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 fertilizing machine for vegetable to make under Egyptian condition. The fertilizing machine was evaluated versus four forward speeds (2.8, 3.2, 3.6, and 4.0 km/h), three feeding areas (50, 100, and 150 cm²), three fertilizing depths (15, 20, and 25 cm) and two bully diameters with land wheel (15 and 25 cm). The results showed that the highest productivity was 31.11 m³/fed; and 82.84% fertilizing homogeneous fertilizing obtained at 2.8 km/h forward speed, 150 cm² feeding area, 25 cm fertilizing depth and bully diameter with land wheel 15cm. The best result field efficiency was 85.12% and minimum specific energy 31.41kW.h/fed at obtained forward speed 4 km/h, 150cm² feeding area, 15 cm fertilizing depth and bully diameter with land wheel 15cm. The maximum consumption and operation cost was 128.78 LE/fed; and 5.79 LE/m³.

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 of height income in short rotation. Further, increase in vegetables production by increasing the yield par is required by controlling the amount of fertilizer application. **Ismail (2011). Weed and Kanwar (1996)** reported that the 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)** indicated that application of tomato plant CV super manmade with organic manure (cattle under El-Minia condition manure and plant residues composite, at 20 m³/fed,) increased growth parameters (plant height and number of branches/plant).

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El-Bahraw (1998) showed that the Physical properties of fertilizer such as: angle of repose, 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 (14 hp), a one-axial compost spreader, device to mix the compost with the soil and injection unit. The investigation corroborate many advantages of the fabricated machine such as low lab our requirement, low cost, high uniformity of distribution and suit to the small farms of Egypt**. Salama (2016)** indicated that the using of the fertilizer machine at forward speed of 3.3km/h, rotating speed of 120 rpm and furrow depth of 20 cm gave the best result (5.44 Mg/fed;) compared with other treatments. While the using of the traditional method gave the lowest value of productivity (3.97 Mg/fed;).And lowest value was 366.06 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 and study some engineering factors affecting compost fertilizing machine and evaluating the performance of developed machine.

MATERIAL AND METHODS

The fertilizing machine was manufactured at local worksops and the experiments were carried out at farm located in Elam village, Ismailia Governorate, Egypt for the season of 2015-2017.

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.

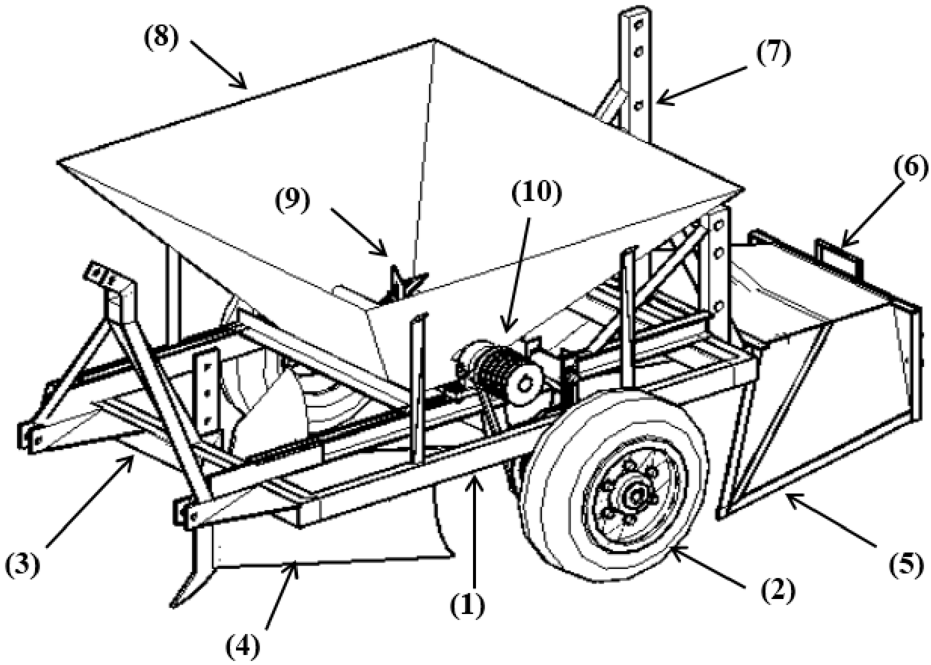
Fertilizer properties	Compost fertilizer
Colour	brown
Consistency	sponge
Form of fertilizer	sponge
Moisture content,%	6-8
Friction angle	45º
Repose angle	42º
Bulk density, kg /m^3	720

2-The fertilizing machine:

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 fertilizering machine is shown in Fig (1) and Table (2).

Table (2) Technical specification of the fertilizer machine.

Item	Specification
Main dimensions : Overall width (cm)	170.0
Overall leigth (cm)	284.5
Overall height (cm)	161.0
Total mass (kg)	735.0
Fertilizer width (cm)	150.0



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

Fig. (1): Components of the fertilizing machine.

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

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

1- The fertilizing rate:

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

$$\mathbf{Q = q / F_e \quad , kg/fed. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(1)}$$

Where :

q : The feed rate of compost, kg/h

F_e : 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

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

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 field time lost during operation **(Kepner *et al.* 1978).** Thus, it was calculated as:

$$A_{fc} = 1/T_t \text{ ……………………(2)}$$

Where:

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

T_t :Total effective operating time, h/fed

4 - Energy:

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

$$Ep = f.c * 2.767 \text{ ……………….(3)}$$

Where:

EP: Engine power, kW.

f.c: Fuel consumption, L/h.

$$E_R = EP/Afc \text{ ……………....(4)}$$

Where:

E_r: 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:

$$C = [\frac{p}{h}] * [\frac{1}{l} + \frac{i}{2} + t + r] + [1.2 * RFC * f] + [\frac{m}{144}] + [\frac{p1}{h1}] * [\frac{1}{l1} + \frac{i}{2} + t + r1] \text{……………(5)}$$

Where:

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

P: Initial price of the tractor, (350000 LE).

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

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

i: Annual interest rate, (10%).

t: Annual taxes and overheads ratio,(3%).

r: Annual repairs and maintenance ratio for tractor,(10 %).

f: Fuel price,(3.65 LE/L)

m: Operator monthly salary,(1500 LE/month).

1.2: Factor accounting for lubrication.

144: The operator monthly average working hours, h.
RFC: The actual rate of fuel consumption L/h.
P1: Initial price of the fertilizing machine, (12000LE).
h1: Yearly working hours of the fertilizeng machine, (750 h/year).
L1: Life expectancy of the fertilizng machine,(10 year).
r1: Annual repairs and maintenance ratio for the machine,(1 %).

Total cost per unit area of the experimented machine:

$$T_{ca} = C/Afc \quad \ldots\ldots\ldots\ldots\ldots(6)$$

Where:

T_{ca}: Total cost of unit area, LE/fed.
Afc: Actual field capacity, fed;/h.
C: Cost per hour of operation, LE/h.

RESULTS AND DISCUSSIONS

1- Fertilizing rate:

Fig (2) illustrates the relationship between the fertilizing rate values "F_z" affected by feed open area "F_a", fertilizing depth "F_d" , bully diameter with land wheel "B_d" at all forward speeds "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 15cm; 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.

2- Actual field capacity:

Figure (3) illustrated the relationship between the actual field capacity "fact" (fed;/h) with forward speed "S" (km/h)at different feed open areas "F_a" (cm^2), fertilizing depth "F_d" (cm) and bully diameter with land wheel "B_d" (cm).

The maximum value of actual field capacity was 1.22 fed,/h at forward speed4km/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 100 cm^2, fertilizing depth 25 cm, and bully diameter with land wheel 25cm.

3-Energy requirements:

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

The results showed that energy requirement increased with increasing fertilizing depth and bully diameter with land wheel (d_b) ; 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 2.8km/h, feed open area 100 cm^2, fertilizing depth 25cm, and bully diameter with land wheel 25cm; while minimum value of energy used was 31.41 kW.h/fed; at forward speed 4km/h, feed open area 150 cm^2**,** fertilizing depth 15cm, and bully diameter with land wheel 15cm.

4- Evaluation of fertilizing homogeneous:

Fig (5) shows the relationship between the homogeneous values (%) affected by forward speed(S) (km/h)at different feed open area A_f (cm^2), fertilizing depth d_f (cm) and bully diameter with land wheels B_d (cm).

The results showed that homogeneous decreased with increasing forward speed from 2.8 to 4km/h , fertilizing depth15, 20 and 25 cm; and bully diameter with land wheel 15,25 cm; while increased with increasing feed open area from 50 to 150 cm^2 respectively at all treatments.

The maximum value of homogeneous values was 82.84 (%) at forward speed 2.8 km/h, feed open area 150 cm^2, fertilizing depth 15 cm, and bully diameter with land wheel 15cm; while minimum value of homogeneous values was 8.21% at forward speed 3.6 km/h, feed open area 50 cm^2, fertilizing depth 25 cm, and bully diameter with land wheel 15 cm;

5 - Cost of machine usage: The researchers recommend using fertilizing machine with forward speed 4 km/h, feed open area 150 cm^2, fertilizing depth 15cm and bully diameter with land wheel 15 cm the higher total cost per Fedden was (128.78 LE/fed).

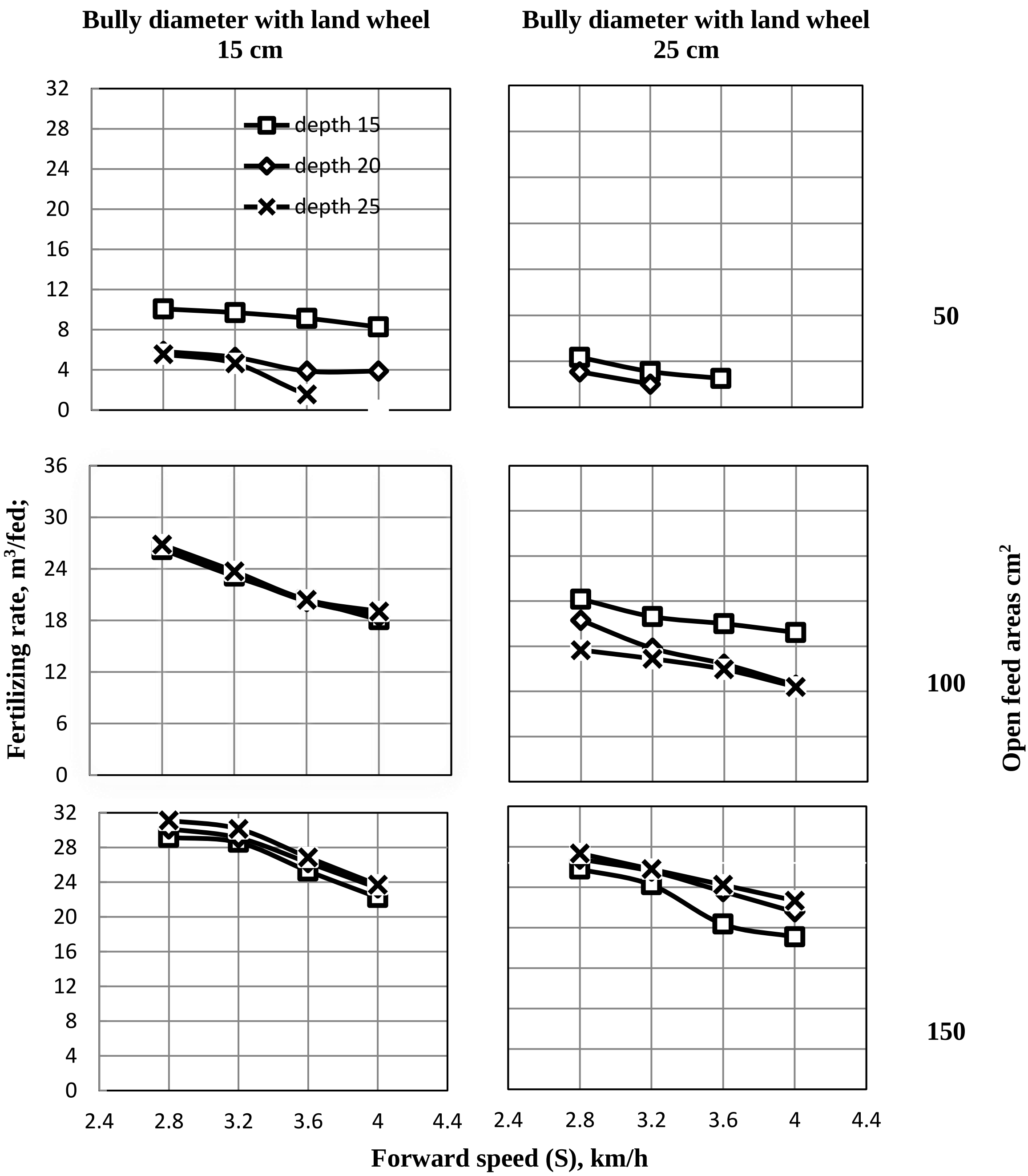


Fig. (4.2): Fertilizing rate F_Z forward speed at different open feed areas, fertilizing depth and bully diameter with land wheel.

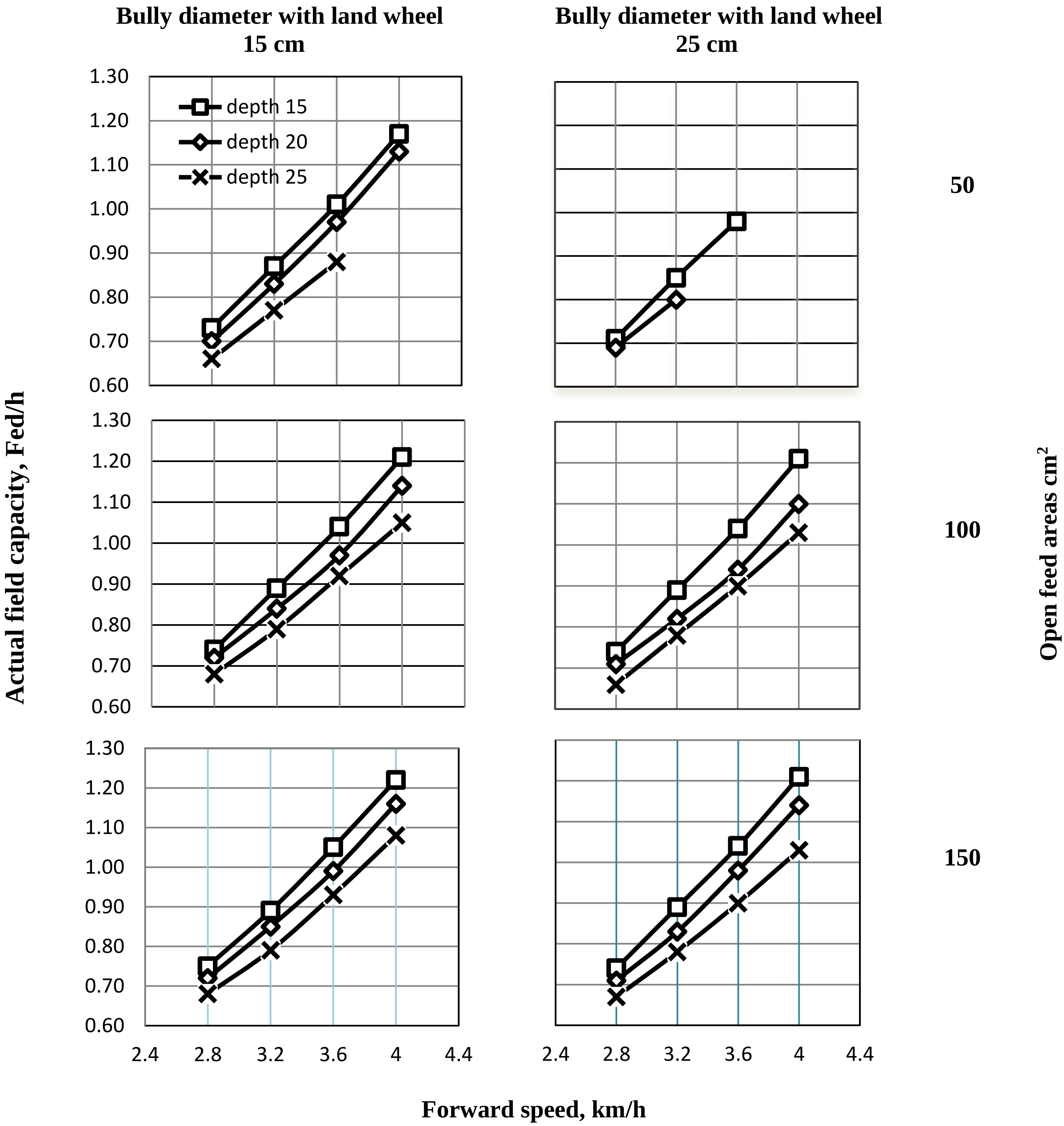


Fig. (4.3): Actual field capacity (VS) forward speed at different fertilizing depths, bully diameter with land wheel and open feed areas.

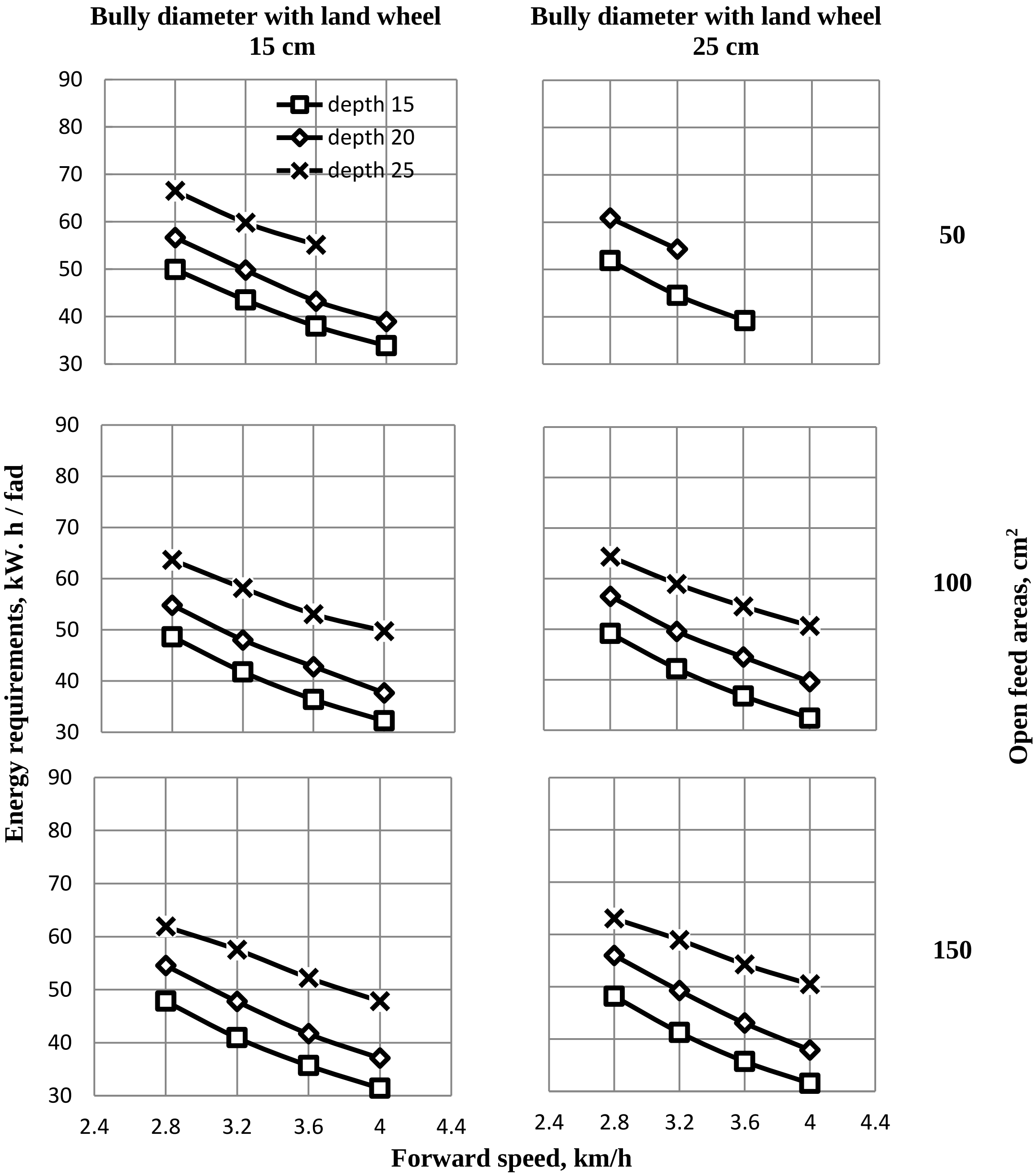


Fig.(4.4): Energy requirements Vs forward speed at different fertilizing depths, bully diameter with land wheel and feed opening areas.

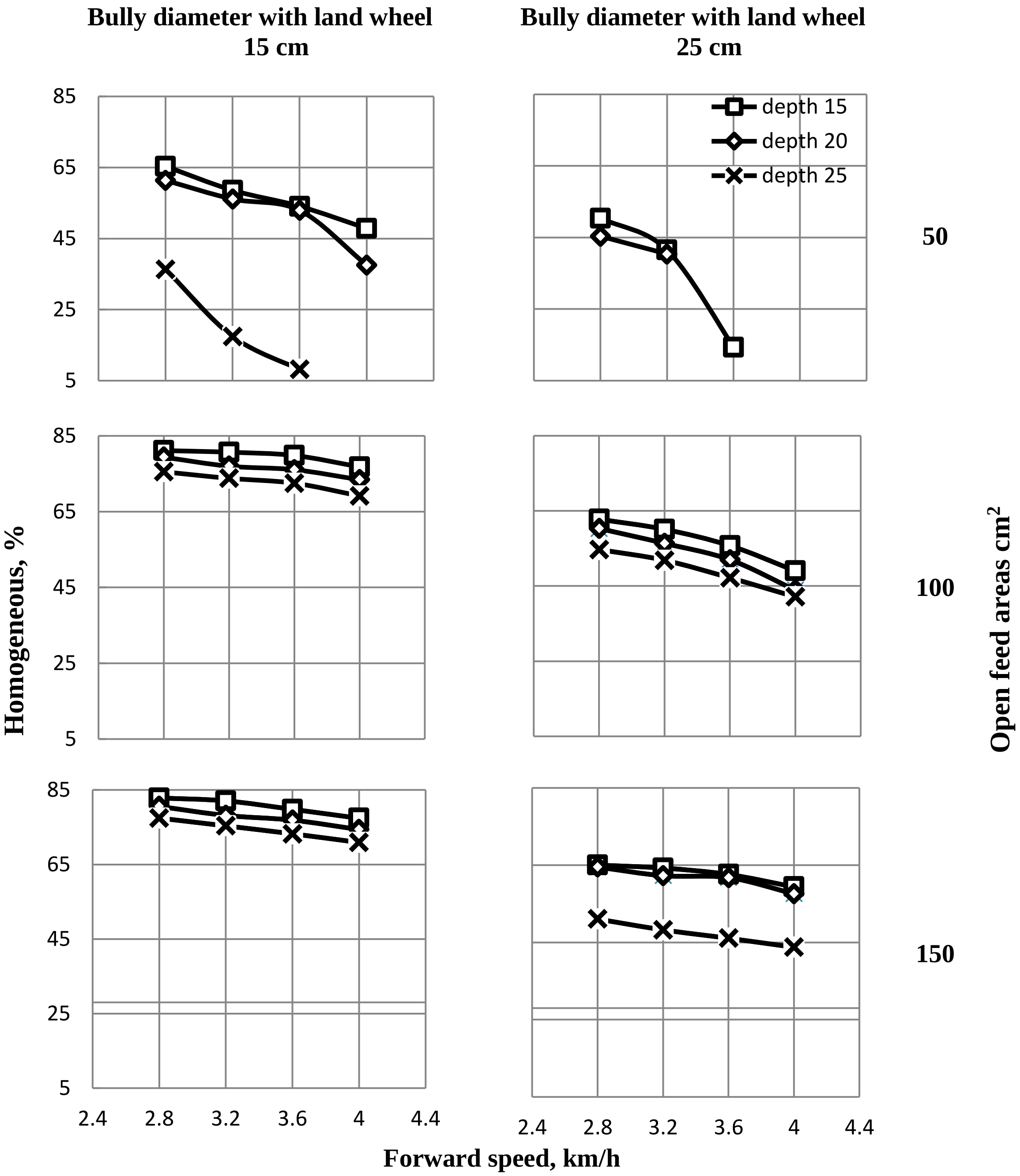


Fig. (4. 5): Homogeneous (VS)forward speed at different fertilizing depths, bully diameter with land wheel and feed opening areas.

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الملخص العربي

تطوير آله لتسميد محاصيل الخضر بالكمبوست

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٤- محمود أحمد مسلم و ٥- محمود محمد مبروك عليوه

في مجال السعي للتطور الزراعي وما تبذلة الحكومة المصرية في التوسع الزراعي خاصة في مجال زيادة الرقعة الأفقية المزروعه وذلك عن طريق زيادة الأراضي المستصلحة والزيادة الرأسية عن طرق زيادة الإنتاج لمواكبة الزياده السكانية، تعتبر عملية التسميد واحده من أصعب العمليات التي تواجه المزارع المصري في الوقت الحالي وتمثل عبأ إقتصاديا لنقص الإيدي العاملة وإرتفاع إجورها ونظرا لإرتفاع أسعار اللأسمدة الكيماوية والعمل علي تحسين خواص التربة خاصة الأراضي المستصلحة وزيادة محتواها من العناصر الغذائية وزيادة القدرة علي الاحتفاظ بالمياه تم إجراء هذا البحث خلال عام ٢٠١٥- ٢٠١٧م في محافظة الاسماعيليه - قرية الأمل ٠ويهدف هذا البحث الى دراسة بعض العوامل الهندسية والتشغيلية التى تؤثر على أداء آلة التسميد من خلال تطوير آله محلية الصنع للتسميد بالكمبوست في محاصيل الخضر٠ وللوصول الى هذا الهدف من خلال الآتى - دراسة بعض الخواص الطبيعية والميكانيكية لسماد الكمبوست والتى تساعد فى تحديد أنسب تصميم للآله - تصنيع آلة محلية للتسميد بالكمبوست بسيطة وسهلة الصيانه

- دراسة بعض العوامل الهندسية التى تؤثرعلى أداء وكفائة آلة التسميد وهى

- سرعة الآلة الأمامية وتم استخدام أربع سرعات أامامية (٢،٨ ، ٣،٢ ، ٣،٦ و٤كم/س)
- عمق التسميد وتم إستخدام ثلاثة أعماق مختلفة (١٥،٢٠و٢٥سم)
- فتحه التغذية للآله وتم إستخدام ثلاثة فتحات للتغذية (٥٠ ، ١٠٠و١٥٠ سم٢)
- قطر طاره علي عجله الأرض لنقل الحركه للقلاب (١٥ و٢٥ سم)

وكانت أهم النتائج المتحصل عليها .

١- انتاجية الآلة تزيد مع زيادة فتحة التغذية وعمق التسميد وتقل مع زيادة السرعة الامامية للآلة وقطر طارة نقل الحركة من عجلة الارض للتغذيه ، وكانت أعلى إنتاجية للتسميد (٣١,١١م٣/ف) مع إستخدام سرعة أمامية ٢،٨ كم/س وفتحة تغذية ١٥٠ سم٢ وعمق تسميد ٢٥ سم وقطر طارة نقل الحركة من عجلة الارض للتغذية ١٥ سم ٠

٢- الكفائة الحقلية تزيد مع زيادة فتحة التغذية والسرعة الأمامية للآله وتقل مع زيادة عمق التسميد وقطر طاره نقل الحركة من عجلة الارض للتغذيه مع كل التجارب.

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وكان أقصى كفائة حقلية (٨٥,١٢ %) عند إستخدام سرعة أمامية ٤ كم/س وفتحة تغذية ١٥٠ سم٢ وعمق تسميد ١٥ سم وقطر طاره نقل الحركة من عجلة الارض للتغذيه ١٥ سم .

٣- الطاقة النوعيه المطلوبة تزيد مع زيادة عمق التسميد وقطر طاره نقل الحركة من عجلة الأرض للتغذيه وتقل مع زيادة السرعة الأمامية للآله وفتحة التغذية وكان أقصى طاقة نوعية مطلوبة (٦٤،٣٥ كيلووات .ساعه/فدان) مع إستخدام سرعة أمامية ٢،٨ كم/س وفتحة تغذية ١٠٠ سم٢ وعمق تسميد ٢٥ سم وقطر طاره نقل الحركة من عجلة الارض ١٥ سم.

٤- نسبة تجانس توزيع السماد تزيد مع زيادة فتحة التغذية وتقل مع زيادة السرعة الأمامية للآله وعمق التسميد وقطر طاره نقل الحركة من عجلة الأرض للتغذيه وكان أعلي نسبة تجانس لتوزيع السماد (٨٢،٢٤ %)عند إستخدام سرعة أمامية ٢،٨ كم/س وفتحة تغذية ١٥٠سم٢ وعمق تسميد ١٥ سم وقطر طاره نقل الحركة من عجلة الأرض للتغذيه ١٥ سم ٠

٥- حقق إستخدام الآله المطوره إنخفاض بمقدار (٦٥٢%) فى التكاليف الكليه لعمليه التسميد مقارنه بالطرق التقليديه.

٦- ويوصي البحث بإستخدام آله التسميد عند سرعة أمامية ٤ كم/س وعند فتحة تغذية ١٥٠سم وعمق تسميد ١٥ سم وقطرطارة نقل الحركة من عجلة الارض للتغذية ١٥ سم وكانت التكاليف لهذه المعاملة ١٢٨،٧٨ جنية /ف.

الدراسات المستقبليه:

١- زيادة عرض التشغيل عن طريق عمل وحدتين تسميد
٢- عمل تعديل في جهاز التقليب
٣- التحكم الهيدرولكي فى العمق و مستوى التغطيه علي السماد