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STUDY THE EFFECT OF MECHANICAL INJECTION TECHNIQUE ON CONTROLLING RED PALM WEEVIL

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ABSTRACT: Field experiments were carried out to develop and evaluate a hydraulic injection device at El-Kasassen Horticultural Research Station, Ismailia Governorate, Egypt, and El-Salehia farms, Sharkia Governorate, Egypt. A hydraulic injection device has been developed to be suitable for controlling Red Palm Weevil (RPW) at young date palm also to determine and control the injection dose in young date palms and offshoots especially at top infestation. The performance was conducted under the following parameters: four injection pressures 100, 150, 200, and 250 kPa., three different diameters < 30, 30-40, and 40-50 cm, three different materials for controlling, two insecticides (chlorpyrifos and profenofos (48%) and natural material (Neem extract) on three different palm tree varieties, *i.e.,* Hayani, Samani and Zaghlool. The performance of the developed hydraulic injection device was evaluated taking into consideration: controlling spent time and productivity, controlling efficiency, total consumed power, and controlling cost. From the obtained data it was concluded that, the proper values for red palm controlling at Hayani variety were obtained under injection pressure of 150 kPa, palm tree diameter of 30-40 cm and chlorpyrifos insecticide.

Key words: Date palm, red palm weevil, injection device, mechanical controlling pest.

INTRODUCTION

Date palm is an important fruit crop in the palm family cultivated in the arid regions of the world. Red palm weevil, *Rhynchophorus fierrugineus*, is an economically important tissue-boring pest and a serious pest for the different cultivated palms in many parts of the world. Red palm weevil was introduced to Egypt since 1992, through a gift from some Arabian countries.

El-Rabee (2004) developed a local hydraulic device for date palm trunk injection. The hydraulic motion of the device is achieved by means of hydraulic oil pump of Ferguson 35 hp tractor through hose connection.

Hernandez-Marante *et al.* (2003) conducted field experiments in southern Spain to determine the effect of 9 insecticides and different application methods (soil application, trunk injection, sprays and combination of trunk injection and sprays) to control red palm weevil. The highest mortality was obtained with the combination of trunk injections and sprays with some insecticide.

The United Arab Emirates (UAE) has made extensive efforts to destroy this weevil, but so far these efforts have been unsuccessful. It is expected that about 100 thousand date palms will be lost in the next 10 years due to the RPW, (Al-Hammadi, 2006).

Imtiaz *et al.* (2005) found that injections with systemic insecticides have been economically cheap, environmentally safe and comparatively effective for the control of leaf miner and sucking pests. Huang-Zhen (2006) reported that

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the controlling efficiency of insecticides applied through tree trunk injection and lacquer technique reached 98% and 81%, respectively. The rates of population reduction were more stable when the insecticides were applied through tree trunk injection and lacquer method than when insecticides were sprayed to the foliage.

Girgis *et al.* (2002) compared between four trunk injection methods to remedy the infested palm trees with RPW. The differentiation between them was depended on depth, width, directions of cavities made by larvae and number of holes. A hole is made by an iron pin (40 cm long and 2.5 cm diameter). The fourth method (7-13 substitutive holes and 15-20cm depth) was the best for remedy of the infested palm trees and can be recommended for the control of RPW infesting in Egypt.

Soroker *et al.* (2004) developed a monitoring system that will identify and differentiate larval activity from among the mixture of sounds captured by the sensitive microphone attached to the palm trunk. Using a sampling frequency of 44.1 kHz the typical crunching sound was found to appear in bouts lasting each 3 to 10m/sec.

In Oman, Abdallah and Khatri (2000) investigated the effectiveness of trunk injection in comparison to using fumigant action of phosphine in controlling the RPW in making a hole. An electric drill with a bit of 40 cm long and 1.9cm diameter was used a hole 30 – 35 cm deep and inclined at an angle 30 downward from horizontal, and a plastic tube 45 cm long and 1.3 cm diameter was inserted into the hole.

Eliwa *et al*. (2007) and Morad and Eliwa (2008) studied the economic and technical determinants for origination a specific technical workshop for fabricating RPW controlling device. As well as they studied the difficulties and obstacles that distribution device hinders and how to overcome such problems. The study depended largely on methods and economic analysis to evaluate achievement.

Eliwa (2012) and Eliwa and Kotb (2016) developed a controlling red palm weevil device, the highest productivity was recorded under manual method using boring bar with 6mm pitch and electricity method. The controlling cost was 12.05 LE/palm while it was 13.75 LE/palm in addition to providing an electricity source. In despite of decreasing the operation cost in electric method, but the movable boring bar with 3mm pitch achieved the highest recovery comparing to other methods.

The objectives of the work are:

1. Developing a hydraulic injection device to be suitable for controlling young date palm trees.
2. Developing the injection pump of the device to be control the pump discharge.
3. Evaluating the developed device performance under different operating parameters.

MATERIALS AND METHODS

The developed hydraulic injection device was fabricated in a private workshop at Sharkia Governorate, Egypt and tested in El-Kasassin Horticultural Research station, and El-Salehia farms at 2014 and 2015.

Materials

The hydraulic injection device before development

The hydraulic injection device (Eliwa, 2012) in Fig. 1 consists of the following parts:

Boring device

The boring part consists of frame, binding bar, binding chain and boring bar with boring bite with total mass of 8 kg. It is connected with another same metal pipe having 50cm length to hang the pump for top infestation.

Injection pump

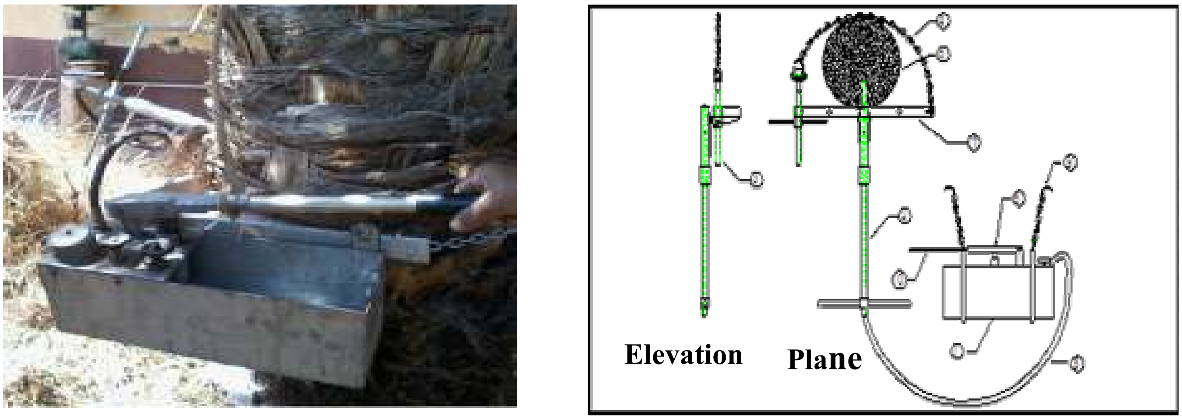
The hydraulic injection pump had insecticide tank 50 × 15 ×17 cm it made from galvanized sheet with 2 mm thickness. It was fixed on the frame by two hooks.

The hydraulic injection device after development

The previous hydraulic injection device was developed to be suitable for operating and controlling young date palm trees and offshoots (Fig. 2). It consists of:

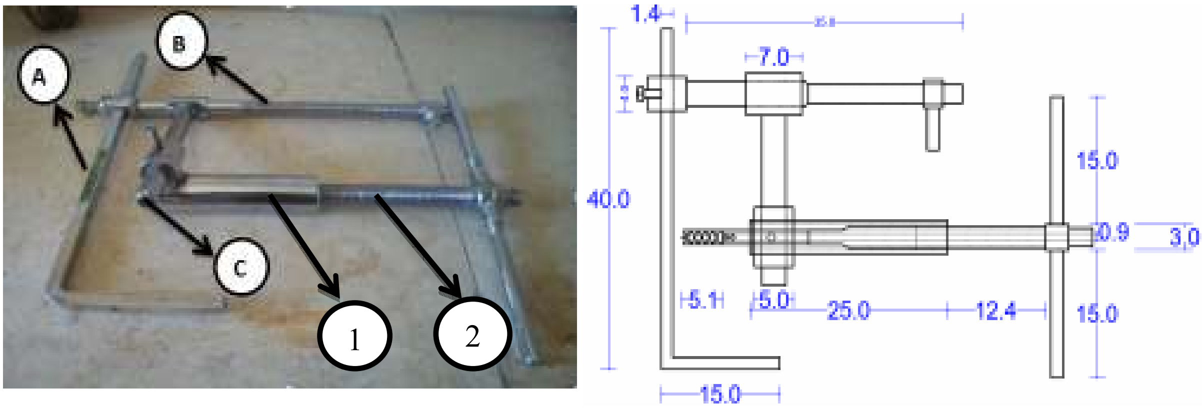
Boring frame

The boring frame consists of three parts:



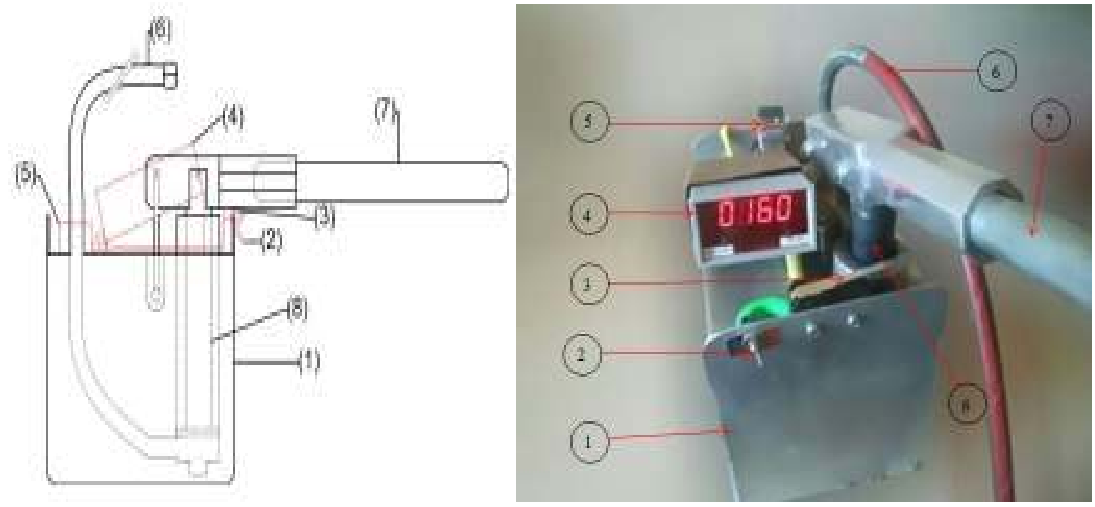
No.	Item	No.	Item
1	Frame	6	Piston pump
2	Boring bar with bring bit	7	Injection insecticide pump
3	Binding bar	8	Rubber hose
4	Detachable link chain	9	Hook
5	Infestation date palm	10	Hand of the pump

Fig. 1. The photograph and schematic diagram of the hydraulic injection device before development



No.	Item
A, B and C	Boring frame
1	Boring cover
2	Boring bar

Fig. 2. The photograph and view of boring frame



No.	Item	No.	Item
1	Tank 4 L	5	Battery 9 V.DC
2	Switch	6	Rubber tube 1.25 m
3	Sensor	7	Handle
4	Digital screen	8	Piston pump

Fig. 3. The View and photograph of the developed hydraulic injection device

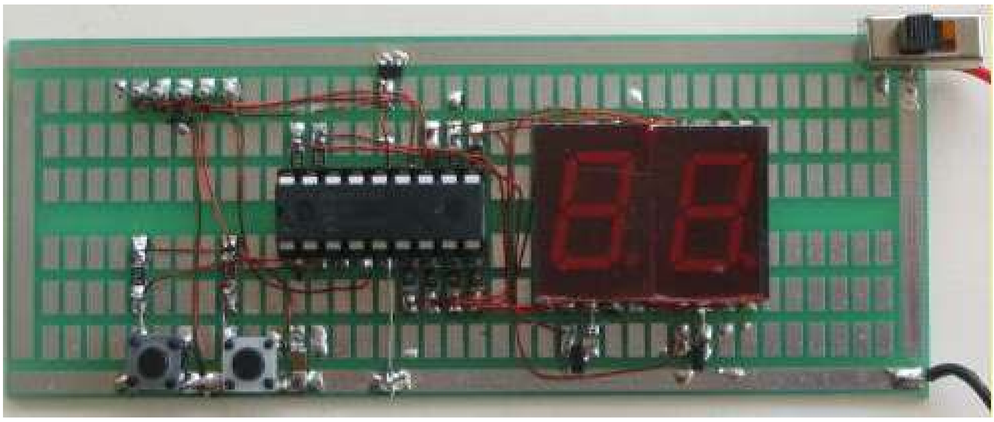


Fig. 4. Photograph of the up counter circuit

Part A is an iron bar with a square section 1.4 × 1.4 cm and total length 55 cm surrounding the trunk. Part B is an iron bar 35 cm length; there is a hole on its front with a square section 1.6×1.6 cm to allow the part A to move in it. There is a binding nail to attach A, and B at the same time. Part B having 15 cm length with 25 mm diameter, and 20 cm screwed length with 22 mm diameter. There is a binding nut with arm in part B to collect the parts under different diameters. Part C is an iron bar having 20 cm length with 25 mm diameter, there is a bush fixed in its front with 7 cm length, 27 and 35 mm inside and outside diameters, respectively. It is moving forward and back in the part B depend on the palm diameter. The boring cover is moving on the part C with a bush having 5 cm length, 27 and 35 mm inside and outside diameters, respectively to choose the suitable injection point. There is a nail to fix the bush cover with the part C, to be not rebounding during injection process.

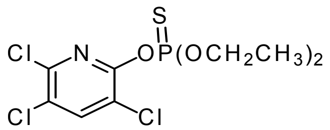
Injection pump after development

An electronic counter is fixed in the developed pump to measure the pump discharge (40 ml/Stroke). The counter is an electronic circuit when receiving the signal from the sensor, it is working on counting this signal by 40 ml on digital screen. Counter is also equipped with the key to re-set where it works to re-zero the counter, and provider of key operating and separation (on/off) switch. It consist of a button last count to find out the latest reading of the counter before disconnecting the power supply. Sensor (push button switch) converts kinetic energy into electrical energy.

Insecticide materials

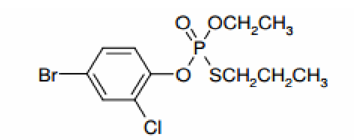
The insecticides used were chlorpyrifos (Chlorzane 48% EC), profenofos, and neem exrtact.

Chlorpyrifos (Chlorozane 48% EC)



O,O-diethyl O-3,5, 6-trichloro-2-pyridyl phosphorothioate

Profenofos



O-4-bromo-2-chlorophenyl O-ethyl S-propyl phosphorothioate

Neem extract

20 cm^3/litter water.

Methods

The performance of the developed hand hydraulic injection device was evaluated under the following conditions:

1. Four injection pressures: 100, 150, 200, and 250 kPa.
2. Three different diameter groups of palm trees: < 30, 30-40, and 40-50 cm.
3. Three different materials for controlling: chlorpyrifos, profenofos insecticid, (0.05%) and neem extract.
4. Three different variety of palm trees: Hayani, Samani, and Zaghlool.

Measurements

Controlling spent time

The total time of application for each tree was estimated by stop watch as the follows:

Controlling spent time (T_t) = $t_p + t_b + t_j + t_c + t_e$

Where:

t_p: Time of preparing device and mounting it on the trunk, sec.

t_b: Boring time, sec.

t_j: Insecticide injection time, sec.

t_c: Borer coming out time, sec.

t_e: Time of separating device from the trunk, sec.

Controlling device productivity

For one hour, the productivity of the hydraulic injection device was estimated by the following equation:

$$C.P = \frac{60}{T_t} \text{ plam/hr.}$$

Where:

C.P: controlling device productivity, palm/hr.

T_t: Total controlling time for one date palm, min.

Viscosity

Viscosity was determined by Hoppler Viscosimeter B3 according to the method described by Zeid (1996). The falling time in seconds of the balls was recorded:

Cn= T (Sb – Sf) B

Cn: Absolute viscosity, centipoise.

T: Time of the ball falling, sec.

Sb: Specific gravity of ball.

Sf: Specific gravity of the sample measured.

B: Ball constant.

Controlling efficiency

The total controlling efficiency was calculated according to percentage of recovery trees, three weeks after application, and the results were evaluated as, of infestation symptoms. It was calculated as follows:

Controlling efficiency (%) =

$$\frac{\text{Number of recovery trees}}{\text{Total number of treated trees}} \times 100$$

Total consumed power

Manual labor could be determined as mechanical power equal to (0.057 to 0.10 hp) at continuous work.

Worker power = 0.10 hp (0.075 kW)

So, the specific energy can be calculated as following:

$$\text{Specific energy} = \frac{\text{Worker power (kW)}}{\text{Productivity}\left(\frac{\text{palm}}{\text{hr}}\right)} \text{kW} \frac{\text{hr.}}{\text{palm}}$$

Operating cost

The required criterion cost for hydraulic injection device was estimated according to Kumar and Goss (1980) as following:

Criterion cost, LE/palm = Operating device cost + insecticide Requirement

$$\text{Operting cost} = \frac{\text{Device hourly cost}\left(\text{LE}\frac{}{\text{hr}}\right)}{\text{Productivity}\left(\text{palm}\frac{}{\text{hr}}\right)}\left(\text{L.}\frac{\text{E}}{\text{palm}}\right)$$

RESULTS AND DISCUSSION

The influence of some operational parameters included (injection pressure, palm tree diameter, type of insecticide and date palm variety) on the performance of the developed hydraulic injection device for controlling Red Palm Weevil was investigated and the obtained results were discussed under the following heads:

Effect of Some Operating Parameters on Controlling Spent Time

The effect of injection pressure on the spent time under different palm diameters, and different palm tree varieties was shown in Fig. 5. It is noticed that the increase of injection pressure from 100 to 250 kPa was accompanied with a decrease in spent time with percentage of 7.3% in both of Chloropyrifos and Profenfos insecticides, whereas the time decreased from 15.5 to 13.5, from 17.8 to 16.3 and from17.5 to 15.4 min. for Hayany, Samany and Zaghlol, respectively.

On the other side the using of Neem extract recorded the highest values of spent time comparing with the mentioned insecticides, which having viscosity (41.37 centipoise) owing to slowly translocation between cells inside the trunk. Regarding to the effect of palm tree diameter on spent time, it was clearly noticed that increasing palm diameter increase both boring time and separating device time from the trunk owing to increase the injection depth. The highest value of spent time 22.3 min. which achieved under palm diameter of 40-50 cm and injction pressure of 100 kPa when using Neem extract. Whereas, the lowest spent time 13.5 min. was recorded at 30 cm diameter, 250 kPa when using Profenfos and Chlorpyrifos in Hayany date palm.

Effect of Some Operating Parameters on Device Productivity

The effect of injection pressure on the device productivity under different palm diameters, and different palm tree varieties was shown in Fig. 6. It is noticed that the increase of injection pressure from 100 to 250 kPa was accompanied with increase in the device productivity with percentage of 5.3% in the case of using both of Chlorpyrifos and Profenofos insecticides, whereas the productivity increased from 3.9 to 4.4, from 3.4 to 3.7 and from 3.4 to 3.9 Palm/hr., for Hayany, Samany and Zaghlol, respectively.

Using of Neem extract recorded the lowest values of device productivity comparing with the mentioned insecticides, which having viscosity (41.37 centipoise) owing to slowly translocation between cells inside the trunk.

By increasing palm-tree diameter from 30 to 50 cm, the device productivity decreased by 8.8% at all tested parameters. The average of device productivity was 3.5 palm/hr., at < 30 cm palm tree diameter, it decreased to 3.2 palm/hr., at 40-50 cm palm tree diameter.

The highest value of device productivity was 4.4 palm/hr., when using chlorpyrifos and profenofos insecticides, pressure 250 Kpa, and diameter 30 cm with Hayani variety. While the lowest value of device productivity was 2.7 palm/hr., when using Neem extract, pressure 100 Kpa, and diameter (40-50 cm) with Samany and Zaghlol variety.

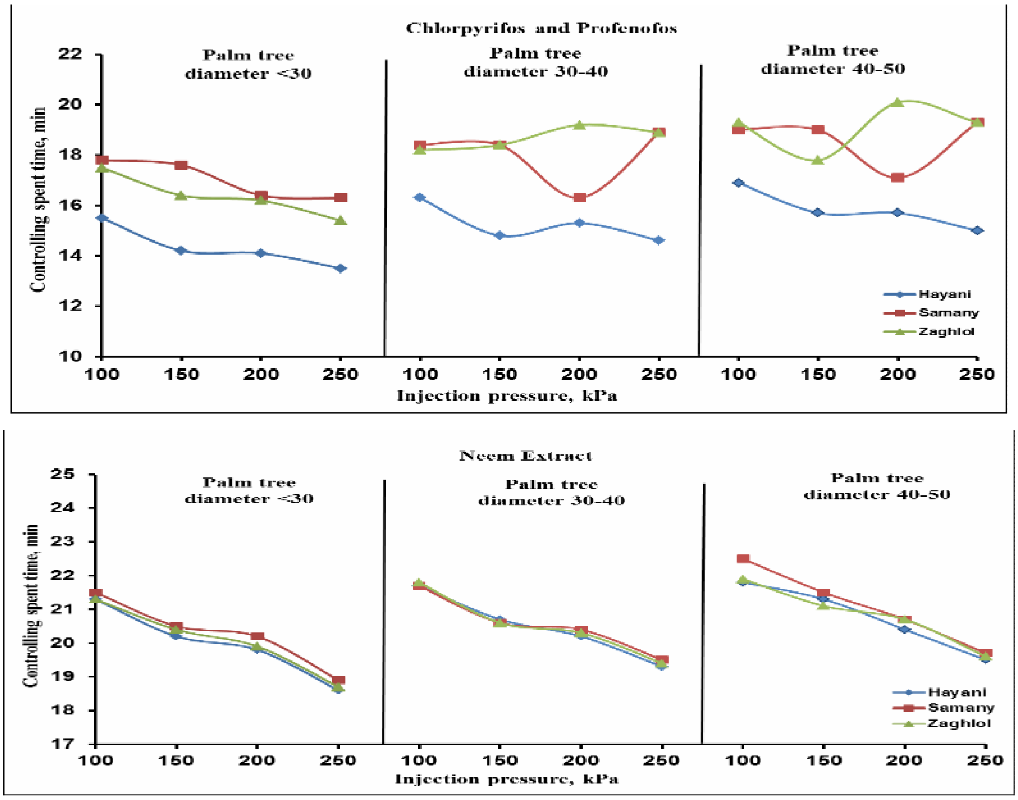


Fig. 5. Effect of injection pressure on controlling spent time under palm tree diameters and variets by using chlorpyrifos, profenofos insecticides and Neem extract

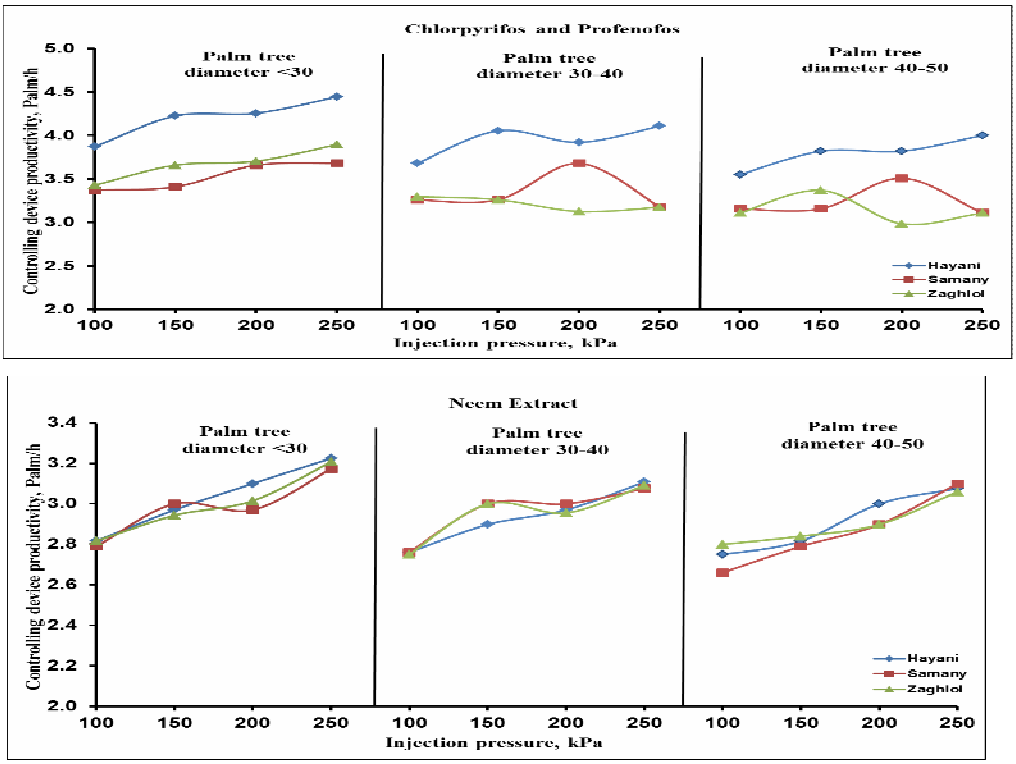


Fig. 6. Effect of injection pressure on controlling device productivity under palm tree diameters and variets by using chlorpyrifos, profenofos insecticides and Neem extact

Effect of Some Operating Parameters on Controlling Efficiency

Controlling efficiency is an important indicator for red palm weevil controlling. Fig. 7 clear that increasing date palm diameter from 30 to 50 cm lead to increase controlling efficiency with all treatments. It was increased from 80 to 83% in Hayany and Zaghlol, and from 79 to 82% in Samany variety. Increasing injection pressure from 100 to 150 kPa lead to increasing controlling efficiency from 80 to 93%, from 79 to 90% and from 80 to 90% under 30 cm diameter, from 82 to 94%, from 80 to 91% and from 82 to 92% under 30- 40 cm diameter, while increased from 83 to 90, from 82 to 92% and from 83 to 93% when using 40-50 cm palm diameter. It is also observed that, increasing injection pressure from 150 to 250 kPa decreased controlling efficiency from 93 to 86%, from 94 to 89% and from 90 to 84% under different palm tree diameters of 30, 30-40 and 40-50 cm, respectively. This decrease could be attributed to that insecticide don't arrival to the apical bud or heart of the tree which leads to date palm death not from the insect but from apical bud contamination by insecticide. The obtained results showed that, no significant in controlling efficiency when using Chlorpyrifos and Profenofos in Hayany, Samany and Zaghlol, respectively. But there are more variation in controlling efficiency results when using Neem extract, the highest value of controlling efficiency of 48% was achieved at 250 kPa with 40-50 cm diameter in Samany palm tree, the lowest value of controlling efficiency of 27% was recorded at 100 kPa with 30cm diameter. These results are in agreement with El-Sebay and Abbas (2008).

The obtained results of controlling efficiency indicated that the highest value of controlling efficiency was 94%, when using chlorpyrifos insecticide, pressure 150 kPa, and diameter (30-40 cm) with Hayani variety. While the lowest value of controlling efficiency was 27%, when using Neem extract, pressure 100 Kpa, and diameter 30 cm with Samany variety.

Effect of Some Operating Parameters on Specific Energy Requirement

The effect of injection pressure on specific energy under different palm diameters, and different palm tree varieties was shown in Fig. 8. It is noticed that the increase of injection pressure from 100 to 250 kPa was accompanied with a decrease in specific energy with percentage of 6.9% in the case of using both of Chlorpyrifos and Profenofos insecticides, whereas the specific energy decreased from 19.2 to 17, from 22.1 to 20.3 and from 22.3 to 19.2 W.hr./tree for Hayany, Samany and Zaghlol, respectively.

Regarding to the effect of palm tree diameter and specific energy, it was clearly noticed that increasing palm diameter increase both boring time and separating device from the trunk owing to increase the injection depth. By increasing palm-tree diameter from 30 to 50 cm, specific energy increased by 8.1% at all tested parameters. The highest value of total consumed power was 27.8 W.hr.,/tree, when using Neem extract under pressure of 100 Kpa, and diameter of (40-50 cm) with Samany and Zaghlol varieties. While the lowest value of specific energy was 17 W.hr./ tree, when using chlorpyrifos and profenofos insecticides under pressure of 250 Kpa, and diameter of < 30 cm with Hayani variety.

Effect of Some Operating Parameters on Total Cost

The obtained results in Fig. 9 illustrate that, increasing injection pressure from 100 to 250 kPa tends to decrease the total cost by 6.5% with all treatments, it decreased from 5.60 to 5.00, from 6.40 to 5.90 and fom 6.40 to 5.60 LE/palm when using Chlorpyrifos and Profenofos in Hayany, Samany and Zaghlol, respectively.

It was noticed that significant increase in controlling cost when using Neem extract comparing to Chlorpyrifos and Profenofos for controlling process owing to slowly translocation between cells inside the trunk. The average controlling cost of 6.20 LE/palm obtained under injection pressure of 100 kPa, it increased to 7.80 LE/palm when using Neem extract in Hayany, Samany and Zaghlol, respectively. Regarding to the effect of palm tree diameter on controlling cost, it was clearly noticed that increasing palm diameter increases the injection depth.

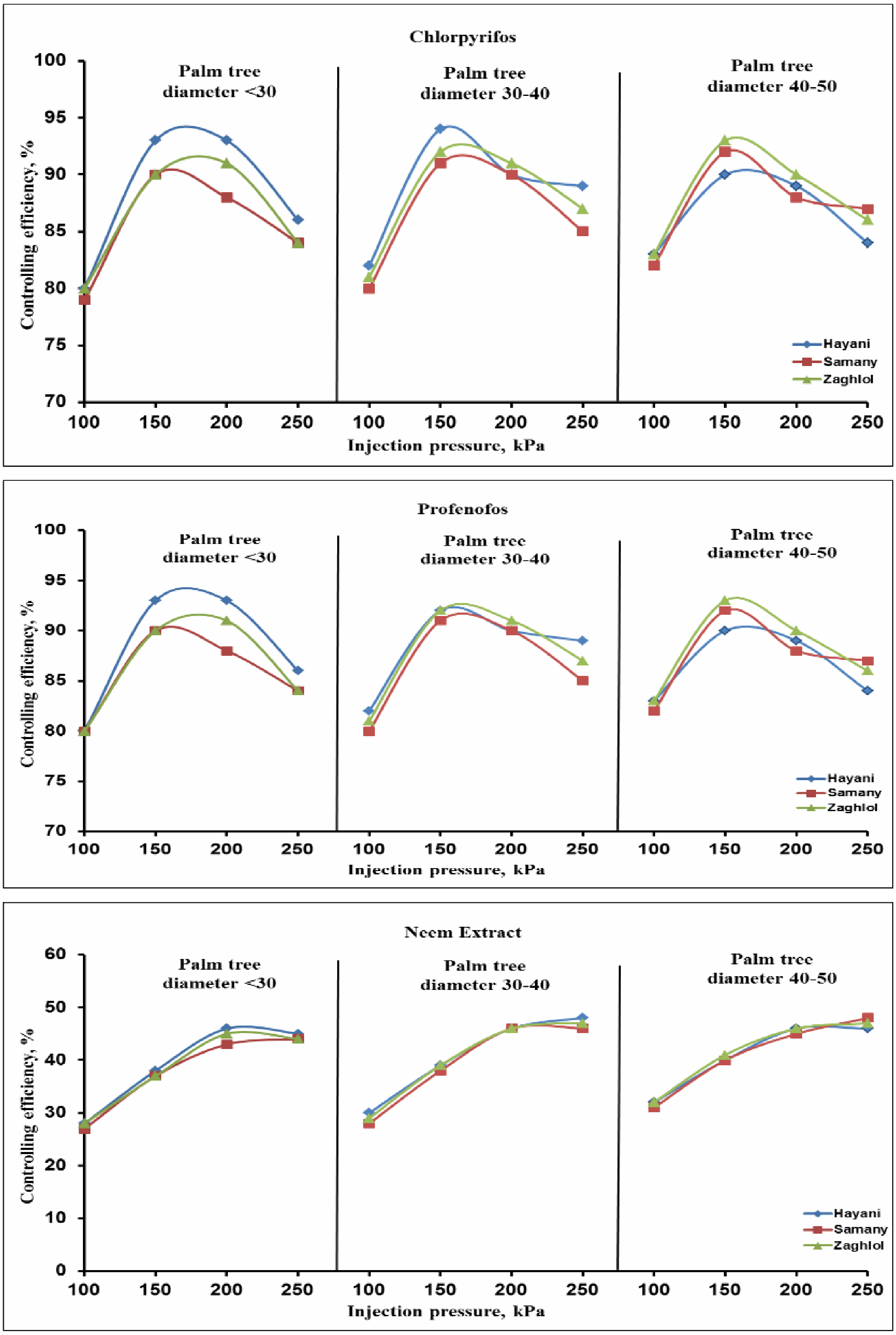


Fig. 7. Effect of injection pressure on controlling efficiency under palm tree diameters and varieties by using chlorpyrifos, profenofos insecticides and Neem extract

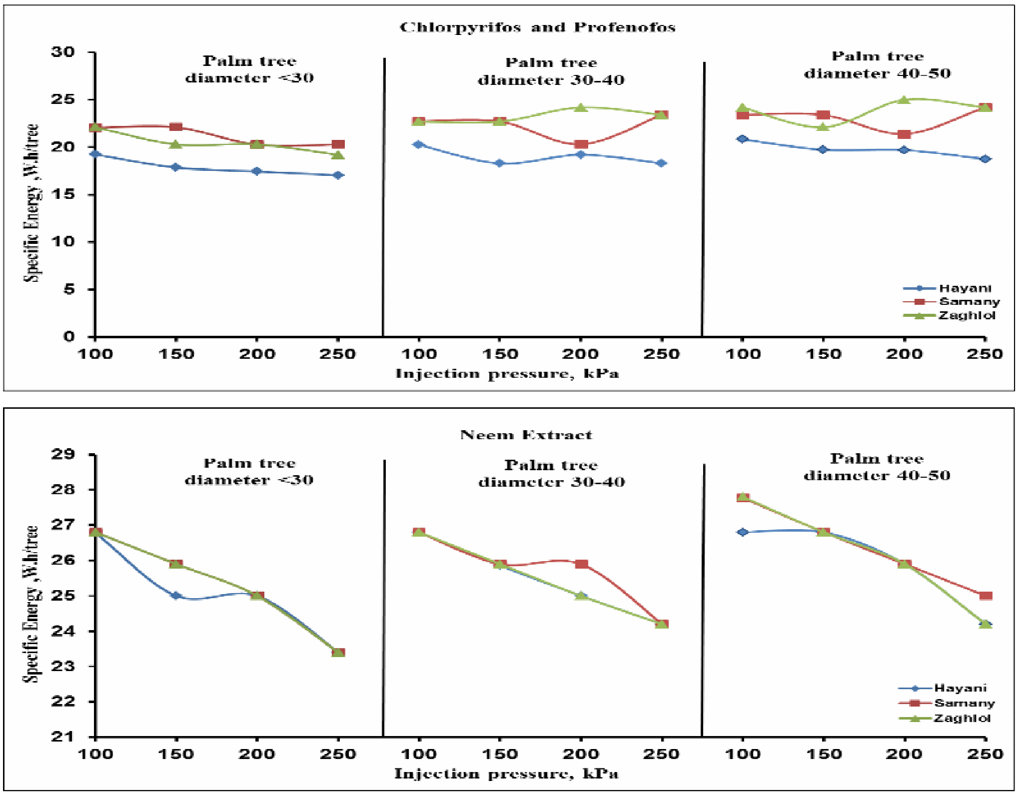


Fig. 8. Effect of injection pressure on specific energy under palm tree diameters and varieties by using chlorpyrifos, profenofos insecticides and Neem extract

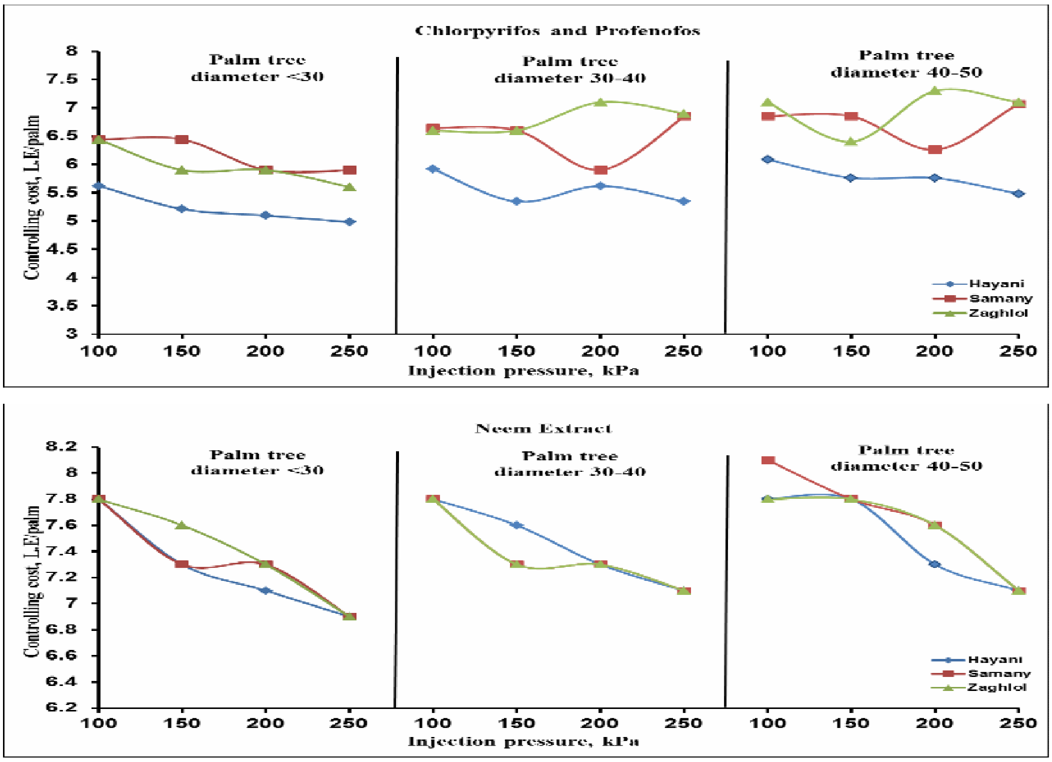


Fig. 9. Effect of injection pressure on controlling cost under palm tree diameters and varieties by using chlorpyrifos, profenofos insecticides and Neem extract

By increasing palm-tree diameter from 30 to 50 cm controlling cost increased by 8.1% at all tested parameters. The average of controlling cost was 6.30 LE/palm at 30 cm palm tree diameter, it increased to 6.90 LE/palm at 40-50 cm palm tree diameter.

Generally the obtained results indicated that the highest value of controlling cost was 8.10 LE/palm, when using Neem extract under pressure of 100 Kpa, and diameter (40-50 cm) with Samani variety. While the lowest value of controlling cost was 4.54 LE/palm, when using chlorpyrifos and profenofos insecticides under pressure 250 Kpa, and diameter of (< 30 cm) with Hayany variety.

Conclusion

- The proper value of spent time was 13.5 min when using chlorpyrifos and Profenofos insecticides, injection pressure 250 kPa, and palm tree diameter (< 30 cm) with Hayani variety.
- The proper value of efficiency was 94% when using chlorpyrifos insecticide, injection pressure 150 kPa, and palm tree diameter (30-40 cm) with Hayani variety. While, the lowest value of efficiency was 48% when using Neem extract for controlling process.
- The proper value of controlling cost was 4.54 L.E/palm, when using chlorpyrifos and profenofos insecticides, injection pressure 250 Kpa, and diameter (< 30 cm) with Hayany variety.

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دراســــة تأثيــــر تقنيـــــة الحقـــن الميكـــانيكـــى علـــى مكـــافحـــة ســـوســـة النخيـــل الحمـــراء

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٢- قسم الهندسة الزراعية – كلية الزراعة – جامعة الزقازيق – مصر

٣- قسم وقاية النبات – كلية الزراعة – جامعة الزقازيق – مصر

أجرى هذ العمل خلال عامى ٢٠١٤، ٢٠١٥ فى محطة بحوث البساتين بالقصاصين – محافظة الإسماعيلية، وبعض مزارع النخيل بالصالحية – محافظة الشرقية - مصر لتقييم جهاز حقن هيدروليكى يدوى تم تطويرة ليناسب حقن النخيل ذات الأعمار الحديثة والفسائل، شمل التعديل تركيب عداد إليكترونى فى طلمبة الحقن لتمكين العامل من حساب وتحديد الكمية المنصرفة من الطلمبة وهذا له أهمية كبيرة عند حقن النخيل الحديث وخاصة للإصابات القمية، تم إجراء الدراسة تحت ظروف تشغيل وعوامل مختلفة حيث تم استخدام: أربع ضغوط للحقن (١٠٠، ١٥٠، ٢٠٠ و٢٥٠ كيلوبسكال)، ثلاثة أقطار مختلفة للنخيل (أقل من ٣٠، من ٣٠-٤٠ و ٤٠-٥٠ سم)، واستخدام ثلاثة مواد مختلفة للحقن إثنان منهما مبيدات حشرية هما (الكلوروبيروفوس ٤٨% والبروفينوفوس ٤٨%)، ومركب طبيعى ثالث وهو مستخلص النيم بالإضافة إلى تقييم الأداء تحت ظروف ثلاثة أصناف من النخيل هي حيانى، زغلول وسمانى، تم تقييم الجهاز من حيث: الوقت اللازم لعملية المكافحة، إنتاجية الجهاز، كفاءة عملية الحقن والمكافحة، الطاقة الكلية المستهلكة و التكاليف، تم حساب لزوجة السائل المستخدم فى الحقن وذلك لاختلاف حركة السائل داخل الخلايا تبعا للزوجته وتأثير ذلك على كفاءة الحقن، أوضحت النتائج المتحصل عليها أن أعلى أنتاجية للجهاز كانت ٤,٤ نخلة/ساعة، عند ضغط ٢٥٠ كيلو بسكال وذلك عند استخدام مبيدى الكلوروبيروفوس والبروفينوفوس مع الصنف الحيانى، وأفضل قيم لكفاءة العلاج ٩٤% تحققت عند استخدام ضغط ١٥٠ كيلوبسكال، وذلك عند استخدام مبيد الكلوروبيروفوس مع الصنف الحيانى.بينما كانت أقل تكلفة لتشغيل الجهاز ١٧ وات ساعة/ نخلة وذلك عند ضغط ٢٥٠ كيلو بسكال عند استخدام مبيدى الكلوروبيروفوس والبروفينوفوس مع الصنف الحيانى، مما تقدم توصى الدراسة بما يلى: استخدام الجهاز المطور للحقن ومكافحة سوسة النخيل الحمراء فور اكتشافها والحقن تحت ضغط ١٥٠ كيلو بسكال باستخدام المبيدات الكيماوية الموصى بها من وزارة الزراعة المصرية سواء الكلوروبيروفوس ٤٨% أو البروفينوفوس٤٨ % التى حققت نتائج أفضل من المركبات الطبيعية مثل النيم.

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