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THE REQUIREMENTS OF MECHANICAL PLANTING OF GRAPE

EL-Shal, M.S.*; T.A. Abou Sayed Ahmad; S.E. Badr ***
and Noha M. Salem***

*** Agric. Eng. Dept., Fac. Agric., Zagazig Univ.**

**** Hort. Dept., Fac. Agric., Zagazig Univ .**

***** Agric. Eng. Res. Inst., Agric. Res. Cent., Dokki, Egypt.**

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ABSTRACT: **Two different methods (manual and mechanical) of digging were used for digging holes for planting grape (*Vitis vinifera* L.) nurslings. Performance of post hole digger was investigated as a function of digger revolution speed (100 , 150 and 200 rpm equal 125.6 , 188.4 and 251.2 m/sec) and soil moisture contents (14 , 20 and 25%). Manual digging was carried out at the same moisture contents (MC).**

The obtained results reveal the following the maximum productivity of (190 holes/h) was obtained at (251.2 m/sec.) 200 rpm revolution speed (RS) and 25% moisture content, weheras minimum productivity (106 holes/h) was obtained at (125.6 m/sec.) 100 rpm auger revolution speed (ARS) and 14% MC. Minimum feul consumption was 4.3 l/h and required energy was 7.94 K.W.h / 100 holes at auger speed 100 rpm and 25% MC. In comparison with manual digging, the mechanical planting of grapes significantly increased vegetative growth of vines in terms of leaf surface area , leaf fresh and dry weights by 26.08 , 36.12 , and 31.45%, respectivily. Weight of prunings wood, number of canes / vine , total length of canes / vine , and trunk thickness were also increased by 50.62 ,68.50 , 78.57 and 14.23%, respectivily. Yield /vine and average bunch weight were increased by 28.57 and 23.03%, respectively as compared with manual planting.

So, it is recommended to use mechanical soil preparing and hole digging for planting grape nurslings.

Keywords: Manual and mechanical digging, grape, revolution speed, vegetative growth, yield.

INTRODUCTION

Grape (*Vitis vinifera* L.) is one of the most important and profitable fruit crops grown in Egypt and world . In Egypt , grapes ranks second among fruit crops after citrus . Mechanization is considered the key of solving agricultural production proplems, especially in horticultural production where , manual operations need more time , effort and cost. Mechanizing the digging action is the worthy answer to save the consumed effort , moreover , uniformed holes will be expected .

Concerning preparing soil for planting grape nurslings, Winkler *et al.* (1974) reported that the supsoiler can be used to good advantages, since hard spots are broken up , water penetrtion is improved and vine growth is more vigorous and uniform . The plowed surface should be smoothed to facilitate laying out the vineyard and planting the vines. They also revealed that , if poor practice has permitted the development of plow sole or heavy used for cattle has formed a hard layers, subsoiling or deep plowing should be used to break these layers up, they added that in the trenching operation the fertile surface soil together with added organic matter or other fertilizers are placed down in the root zone and the exhausted sub-soil is brought to the surface to be enriched by natural weathring and fertilizer application. Trenching is usually done to a depth of 2 to 3 feet. It would be interesting to know wheather results equivalent to trenching could be obtained by injecting a water solution of the needed fertilizer elments deep into the soil through a pipe fastened to the near edge of the standard of subsoiler.

The depth to which the soil should be broken up depends on its structure and previous treatments. Where it is uniform in texture and not depleted in fertility and has no plow sole, ordinary plowing from 8 to 10 inches deep is adequate. The plowed surface should be smoothed to facilitate laying out the vineyard and planting the vines.

Relating to hole digging for planting grape nurslings, Singh (1982) stated that the diameter and depth of the post hole digger are considered the most effective factors affecting the feul consumption under a post diameter of 15 cm and 200 cm depth. It can make 1472 holes of 50 cm depth per day at spacing of 5 x 5 m square, whereas the screw type, blade type auger, and local tool "Khanti" can make only 43.26 and 18 holes/day, respectively. For 150 cm depth digging only the tractor-mounted digger and blade type auger can be used and the output was 320 and 9 , holes/day, respectively.

Holmes and Wuertz (1990) designed asystem to plant trees in root control bags. The system involves digging a hole with a PTO powered auger and conveying the soil to previous dug hole where the tree is planted in the root-control bag. Planting rates of 3 trees per min, were achieved.

El-Shal (1993) investigated the performance of the post-hole digger as a function of digging depth, digger diamiter, soil type and soil moisture content and reported that the maximum productivity of (110 hole / h) and minimum fuel consumption 0.36 lit/10 hole, fallen soil in the hole bottom of 5% and cost were obtained in the case of using digger with diameter of 40cm under depth of 50 cm and 26% and 18% moisture contents for clay loamy and sandy clay soil types, respectively.

MATERIALS AND METHODS

Materials :

1. Tractors:

1.1. Universal : (4) wheel drive. Romania U (1010) Dt model, Diesel engine 80.88 kW, mass 3900 kg and PTO speed 540 rpm.

1.2. Universal : Romania, Diesel engine, 55.15 kW, mass 2500kg and PTO speed 540 rpm.

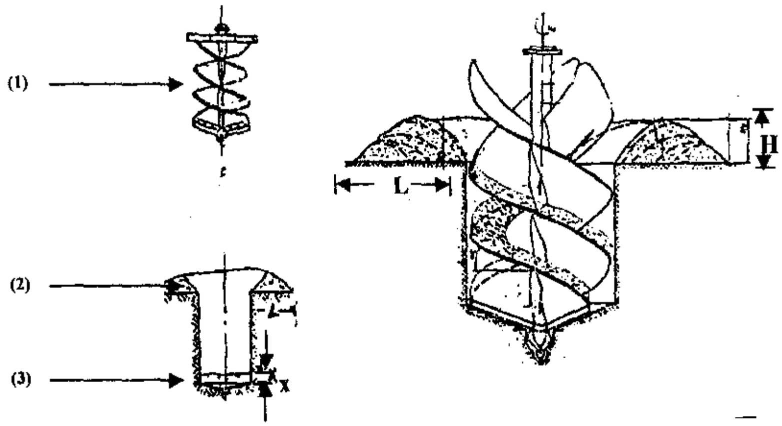
1.3. Nasr : (2) Wheel drive, M. 34 / T model, Diesel engine, 44.12 KW, mass (2255) kg and PTO 540 rpm speed.

2. ***Sub-solier plow:*** So. GE. M.A model Japanese, mounted type, 2 tins hydraulic control, 350 kg mass and working width 180 cm.

3. ***Chisel plow:*** EL-Behera model, made in Egypt, mounted type, 7 tins hydraulic control, 200 kg mass and working width 175 cm.

4. ***Disk harrow:*** PBA 1433 A model, Italian, mounted type, 650kg kg mass and working width 240 cm.

5. ***Land leveller:*** EL-Behera Co. model, Egypt, trailed type hydraulic control, 770 kg mass and working width 305 cm.
6. ***Post hole diggers:*** Fig.(1) Tanta motors Co. model, Egypt, 300 kg mass 40 cm diameter, Digging depth 100 cm, mounted.
7. ***Penetrometer:*** SR-2 model, Dik 5500.
8. ***Grape nurslings:*** One-year-old, 30-40 cm length (3-4 internods) and 8 – 10 mm in diameter.



(1): Post hole digger.

(2): The accumalted soil resulting from digging.

(3): x % fallen soil percentage in hole bottom after digging.

L : The width of the soil resulting from digging (cm).

H : The height of soil resulting from digging (cm).

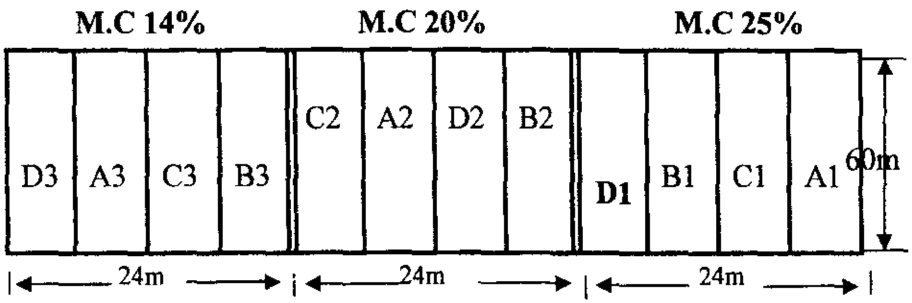
X : The height of of the soil in hole bottom after digging (cm).

Fig.(1): Post hole digger.

Methods :

The experimental work was divided into two stages : the first stage a prototype experiment was carried out in about 1.0 feddan to determine the suitable auger revolution speed and soil moisture content, which give the optimum hole shape to sow grape nurslings. Two different methods (manual and mechanical) were used for digging the holes. The experiment was arrenged as follows in fig. (2)

The experimental soil was managed by subsoiler, chisel plough twice, harrowed by disk harrow and levelled by land leveller.



A: manual digging.

B: mechanical digging at R.S 100 rpm.(125.6 m/sec)

C: mechanical digging at R.S 150 rpm.(188.4 m/sec).

D: mechanical digging at R.S 200 rpm. (251.2 m/sec).

Fig.(2): The frist experiment arrangement.

The following measurements were determined :

Soil penetration resistance before prepraing and before hole digging were determined using the cone penetrometer , soil mechanical analysis was done using the hydrometer method and the mechanical analysis of the experimental soil is shown in Table 1.

Table (1) : Mechanical analysis of the experimental soil .

Clay	Silt %	Sand %	Textural class
43.8	39.7	16.5	clay loam

Moisture content: was measured by oven method at 105 °C for 24 h, consumed time for digging, post hole digger productivity and digging efficiency (the percentage of fallen soil in hole was estimated by measuring the hieght of fallen soil in the hole bottom after digging, and the width and hight of heaped soil round the hole were measured. Fuel consumption : was determined by measuring the required fuel to refill the fuel tank. Energy requirements for hole digging was determined using the following formula :

$$\text{Energy requirements} = \frac{\text{Required power (kW)}}{\text{Field capacity (fed/h)}}$$

$$P\ (kW) = Wf * C.V * \eta th * 427 / 75 * 1/1.36.$$

Where:

Wf: rate of fuel consumption, (kg/s).

C.V: calorific value of fuel by kcal/kg. (average C.V of fuel is 10000 kcal/kg).

427: thermo-mechanical equivalent, (kg.m/kcal).

ηth: thermo efficiency of the engine. (considered to be 30% for diesel engine).

The second stage was carried out in 2.0 feddans which were divided into 4 parts for digging holes at the suitable revolution speed and misture content as shown in fig.(3).

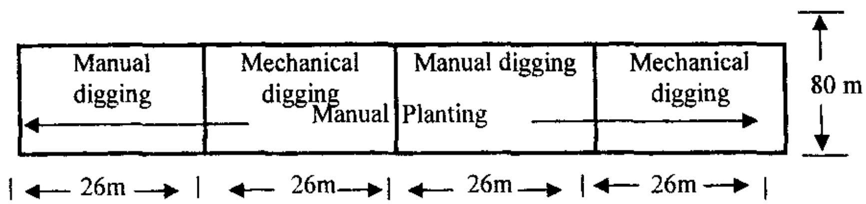


Fig.(3): The second experiment arrangement.

Vegetative growth, yield and yield components measurements :

The effect of planting methods on vegetative growth and yield / vine were determined through the following prameters :

Leaf surface area: was estimated according to the following equation.

$$L.A = \frac{3.14 \times D^2}{4}$$

(Souril *et al.,* 1985)

Where : L.A = leaf area.

D = leaf diameter.

Weight of pruning woods : was determined after winter pruning of three-year-old vines (g).

Trunk diameter at 20 cm above soil surface was recorded (cm).

Number and length of canes / vine were also recorded (cm).

Number of bunches and yield/ vine (kg/vine) were recorded at harvest time.

Coste determination of planting grape nurslings by mechanical and manual mrethods :

The machine cost (L.E / h) was determind using the following equation (Awady, 1978).

$$C = P/h\,(1/a + i/2 + t + r) + (0.9W.S.F) + m/144$$

RESULTS AND DISCUSSION

1. Post hole digger Productivity:

The obtained results show that the maximum number of holes per hour (190 holes/h) was produced at 200 rpm (251.2 m/sec) revolution speed and 25% M.C while the minimum productivity 106 hols/h was produced at 100 rpm (125.6 m/sec) R.S and 14% M.C. These results are shown in fig. (4).

2- The digging efficiency :

The digging efficiency can be determined by measuring the height of fallen soil in hole bottom in addition measuring the width of heaped soil round the hole (L cm) and the height of heaped soil round the hole (H1 cm.).

The least value of L was 11 cm at 25% moisture content and 100 rpm (125.6 m/sec), whereas the L maximum value reached 47cm at 14% moisture content and 200 rpm (251.2 m/sec) revolution speed.

The best L values were (13 to 44 cm) were obtained when moisture content was 20% and revolution speed 200 rpm.

Moreover, the minimum value of H1 was 8cm when moisture content was 14% and revolution speed 200 rpm. (251.2 m/sec), but the maximum value was 27 cm under 25% moisture content and revolution speed 100 rpm. (125.6 m/sec) The values of H1 under 20% moisture content ranged between 10 – 25 cm.

In addition the least value of fallen soil percentage in hole bottom after digging (X%) was 22% noticed at 25% moisture content and revolution speed 200 rpm. (251.2 m/sec) The maximum value of X% 70% was noticed at 14% moisture content and 100 rpm (125.6 m/sec) revolution speed. The optimum values of X% ranged between 39% to 64% under 20% moisture content these values were shown in Table 2.

Table (2): The effect of revolution speed and moistur content on digging efficiency [L (cm.) , H (cm.) , X (cm, %)].

M.C%	14%				20%				25%			
Parameters / R.S rpm	L (cm)	H (cm)	X		L (cm)	H (cm)	X		L (cm)	H (cm)	X	
			cm	%			cm	%			cm	%
100	15	24	25	70	13	25	32	64	11	27	21	42
150	35	13	23	64	32	18	25	50	30	17	15	30
200	47	8	30	60	44	10	20	39	43	13	11	22

3. Effect of moisture content on penetration resistance :

Fig. (5a) show that at 10 cm depth the penetration resistance was 3.49 , 3.04 and 2.85 kg/cm^2 under 14 , 20 and 25% moisture contents, respectivily. It is clear that by increasing moisture content, the penetration resistance was decreased. Also, the same trend was recorded at the determined depths where, at 50 cm depth penetration resistance was 3.01, 2.74 , and 2.60 kg/cm2 at 14, 20% and 25% moisture contents. This may be due to the cohesion and adhesion forces where these forces decreased by increasing soil moisture content.

As shown in Figger 5b the, values of penetration resistance were decreased by increasing moisture content from 14 – 25% and by increasing measuring depths from 10 to 50 cm. It seen also that penetration resistance values before digging were lower than its values before soil preparing This may be due to the cohesion and adhesion forces before and after preparing.

4. Energy requirements for preparin g soil:

The experimental soil managed by subsoiler plough, chisel plough twice, harrowed by disk harrow, and levelled by land leveller. From Fig. (6) it is seen that the consumed energy of 14.84, 28.36 , 14.25 and 65.31 kW.h/feddan were achived by subsoiler, chisel plough, disck harrow and land leveller respectivity.

5. Enegy requirements for hole digging process :

Fig. (7) shows that the maximum energy 77.53 KW.h/feddan was recorded by digging holes at 14% M.C and 100 rpm (125.6 m/sec) revolution speed and the minimum value was 54.43 at 25% M.C and 150rpm (188.4 m/sec). This may be due to the effect of moisture content and revolution speed where, pnetration resistanse was increased by decreasing moisture content and decreased by icreasing R.S

6. The effect of digging method on vegetative growth and yield / vine:

6.1. Effect on leaf characteristics:

Figs. 8 (a , b and c) show the effect of digging methods on leaf area, leaf fresh and dry weights as well as water content per unit leaf dry matter (hydration ratio). However, planting methods were of significant effect on the considered leaf characteristics, expect that of hydration ratio. Mechanical hole, digging led to increase leaf surface area (136.8 cm2), leaf fresh (32.67 g) and dry (15.17 g) weights compared to those of manual digging (108.5 cm^2, 24.0 and 11.54 g) for leaf area, fresh and dry matter (Hydration ratio) was also increased by mechanical digging of planting hole, but it was not significant.

As a general, mechanical preparing of planting hole significantly increased vegetative growth of Thompson seedless grapevines in terms of leaf surface area, leaf fresh and dry weights. Moreover, mechanical planting gained 26.08, 36.12, 31.45% increase in the average of leaf area, fresh and dry weights, respectively in comparison with manual planting.

6.2. Effect on vine vigour :

Figs. (9 a , b , c and d), show that digging methods was of significant effect on vine vigour as indicated by weights of pruning, number of canes/vine, total length of canes/vine and trunk thickness. However, the highest values of previous vine vigour parameters were recorded for mechanical digging. Average cane length under mechanical digging method was also higher those manual method, but it was insignificant, the weight of pruning wood resulted from 3-year-old Thompson seedless grapevines was 187.77 g and 124.66 g for mechanical and manual planting, respectively. In addition, average number of canes emerged on the tested vines was 3.37 and 2.00 total length of canes vine 124.00 and 69.44 cm, average cane length 37.06 & 34.77 cm and trunk thickness 1.86 & 1.56 cm for mechanical and with manual of pruning wood by 50.62% , number of canes/vine by 78.57% and those of trunk thickness by 19.23%. Generally mechanical planting of Thomson seedless nursling significantly increased vine vigour expressed as weight of pruning wood, number of canes / vine, total length of canes .vine and trunk thickness by 50.62, 68.50, 78.57 and 19.23 respectively compared to manual planting.

6.3. The effect of planting methods on yield /vine and yield components:

It is clears from figs. (10 a , b and c) that, digging method significantly affected average yield /vine and average weight bunch, while number of bunches /vine was insignificantly affected. The highest (2.61 kg/vine) and lowest (2.03 kg/vine) yield /vine was recorded for mechanical and manual planting methods, respectively. In addition, the highest bunch weight (54933 g) was gained by mechanical planting compared to those of manual method (446.50 g). number of bunches /vine was insignificantly affected by planting methods, indicating that the highest yield of

mechanical planted vines may be attributed mainly to the highest bunch weight of these vines. Moreover, increasing average bunch weight of mechanical planted vines and therapy yield /vine may be due to increasing vegetative growth and vine vigour of these vines compared to manual planted ones.

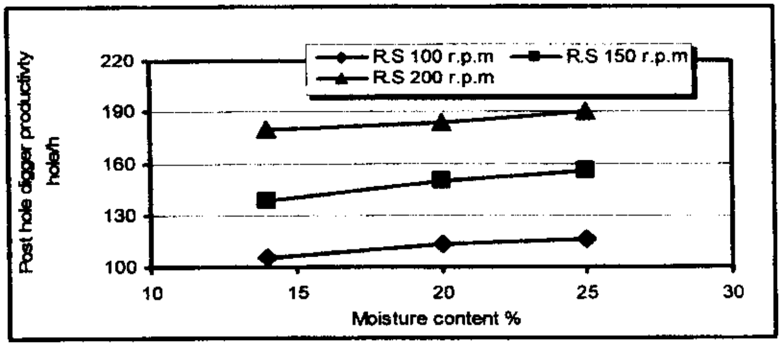


Fig.(4): Effect of mechanical digging on hole productivity (hole/h) under different moisture contents and different revolution speed.

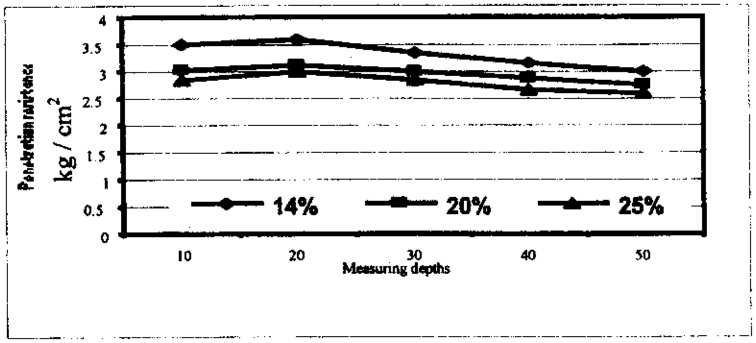


Fig. (5a): Penetration resistance before soil preparing.

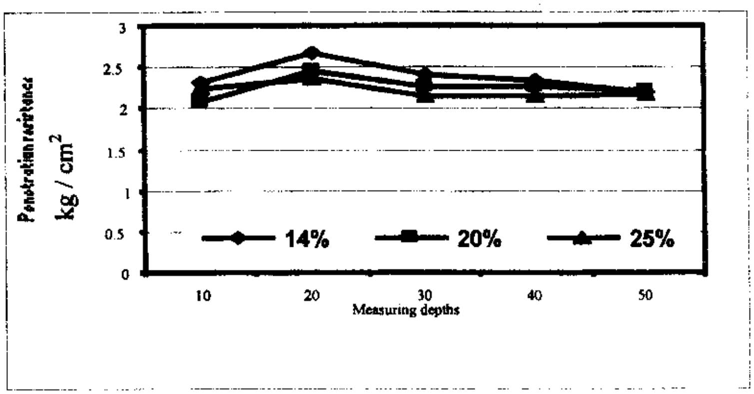


Fig. (5b): Penetration resistance before hole digging.

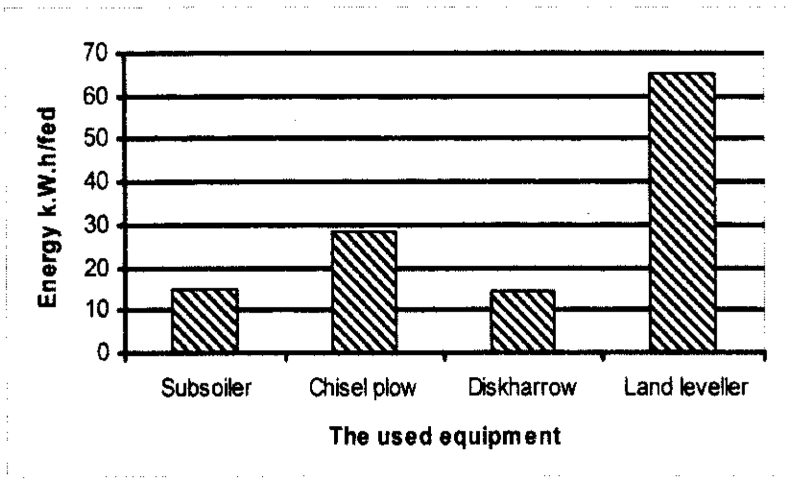


Fig. (6): Energy requirements for preparing soil.

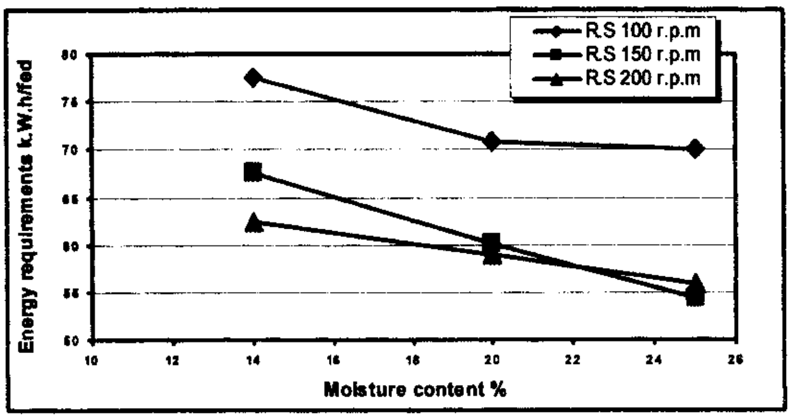


Fig (7): Energy requirements for hole digging at different moisture contents and different revolution speeds.

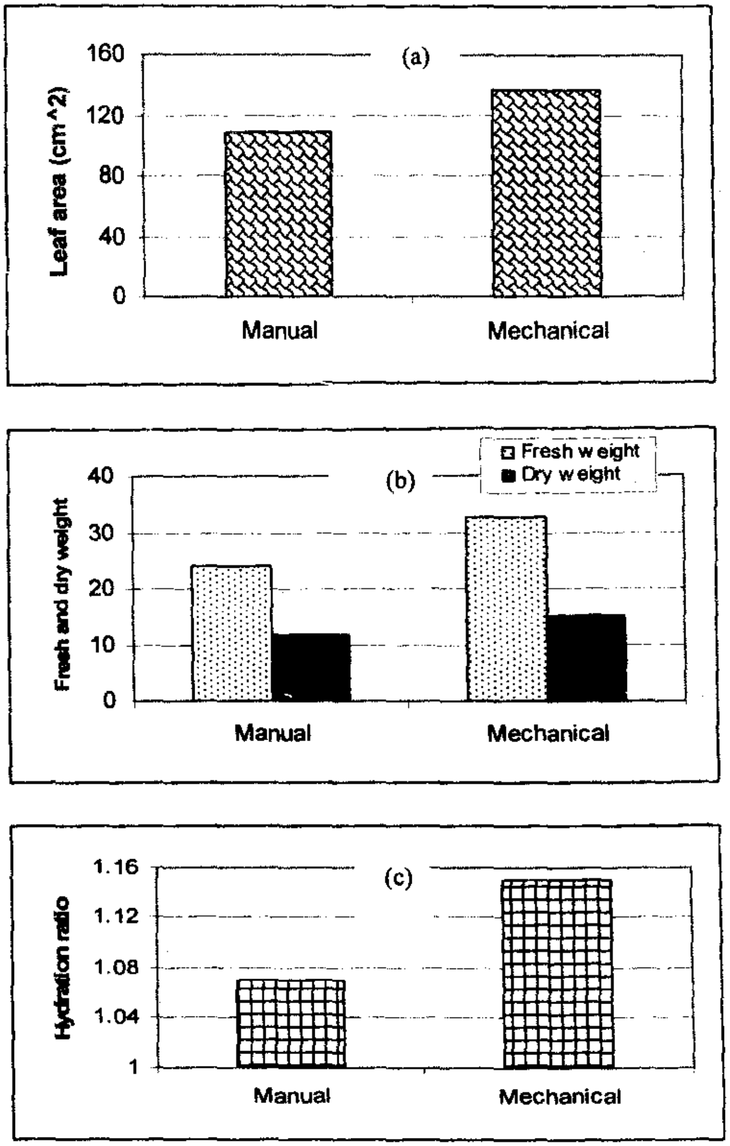


Fig (8): Effect of planting method on vine vigour (a) leaf surface area, (b) leaf fresh and dry weight and (c) hydration ratio.

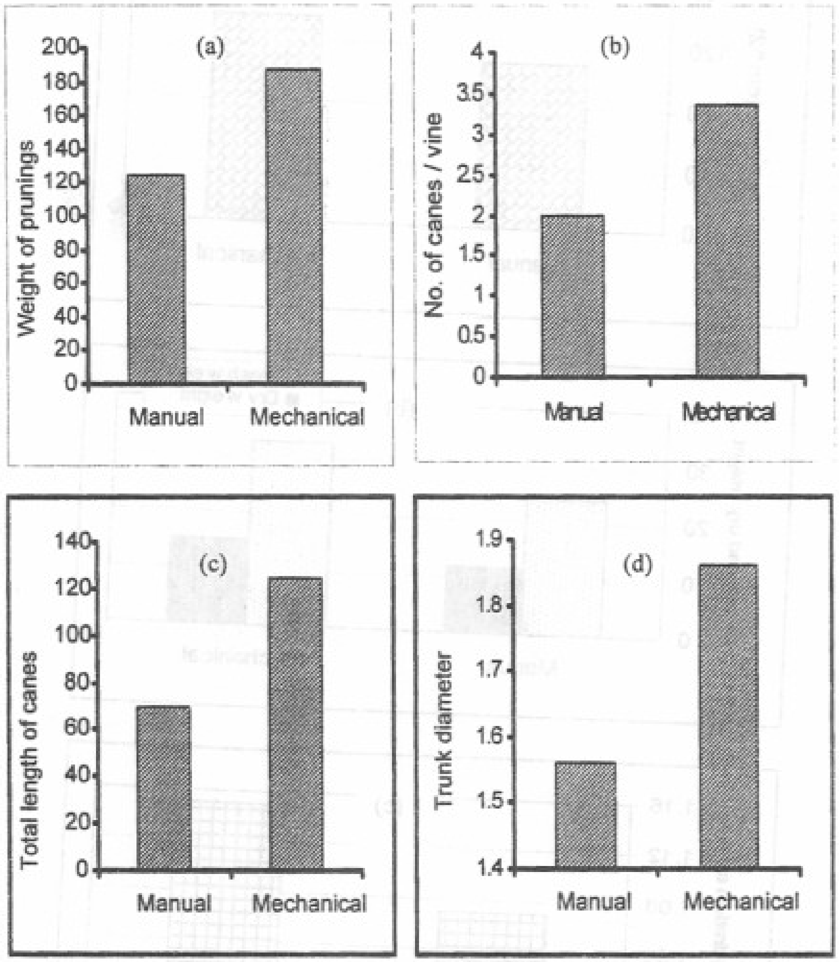


Fig (9): Effect of planting methods on (a) weight of prunings, (b) number of canes / vine, (c) total length of canes / vine and trunk diameter of (d) Thompson seedless nurslings.

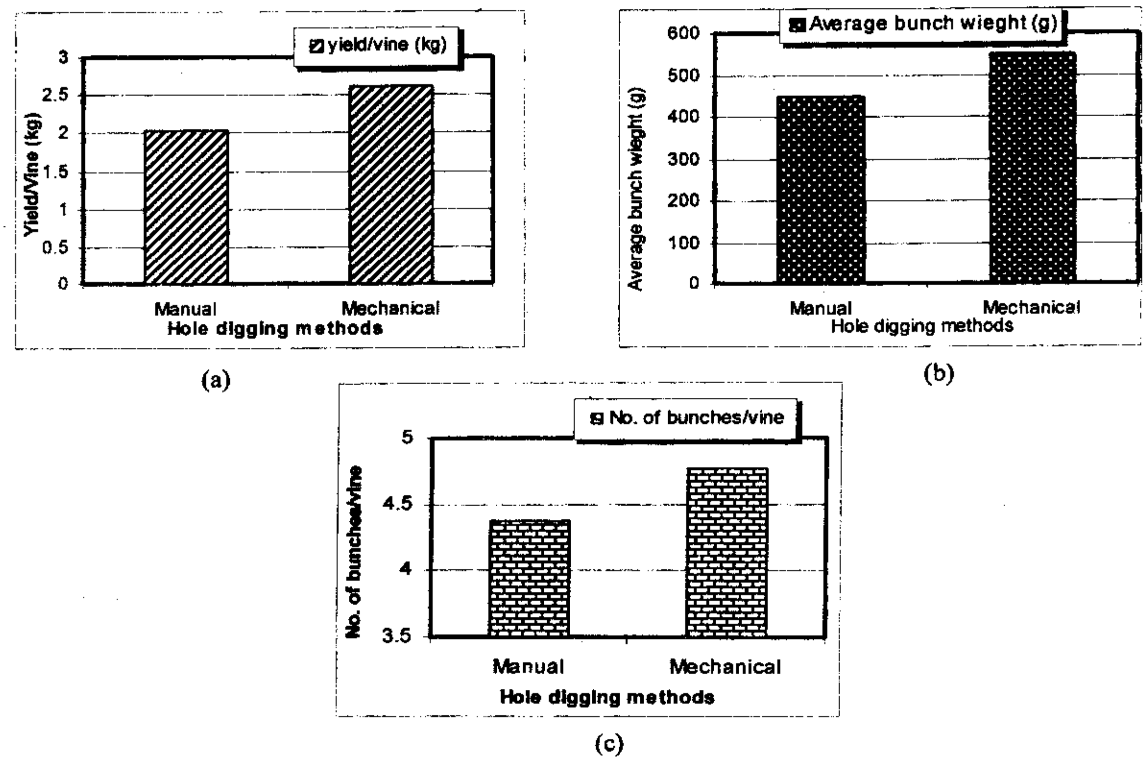


Fig.(10): Effect of planting methods on yield/vine (kg), number of bunches/vine and bunch weight (g) of 3 year old Thompson seedless grapevine.

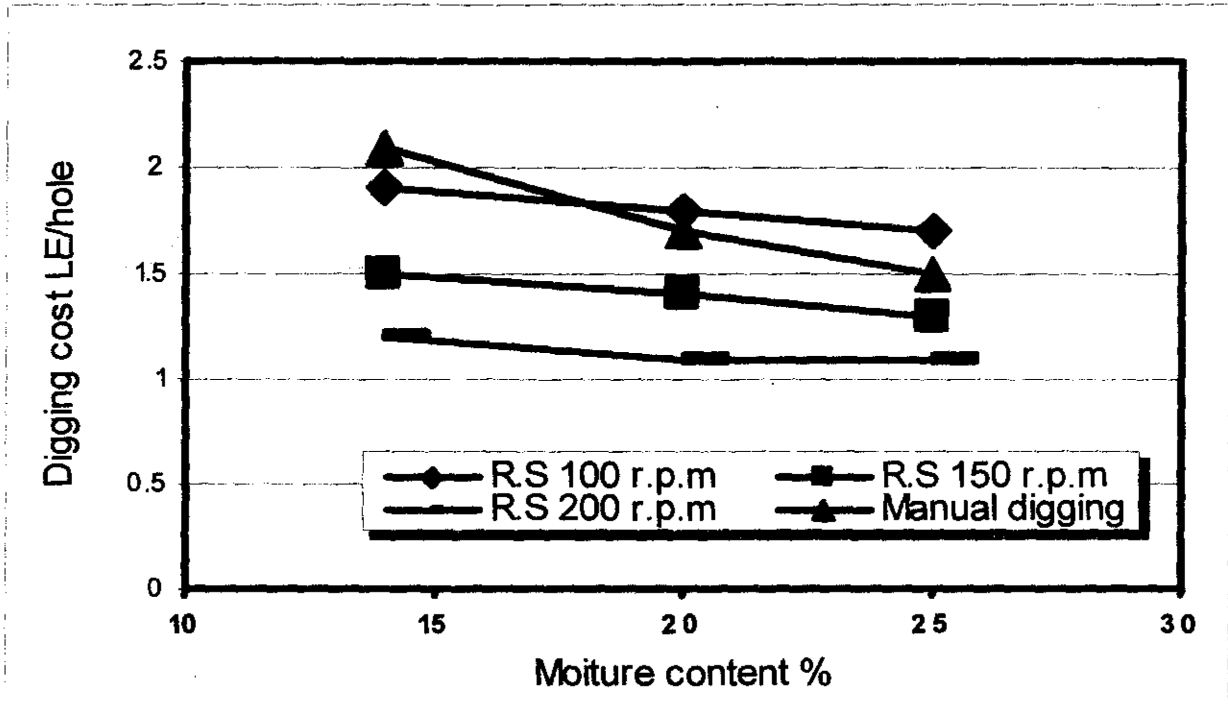


Fig.(11): Cost requirements of mechanical and manual digging at different moisture contents and different revolution speeds.

As general, mechanical digging significantly increasing yield /vine and average bunch weight by 28.57 and 23.03 % respectively in comparison with manual planting. Yield of 3- year –old Thompson seedless vines ranged between 2.03 and 2.61 kg/vine for manual and mechanical planting respectively. When vine were planted in feddan, the yield of these vines may reach to 1.42 and 1.83 t/fed, respectively.

Cost requirements :

It is clear from fig. (11) that under mechanical digging the maximum cost (1.9 L.E /10 hole) was recorded for digging at 14% M.C and 100 rpm (125.6 m/sec), the minimum costs (1.1 L.E /10 hole) was recorded at 25% M.C and R.S 150 and 200 rpm. (251.2 m/sec). Under manual digging the maximum costs was 2.1 L.E /10 hole and the minmum cost was1.5 L.E / 10 hole at 14% M.C and 25%, respectivly.

Recommendations

1. It is recommended to prepare the soil by subsoil plow at operating depth of 60 cm., plowed it by chiseling plow twice and leveled by land leveling.
2. It is recommended to operate the used digger at revolution speed of 200 r.p.m. (251.2 m/sec) and soil moisture content of 20%.

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متطلبات الزراعة الآلية لشتلات العنب

محمد سعد الدين الشال*- طلعت على أبو سيد احمد- سامى السعيد بدر***- نهى مرتضى نصر***

*** قسم الهندسة الزراعية – كلية الزراعة- جامعة الزقازيق**

**** قسم البساتين – كلية الزراعة- جامعة الزقازيق**

***** معهد بحوث الهندسة الزراعية- مركز البحوث الزراعية – الدقى –القاهره**

استخدمت طريقتين مختلفتين (يدوية وميكانيكية) لحفر الجور المناسبة لزراعة شتلات العنب وتم تقييم أداء بريمة حفر الجور تحت تأثير سرعات دورانية مختلفة (١٠٠ و ١٥٠ و ٢٠٠ لفة / دقيقة) و(١٢٥,٦ و ١٨٨,٤ و ٢٥١,٢ م/ث) تحت مستويات رطوبة مختلفة للتربة (١٤ و ٢٠ و ٢٥%) وتم تنفيذ الحفر اليدوى للجور تحت نفس نسب الرطوبة السابقة و فيما يلى اهم النتائج:

تحققت أقصى إنتاجية (١٩٠ جورة / ساعة) عند سرعة دورانية ٢٠٠ لفة / دقيقة (٢٥١,٢ م/ث) ونسبة رطوبة ٢٥% وأقل إنتاجية (١٠٦ جورة / ساعة) عند ١٠٠ لفة / دقيقة (١٢٥,٦ م/ث) و ١٤% نسبة رطوبة ، وكان أقل استهلاك للوقود ٤,٣ لتر / ساعة عند سرعة دورانيه ١٠٠لفة /دقيقة ونسبة رطوبة ٢٥% وأقصى استهلاك وقود ٦لتر/ساعة عند ٢٠٠لفة/دقيقة ونسبة رطوبة ١٤ % و اقل طاقة مطلوبة لحفر ١٠٠ جورة ٧,٩٤ كيلو . وات. ساعة و أقصى طاقه مستهلكه ١٠,٩٢ كيلو وات . ساعه.

أدى الحفر الآلى للجور إلى حدوث زيادة معنوية فى النمو الخضرى لنباتات العنب تومسون سيدلس حيث زادت مساحة الورقة والوزن الغض والجاف لها بنسبة ٢٦,٠٨ و ٣٦,١٢ و ٣١,٤٥% على التوالى ، كذلك زاد وزن نواتج التقليم وعدد القصبات لكل كرمة والطول الكلى للقصبات وسمك الجذع بنسبة ٥٠,٦٢ – ٦٨,٥٠ – ٧٨,٥٧ – ١٤,٢٣% على التوالى.كما زاد محصول الكرمة بنسبة ٢٨,٥٧% ومتوسط وزن العنقود بنسبة ٢٣,٠٣% بالمقارنة بالحفر اليدوى للجور.

ولذلك ينصح باستخدام الميكنة عند اعداد التربة وحفر الجور لزراعة شتلات العنب.