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Developing a machine for fertilizing vegetable crops with compost

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ABSTRACT

The objective of the present work was to develop and evaluate compost fertilizing machine for vegetable to make under Egyptian condition. The compost fertilizing machine was evaluated versus four forward speed (2.8, 3.2, 3.6 and 4.0 Km/h), three feeding area (50, 100 and 150 cm^2), three fertilizing depth (15, 20 and 25 cm) and two bully diameter with land wheel (15 and 25 cm). The results showed that the highest productivity was 31.11 m^3/fed and 82.84% fertilizing homogeneous fertilizing obtained at 2.8 km/h forward speed ,150 cm^2 feeding area, 25 cm fertilizing depth and bully diameter with land wheel 15 cm. The best result field efficiency was 85.12% and minimum specific energy 31,41 kw.h/fed at obtained forward speed 4 km/h, 150 cm^2 feeding area, 15 cm fertilizing depth and bully diameter with land wheel 15 cm. The maximum operation cost was 128.27 LE/fed and 5.76 LE/ m^3.

1. Introduction

During the last decade a great deal of attention gave to reclaim new lands (desert lands) and grow these lands by vegetable crops whereas these crops are considered to be high income in short rotation. Further, increase in vegetables production by increasing the yield per is required by controlling the amount of fertilizer application. Field crop residues are considered one of the most critical problems which face the Egyptian farmer. In Egypt, there are about 32 million tons/year (Ministry of Agriculture, 2007). Weed and Kanwar, (1996) reported that compost and agricultural management practices are important factors that strongly affect soil properties and water entry, and subsequent nutrients cycling processes in the soil profile. Moursy et al. (2001) under El- Minia condition indicated that application of tomato plant CV super manmade with organic manure (cattle manure and plant residues composite, at 20 m^3/fed) increased growth parameters (plant height and number of branches/plant). El-Bahrawy (1998) showed that the Physical properties of fertilizer such as: angle of repose and friction angle and shape; bulk density and moisture content are the important factors in determining the distribution uniformity. El.Attar (1995) designed and fabricated self-propeller liquid and organic fertilizer machine for small holding. The fabricated machine consists mainly of power tiller (14hp), a one-axial compost spreader, device to mix the compost with the soil and injection unit. The investigation corroborates many advantages of the fabricated machine such as low labour requirement, low cost, high uniformity of distribution and suit to the small farms of Egypt. Salama (2016) indicated that the using the fertilizer machine at forward speed of 3.3 km/h, rotating speed of 120 rpm and furrow depth of 20 cm gave the

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best result (4.44 Mg/fed) compared with other treatments. While using the traditional method gave the lowest value of productivity (3.97 Mg/fed). And lowest value was 36.06 kw.h/fed at furrow depth of 15 cm and forward speed of 3.3 km/h.

The main objective of the present work is to develop a machine locally made compost fertilizing machine and study some engineering factors affecting compost fertilizing machine and evaluating the performance of machine.

2. Materials and methods

The fertilizing machine was manufactured at workshop and experiment was carried out at farm located in Elam village, Ismailia Governorate, Egypt from the season of 2015-2017.

2.1. Type of fertilizer

Experiments were carried out on compost fertilizing. Some physical and mechanical properties of listed in Table 1.

Table 1
Some properties of the compost fertilizer.

Fertilizer properties	Compost fertilizer
Colour	brown
Consistency	sponge
Forme of fertilizer	sponge
Moisture content	6-8%
Friction angle	45°
Repose angle	42°
Bulk density, kg /m^3	720

2.2. The fertilizing machine of compost

The fertilizing machine was constructed of frame and wheels; compost box and agitator; furrow opener and covering device; feed unit, and control gate. The constructed of a fertilizer machine was carried at local workshop. The technical specification and operating parameters of fertilizer machine is shown in Figure 1 and Table 2.

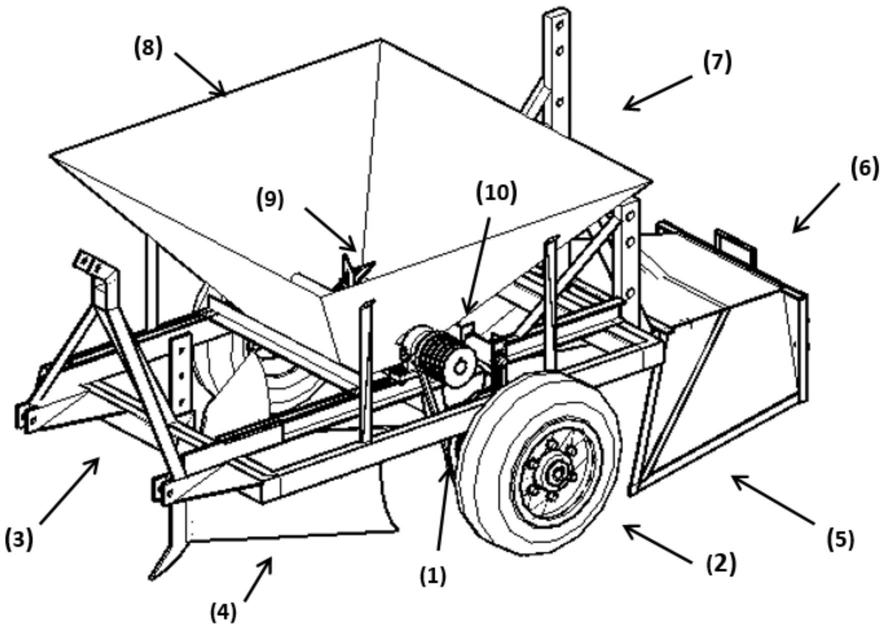

Figure 1. Components of fertilizing machine.
(1) Frame. (2) Wheels. (3) Hanging points with tractor. (4) Furrow opener. (5) Covering device. (6) Controller in level of covering. (7) Hanging points with covering device. (8) Compost box. (9) Agitator. (10) Moving transporter.

Table 2
Technical specification of the fertilizer machine.

Item	specification
Main dimensions:	
Overall width (cm)	170
Overall leigth (cm)	284.5
Overall height (cm)	161
Total mass (kg)	735
Fertilizer width (cm)	150

The effect of the following variables on the fertilizing machine productivity, specific energy requirement and fertilizing homogeneous for compost were studied:

1. Four forward speeds of 2.8, 3.2, 3.6 and 4.0 Km/h
2. Three feeding area 50, 100 and 150 cm^2.
3. Three fertilizing depth 15, 20 and 25 cm.
4. Two bully diameters with land wheel 15 and 25 cm.

1. The fertilizing rates

The application rate (Q) in kg/fed was determined from the following formula:

$$Q = q / Fe$$

where:

q: The feed rate of compost, kg/h

Fe: The field capacity, fed/h.

2. The compost distribution homogeneity

Sufficient samples were taken for each experiment: Homogeneity is calculated by determining both maximum and minimum sample, then calculating the deviation between maximum sample and mean and also between minimum sample and mean then the greater value is divided by mean and multiplying by 100. It can be also explained as following (Coates and Tanaka, 1992)

1. Determine maximum sample.
2. Determine minimum sample.
3. Deviation between maximum and mean.
4. Deviation between minimum and mean.

$$\text{Homogeneity} = \frac{\text{The greater of step (3)or(4)}}{\text{Mean}} \times 100$$

3. Actual field capacity

Actual field capacity is the actual average rate of coverage by machine, based upon the total effective operation time. It is a function of the rated width of the machine, the percentage of rated width actually utilized, the speed of travel, and the amout of field time lost during operation (Kepner et al. 1978). Thus, it was calculated as:

$$A_{fc}= 1/T_t$$

where:

A_{fc}: Actual field capacity, fed/h.

T_t: Total effective operating time, h/Fed

4. Energy used

The following formula was used to estimate the engine power according to (Embaby, 1985):

$$Ep=f.c*2.767$$

where:

EP: Engine power, kW.

f.c: Fuel consumption, L/h.

$$ER=EP/A_{fc}$$

where:

ER: Energy requirements, kW.h/fed.

EP: Engine power, kW.

A_{fc}: Actual field capacity, fed/h.

5. Total cost

The following relationship was developed by (Awady 1978) to estimate the hourly cost of tractor operation:

$$C =[p/h] * [1/l+i/2+t+r] +[1.2*RFC*f]+ [m/144]+ [p1/h1]* [1/l1+i/2+t+r1]$$

where:

C: Cost per hour of operation, LE/h.

P: Initial price of the tractor, (80000 LE).

h: Yearly working hours of tractor, (1000).

L: Life expectancy of the tractor, (10year).

i: Annual interest rate, (10%).

t: Annual taxes and overheads ratio, (1%).

r: Annual repairs and maintenance ratio for tractor, (3.5 %).

f: Fuel price, (2.35 LE/L)

m: Operator monthly salary, (2000 LE/month).

1.2: Factor accounting for lubrication.

144: The operator monthly average working hours, h.

R_{FC}: The actual rate of fuel consumption L/h.

P_1: Initial price of the fertilizing machine, (7650LE).

h_1: Yearly working hours of fertilizing machine, (400 h/year).

L_1: Life expectancy of the fertilizing machine, (10 year).

r_1: Annual repairs and maintenance ratio for the machine, (1 %).

6. Total cost per unit area of the experimented machine

$$T_{ca} = C/A_{fc}$$

where:

Tca: Total cost of unit area, LE/fed.

Afc: Actual field capacity, Fed/h.

C: Cost per hour of operation, LE/h.

3. Results and discussions

3.1. fertilizing rate

Figure 2 illustrate the relationship between the fertilizing rate values "Fz" affected by feed open area "Fa", fertilizing depth "Fd", bully diameter with land wheel "Bd" with at all forward speed "S."

The maximum value of fertilizing rate was 31.11 m^3/fed at forward speed 2.8 km/h, feed opening area 150 cm^2, fertilizing depth 25 cm and bully diameter with land wheel 15 cm; while the minimum value of fertilizing rate was 1.56 m3/fed at forward speed 3.6 km/h, feed opening area 50 cm^2, fertilizing depth 25 cm and bully diameter with land wheel 15cm.

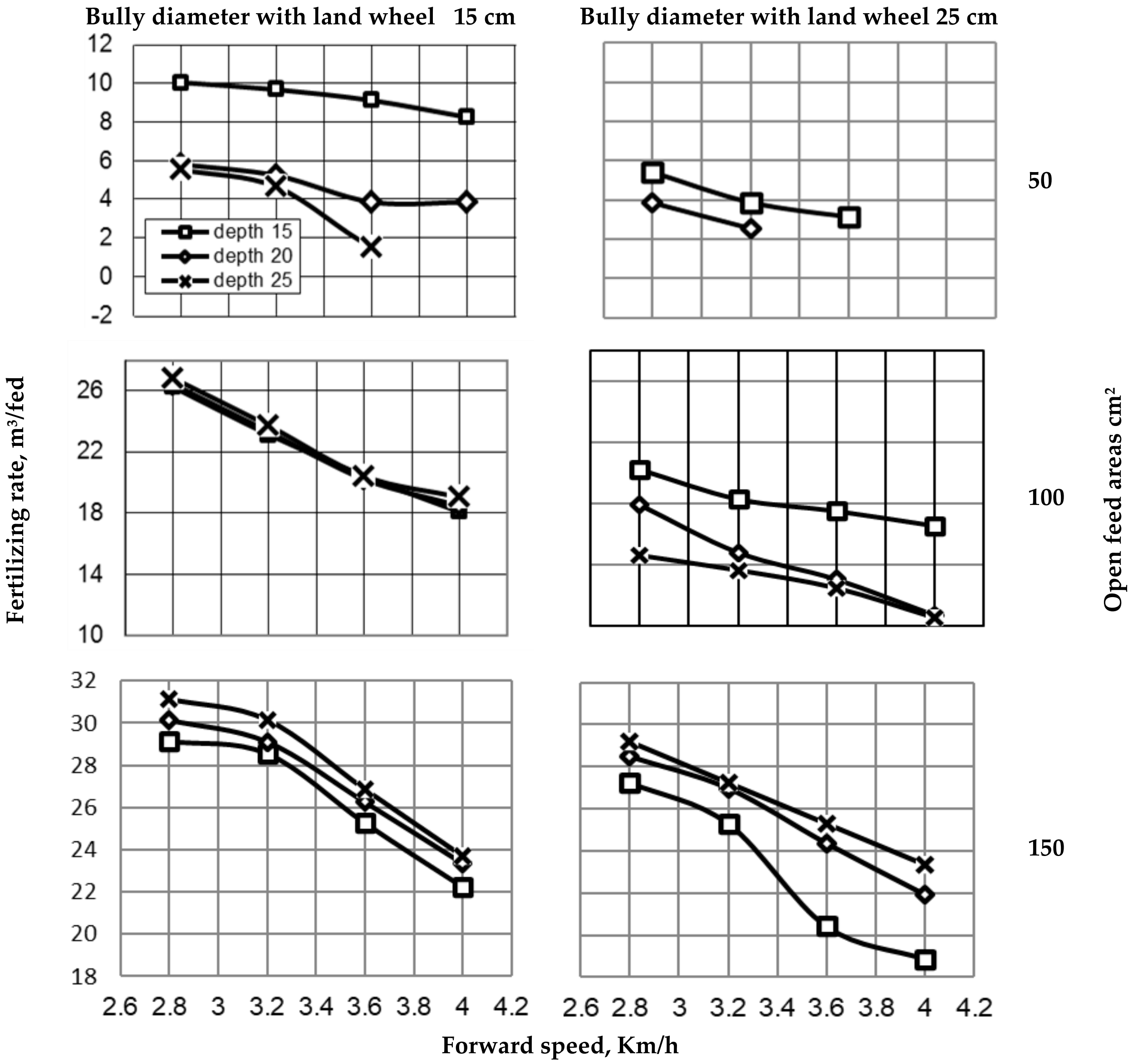

Fig. 2. Fertilizing rate Vs forward speed at different open feed areas, fertilizing depth and bully diameter with land wheel.

3.2. Actual field capacity

Figure 3 illustrated the relationship between the actual field capacity "Afc" (fed/h) with forward speed "S" (km/h) at different feed open area "Fa" (cm^2), fertilizing depth "Fd" (cm) and bully diameter with land wheel "Bd" (cm).

The maximum value of actual field capacity was 1.22 fed/h at forward speed 4 km/h, feed open area 150 cm^2, fertilizing depth 15 cm, and bully diameter with land wheel 15 cm; while minimum value of actual field capacity was 0.66 fed/h at forward speed 2.8km/h, feed open area 100cm^2, fertilizing depth 25 cm, and bully diameter with land wheel 25 cm.

3.3. Energy requirements

Figure 4 illustrated the relationship between the energy requirements values (kW.h/fed) affected by forward speed(S) (km/h) at different feed open area (Af) (cm^2), fertilizing depth (Fd)(cm) and bully diameter with land wheel (Bd)(cm) .

The results showed that energy requirement increased with increasing fertilizing depth and bully diameter with land wheel (Bd); while decreased with increasing forward speed from 2.8 to 4 km/h and feed open area from 100 to 150 cm^2 respectively at all treatments.

The maximum value of energy used was 64.35 kW.h/fed at forward speed 2.8 km/h, feed open area 100 cm^2, fertilizing depth 25 cm, and bully diameter with land wheel 25 cm; while minimum value of energy used was 31.41 kW.h/fed at forward speed 4 km/h, feed open area 150 cm^2, fertilizing depth 15 cm, and bully diameter with land wheel 15 cm.

3.4. Evaluation of fertilizing homogeneous

Figure 5 show relationship between the homogeneous values (%) affected by forward speed(S) (km/h) at different feed open (Af) cm², fertilizing depth (Fd) cm and bully diameter with land wheels (Bd) cm.

The results showed that homogeneous decreased with increasing forward speed from 2.8 to 4 km/h, fertilizing depth 15,20 and 25 cm; and bully diameter with land wheel 15,25 cm; while increased with increasing feed open area from 50 to 150 cm² respectively at all treatments.

The maximum value of homogeneous values was 82.84 (%) at forward speed 2.8 km/h, feed open area 150 cm², fertilizing depth 15 cm, and bully diameter with land wheel 15 cm; while minimum value of homogeneous values was 40.42 % at forward speed 4 km/h, feed open area 50 cm², fertilizing depth 20 cm, and bully diameter with land wheel 25 cm.

3.5. Cost of machine usage

The researcher recommends using fertilizing machine with forward speed 4 km/h, feed open area 150 cm², fertilizing depth 15 cm and bully diameter with land wheel 15 cm the higher total cost per Fedden was (128.27 LE/Fed).

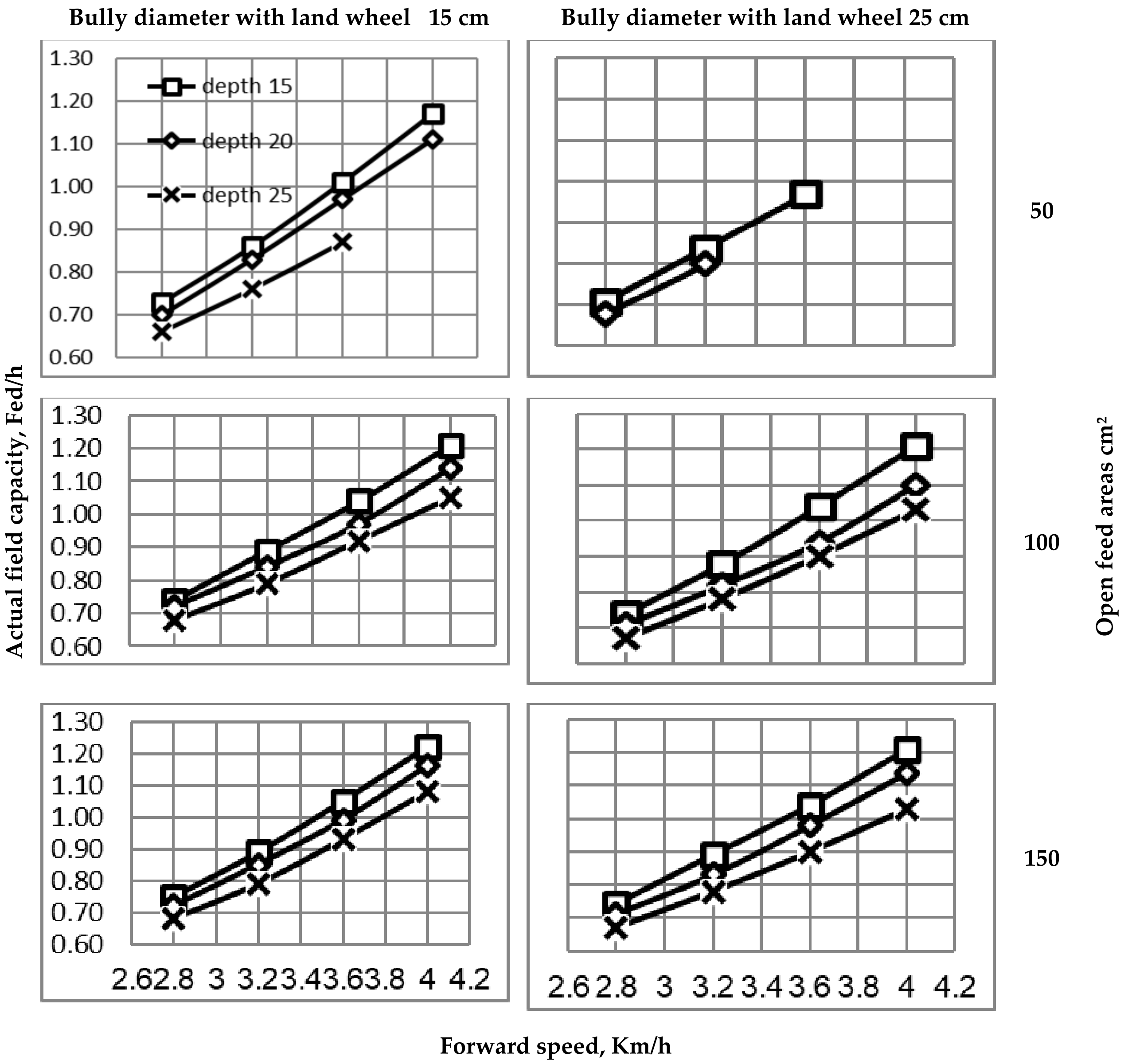

Fig. 3. Actual field capacity Vs forward speed at different open feed areas, fertilizing depth and bully diameter with land wheel.

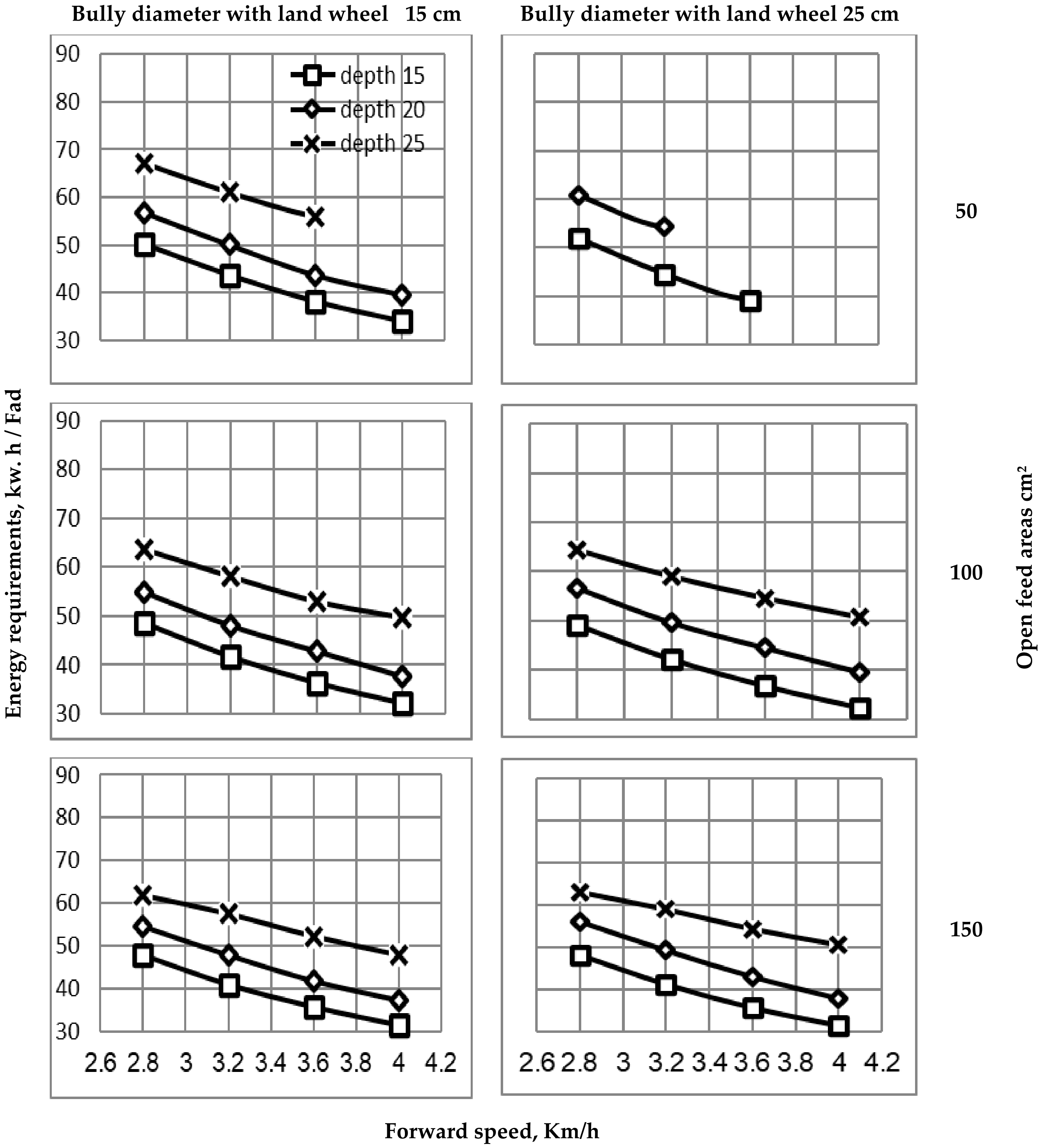

Fig. 4. Energy requirements Vs forward speed at different fertilizing depths, bully diameter with land wheel and feed opening areas.

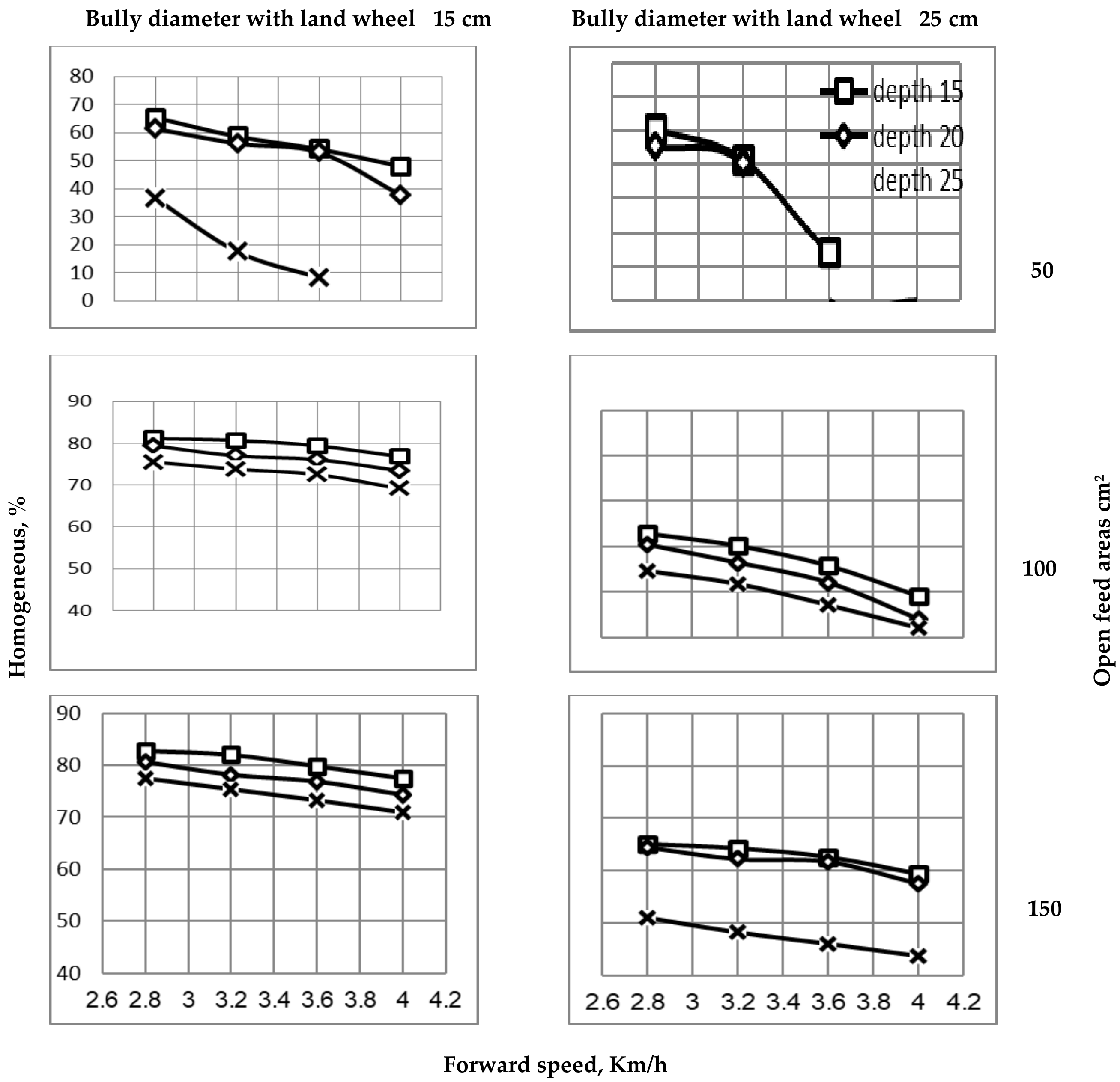

Fig. (5): Homogeneous, (VS)forward speed at different fertilizing depths, bully diameter with land wheel and feed opening areas.

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تطوير آلة لتسميد محاصيل الخضر بالكمبوست

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الملخص العربي

في مجال السعي للتطور الزراعي وما تبذله الحكومة المصرية في التوسع الزراعي خاصة في مجال زيادة الرقعة الأفقية المزروعة وذلك عن طريق زيادة الأراضي المستصلحة والزيادة الراسية عن طريق زيادة الإنتاج لمواكبة الزيادة السكانية, تعتبر عملية التسميد واحده من أصعب العمليات التي تواجه المزارع المصري في الوقت الحالي وتمثل عبأ اقتصاديا لنقص الأيدي العاملة وارتفاع أجورها ونظرا لارتفاع أسعار الأسمدة الكيماوية والعمل علي تحسين خواص التربة خاصة الأراضي المستصلحة وزيادة محتواها من العناصر الغذائية وزيادة القدرة علي الاحتفاظ بالمياه لذلك. يهدف هذا البحث إلى ما يلي:

١) تطوير آلة للتسميد بالكمبوست تحت التربة لزراعة محاصيل الخضر في الأراضي المستصلحة مع مراعاة الآتي:

- بساطة التصميم وسهولة الاستخدام.
- قليلة التكاليف لتناسب الظروف المصرية.
- التصنيع من خامات في الورش المصرية.

٢) دراسة بعض العوامل الهندسية والتشغيلية التي تؤثر على أداء الآلة.

وذلك من خلال النقاط الآتية:

أ- دراسة بعض الخواص الطبيعية والميكانيكية لسماد الكمبوست.

ب- استخدام أربع السرعة الأمامية للآلة (٢,٨ ، ٣,٢ ، ٣,٦ و ٤ كم / س).

ج- ثلاث عمق التسميد (١٥ ، ٢٠ و ٢٥ سم).

د- ثلاث فتحات للتغذية (٥٠ ، ١٠٠ و ١٥٠ سم٢).

هـ- قطر طارة عجلة الأرض (١٥ و ٢٥ سم).

وكانت أهم النتائج:

١) يزيد معدل التسميد بزيادة فتحة التغذية بينما يقل بزيادة السرعة الأمامية وقطر طارة نقل الحركة وكان أقصي معدل تسميد ٣١,١١ م٣ / ف مع استخدام سرعة أمامية ٢,٨ كم /س وفتحة تغذية ١٥٠ سم٢ وعمق ٢٥ سم وقطر طارة ١٥ سم.

٢) أقصي معدل الأداء الحقلي ١,٢٢ ف / س مع استخدام سرعة أمامية ٤ كم /س وفتحة تغذية ١٥٠ سم٢ وعمق ١٥ سم وقطر طارة ١٥ سم.

٣) اقل استهلاك للقدرة ٣٥,٧٧ كيلووات مع استخدام سرعة أمامية ٢,٨ كم /س وفتحة تغذية ١٥٠ سم٢ وعمق ١٥ سم وقطر طارة ١٥ سم.

٤) اعلي نسبة تجانس لتوزيع السماد ٨٢,٢٤٪ مع استخدام سرعة أمامية ٢,٨ كم /س وفتحة تغذية ١٥٠ سم٢ وعمق ١٥ سم وقطر طارة ١٥ سم.