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DEVELOP A SOLID FERTILIZER SPREADER FOR PUTTING FERTILIZERS UNDER VEGETABLE SEEDLINGS IN NEW LANDS

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ABSTRACT

The planting of vegetable under drip-irrigation needs prepared soil to be suit bed for vegetables seedlings. To carry out this work the manure spreader was developed to put mixture fertilizers in trenches and covered it. The studied parameters were; three forward speeds of 5.96, 7.95 and 10.04 km/h; three feeding gate height of 60, 80, and 100 mm and three conveyor rotating speeds of 14, 22 and 31 rpm. The obtained results showed that at forward speed of 5.96 km/h, 100 mm feeding gate height and conveyors speed of 31 rpm gave the best needs of vegetables seedling where in this case showed the minimum operating cost was 2.73 L.E/m^3, volumetric of mixture fertilizers was 5.08 m^3/fed, established thickness of fertilizer layer in trench was 3.63 mm and the lower power consumed was 14.74 kW. The research concluded that the developed machine can prepare the soil to suitable for vegetable seed or seedling plant. The developed fertilizing machine makes a trench, put the mixture fertilizers in the trench and cover the fertilizer by metal plate. Consequently, this machine can be widely used to prepare the soil in new reclaimed and desert lands especially for the vegetable crops commonly sensitive for fertilizer reduced.

Keywords: Fertilizing machine efficiency, fertilizer rate, gate height, conveyor speed, forward speed.

INTRODUCTION

Many efforts had been done to increase the agriculture production in new reclaimed lands using modem irrigation systems and modem technology. It is knows that there are different methods of fertilizer applications, thrown, drilling under neath soil surface. At additional the fertilizer in trenches lead to increasing the productivity, improving the soil characteristics specially in new land, keep the moisture of soil surface to large time and decreasing the water requirement for irrigation. At put the fertilizer in trenches, effective roots area, decreasing the losses quantity from put it in total area.

Kepner *et al.* (1982) indicated some of the applications for dry fertilizer are as follows: (1) Broadcasted before plowing or placed at the plowing depth by a distributor on the plow that drops fertilizer in each furrow. (2) Deep placement with chisel-type cultivators. (3) Broadcasted and mixed into soil (or drilled into the soil) after plowing and before planting. Meanwhile, Chambers *et al.* (2001) reported that the three main types of solid manure spreaders are commonly used that are rotates, rear discharge and dual purpose. Therefore, the rear discharge is the best type especially at the work rate, accuracy of discharge rate, lateral precision, ease of bout matching. Consequently, El-Nakib (1990) designed a rotary broadcast spreader and used it in spreading agricultural materials. The performance of the machine was investigated by changing the forward speed and the gate opening area. Flow rate through gate opening is not constant with speed because of the bridging of seeds over gate at low speeds. The resulting application intensity decreases with forward speed were recorded. Also the rate of spreading increased with gate opening area. Also, Khiery (1992) indicated to the new prototype applicator can be used for both chemical and fertilizer application. It is pushed forward manually by the labor hand. This method helps the machine to give enough penetration into soil for nitrogen application (10 cm below soil surface). The results showed that, the application of liquid urea using the prototype machine increased the corn yield by about 36% over the surface application method. The prototype applicator was effective machine for reducing nitrogen loss and increasing crop yield. Then, Funk and Robert (2005) cleared that the manure nutrients helps save commercial fertilizer costs and helps establish the value of manure assigned to neighboring crop farmers.

Kassem (1987) studied the effect of nitrogen applied methods on the orange. He found that the trench method of soil application decreased the amounts of N losses in drainage water and increased the total N in soil profile. El-Rayess (1993) determined that, the effects of operation speed on the performance of manure spreaders. He found that no significant influence of the speed on manure distribution uniformity. The best machine was the IPTU-6 Russian manufactured manure spreader of 180 cm width. It gave the highest field capacity and lowest cost. When applied it at different areas (0.5, 1.5 and 3.0 feddans) at forward speeds 7.98 km/h, the field capacity was 2.3, 2.44 and 2.65 fed/h, and costs were 31.97, 30.71 and 28.28 LE/fed, respectively. Therefore, the effects of moisture content of fertilizer were studied by Csizmazia and Andersson (2000). They found that increasing moisture available to the maize, increasing yields by 5.25% (green matter) and 9.26% (grain), that at comparison between soil prepared by conventional moldboard ploughing 25-27 cm deep after broadcasting of fertilizer (control) and ploughing to a depth of 25-27 cm plus loosening to a depth of 35-40 cm with broadcasting of fertilizer on the surface, or applying it in the deep loosened layer. Hence, Kadry and Baker (1998) found that the forward speed of prototype is very important at the same opening. It is dependent on the fertilizer rate. They indicated to the effect of the both depth of 10 and 15 cm, the depth of 10 cm is economic compared with 15 cm. Whereas the soil resistance was decreased also, the required energy would be decreased, thus the cost of yield decreased, that is at using prototype of fertilizing machine in place the mineral fertilizer in furrow trench into the citrus orchard soil. Consequently, Fouda (2007) dveloped a fertilizer applicator for using the proposed combined unit for fertilizing and conform the wide-bed profile. He concluded that the optimum rate of frtilizing was 4.4 m/s and orifice gate area was 48 cm^2 for Nitrate fertilizer recorded the high volumetric efficiency, 87 %. Therefore, he used the moldboard profile maker at the sequence condition with forward speed of 5 km/h, sitting angle of 20° and operating depth of 10 cm to put the fertilizer at 7.5 depth for the vegetable crops.

The investigation objective aims to develop the manure spreader to be suits for putting the manure fertilizer in trenches and covering the trenches with small soil layer before sowing some vegetables seedling in new reclaimed land.

MATERIALS AND METHODS

The spreader machine (New-Holand) before developing was used to broadcast the Agricultural Gypsum on soil surface. The machine was consists of hopper, land wheel drive, two spinning discs, conveyor to transfer the manure or fertilizer to spinning discs and belts of power transmission to machine parts.

The machine specification before developing (Table 1): The machine consists of land wheel drive, spinning disc and guide plate. Then it trailed by tractor.

Table 1: The specification of the machine before developing.

Dimension of fertilizer box	1.84 × 1.84 m upper 0.22 × 0.22 m lower
Dimension of guide plate54	2.56 × 0.22 m
Length of machine	4.064 m
Width of machine	2.45 m
Distance between two wheel drive	1.27 m
Dimension conveyor	1.5 x 0.22 m

The modified machine specification: The machine was developed (Fig. 1) to suitable for putting the mixture fertilizers in trench and covering it with shallow layer (about 5 cm) of soil before sowing (seeds or seedlings) in this layer. The developed points were:

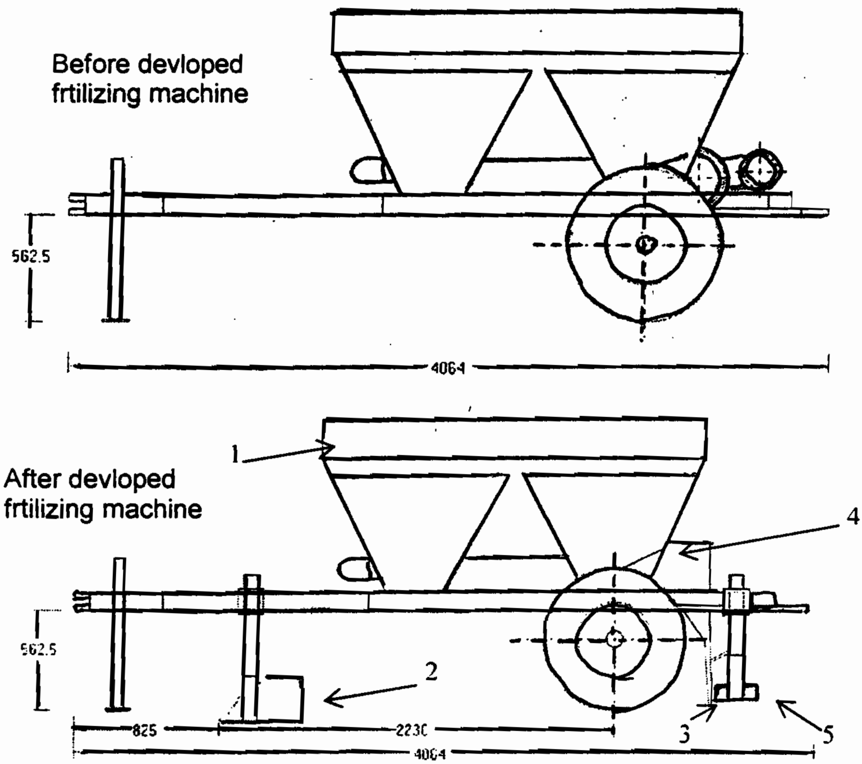
1. The spinning discs were removed and assembling spout in order to collect the fertilizer to be transfer it throuh the tube in trench.
2. Assembling furrow opener on the frame to make a trench. The furrow opener width of 0.2 m and the operating depth was 0.2 m
3. Assembling steel plate rear the machine (10, 20 and 70 cm thickness, width and length respectively) fixed on carrier of behind the fertilizing tube to cover trench with shallow layer of soil.

The developed machine can be driven by Nasr tractor 60 Hp (44.12 kW).

The shape of the furrow section after using the developed fertilizing machine can be shown in Fig. (2). It consists of many layers; 1- slither soil layer (about 11 cm) resulting to sloping soil from two sides row after operation of furrow opener, 2- Fertilizer layer about 0.4 cm thickness, 3- Soil layer (about 7 cm) resulting to putting plants in row using steel plate (covering unit) and 4- Slopping zone as indicator to putting plants in row.

Mixture fertilizers components are organic manure, loam soil and super phosphate, the quantities were 818 kg (1.0 m^3). 1180 kg (1.0 m^3) and 140 kg respectively (accoring to the land department in Gimmeza Rs. Station concluded 2007), were mixed in good shape. That mixture is suitable for growing the most vegetable crops such as squash, egg plant and pea. The moisture content of mixture fertilizers was about 15 %.

The machine was calibrated before the experimental testes. Then the experimental tests were carried out in El-Gemmiza Research Station at season 2007-2008 under three studied parameters forward speeds of 5.96, 7.95 and 10.04 km/h, height of gate opening of 6.0, 8.0 and 10.0 cm and conveyor speed of 14.0, 22.0 and 31.0 rpm. The field experiments were done in split split plot design at three replicates. The field test area was about one feddan. The experimental study was fertilizing new land before planting by mixture fertilizers after developed spreader. It put the mixture fertilizers in trenches. To evaluate the developed machine performance the fertilizing rates (weight of mixture fertilizers in one longitudinal meter, fertilizing rate "kg/fed", volumetric rate "m^3/fed" and layer of fertilizer thickness "mm"), fertilizing machine capacity, "m^3/h" and the fertilizing machine efficiency (field capacity, energy requirement and operating cost) were determined.



1- Hopper 2- Furrow opener 3- Fertilizing tube 4- Feeding gat 5- Steel plat

Fig. 1: The developed fertilizer machine.

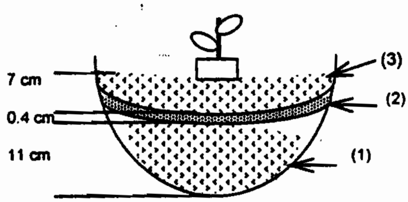


Fig. 2: Schematic digram of furrow after using the developed fertilizing machine and putting the vegetable seedling.

The effective field capacity can calculated as follows

$$F_c = \frac{V_m \; W \; F_e}{4200}$$

where:

F_c : effective field capacity, Fed/h
V_m : speed of travel, km/h
W : rated width of the implement, m
F_e : field efficiency, %.

To determine the energy requirements the following formula was used to estimate the power requirement:

$$PR = F_c \times \frac{1}{60 \times 60} \times L_{cv} \times \rho_f \times 427 \times \eta_{th} \times \eta_m \times \frac{1}{75} \times \frac{1}{1.36}$$

Where: PR = Power required, kW
F_c = Fuel consumption, L/h
L_{cv} = Lower colorific value of fuel, (11000 kcal/kg)
ρ_f = Density of fuel, 0.85 kg/L
427 = Thermo-mechanical equivalent, kg.m/kcal
η_{th} = Thermal efficiency of the engine, (30%-35%)
η_m = Mechanical efficiency of the engine, (80%- 85%)

So, the energy can be calculated as following:

$$\text{Energy requirement} = \frac{\text{Engine power (kW)}}{\text{Production (kg/h)}} \qquad \text{kW.h/kg}$$

The cost of fertilizing machine was determined a cording to the following equation, (Awady, 1978).

$$C = \frac{P}{h}\left(\frac{1}{e} + \frac{I}{2} + t + r\right) + \left(0.9w \times f \times s\right) + \frac{m}{144}$$

Where:

C : Hourly cost, LE/h
P : Capital investment, LE
h : Yearly operation hours, h
e : Life expectancy of equipment in years, %
I : Interest rate, %
t : Taxes and over heads, %
r : Repairs ratio of the total investment, %
0.9 : A factor including reasonable estimation of the oil consumption in addition to fuel.
w : Horse power of the engine, hp
f : Specific fuel consumption is L/hp.h
s : Price of fuel per liter, LE/L
m : Labors wage rate per month in LE.
144 : Reasonable estimation of monthly working hours.

RESULTS AND DISCUSSION

Effect of conveyor speed on rates of mixture fertilizers

1- The effect on one longitudinal meter

Fig. (3) shows the relation between conveyor speed on mixture fertilizers rate in one longitudinal meter at different gate height and forward speed. The results indicated that the amount of the mixture fertilizers increased by increase the both of conveyor speed and gate height but decreased when the forward speed increased. From the data the highest value of mixture fertilizers rate in one longitudinal meter was 776 g occurred at the highest conveyor speed and gate height and the lowest forward speed. Then the lowest value was 211 g found at the lowest conveyor speed and gate height and the highest forward speed.

2- The effect on fertilizing rate

The above same trend obtained when the fertilizing rate was estimated. Fig. (4) illustrates that the relation between conveyor speed on mixture fertilizing rate at different gate height and forward speed. The results cleared that the mixture fertilizers rate increased from 4.81 to 5.44 ton/fed and from 2.44 to 5.44 ton/fed by increase the both of conveyor speed from 14 to 31 rpm and gate height from 60 to 100 mm respectively. While it decrease from 5.44 to 3.68 ton/fed at the forward speed increasing from 5.96 to 10.04 km/h.

3- The effect on volumetric rate

From Fig. (5) the data clarifying that the volumetric rate of mixture fertilizers increased by increase the both of conveyor speed and gate height but decreased when the forward speed increased. The results seen that the values of volumetric rate of mixture fertilizers ranging from 1.39 to 5.08 m^3/fed at the studied parameters under study.

4- The effect on layer of fertilizer thickness

Fig. (6) clear that the relation between conveyor speeds and layer of fertilizer thickness at different gate height and forward speed. The Fig. shows that the layer of fertilizer thickness increased by increase the conveyor speed and gate height while decreased by increase the forward speed. From the data the highest value of layer of fertilizer thickness was 3.63 mm at 31 rpm conveyor speed and 100 mm gate height and 5.96 km/h forward speed. Then the lowest value was 1.00 mm at 14 rpm conveyor speed and 60 mm gate height and 10.04 km/h forward speed.

Generally, the developed fertilizing can be put the mixture solid fertilizers irregularly in the trench with the suitable rate and thickness layer. Therefore, the volumetric rate can be adjusted as the type of the vegetable crop.

Effect of conveyor speed on fertilizing machine capacity

Fig. (7) cleared that the relation between çonveyor speeds on fertilizing machine capacity at different gate height and forward speed. From the data the fertilizing machine capacity increased from 2.52 to 2.94 m^3/h at increase of conveyor speed from 14 to 31 rpm respectively. Also, it increased from 1.79 to 3.88 m^3/h at increase of gate height from 60 to 100 mm respectively. Hence, it increased from 2.61 to 2.92 m^3/h respectively by increasing the forward speed from 5.96 to 10.04 km/h.

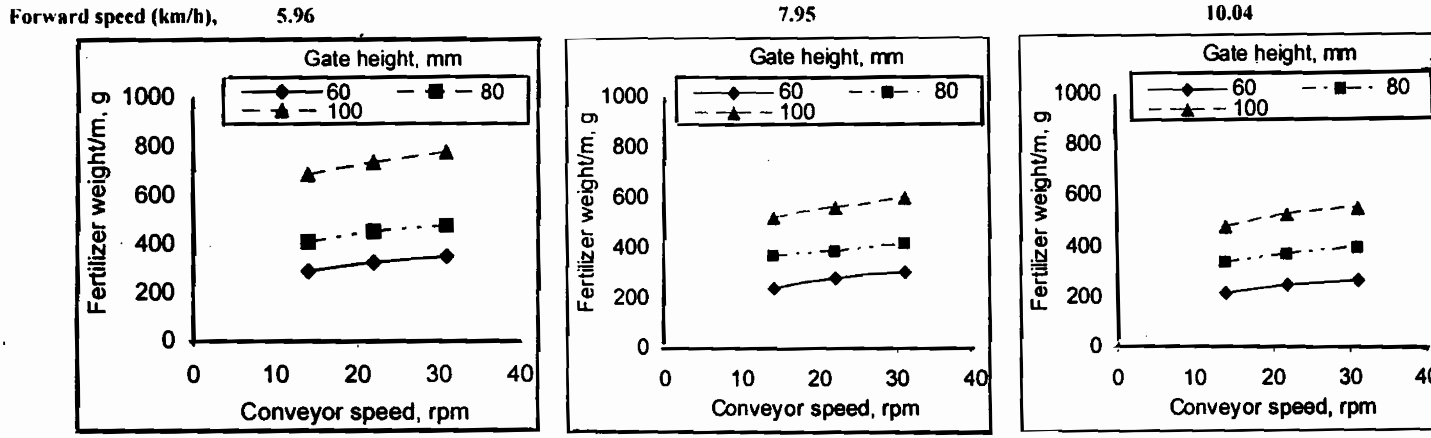


Fig. 3: Effect of conveyor speed on mixture fertilizers rate in one longitudinal meter.

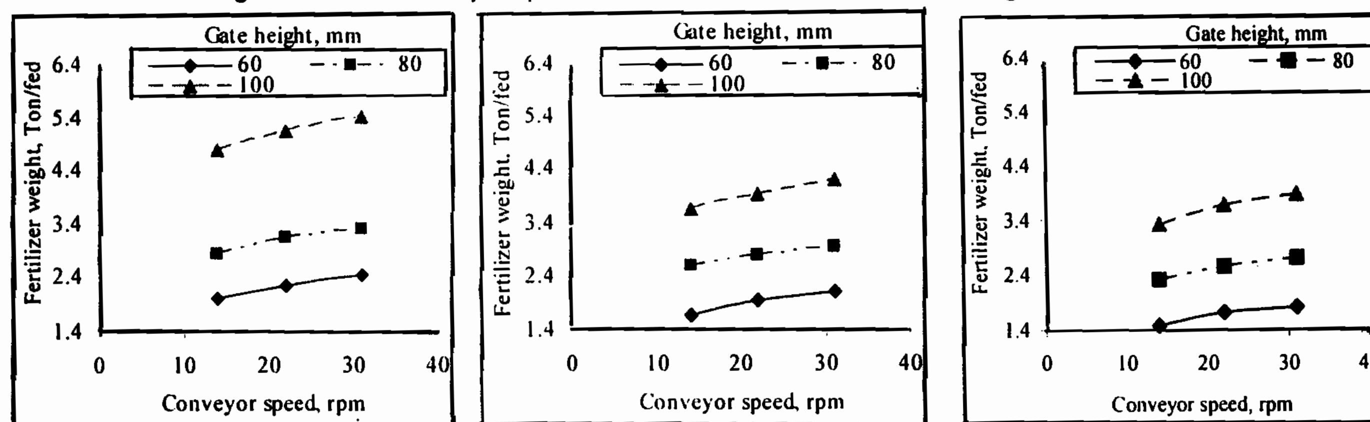


Fig. 4: Effect of conveyor speed on mixture fertilizing rate.

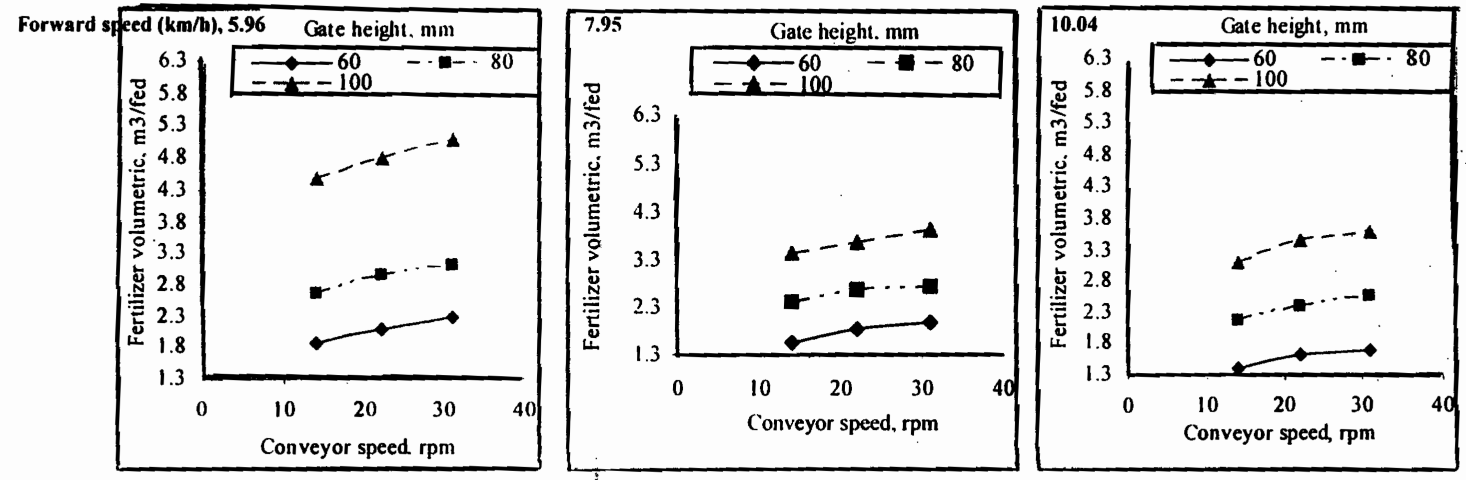


Fig. 5: Effect of conveyor speed on volumetric rate.

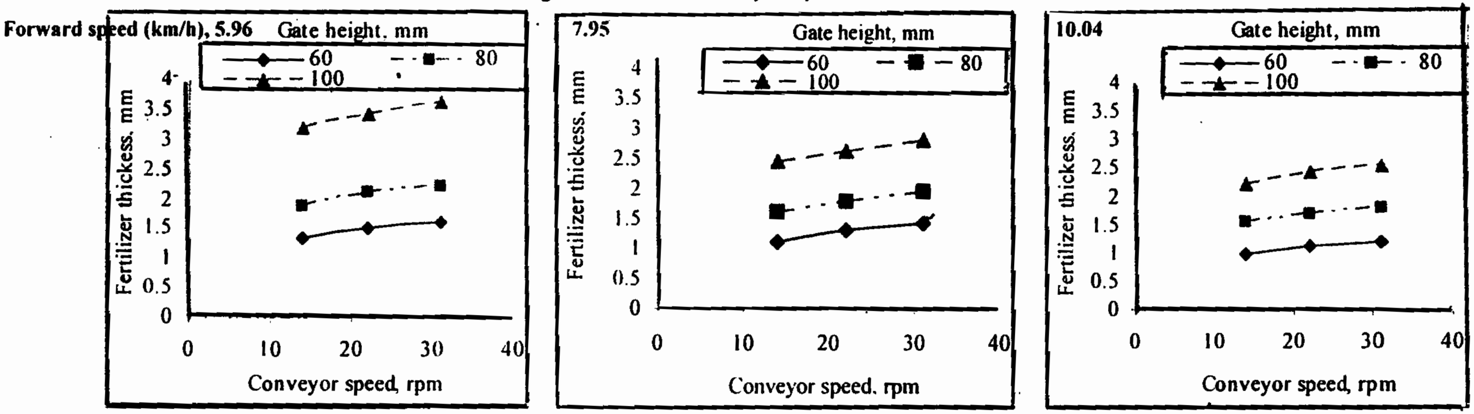


Fig. 6: Effect of conveyor speed on layer of fertilizer thickness.

Effect of conveyor speed on fertilizing machine efficiency

The relation between conveyor speeds on fertilizing machine efficiency at the different forward speeds can be shown in Figs. (8 and 9) and Table (2). From figure (8) the energy requirements decreased by increasing the conveyor speed but increased when the forward speed increased. From the data the highest value of energy requirements was 6.41 kW.h/fed obtained at 14 rpm conveyor speed, 10.04 km/h forward speed and optimum gate height (100 mm). Then the lowest was 2.90 kW.h/fed occurred at 31 rpm conveyor speed and 5.96 km/h forward speed. On the other hand Fig. (9) illustrates the effect of conveyor speed on operating cost of fertilizing machine. The fertilizing machine operating cost decreased from 2.73 to 3.35 LE/m^3 by decreasing the previous studied parameters. Therefore, Table (2) clarify that the optimum fertilizing machine efficiency at different forward speed. The data cleared that by increase the forward speed the field capacity, fuel consumption, power consumed and the operating cost increased. Meanwhile, when the forward speed increased from 5.96 to 7.95 km/h the increment as a percentage of field capacity was 20 %, fuel consumption was 21.57 %, power consumed was 21.55 % and the operating cost was 3.52 %. On the other side, at forward speed increased from 7.95 to 10.04 km/h the increment as a percentage of field capacity was 20 %, fuel consumption was 11.29 %, power consumed was 11.24 % and the operating cost was 2.18 %. These results clear that the differences in fuel and power consumed are lower at the forward speed increased from 7.95 to 10.04 the forward speed increased from 5.96 to 7.9 km/h than the forward speed increased from 5.96 to 7.9 km/h.

Table 2: The optimum fertilizer efficiency at different forward speed.

Forward speed km/h	Field capacity Fed/h	Fuel consumption L/h	Power consumed kW	Operating cost L/h
5.96	0.8	5.1	14.74	11.09
7.95	1	6.2	17.92	11.48
10.04	1.2	6.9	19.94	11.73

Conclusion

The developed fertilizing machine could be used to put the mixture fertilizers in trenches and covering it by shallow layer of soil (about 5 cm) and planting seedlings above these layers in new lands. This developed improved soil characteristics, decreasing water requirement to irrigate the plants through growth session.

The performance of machine was evaluated at three forward speeds of 5.96, 7.95 and 10.04 km/h; three feeding gate height of 60, 80, and 100 mm and conveyor speeds of 14, 22 and 31 rpm. The best results recorded at forward speed of 5.96 km/h, 100 mm feeding gate height and conveyors speed of 31 rpm gave the most needs of seedling of vegetables where in this case showed the minimum of operating cost was 2.73 L.E/m^3, volumetric mixture fertilizers was 5.08 m^3/fed, established thickness of fertilizer layer in trench was 3.63 mm and the lower power consumed was 14.74 kW. Then the research recommended that this machine can be widely used to prepare the soil in new reclaimed and desert lands especially for the vegetable crops commonly sensitive for fertilizer reduced.

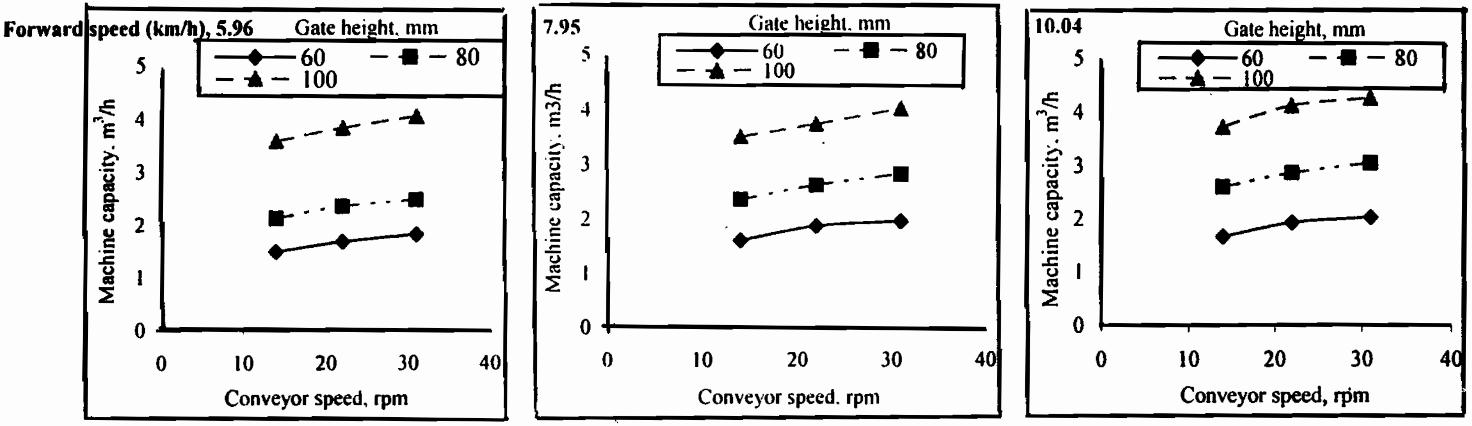


Fig. 7: Effect of conveyor speed on fertilizing machine capacity.

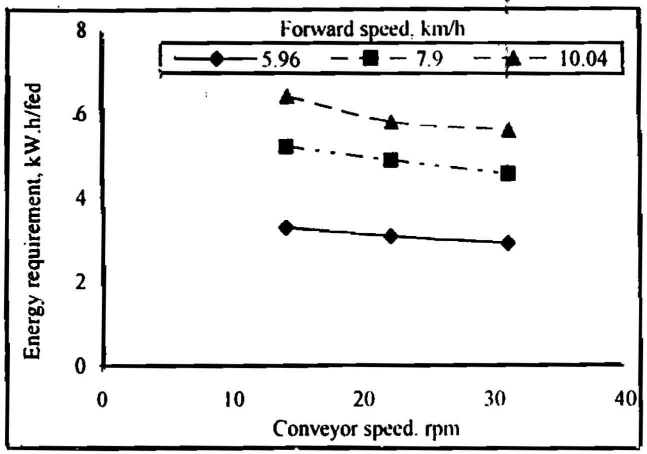


Fig. 8: Effect of conveyor speed on energy requirements.

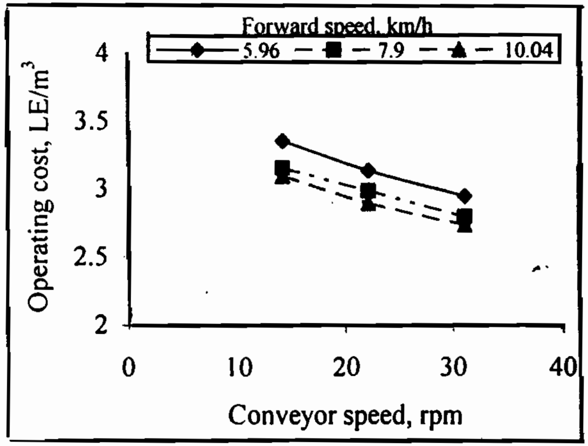


Fig. 9: Effect of conveyor speed on oprating cost.

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تطوير آلة نثر السماد لتناسب وضع السماد أسفل شتلات الخضر فى الأراضى الجديدة

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يهدف هذا البحث إلى تطوير آلة نثر السماد لتناسب وضع طبقة رقيقة من مخلوط الأسمدة الجافة فى أخدود ثم تغطيته بطبقة رقيقة من التربة (٥ سم). وقد تضمنت عملية التطوير تزويد القرص الدوار بزوائد لتجميع السماد ووضعه فى أخدود خلف فاتح الخط، وتثبيت فاتح خطوط فى شاسيه الآلة لعمل أخاديد بعرض ٢٠ سم وعمق ٢٠ سم، كذلك تثبيت شريحة من الصلب كزحافة خلف الآلة بأبعاد ١٠ × ٢٠ × ٧٠ سم سمك، عرض، طول لتغطية الجور بطبقة رقيقة من التربة(٧ سم). وقد إشتملت عوامل الدراسة على ثلاث مستويات لسرعة تقدم الآلة ٥,٩٦، ٧,٩٥، ١٠,٠٤ كم/ساعة، ثلاث مستويات لإرتفاع فتحة التغذية ٦٠، ٨٠، ١٠٠ مم، ثلاث مستويات لسرعة سير التغذية ١٤، ٢٢، ٣١ لفة/دقيقة. وقد نتج من التجارب أن أفضل مستويات تشغيل لآلة نثر السماد هى سرعة تقدم ٥,٩٥ كم/ساعة، إرتفاع فتحة التغذية ١٠٠ مم، سرعة سير التغذية ٣١ لفة/دقيقة حيث أعطت أقل تكاليف (٢,٧٣ جنيه/م^{٣})، ومعدل إضافة السماد الحجمى (٥,٠٨ م^{٣}/فدان)، وسمك طبقة السماد ٣,٦٣ مم، أقل متطلبات للطاقة ٢,٩٠ كيلووات.ساعة/فدان. وتوصى الدراسة بإمكانية إستخدام هذه الآلة حيث أنها تقوم بعدة عمليات عند تجهيز التربة للزراعة وهى فتح الأخدود ووضع السماد ثم تغطيته وهذه العمليات تعد تجهير متكامل للتربة قبل زراعة البذور أو الشتلات. وهذه الآلة من الناحية التطبيقية لها أهمية خاصة فى الأراضى الجديدة والأراضى الرملية عند زراعة محاصيل الخضر المعروفة بحساسيتها للتسميد، لما للتسميد من أهمية استراتيجية فى الوقت الراهن.