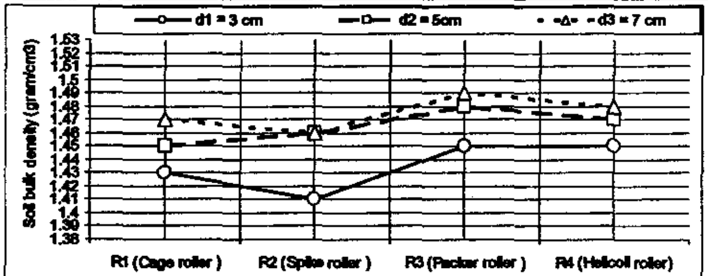

Fig. (5-c): Soil bulk density (Bd) at four types of rollers and Fs3 with different depths d.

4-The emergence ratio (E.R):

Inspection of data demonstrated in figs. (6-a through 6-c) shows the effect of different four types of rollers (R) under three depth levels (d) and three forward speeds (Fs). One can say that, the highest emergence ratio achieved at Packer roller (R_3) at depth ($d_2 = 5$ cm) and the forward speed ($Fs_1 = 2.8$ km/h), because of these factors obtained the optimum soil bed preparation (good constructer) for the sowing depth of sugar beet seeds (3 cm). While the lowest value achieved at spike roller (R_2) at depth ($d_1 = 3$ cm) and the forward speed ($Fs_3 = 4.6$ km/h),

this may be due to increasing of tractor forward speed, light weight of roller and shallow depth of rear roller caused poor constructer of soil.

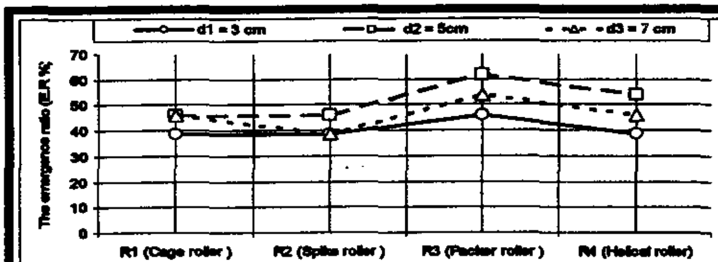

Fig. (6-a): The emergence ratio (ER%) at four types of rollers and Fs1 with different depths d.

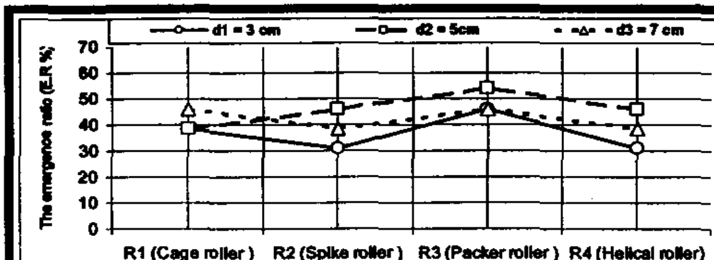

Fig. (6-b): The emergence ratio (ER%) at four types of rollers and Fs2 with different depths d.

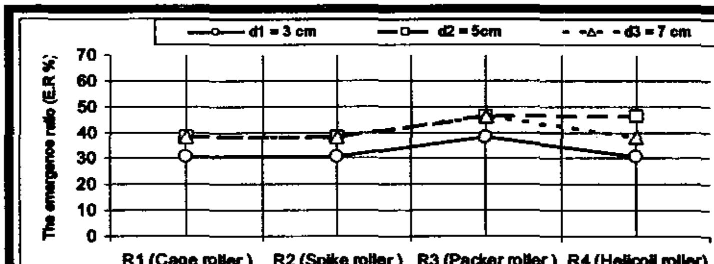

Fig. (6-c): The emergence ratio (ER%) at four types of rollers and Fs3 with different depths d.

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الملخص العربى

دراسة تأثير أنواع مختلفة من البكرات الخلفية الملحقة بالمحراث الدورانى الرأسي في الأراضي الرملية الطميية

د. رضا جمعه سالم* , د.طارق حسنى الشبراوى **

المحراث الدورانى الرأسى من أهم آلات إعداد التربة فى أراضى الإستصلاح الجديدة فى مصر حيث يقوم بإجراء عملية الحرث الثانوى عقب الحرث الإبتدائى بالقلاب المطرحى فى محاصيل القمح والذرة والبطاطس وبنجر السكر. وملحق بهذا المحراث جزء أساسى وهو البكرة الخلفية والتى تقوم بإعادة بناء التربة وتسويتها مع ضغطها نسبياً وذلك لإعداد مهد جيد للبذرة .

*معهد بحوث الهندسة الزراعية

** قسم الهندسة الزراعية- كلية الزراعة- جامعة المنصورة

و تمت دراسة تأثير أربعة أنواع من هذه البكرة وهى (القفصىcage – السنبلى Spike– الحزمى packer – الحلزونى Helical) وتعرض هذا البحث لدراسة هذه الأنواع بهدف الوصول للنوع الذى يناسب التربة المصرية فى الأراضى الجديدة حيث يحتاج المستثمرين لمعرفة ذلك عند إستيراد هذه المحاريث الدورانية الرأسية. وتمت هذه الدراسة فى الأراضى الخاصة بإحدى الشركات المتخصصة فى زراعة بنجر السكر بمشروع الصالحية الزراعى بمحافظة الشرقية. وتركزت عوامل الدراسة فيما يلى:

١. سرعة تقدم الجرار وكانت: (٢,٨ – ٣,٩ – ٤,٦ كم/س).
٢. نوع البكرة الخلفية : (القفصىCage – السنبلى Spike– الحزمى Packer – الحلزونى Helical)
٣. عمق الخدمة بالبكرة الخلفية: (٣ – ٥ – ٧ سم).

كما تركزت القياسات فيما يلى:

١. مقاومة الإختراق التربة.
٢. القطر المتوسط لحبيبات التربة.
٣. الكثافة الظاهرية للتربة.
٤. نسبة الإنبات.

وخلصت الدراسة للنتائج التالية:

- تحقق أقل قطر متوسط لحبيبات التربة عند سرعة تقدم (٤,٦ كم/س.) ، و عمق بكرة خلفية (٣ سم) مع النوع الحزمى من البكرات.
- تحققت أعلى قيمة لمقاومة الإختراق و أعلى قيمة للكثافة الظاهرية عند أقل سرعة (٢,٨ كم/س.) و أكبر عمق للبكرة الخلفية (٧ سم) مع النوع الحزمى.
- و كانت أعلى نسبة إنبات عند سرعة تقدم (٢,٨ كم/س.) و عمق بكرة خلفية (٥ سم) مع النوع الحزمى من البكرات.

و توصى الدراسة بإستعمال المعاملات التى حققت أعلى نسبة إنبات.