A STUDY ON MECHANIZATION OF AERATION IN TURFGRASS

H. A. FOUAD*, S. H. DESOKY**, R. A. WERBY**, H. A. A. SAYED***

ABSTRACT

The objective of the present work was to develop and evaluate aeration machine for turfgrass to make under Egyptian condition. The aeration machine was evaluated versus two holes density (24 and 48 hole/m^2), two hollow tine diameters (2.5 and 3 cm), three average depths of aeration (4, 6 and 8 cm) and four forward speeds (2, 2.7, 3.6 and 4 km/h). After 7 days from aeration operation the results showed that the lower bulk density and penetration resistance values was 0.960 g/cm^3 and 154 kPa, respectivaly opposite it the higher porosity and void ratio values were 65.09% and 1.865, respectively at 48 hole/m^2 holes density, 3 cm tine diameter, 8 cm depth of hole and forward speed 2 km/h comparing with control 1.271 g/cm^3, 337 kPa, 53.79% and 1.164 for density, penetration resistance, porosity and void ratio, respectively. The higher actual field capacity was (0.941 fed/h) at 24 hole/m^2 holes density, 2.5 cm tine diameter, 4 cm depth of hole and forward speed 4 km/h. The lower energy required was 16.223 kw.h/fed, at 24 hole/m^2 holes density, 2.5 cm tine diameter, 4 cm depth of hole and forward speed 4 km/h.

INTRODUCTION

Turfgrass in golf courses, clubs, public garden and stadiums play a vital role in population life. Turfgrass refines the atmosphere from the bad particles which cause pollution in the air (**Morad *et al.*, 2003**). Turfgrass plants are normally perennial which grow through tillering, stolon and rhizomatous growth, and ideally, develop new vegetative shoots continually throughout the year. Cool-season turfgrass grow strongly in winter. Warm-season perennial grasses are growing in summer to autumn (**Lodge *et al.*, 1990**). Traffic of machine and human usually compacts the top 5 to 7.5 cm in turf situations with the top 2.5 cm

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being the most severely compacted. Thatch is accumulation of living and dead grass leaves, stems and organic debris between the soil surface and the green vegetation in a turf **(Beard, 1973).** Excessive thatch can lead to increase disease incidence, reduce tolerance to environmental stress, and water management difficulties **(Fontanier *et al.,* 2011)**. Soil compaction decreased stand uniformity and plant growth, restricted root growth, reduced soil aeration, reduced water infiltration, reduced internal drainage and reduced effectiveness of underground drainage systems **(Larson *et al.,* 1994).** There are many proposed benefits of aeration including increased air-filled space, decreased compaction, increased infiltration and drainage, increased root growth, improving the application of fertilizer **(Binns, 2001).** Aeration is a cultivation method in which small holes are made in the soil, usually by removal of small cylinders or plugs of soil and turf. These plugs are pulled out with hollow tines, spoons, or screws, discharged on the surface and then either removed or be broken up and worked back into the turf **(Pessarakli, 2007).** Core size varies from (0.635 to 2.54 cm) in diameter and the vertical length of the cores is usually (7.62 cm) **(Turgeon, 2002)**. Mechanical aeration reduced bulk density and penetration resistance comparing to control (no aeration) **(Abrougui et al., 2012).** The hydraulic conductivity increased after mechanical aeration **(Abrougui et al., 2012).** Soil compaction may increase soil strength and compacted soil layers can effect on root and shoot growth. Root growth is generally noted down into the holes created by coring and coring promotes deep rooting of warm season grasses in particular **(Zontek, 2002)**.

MATERIAL AND METODS

The aeration machine was manufactured at workshop and the experiment was carried out at Farm located in Nafesha village, Ismailia Governorate, Egypt from 2014 - 2015.

1. Soil and turfgrass:

The mechanical analysis of soil was classified as sandy and the real soil density is 2.75 g/cm^3 and turfgrass type was *Paspalum*.

2. The aeration machine of turfgrass:

The aeration machine Figures (1 and 2) is constructed of main frame, hitching system, flanges, shaft, bearing and core tines. The overall

dimension of aeration machine were 117*63.5*86 cm. The distance between each flange was 8 cm. The distance between centers of two consecutive core tines was 125 cm. The total weight of aeration machine was 255 kg. Each flange has sex core tines based on it and each core tine fixed by two bolts and nuts.
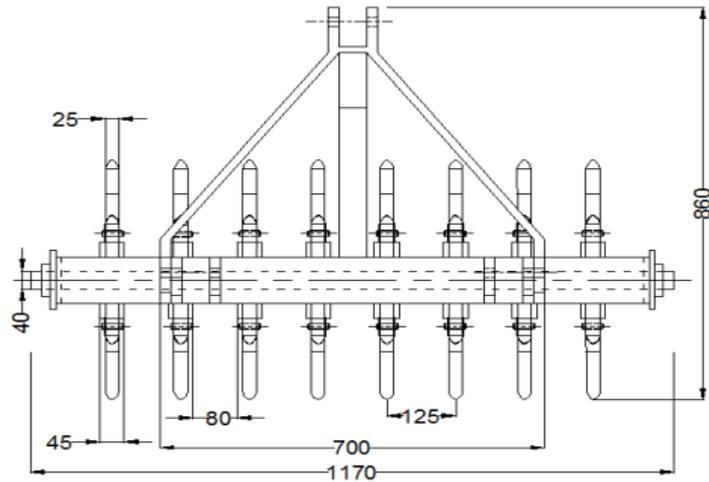
Fig. (1): Elevation of aeration machine.
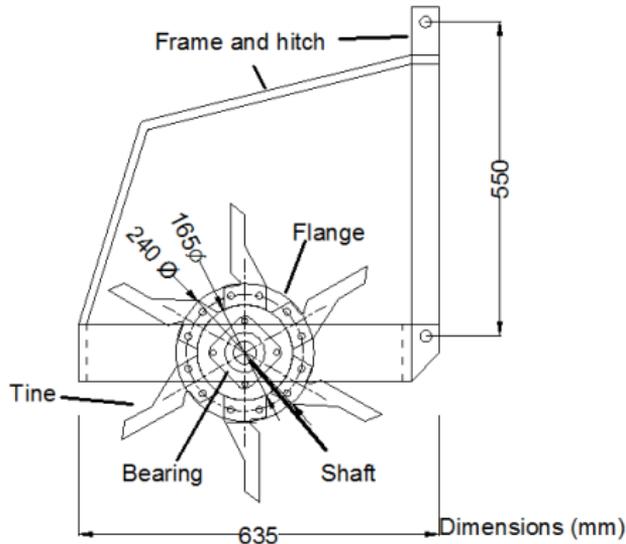
Fig. (2): Side view of aeration machine.

The flange had two diameters the big diameter is 240 mm with thickness 25 mm and the small diameter is 165 mm with thickness 45 mm. The shaft was manufactured from medium carbon steel, 117 cm length and 4 cm diameter.

3. Source of power:

The characteristics of the agricultural tractor are driving wheel 2WD, engine power 33 hp (24.6 kW) at 2700 rpm and source of manufacture is Japan.

4. Soil bulk density:

Soil samples were taken with cylindrical core (100 cm^3 volume). The core samples were immediately weighted and then they were dried at 105 C^o for 24 hours. Soil bulk density was determined according the following formula:

$$\rho_b = \frac{W_d}{T_v}$$

Where:

ρ_b: Soil bulk density, g/cm^3.

W_d: Dry soil mass, g.

T_v: Total soil volume, cm^3.

5. Soil porosity:

Soil porosity was determined by using the following formula:

$$S_p = \left\{ 1 - \left(\frac{\rho_b}{\rho_s} \right) \right\} * 100$$

Where:

S_p: Soil porosity (%).

ρ_s: Real soil density, g/cm^3.

6. Void ratio:

Void ratio (e) was calculated using the following formula:

$$e = \frac{\rho_s - \rho_b}{\rho_b}$$

7. Penetration resistance:

Soil resistance to insertion of penetrometer was determined by using the following formula:

$$PR\ (kPa) = \frac{F*9.81}{A*10^3}$$

Where:

PR: Penetration resistance, kPa.

F: Force required to penetration, kg.

A: Average cone area, m^2.

8. Actual field capacity:

Actual field capacity was calculated by using the following formula:

$$A_{fc} = \frac{1}{T_t}$$

Where:

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

T_t: Total effective operating time, h/fed.

9. Energy requirements:

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

$$EP = f.c \left(\frac{1}{3600}\right) \rho_f * L.C.V * 427 * \eta_{th} * \eta_m * \frac{1}{75} * \frac{1}{1.36}$$

Where:

EP: Engine power, kW.

f.c: Fuel consumption, L/h.

ρ_f: Density of fuel, 0.85 kg/L for diesel.

L.C.V: Lower calorific value of fuel, 10000 kcal/kg for diesel.

427: Thermo-mechanical equivalent, kg.m/kcal.

η_{th}: Thermal efficiency of engine, 80% for diesel.

η_m: mechanical efficiency of engine, 35% for diesel.

The energy requirements were calculated by using the following equation:

$$ER = \frac{EP}{A_{fc}}$$

Where:

ER: Energy requirements, kW.h/fed.

RESULTS AND DISCUSSION

1. Effect of forward speed on soil bulk density:

Results show that the values of bulk density were decreased by using aeration machine in all treatments comparing with the control (no aeration treatment). Figure (3) shows that the lower value of bulk density was (0.960 g/cm^3) at 48 hole/m^2 holes density, 3 cm tine diameter, 8 cm depth and forward speed 2 km/h. Bulk density at 24 hole/m^2 holes density, 2.5 cm tine diameter, 4 cm depth and forward speed 4 km/h was higher value of bulk density (1.136 g/cm^3), comparing with the control (1.271 g/cm^3).

The bulk density values decreased with decreasing forward speed and increasing (holes density, tine diameter and depth of hole).
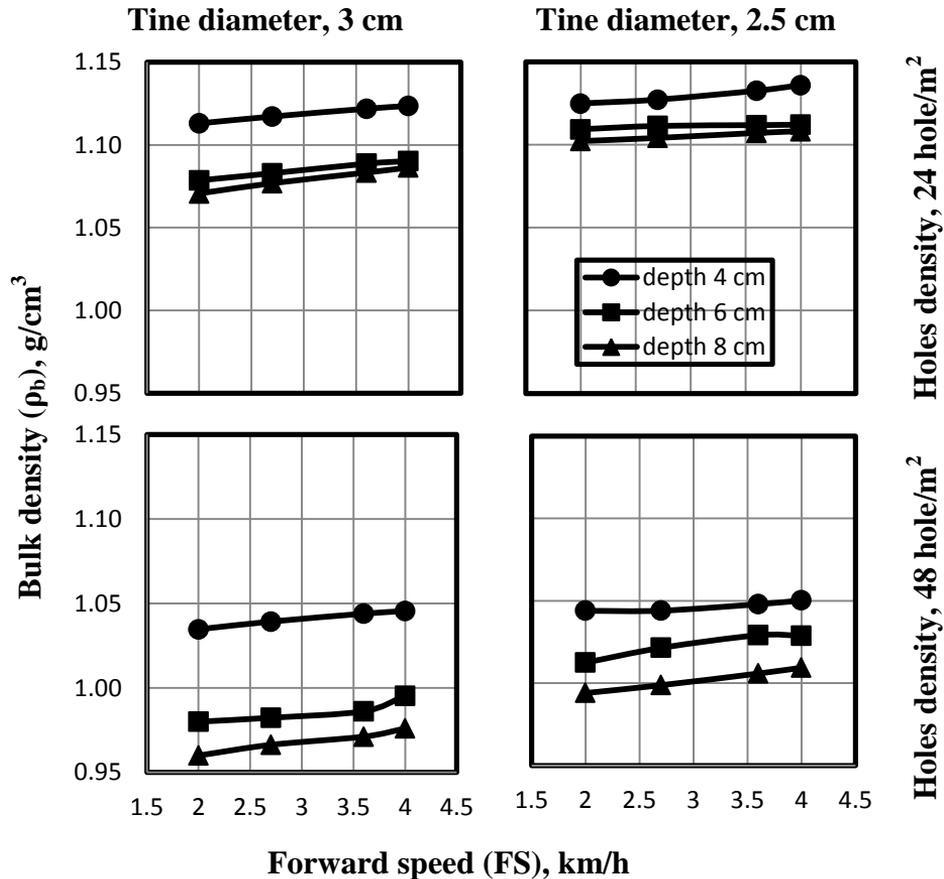
Fig. (3): Bulk density Vs forward speed during different holes density, tine diameter and depth of holes after 7 days from aeration.
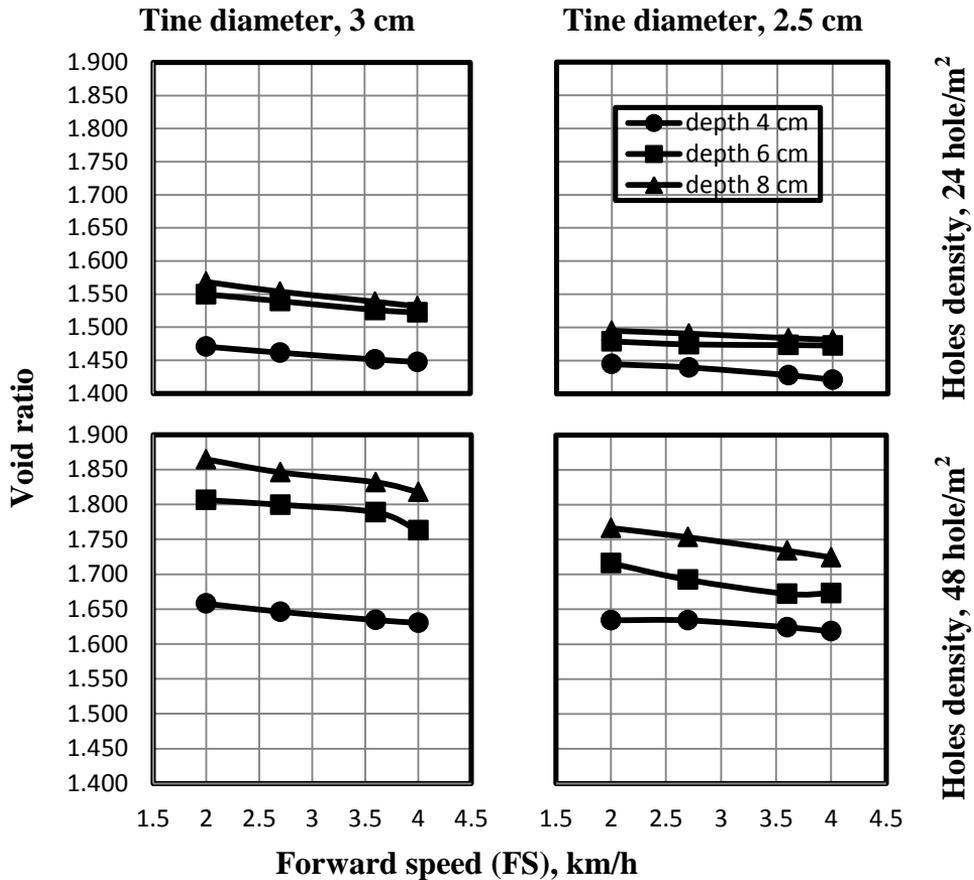
2. Effect of forward speed on soil porosity:

Results show that the values of porosity were increased by using aeration machine in all treatments comparing with the control (no aeration treatment). Figure (4) shows that the higher value of porosity was (65.09 %) at 48 hole/m^2 holes density, 3 cm tine diameter, 8 cm depth and forward speed 2 km/h. porosity at 24 hole/m^2 holes density, 2.5 cm tine diameter, 4 cm depth and forward speed 4 km/h was lower value of porosity (58.69 %), comparing with the control (53.79 %). The porosity values increased with decreasing forward speed and increasing (holes density, tine diameter and depth of hole).
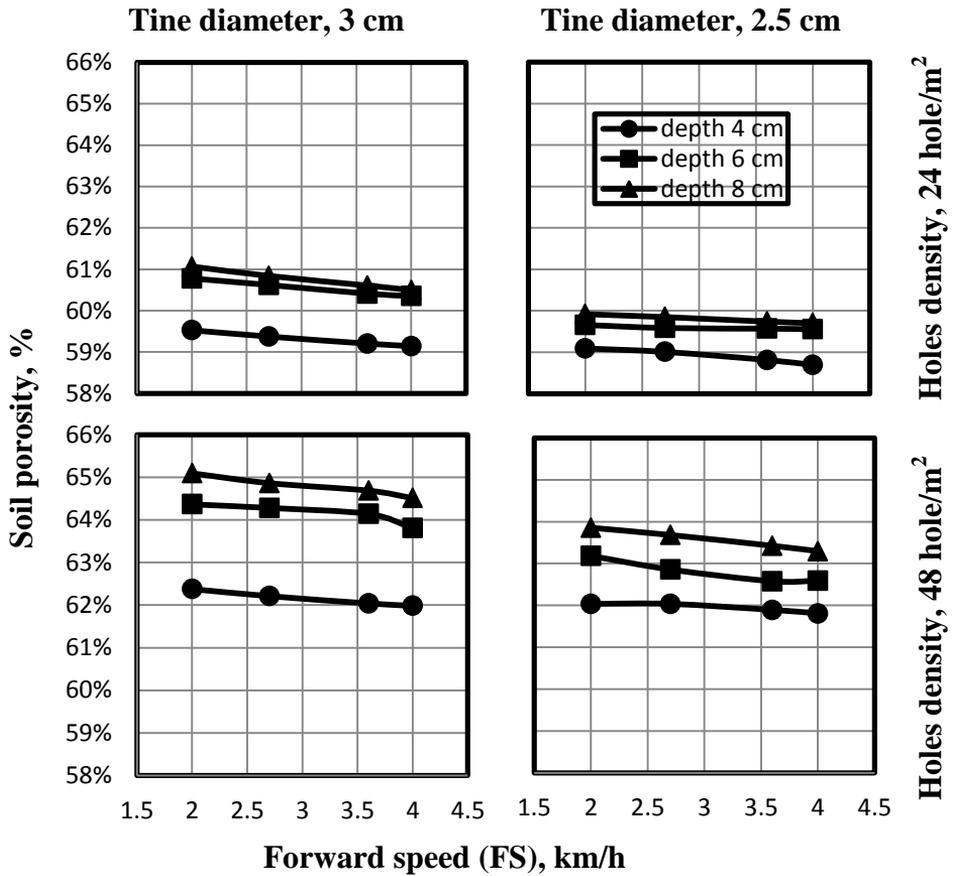
Fig. (4): Porosity Vs forward speed during different holes density, tine diameter and depth of holes after 7 days from aeration.

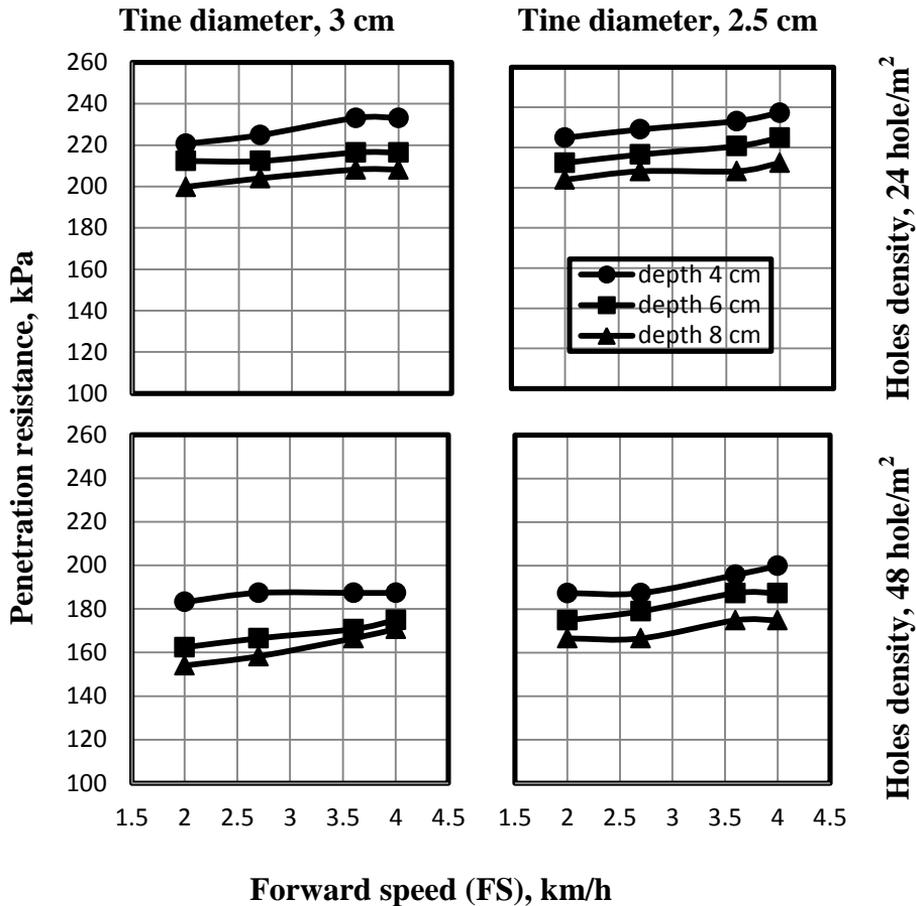## 3. Effect of forward speed on void ratio:

Results show that the values of void ratio were increased by using aeration machine in all treatments comparing with the control (no aeration treatment). Figure (5) shows that the higher value of void ratio was (1.865) at 48 hole/m^2 holes density, 3 cm tine diameter, 8 cm depth and forward speed 2 km/h. Void ratio at 24 hole/m^2 holes density, 2.5 cm tine diameter, 4 cm depth and forward speed 4 km/h was lower value of void ratio (1.421), comparing with the control (1.164). The void ratio values increased with decreasing forward speed and increasing (holes density, tine diameter and depth of hole).

Fig. (5): Void ratio Vs forward speed during different holes density, tine diameter and depth of holes after 7 days from aeration.

## 4. Effect of forward speed on penetration resistance:

Results show that the values of penetration resistance were decreased by using aeration machine in all treatments comparing with the control (no aeration treatment). Figure (6) shows that the lower value of penetration resistance was (154 kPa) at 48 hole/m^2 holes density, 3 cm tine diameter, 8 cm depth and forward speed 2 km/h. Penetration resistance at 24 hole/m^2 holes density, 2.5 cm tine diameter, 4 cm depth and forward speed 4 km/h was higher value of penetration resistance (237 kPa), comparing with the control (337 kPa). The penetration resistance values decreased with decreasing forward speed and increasing (holes density, tine diameter and depth of hole).

Fig. (6): Penetration resistance Vs forward speed during different holes density, tine diameter and depth of holes after 7 days from aeration.

## 5. Effect of forward speed on actual field capacity:

Figure (7) shows that the higher value of actual field capacity was (0.941 fed/h) at 24 hole/m^2 holes density, 2.5 cm tine diameter, 4 cm depth and forward speed 4 km/h. Actual field capacity at 48 hole/m^2 holes density, 3 cm tine diameter, 8 cm depth and forward speed 2 km/h was lower value of actual field capacity (0.449 fed/h). The actual field capacity values increased with increasing forward speed and decreasing (holes density, tine diameter and depth of hole).
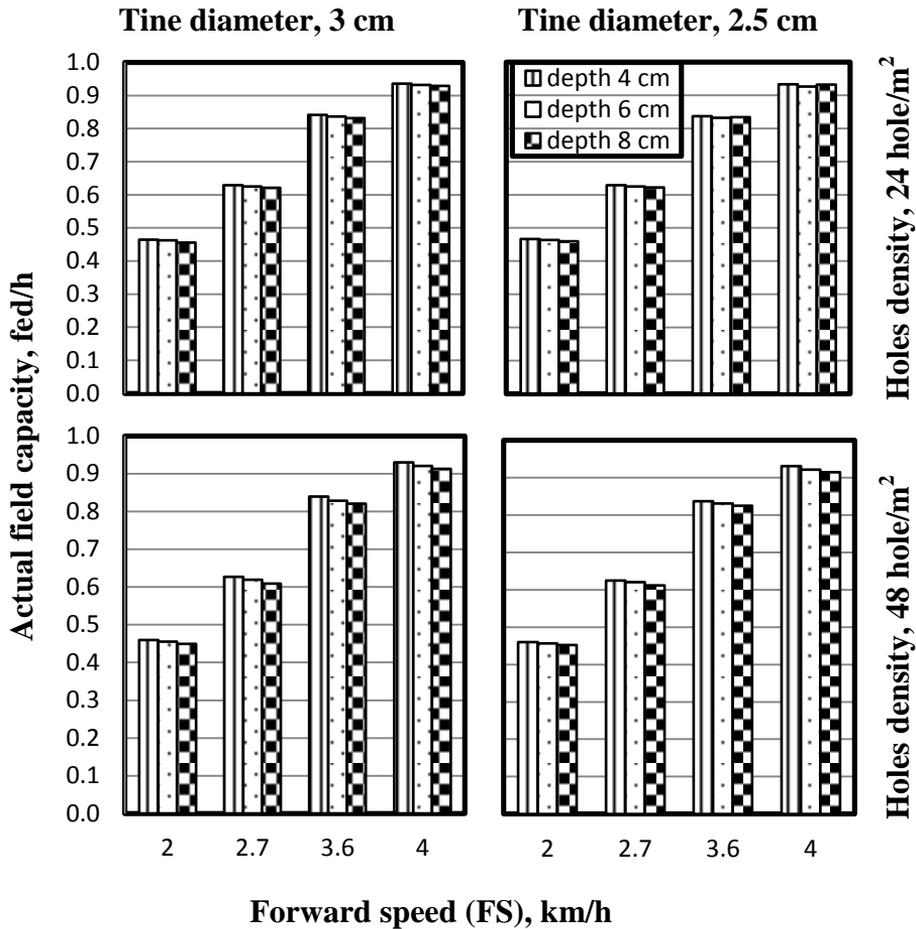
Fig. (7): Actual field capacity Vs forward speed during different holes density, tine diameter and depth of holes after 7 days from aeration.

6. Effect of forward speed on energy requirements:

Figure (8) shows that the lower value of energy requirements was (16.223 kW.h/fed) at 24 hole/m^2 holes density, 2.5 cm tine diameter, 4 cm depth and forward speed 4 km/h. Energy requirements at 48 hole/m^2 holes density, 3 cm tine diameter, 8 cm depth and forward speed 2 km/h was higher value of energy requirements (27.935 kW.h/fed). The energy requirements values decreased with increasing forward speed and decreasing (holes density, tine diameter and depth of hole).
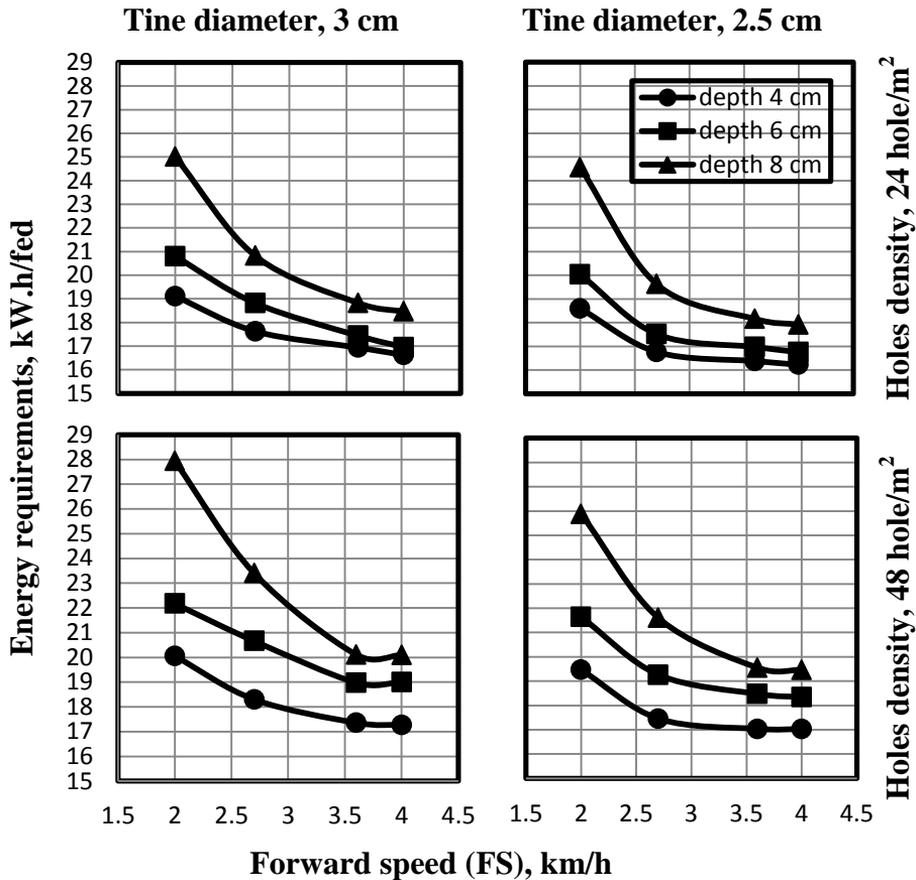
Fig. (8): Energy requirements Vs forward speed during different holes density, tine diameter and depth of holes after 7 days from aeration.

CONCLUSION

- The lower value of bulk density and penetration resistance were 0.960 g/cm^3 and 154 kPa, respectively at 48 hole/m^2 holes density, 3 cm tine diameter, 8 cm depth and forward speed 2 km/h comparing with control 1.271 g/cm^3 and 337 kPa .

- The higher porosity and void ratio was 65.09% and 1.865 respectively at 48 hole/m^2 holes density, 3 cm tine diameter, 8 cm depth and forward speed 2 km/h comparing with control 53.79 % and 1.164.

- The higher actual field capacity was (0.941 fed/h) at 24 hole/m^2 holes density, 2.5 cm tine diameter, 4 cm depth and forward speed 4 km/h.

- The lower value of energy consumption was (16.223 kW.h/fed) at 24 hole/m^2 holes density, 2.5 cm tine diameter, 4 cm depth and forward speed 4 km/h.

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الملخص العربى

دراسة على ميكنة التهوية فى النجيل

حسن على فؤاد* سمير حافظ محمد دسوقى** رأفت على أحمد وربى**
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زيادة المسطحات الخضراء من أساسيات الدول المتقدمة وقد زاد الإهتمام بها فى السنوات الأخيرة فى مصر عن طريق زراعتها فى الحدائق والملاعب والمنازل. وبسبب كثرة المرور على التربة تندمج ويحدث لها انضغاط لذلك اهتم البحث بتطوير وتصنيع آلة محلية تناسب الظروف المصرية تعمل على تهوية التربة مما يعطى النبات القدرة على امتصاص الماء والغذاء كذلك مواجهة مشكلة ارتفاع ثمن الآلة المستوردة. وقد تم إجراء التجارب الحقلية فى مزرعة بمحافظة الإسماعيلية خلال عام ٢٠١٤ – ٢٠١٥.

وقد تم اختبار الآلة باستخدام:

- كثافتين من الثقوب (٢٤ و ٤٨ ثقب/م^2)
- قطرين مختلفين للأسنان المجوفة (٢.٥ و ٣ سم).
- ثلاثة أعماق مختلفة للتهوية (٤ ، ٦ و ٨ سم).
- أربع سرعات أمامية (٢ ، ٢.٧ ، ٣.٦ و ٤ كم/ساعة).

وكانت أهم النتائج المتحصل عليها:

- كانت أقل قيمة للكثافة الظاهرية (٠.٩٦٠ جم/سم^3) مقارنة بالكنترول (١.٢٧١ جم/سم^3) عند كثافة ثقوب ٤٨ ثقب/م^2، قطر ٣ سم، عمق ٨ سم وسرعة أمامية ٢ كم/ساعة.

- كانت أعلى قيمة للمسامية (٦٥.٠٩ %) مقارنة بالكنترول (٥٣.٧٩ %) عند كثافة ثقوب ٤٨ ثقب/م^2، قطر ٣ سم، عمق ٨ سم وسرعة أمامية ٢ كم/ساعة.

- كانت أعلى نسبة للفراغات (١.٨٦٥) مقارنة بالكنترول (١.١٦٤) عند كثافة ثقوب ٤٨ ثقب/م^2، قطر ٣ سم، عمق ٨ سم وسرعة أمامية ٢ كم/ساعة.

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- كانت أقل قيمة لمقاومة الإختراق (١٥٤ ك باسكال) مقارنة بالكنترول (٣٣٧ ك باسكال) عند كثافة ثقوب ٤٨ ثقب/م٢، قطر ٣ سم، عمق ٨ سم وسرعة أمامية ٢ كم/ساعة.

- حققت الآلة أعلى سعة حقلية (٠.٩٤١ فدان/ساعة) عند كثافة ثقوب ٢٤ ثقب/م٢، قطر ٢.٥ سم، عمق ٤ سم وسرعة أمامية ٤ كم/ساعة.

- كانت أقل استهلاك للطاقة (١٦.٢٢٣ ك وات.ساعة/فدان) عند كثافة ثقوب ٢٤ ثقب/م٢، قطر ٢.٥ سم، عمق ٤ سم وسرعة أمامية ٤ كم/ساعة.

- ويوصى البحث باستخدام آلة لتهوية المسطح الأخضر ذات كثافة ثقوب ٤٨ ثقب/م٢، قطر ٣ سم، عمق ٨ سم وسرعة أمامية ٢ كم/ساعة لتحقيقها أعلى قيمة للمسامية والفراغات وكذلك أقل قيمة للكثافة ومقاومة الإختراق.