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PERFORMANCE IMPROVEMENT OF AN AMERICAN MACHINE FOR GRAPEVINES GRAFTING UNDER EGYPTIAN CONDITIONS

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ABSTRACT

Grafting of grapevines on different original rootstocks of grapevines is considered very important for cross and overcome some problems. The Bench machine of grafting fabricated in America was used for grapes grafting in the Horticultural Research Institute in 2003, at Viticulture Research Department. To get the proper operational performance of bench machine grafting of grapevines.

The studied variable included: Operational speeds of 188, 201 and 214 m/s; Thickness values of grapevines of 0.5, 0.8, 1.0, 1.2, 1.4 cm and electric of energy consumption were 660, 1980, 3300 J.

The optimum operational conditions of grafting machine was as follows: (1) The proper operational speed was 201 m/s, because of it had the highest cutting efficiency of grafting grapevines 90 % with good quality which had about 10-15 % of bark maintain and damage; (2) The time of grafting grapevines was distributed as 37.5, 37.5 and 25% for cutting time by hour, cutting time of bench machine and grafting by hand, respectively.; (3) The proper thickness of grapevines ranged between 0.5 to 1 cm, because these ranges had the highest cutting efficiency of 85 to 95 % with the damage range of 5 to15 % which to be the lowest. (4) The operational time did not change exceed 8 seconds for the thickness values of 0.5 to 0.8 and 1cm. These operational times gave the highest efficiency values of grafting which were 95, 90 and 85 %, respectively, with less damage of 5, 10 and 15 % and (5) The proper electric of energy consumption was 1980 J at operation speed of 201 m/s which gave the maximum cutting efficiency of grapevines grafting (90%).

INTRODUCTION

Grafting of grapevines is considered very important for cross and overcome some problems. Such as grafting varieties of grapevines on original rootstock will be suitable of soils having high carbon dioxide or high salinity percentage or high resistance of thirsty and infection of Nematode as well as the grafting very useful in change verity has low production with other high production.

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There are many methods for grafting of grapevines such as Bench, whip, eye, cleft, notch, bark grafting and notch grafting for rooting. Cutting machine of Omega, V-shaped and Saw-type was used. Total cultivation area of grape was about 150,000 fed. In egypt, the grap production was 1,200,000 Mg/year. (Agricultural statistics, 2001).

Biredbent (1989) tried four grapevines grafting method of chip bud and T-bud techniques, the whip bud technique, mechanical grafting and aerial grafting. The T-bud method is the easiest and the most commonly used, although it could only be done in late May or early June. The aerial grafting method, conducted in 1988 on chardonnay and cabernet sauvignon, was only successful when it was carried out on vigorously growing vines. The results of grafting were in all cases difficult to predict, and caution was recommended when large numbers of vines were to be treated.

Popov (1989) Showed that in 3 year trials, the translocation of 14c label led compounds from B X R kober 5BB rootstocks into cv. Caberent sauvignon grapevine
scions was investigated. The radioactive compounds moved into the scions during stratification after graft union was complete and scion buds emerged. The process was more rapid in machine-grafted than in hand-grafted material. The 14c-label led compounds comprised hydrocarbons (sugars, starch, hemicellulose and cellulose), amino, organic and nucleic-acids, lipids and proteins.

Lahogue et al. (1995) Illustrated that inoculation techniques were studied for screening a large number of grape varieties for resistance to virus diseases. As mechanical inoculation of grape was only successful under limited conditions, different grafting techniques were compared, including dormant grafting and green grafting. The latter was tested with and without the previously rooted rootsrocks. For each of the 3 methods tested, the inoculum was used as the rootstock or the scion. The results indicated that dormant grafting using a rootock as an inoculum source was the most efficient inoculation method. However, good results were also obtained using the green grafting technique without the previously rooted rootstock with a rootstock as an inoculnm source. As the green grafting method did not require large area of land, was not time consumpting and could be performed throughout the year. It is thought to be a highly convenient method for simultaneous inoculation of great number of grape varieties.

D'Khili et al. (1996) Investigated grafting incompatibility between clones of vitis vinifera cultivars and rootstock cultivars by

using 3 grafting methods in vitro micrografting, green grafting and woody grafting, and several compatible and incompatible scion/rootstock combinations. Studies of in vitro micrografting allowed the rapid, early identification of graft translocated incompatibility such as that shown by the combination translocated incompatibility and such as that shown by the combination Jaoumet/57 Richter (V. rupestris X V. berlandieri) and suggested this was due to hormonal imbalance; the addition of auxins removed this incompatibility. Study of green grafts allowed the early detection of incomatility between syrah clone 101 and So4 clone 5 (V. riparia X V. berlandieri).

Cloquemin et al. (1998) Showed that serological methods allowed the rapid detection of the majority of known viruses. The graft-indexing method was longer but allowed the detection of viruses not yet detectable by serological tests. It was based on the visual observation of symptoms expressed in indicator plants, which had been contaminated by index plants. With grape, grafting allows the transmission of viruses from the index plant to the indicator. The green-grafting technique allowed a faster detection (a few months) in comparison with traditional testing with woody material (1-3 years)

Kuniyuki et al. (1998) Said that a leaf grafting method, similar to that routinely used for indexing strawberry for viruses, was tested on grapevines. The graft was a 4-5 cm^2 piece of the foliar lamina attached to the 4-6 cm long petiole. Mature, well developed leaves were a better source of grafts than the young ones. The petiole without the blade of the indicator plant was easier to handel than the petiole with the lamina. Success rates of 73.3 and 93.3 % were obtained with 1 and 2 grafts / plant, respectively. Percentages virus transmission were obtained when the grafting was made during early autumn. It was concluded that leaf grafting was a simple and efficient method for the detection of diseases that induce symptoms on leaves and canes, and was useful when grape material was not suitable for routine indexing tests.

Celik (2000) Studied the effect of grafting method (chip-budding, cleft and omega cut manual grafting, carried out on 15 March on the successful production of Amasya Beyazi and Alphonse Lavallee grape cultivars [on 5 BB (Vitis berlandieri X V. riparia rootstock] in 1996 and 1997. One year old rooted rootstocks were used. The highest cut grafts for chip-budding were 87 % for Amasya Beyazi and 82.5 % for Alphonse Lavallee. The success of cleft and omega cut grafts were 81 and 74.25 % for Amasya Beyazi,

79.75 and 74.5 % for Alphonse Lavallee in 1996 and 1997, respectively. Chip-budding was the best for plant survival and the cut grafts were 54.19 and 61.5 % for Amasya Beyazi and Alphonse Lavallee, respectively.

Abdallah et al. (2003) Tiered a grafting method adapting the usual indexing by green grafting technique to in vitro culture conditions. The local grapevine cultivars was infected with infectious degeneration, leafrool,vein mosaic, corky bark and vein necrosis diseases. Virus expression was greater on media having a greater number of nutrients such as the van hoof medium containing 12 macronutrients. On the other hand, the addition of BAP (benzyladenine) (0.25 mg 1-1) to the medium reduced external virus symptoms on newly sprouted axillary shoots. When these shoots were transferred to fresh culture medium supplemented with IBA (0.1 mg 1-1), typical and specific symptoms of major virus diseases clearly developed. Re-grafting of axillary shoots on the fragment of an infested clone can be used to overcome difficulties related to corky bark and vein mosaic symptom expression.

Objectives of the present study may be summeried as follows:

1- Improvement of Bench grafting of grapevines machine to suit Egyptian conditions.
2- Reducing the percentage of damage to be minimum.
3- Increasing the cutting efficiency percent.

MATERIAL AND METHODS

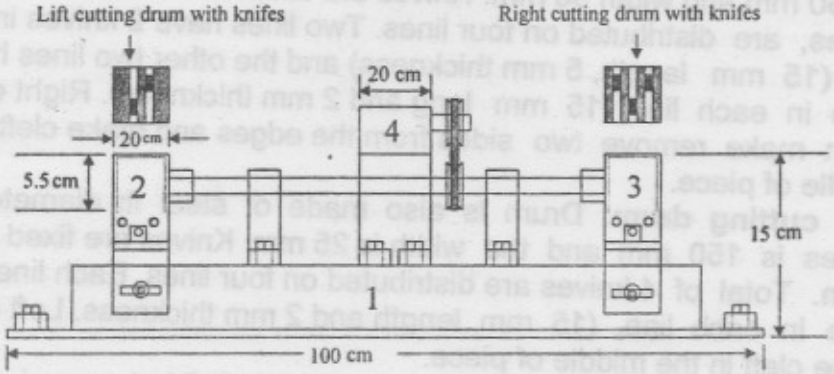
1-Machine Specifications and description:

In the present study, the Bench machine of grafting used for grapes grafting in the Horticultural Research Institute in 2003, at Viticulture Research Department. This machine made in U.S.A

The grafting machine consists of base, right cutting drum, left cutting drum, and electric motor as shown in Fig.1 (a and b). General specifications of grafting machine are shown in Table 1.

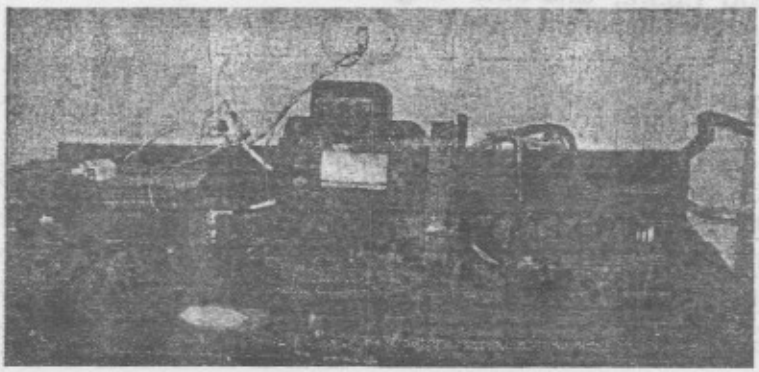
Table 1: General specifications of grafting machine:

Item	Specification
Overall length, mm	1000
Overall width, mm	350
Overall height, mm	250
Power, kW (hp)	0.375 (0.5)
Capacity, grapevine/h.	720
No. of labor requirement	1



1-Base of machine, 2- Lift cutting drum, 3- Right cutting drum and 4- Electric motor

a : Sketch of grafting grapevines machine.



b : Photo of saw-cutting machine.

Fig. 1 : Sketch and photo of grapevines grafting machine.

Base: is made of steel sections with dimensions of 1000 x 450 x120 mm

Right cutting drum: Drum is made of steel its diameter with knives is 150 mm and width 30 mm. Knives are fixed on the drum. Total of 6 knives, are distributed on four lines. Two lines have 2 knives in each line (15 mm length, 5 mm thickness) and the other two lines have 1 knife in each line (15 mm long and 2 mm thickness). Right cutting drum make remove two sides from the edges and make cleft in the middle of piece.

Left cutting drum: Drum is also made of steel its diameter with knives is 150 mm and the width is 25 mm. Knives are fixed on the drum. Total of 4 knives are distributed on four lines. Each line has 1 knife in each line, (15 mm length and 2 mm thickness. Left cutting make cleft in the middle of piece.

Electric motor: It has a power of 0.375 kW (0.5 hp), speed of 3450 r.p.m. 220 V, and 4.9 A. The power is transmitted to the moving parts of machine grafting by means of pulleys and belt.

2- Instrumentation:

Speedometer: Speedometer was used to measure the rotation speed in three ranges. First range; 40-500 r.p.m., second range; 400-5000 r.p.m., and thrid range :4000-5000 r.p.m. (direct reading). Speedometer specifications are given in Table 2.

Table 2: General specifications of speedometer.

Item	Specification
Type	Hand speedometer
Speed, rpm	40-50000
Accuracy	± 1% full scale
Making country	Germany
No. of sets	3 diameter dial

Digital dial caliper: Dimensions of stocks grapes were determined to have thickness of stocks. A digital dial caliper reading up 15 cm was used. Its accuracy was 0.05 mm.

Super clamp meter: An super clamp meter was used for measuring the A, V, and Ω. It was made in Japan. It was used to measure A in 5 ranges. First range: 0-6, second range: 0-15A, third range: 0-60A, fourth range 0-300A, five range:0-700A direct reading. Type 700 K and 600 V ? AC 50 Hz.

3- Crop properties:

Crop grape variety was Thompson seedless cultivated in area of about 60-70 % from total area in Egypt which represents 150,000 fed. The grapenive of grape dimensions are 12 – 15 mm thickness and 25–30 cm length. Cultivation requirement of one feddan is about 700 – 900 seedling according to cultivated area and different suported methods. The distance clutivated area is about 1.5 X 3 m and average of priductivity is about 7 –8 ton/fed.

Method of grafting :

There are many methods for grafting of grapevines such as bench, whip, eye, cleft, notch, bark grafting and notch grafting for rooting. Kind of cutting machine was omega, V-shaped and saw-type. In the present paper the bench grafting method and saw-type electricity powered grafting machine were used. Fig. 2 shows section of cane woody shoot.

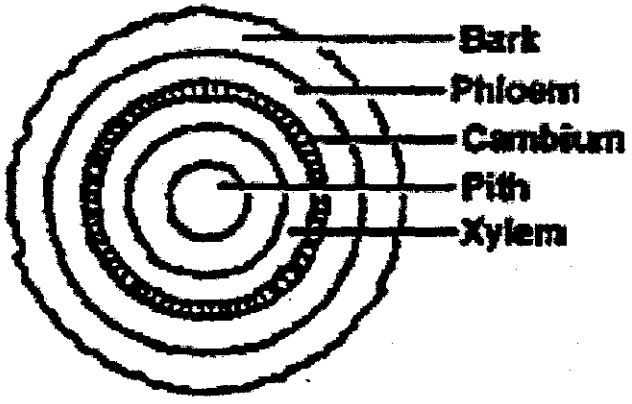


Fig. 2 : Section of cane Woody shoot (surface smooth type).

4- Development of grating machine:

During the priameray experiments on grapes grafting machine it was noticed that that it gave hight damage percentage for stoks about 95%. In this case this machine was not satisfy for grafting in Egypt. However, to obtain the conditions which affect the machine performance, so the expermintal work was carried out. It was found that machine speed the main reason at hihgt damge. To solve this

problem we have reduced the machine speed, but the electric engine had only one speed. So we used a reducer speed to control the engine speeds and gave different speeds institie of the constant speed. After the new experimintal, it was found that there is no damage for stoks and the
machine was saticified for work under Egypyian condations.

5- Factors effecting grafting machine:

- Operational speeds were 188, 201 and 214 m/s.
- Thickness of grapevines were 0.5, 0.8, 1.0, 1.2, and 1.4 cm and
- Electric energy consumption were 660, 1980, 3300 J.

6- Cost analysis:

The operation cost of machine grafting was calculated according to the following equation (1) which was given by Awady, 1978 modified for electerical motor drive:

$$C=P/h(1/y+I/2+t+m)+(w.e)+m/144 \text{ ------- (1)}$$

Where:

C = hourly cost, P = price of machine, h = yearly working-hour, y = life expected of machine, I = interest rate/year, t = taxes and overhead ratio, m= Maintenance and repairs ratio, w = power of motor in kW, e = hourly cost/kW.h, and m/144 = monthly wage ratio. Notice that all units have to be consistent to result in " L.E.*/h".

*** One American dollar=6.20 Egyptian pound (L.E.)according to prices of 2004.**

7- Measurements:

Sides maintain of bark:

Sides maintain of bark was calculated to obtain quality grapevine grafting from equation No.2

$$M = (TB_a / TB_b) * 100 \text{ -------- (2)}$$

Where:

M=Maintain of sides bark,%; TB_a = Bark thickness after grafting, cm; and TB_b = Bark thickness before grafting, cm.

Damage of grapevine percentage:

Damage of grapevine was calculated to obtain quality of grapevine grafting from equation No.3.

$$D = (TG_a / TG_b) * 100 \text{ -------- (3)}$$

Where:
D= Damage of grapevines,%; TG_a = Grapevines thickness after grafting,cm; and TG_b = Grapevines thickness before grafting, cm.

Cutting efficiency of grapevine :
Cutting efficiency of grapevine was calculated to obtain quality of grapevine grafting from equation No.4.

$$\eta_C = 100 - D \quad \text{——— (4)}$$

Where:
η_C = Damage of grapevines, % and D = Damage of grapevines, %.

RESULTS AND DISCUSSION

1- Operational speed:

Fig (3) shows effect operational speed on quality and cutting efficiency grafting of grapevines. It Noticed that the proper operational speed was 201 m/s, because it had the highest cutting efficiency of grapevines grafting (90 %) with a good quality which had about 15-10 % of bark maintain and damage. While the operational speed of 188 m/s was undesirable speed, because the grapevines had cutting efficiency of grapevines grafting about 50 % with damage of 50 % and 50 % of bark maintain. Also, the operational speed of 214 m/s was not preferable, because of the cutting efficiency of grapevines grafting was about 10 % with damage percentage more than 90 % and bark maintain percentage was about 85%.

2- Electric energy consumption:

Fig. (4) shows Effect of quantity of energy consumption on percentages of cutting efficiency of grapevines and damage of grapevines. The electric energy consumption was 660, 1980 and 3300 J. It was noticed that the proper electric power consumption was 1980 J., because of this electric energy gave operation speed about 201 m/s followed with the cutting efficiency of grafting grapevines about of 90%. While, at using electric power consumption about 660 J gave operation speed of 188 m/s, followed that the cutting efficiency of grafting grapevines about of 50 %. Also, at using electric energy consumption about 3300 J gave operational speed about 214 m/s followed that the cutting efficiency of grafting grapevines about of 10 %.

2- Operational time of grafting:

Fig. (5) shows that operational time percentage distributed of grapevines grafting. It noticed that operational time of grafting including three times (cutting time of grapevines by hand scissors, cutting time of grafting by bench machine and component grafting parts by hand). The values of these times were 3, 3 and 2 seconds respectively. The time of grapevines grafting percentage 37, 38 and 25% for cutting time by scissors, cutting time of bench machine and grafting by hand, respectively. While the time to prepare one grafting of grapevines was about 8 seconds. So, one feddan needs about 1000 grapevines. Thus, the needed time to prepare grapevines grafting of one feddan with grafting of grapevines by using bench machine was about 2.30 h.

3-Thickness of grapevines:

Fig. (6) shows effect of thickness of grapevines on quality and cutting efficiency of grapevines grafting and operational time. The results showed that the proper thickness of grapevines ranged between 0.5 to 1 cm, because this range had the highest cutting efficiency of 95 to 85 % with the damage range from 5-15 % which was to be the lowest. While, the thickness grapevine less than 0.5 cm was undesirable, because the distance between knifes of 0.5cm did not make shape of cutting. Also, the thickness of grapevines more than 1cm was unfavorable. Because cutting efficiency of grafting grapevines occur, gradually, decreased by about 15 % Although damage percentage about of 5% and percentage of bark maintain for two sides of grapevines was more than 85 %.

Also, fig. (6) shows effect of thickness grapevines on operational time. It noticed that the operational time did not change (8 seconds) for 0.5-0.8 and 1cm. And this value of operational time gave the highest efficiency of grafting which were 95, 90 and 85 %, respectively, followed by that less damage percentage of 5, 10 and 15 %. While the thickness of grapevines less 0.5 cm was undesirable and grapevines was not valuable for grafting. Also, operational time more than 8 seconds was unfavorable, because the thickness of grapevines more 1cm was undesirable and grapevines was not available for grafting. As well as cutting efficiency of grafting accrue gradually decreased till up 15 % and it did not economically.

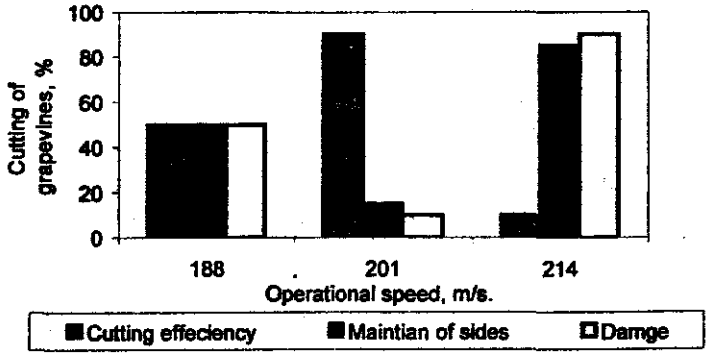


Fig. (3) : Effect operational speed on quality and cutting of grapevine using bench machine

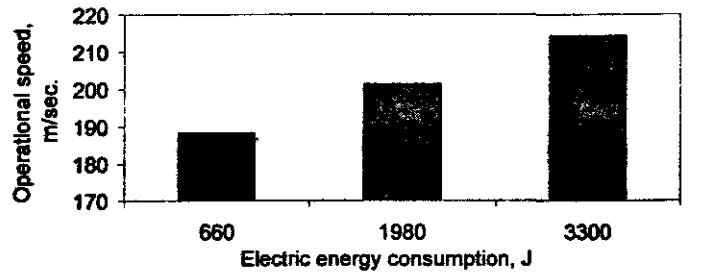


Fig. (4) : Effect of Operational speed on electric energy consumption

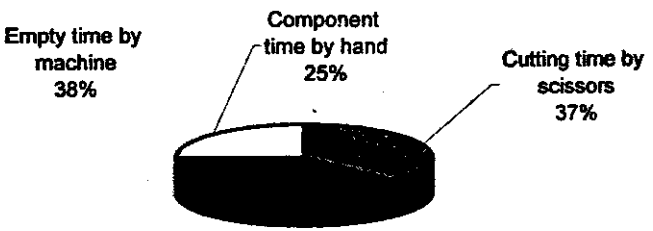


Fig. (5) : Operational time percentage distribution of grapevine grafting by bench machine

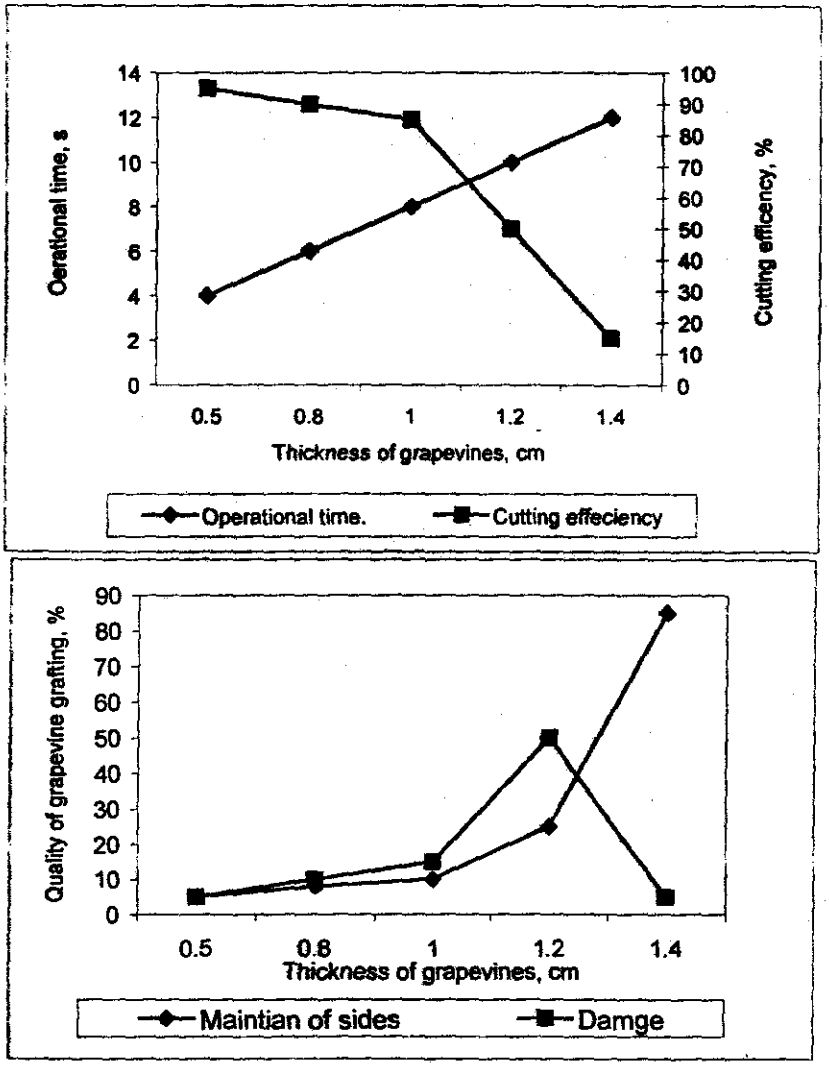


Fig. (6) : Effect of thickness of grapevine on cutting effeiciency and operational time at operational speed of 201 m/s.

5- Cost analysis:

Operational cost of thce machine was found to be 7.69 L.E./h. (0.01 L.E./ piece) against 15 L.E./h. (0.015 L.E./grapevine) for manual.

CONCLUSION

The obtained results were summarized as follows:

1- The proper operational speed was 201 m/s, because it had the highest cutting efficiency of grapevines grafting (90 %) with a good quality which had about 15-10 % of bark maintains and damage.

2- The time of grapevines grafting values were of 37, 38 and 25% for cutting time by hand scissors, cutting time of bench machine and grafting by hand, respectively. While, the time of preparing of one grafting of grapevines was about 8 seconds. So, one feddan needs about 1000 grapevines. Thus, the needed time to prepare grapevines grafting of one feddan by using bench machine was about 2.30 h.

3- The proper thickness of grapevines ranged between 0.5 –1 cm, because this range had the highest cutting efficiency of 95 – 85 % with the damage range of 5-15 % which was to be the lowest.

4- The operational time did not change (8 seconds) for 0.5-0.8 and 1cm. And this value of operational time gave the highest efficiency of grafting which were 95, 90 and 85 %, respectively, followed by less damage percentage of 5, 10 and 15 %.

5- The proper electric power consumption was 1980 J, power gave of operation speed of 201 m/s which gave the maximum cutting efficiency of grapevines grafting (90%).

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تحسين أداء الة أمريكية الصنع لتطعيم العنب تحت الظروف المصرية

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المستخلص العربى

يعتبر محصول العنب محصولا ذى قيمتين غذائية وتصديرية عاليتين فى مصر وتقدر المساحة المنزرعة حوالى ١٥٠,٠٠٠ فدان تنتج سنويا حوالى ١,٢٠٠,٠٠٠ جيجا جرام ، ويمثل الصنف Thompson seedless حوالى ٦٠ الى٧٠ % من إجمالى المساحة المنزرعة.

وترجع اهمية عملية التطعيم فى عقل العنب الى إنها تتغلب على بعض المشكلات الهامة مثل تطعيم أصناف العنب على أصول تناسب أنواع مختلفة من التربة التى تعانى من إرتفاع نسبة الجير والملوحة أو تحمل العطش أو مقاومة الأصابة بالنيماتودا أو تغير صنف منزرع بآخر ممتاز أو عند إكثار صنف لا تتوافر منه العقل اللازمة للزراعة.وقد أجريت التجارب بمعمل قسم بحوث العنب بمعهد بحوث البساتين خلال عام ٢٠٠٣ م بهدف تحسين عملية التطعيم الآلى (التركيب المنضدى) فى عقل العنب وذلك لمعالجة مشكلة عدم ملائمة آلة تطعيم العنب إمريكية الصنع وتحسين ادائها لتناسب الظروف المصرية. حيث ان التجارب الأولية بماكينة تطعيم العنب أعطت نسبة نهتك عالية وصلت الى ٩٥% وهذا راجع الى زيادة سرعة المحرك ولذلك تم ادخال مخفض السرعة للتحكم فى سرعة المحرك لإعطاء سرعات مختلفة وتم استخدام طريقة القطع المنشارى اثناء إجراء عملية التطعيم.

واشتملت التجارب على بعض العوامل المؤثرة فى عملية التطعيم وكانت كالتالى :

١- سرعة التشغيل كانت ١٨٨ ، ٢٠١ ، ٢١٤ م/ث.

٢- سمك طعم (عقلة) العنب كانت ٠,٥ ، ٠,٨ ، ١,٠ ، ١,٢ ، ١,٤ سم .

٣- القدرة المستهلكة فى التشغيل كانت ٦٦٠ ، ١٩٨٠ ، ٣٣٠٠ جول.

وكانت النتائج المتحصل عليها كالتالى :

- أوضحت دراسة تأثير سرعة القطع (سرعة التشغيل) على كفاءة وجودة عملية تطعيم عقل العنب أن أفضل سرعة هى ٢٠١ م/ث ، حيث أعطت هذه السرعة أعلى كفاءة تطعيم (فقد تعدت ٩٠ %) وجودة تطعيم عالية حيث تراوحت نسبة التهتك فى العقلة من ١٠ الى ١٥ %.

- بينت كذلك دراسة تأثير سمك طعم (عقل) تطعيم العنب على كفاءة وجودة عملية التطعيم أن أفضل سمك لطعم العنب يتراوح من ٠,٥الى ١,٠ سم حيث أعطى هذا المدى على أعلى كفاءة لعملية القطع التى تراوحت من ٨٥ الى ٩٥ % خلال عملية التركيب أو التطعيم المنضدى ، وجودة تطعيم عالية تمثلت فى

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(١) باحث – بمعهد بحوث الهندسة الزراعية – مركز البحوث الزراعية – الجيزة – مصر.

الحصول على أقل نسبة تهتك فى عقل العنب حيث تراوحت من ٥ الى ١٥ %.

- تم أحتساب زمن تشغيل العقلة والتى تشمل ٣ مراحل (التقطيع اليدوى باستخدام مقص التقليم ، التفريغ بالقطع باستخدام ماكينة التركيب المنضدى ، وتركيب الطعم فى الأصل يدويا) حيث تساوى تقريبا نسبة زمن القطع اليدوى و التفريغ بالآلة حوالى ٣٧,٥ % بينما كانت نسبة زمن التركيب اليدوى حوالى ٢٥%. حيث استغرقت العملية حوالى ٨ ثوانى وبما أن الفدان يحتاج الى حوالى ١٠٠٠ عقلة مطعمة يكون بالتالى زمن تجهيز عقل مطعمة لفدان واحد حوالى ٢ ساعة و ٣٠ دقيقة.

- تم تقدير قيم القدرة المستهلكة عند استخدام عقل سمك ١,٢ سم فكانت ٦٦٠ ، ١٩٨٠ ، ٣٣٠٠ جول عند سرعات التشغيل ١٨٨ ، ٢٠١ ، ٢١٤ م/ث على التوالى ، ولقد كانت القدرة المناسبة هى ١٩٨٠ جول عند سرعة تشغيل ٢٠١ م/ث. حيث اعطت اعلى كفاءة قطع (٩٠%).

لقد بينت دراسة تأثير سمك الطعم (عقلة) خلال عملية التطعيم المنضدى على زمن التشغيل ، أن زمن التشغيل حوالى ٨ ثوانى لم يتغير خلال تشغيل جميع الطعوم مختلفة السمك من ٠,٥ الى ١,٤ سم وكان أفضل الأسماك هى ٥,٠ ، ٨,٠ ، ١,٠ سم حيث أعطت أعلى كفاءات تطعيم ٨٥ ، ٩٠ ، ٩٥ % وأقل نسب تهتك للعقلة ٥ ، ١٠ ، ١٥ % على التوالى.