EVALUATION OF TRUNK INJECTION DEVICE PERFORMANCE FOR CONTROLLING RHYNCHOPHORUS FERRUGINEUS AND TRANSLOCATION OF TWO INSECTICIDES IN DATE PALM TREES.

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ABSTRACT

Field trials were conducted in date palm trees to determine some operating parameters influencing the performance of trunk injection device for controlling red palm weevil, *Rhynchophorus ferrugineus* Oliver, under different factors, (palm age, different pressures, and doses).

The controlling time, device productivity, energy requirements, controlling cost and efficiency percentages were calculated. The effect of translocation and residues of chlorpyrifos and profenofos in date palm trunk and fruits were studied.

Results indicated that maximum controlling efficiency of 100% was obtained in the case of 2 holes / infestation place and 300 KPa pressure for young trees, while 400 KPa for medium and old trees. Maximum controlling cost 7.78 L.E / palm were obtained in case of 2 holes and low pressure 200 KPa in old trees.

Residues of chlorpyrifos and profenofos in the trunk pulp, above and below 50 cm the area of injection, and in date fruits were determined by a gas chromatographic method. No residues were found in dates, for both insecticides, two hours after the injection. Maximum residues of chlorpyrifos and profenofos in dates reached 0.052 and 0.42 ppm after 1 and 3 days from the injection, respectively.

This study also indicates the translocation of the two insecticides through the plant vessels above and below the injection point following the use of the injection device although they are non-systemic

Key words: Trunk injection device, red palm weevil, chemical control, residues, chlorpyrifos, profenofos.

INTRODUCTION

The red palm weevil (RPW) *Rhynchophorus ferrugineus* Oliver (Coleoptera: Curculionidae) is the most economically important insect pest of date, coconut, oil and ornamental palms throughout South and Southeast Asia (Kalshoven 1950 and Wattanapongsiri, 1966), invaded the Arabian Gulf region in the mid-1980s and recently in Jordon in 1998. It was first discovered in north-eastern Egypt in September 1992 and has now become established as a primary pest of date palm in Egypt, (Saleh 1992, Cox 1993, Hanounik 1998 and Abraham *et al.* 1998).

The spread of, the most serious and destructive pest on date palm trees, RPW has inflicted great losses and forced many farmers to abandon their plantations particularly in heavily infested areas.

Sizeable cavities are created in stem tissue by larvae, the most dangerous and harmful stage of RPW, as they are feeding on the tissues of the trunk making tunnels in all direction with their hard and sharp mouthparts which make it easy for them to penetrate deep into the heart of stem through any holes causing a lot of damage to the internal tissues of the stem in which multiple generations may be completed, and once they have gained access, the death of the palm generally ensures.

During last decade efforts to control RPW in Egypt, as well as in most countries, focused mainly on the use of traditional insecticides, the successful control measures, so the current tactic to manage RPW are mainly based on injection of these chemicals into the palm trunk.

Abdallah and Khatri (2000), in Sultanate of Oman, reported that the injection by drilled in the place where the thick putrid oozed out of the trunk, and two additional holes, the first 20 cm above and the other 20 cm below it. The insecticides (anthio 33% and metasystox at ratio 1:1) were poured into holes then holes sealed with clay. The percentages of larval mortality were 100% and 93.3% respectively. In Egypt, Girgis *et al.*, (2005), compared between four trunk injection

methods to remedy the infested palm trees with RPW, inside one hole above attack point using glucose apparatus, through some holes making crescent shape in upper region of infestation site, using a plastic tubes placed around infestation symptom and injection around and inside region of infestation. The fourth method, 7-13 substitutive holes 15-20 cm depth and 10-15 cm distance using an iron pin of 40 cm long and 2.5 cm diameter, was the best and recommended one for remedy the infested date palm with RPW in Egypt.

It is so hard and difficult, in traditional controlling method, to handle this iron pin and heavy hummer for making holes inside the wood of the palm trunk, in the trunk injection methods to remedy the infested palm trees with RPW; it costs more efforts, times, labours cost, and then non accurate results, so adaptation of the trunk injection device (Morad and Eliwa 2007) to facilitate remedy of the infested palm trees with RPW was essential.

The objectives of the present study are: Field evaluation of the optimum operating parameters of trunk injection device, for controlling RPW under different host conditions and, at the same time, the effect on health of the tree. Assessment of chlorpyrifos and profenofos, the insecticides used to control RPW, residues in trunk and fruits of date palm tree.

MATERIALS AND METHODS

Field experiments were carried out at Al. Kassasseen district, Ismailia governorate, and El-Salhia district El-Sharkia governorate in 2007. Advanced infested young, medium and old date palm trees were subjected to trunk injection, with trunk injection device, using diluted chlorpyrifos and profenofos at concentration of 0.3 %, the advanced date palm tree infestation were selected depending on the quantity, color and odour of fluid oozed out, quantity of damaged fibers and depth, width and directions of cavities made by larvae, and the following parameters were examined:

1- Three ages of advanced infested palms, young, medium and old trees.
2- Three injection pressures, 200, 300 and 400 KPa were applied.
3- Different insecticide doses according to palm age, number of holes / infestation place (1 or 2), and injection pressure applied.

To assessment some parameters affecting the performance of the developed RPW controlling device under different host conditions, the

remedial method was applied on the infested palm with RPW, as fallows:

One or Two holes about 20-25 cm depth and about 20 cm above the attack point (the place where a thick fluid oozed out of the trunk). A hole is making by a boring device unite [40 cm long and 2.5 cm diameter]. Insecticide was poured into the hole by an injection hand pump unite in which one terminal in the hole and the other into tank of the device which full with diluted insecticide and poured in the hole under controlled pressure.

The inspection was carried out two weeks after treatment and the results were evaluated as follows, observation the fluid oozed wherefrom opaque or limpid, acrid odour or odorless and, in some cases, partial dissection was carried out of the remedy area to see any pest stages live or died. The treated palm is consider recovery when, the fluid oozed is limpid and odorless and/or all stages in the infested area are died.

The trunk injection device consists of two main parts, boring device unite and injection hand pump unite (Fig. 1 & 2 and Table 1).

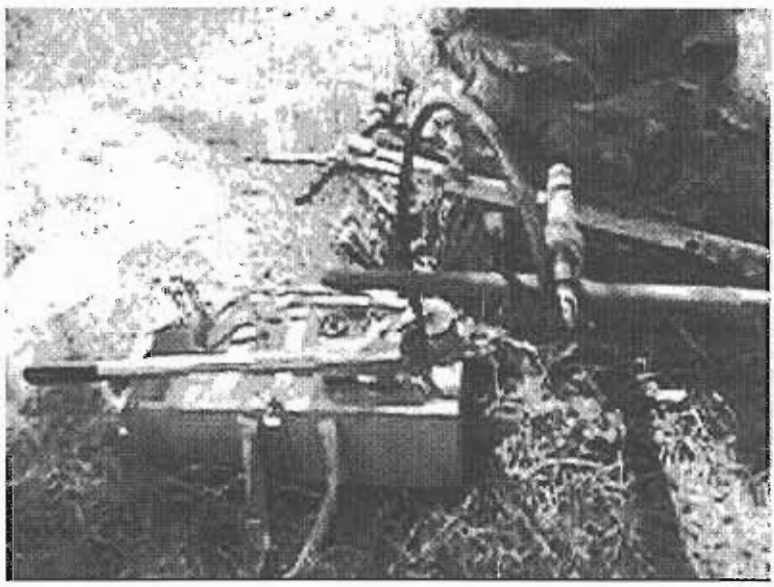
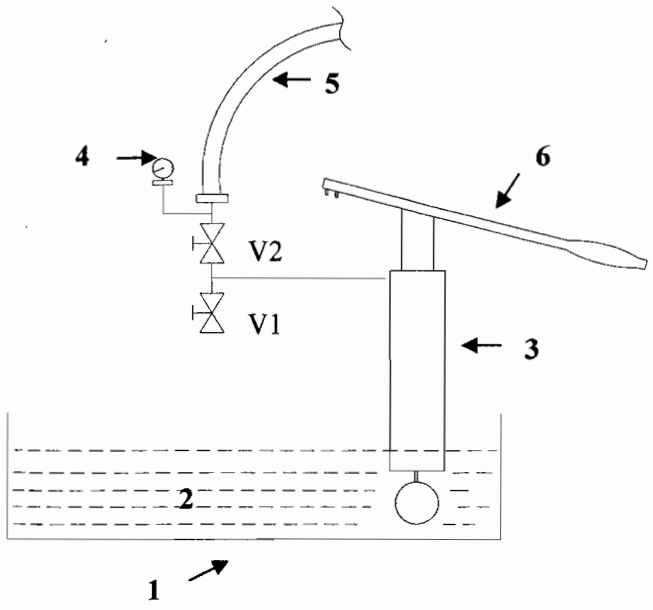


Fig. (1): Trunk injection device for controlling RPW attached to infested date palm tree.



1: insecticide tank, 2: insecticide, 3: piston pump, 4: manometer, 5: rubber tube, and 6: handle.

Fig. (2): Sketch of hand injection pump of the trunk injection device for controlling RPW.

Table (1): Technical specification of the test pump used in the trunk injection device for controlling RPW.

Item	Specification
Country of made	Germany
Model	R P 50---60
Type	Test pump
Overall length mm	480
Overall width mm	160
Overall height mm	270
Laborer requirement, man	1
Total weight	8 Kg
Pressure max.	726 KPa
Temp max	50°C

Measurements:

Controlling time:

The total controlling time can be calculated as follows:

Total time $T_t = t_p + t_b + t_j + t_e + t_s$

Where:

t_p : Preparing device and binding it on the trunk time

t_b : Boring time

t_j : Insecticide injection time

t_e : Separating device from the trunk time

t_s : Ascending and descending time (top infestation)

Controlling device productivity:

After one hour the productivity of the RPW controlling device was determined by the following equation:

$C_d = 60 / T_t$ tree /h.

Where:

C_d = Controlling productivity device, tree / h.

T_t = Total controlling time, min.

Controlling cost:

Hourly cost was calculated by using fixed and variable cost method (straight- line method).

$$\text{Operational cost (L.E./tree)} = \frac{\text{Hourly cost (L.E/h)}}{\text{Device productivity (tree/h)}}$$

The controlling cost was calculated by using the following formula:

Controlling cost (L.E./palm) = operational cost + insecticide cost.

Controlling efficiency %:

The total controlling efficiency was calculated according to percentage of recovery trees and number of dead palms due to injection where the percentage of recovery trees were evaluated as casing of the infestation symptoms and, in some cases, partial dissection was carried out of the treated palm tree and in this case the average mortality of all stages Ma (larva, pupa and adult) was calculated according to Saleh *et al.* (1996) as follows:

$$M_a = \frac{D_d + P_d + L_d}{(D_a + D_d) + (P_a + P_d) + (L_a + L_d)} \times 100.$$

Where:

D_a = No. of alive adults & D_d = No. of dead adults,

P_a = No. of alive pupa & P_d = No. of dead pupa,

L_a = No. of alive larva & L_d = No. of dead larva.

Residues of chlorpyrifos and profenofos in fruits and trunk of date palm trees:

Sampling:

Two commercial formulations of non systemic insecticides were applied on selected date palm trees, 4 meters in height, in the treated infested region about 1.5 meters height for the control of the RPW. Chlorpyrifos 48%EC (O, O-diethyl-O-3,5,6-trichloro-2-pyridyylphosphorothioate) and profenofos 72% EC (O-4-bromo-2-chlorophenyl-O-ethyl-S-propylphosphorothioate), at the rate of 3 ml / l water were applied in the injector apparatus. The injection was made on date trees when fruits were small and green. Samples were taken from date fruits (three replicates of 20 g supsampled from 150 g) and at a certain point in the trunk 0.5 meters below and above the injection site (three replicates of 25 g subsampled from 200 g), at 0, 1, 3, 7, 14, 21, 35, 49 days from the injection time. Samples were stored at – 20°C until the time of analysis.

Extraction:

Residues of chlorpyrifos and profenofos were extracted with methanol using warring blender and then partitioned with methylene chloride in the presence of saturated solution of sodium chloride according to Molhoff (1975) for both date fruits and trunk samples. The extracts were evaporated just to dryness using a rotary evaporator and the residues were ready for the clean up procedure.

Clean up:

Chlorpyrifos:

The florisil column clean up procedure of Mills *et al.*, (1972) was employed by prepared a column filled with 6 g activated florisil (60 – 100 mesh). Residues were transferred to the florisil column with n-hexane and eluted with 200 ml (50% methylene chloride + 48.5% n-hexane + 1.5% acetonitrile). The collected elute was evaporated under

vacuum at 40°C and then dissolved in a known volume of ethyl acetate for the analysis by GC-FPD.

Profenofos:

A Column chromatography using 2% deactivated silica gel eluted with 200 ml hexane /acetone (95 / 5) was adopted in the clean up of both fruits and trunk woods containing profenofos residues according to Abou-Zahw *et al.*, (1993). Both residues were then dissolved in ethyl acetate for GC-FPD analysis.

Determination:

Gas chromatographic analysis by using A Hewlett Packard, serial 6890 plus gas chromatograph equipped with a flame photometric detector operated in the phosphorus mode (526 nm filter) was used for chlorpyrifos and profenofos determination using peak area under the following conditions: the column was DB-1701, (30 m length x 0.32 mm i.d. x 0.25 µm film thickness). Temperatures were 245, 200 and 250°C for injector, column and detector, respectively. Gases flow rates were 3.75, 100 and 100 ml / min for nitrogen, hydrogen and air, respectively. At these conditions, the retention times of chlorpyrifos and profenofos were 2.45 and 3.87 minutes, respectively.

Results were corrected according to the rates of recovery which were determined in fortified untreated samples of dates and trunk woods following the same technique previously mentioned for the extraction and cleaning up. The rates of recoveries in dates were 95.58 and 93.72% and in trunk woods were 87.94 and 89.51% for chlorpyrifos and profenofos, respectively.

RESULTS AND DISCUSSION

The effect of variable parameters on controlling time and device productivity:

Table (2) indicates that the combined effect of palm age and number of holes / infestation place on the time requirement and device productivity. The controlling time increased by increasing palm age and number of holes/infestation. The highest values of controlling time were 27.6, 22.9, and 18.3 min/tree at 2 holes under 200 KPa pressure, 24.5, 20.1 and 17.5 min/tree at 2 holes under 300 KPa and 22.6, 21.2 and 15.4 min/tree at 2 holes under 400 KPa pressure

pressure for controlling old, medium and young trees, respectively. There are contrary relation between the controlling time and device productivity wherefore the highest values of productivity were (6.25, 4.10 and 3.80 tree/h) at 1 hole under (400 KPa) for controlling young, medium and old trees, respectively. The decrease in the device productivity is attributed to the increase in the required controlling time.

Table (2): Effect of all variables under study on device productivity, energy requirement and controlling cost (L.E. / palm)

Treatments		I.P.	No. of holes	Insecticide dose (in liters)	Injection time (in min.)	Device productivity (palm/h)	Controlling cost (L.E/palm)
Palm age	Young	P1	1	3	11.7	5.13	2.70
			2	6	18.3	3.28	3.90
		P2	1	3	9.75	6.15	2.66
			2	6	17.5	3.43	3.72
		P3	1	3	9.6	6.25	2.65
			2	6	15.4	3.9	3.68
	Medium	P1	1	4	16.4	3.66	3.76
			2	7	22.9	2.68	5.18.
		P2	1	4	14.7	4.09	3.65
			2	7	20.1	2.99	5.11
		P3	1	4	15.1	3.97	3.50
			2	7	21.2	2.83	4.95
	Old	P1	1	5	19.8	3.03	5.60
			2	8	27.6	2.17	7.78
		P2	1	5	17.4	3.45	5.40
			2	8	24.5	2.44	7.45
		P3	1	5	15.8	3.80	5.35
			2	8	22.6	2.65	7.35

Where: I. P. = Injection pressure at P1 = 200 KPa P2 = 300 KPa P3 = 400 KPa

The effect of variable parameters on controlling cost.

It has been demonstrated that, the operating cost for controlling RPW included both the operational and insecticide costs. It was remarked that maximum values were 7.78, 5.18 and 3.9 L.E/ tree at 2 holes / infestation under (200 KPa) for controlling old, medium and young trees respectively.

The effect of variable parameters on recovery %, heath of treated trees and, consequently, controlling efficiency %.

Data in Table (3) clearly indicated that, the obvious effect of palm age, pressure applied and dose of insecticide solution on the % recovery of infested palm tree. The highest percentages recovery (100%), whereas all stages of the pest were killed and casing of infestation symptoms, were noticed in two injection holes / infestation place at 400 KPa pressure in both medium and old palm age and at 300 KPa in young palm trees, i.e. the maximum controlling RPW efficiency was 100% in the case of (2 holes x P_2) after injection young palm trees and (2 holes x P_3) for medium and old palm trees.

In case of infested young palm tree applying P_3 (400 KPa) pressure either in one or two holes some treated trees were dead and so it can be recommended the previous techniques for controlling RPW in infested palm trees under different conditions except in young trees pressure chosen must be in careful.

Table (3): Effect of all variables under study on average mortality and controlling efficiency %

Treatments		I. P.	No. of holes	Insecticide dose in liters	% Recovery palm tree	% Dead palms after injection	% Reinfestation	% Controlling efficiency
Palm age	Young	P1	1	3	80	0.0	20	80
			2	6	93	0.0	7.0	93
		P2	1	3	85	0.0	15	85
			2	6	100	0.0	0.0	100
		P3	1	3	93	1.8	9.2	91.2
			2	6	100	4.8	0.0	95.2
	Medium	P1	1	4	80	0.0	20	80
			2	7	81	0.0	19	81
		P2	1	4	84	0.0	16	84
			2	7	96	0.0	4	96
		P3	1	4	90	0.0	10	90
			2	7	100	0.0	0.0	100
	Old	P1	1	5	73	0.0	27	73
			2	8	81	0.0	19	81
		P2	1	5	80	0.0	20	80
			2	8	90	0.0	10	90
		P3	1	5	83	0.0	17	83
			2	8	100	0.0	0.0 .0	100

Effect of trunk injection on health of treated date palm and possibility of reinfestation

Table 3 indicated that, 1.8 and 2.8 % of young age date palm trees were dead after treated with insecticides with the trunk injection device under high pressure (400 KPa) through 1 hole (3 l. dose) and 2 hole (6 l. dose), respectively.

No dead palm trees were observed in low and medium pressures (200 and 300 KPa) in the status of young age date palm trees. Also no dead palm trees were noticed in medium and old age date palm trees under the three different pressures (200, 300 and 400 KPa) and the treated trees did not suffer from any modification and still with a good health after treatment for a long time observation. The death in the young trees, especially under height pressure was due to that the infestation place was nearly from the palm top and consequently harmful effect on the heart of the palm.

The highest percentage from reinfested palm trees were (20, 20 and 27%) under treatment 1 hole x P_1, while not recording any reinfetation cases under 2 holes X P_3 at different palm ages. The number of reinfested trees in 100 neighbor's untreated trees was 43 trees (43%) and so the reinfestation treated trees was accidental in heavily infested area.

Residues in date palm trunk and fruits:

Data in Table (4) demonstrate the residual behavior of chlorpyrifos and profenofos in two different directions from the trunk (below and above) the injection point and in the date fruits at different intervals. No residues in dates were found, two hours after injection for the two insecticides, while the initial deposits of palm trunk pulp were 0.048 and 0.081 ppm for below and above the injection for chlorpyrifos, respectively. The deposits fore-mentioned in the palm trunk were increased by reaching the maximum 89.56 and 43.83 ppm of chlorpyrifos at 3 and 1 day after injection for the below and the above point, respectively. Also dates residues reaching the maximum 0.052 ppm, one day after injection and declined with the progression of time till the end of the experiment.

Also, data in Table (4) represent the residues of profenofos in palm trunk at two different directions (above and below) and in date fruits. The data obtained by the analysis of date fruits, showed that there were no residues detected, two hours after injection, while

residues in palm trunk was 15.79 ppm below the injection point with no residues found above, at the same period. Residues in dates for profenofos reaching the maximum 0.42 ppm, 3 days from the injection then decreased fast to 0.095 ppm, 7 days from the injection. From the results we found that residues in dates reaching the maximum 1 and 3 days after chlorpyrifos and profenofos injected, respectively.

The injection is made up at the trunk in a certain point in which the pressure of injection is accomplished with the solubility of the two insecticides in water content presented in the date palm tree, were very important in the persistence of the two insecticides during the fluids movement in the date palm trunk. Since the solubility of profenofos in water (24 mg/ L) was more significant than for chlorpyrifos in water (1.48 mg / L) Ngan *et al.*, (2005) which can be concluded from the residues obtained from profenofos with respect to that of chlorpyrifos.

Table (4): Residues, in ppm, of chlorpyrifos and profenofos in date palm trunk (above and below) and in fruits after injection.

Intervals after treatment (in days)	Residues in ppm					
	Chlorpyrifos			Profenofos		
	Trunk pulp		Date palm fruit	Trunk		Date palm fruit
	0.5 m Below the injection	0.5 m Above the injection		0.5 m Below the injection	0.5 m Above the injection.	
Initial (zero time) *	0.048	0.081	ND**	15.79	ND**	ND**
1	52.58	43.83	0.052	43.16	46.21	0.16
3	89.56	39.48	0.046	24.38	66.89	0.42
7	49.83	31.89	0.042	18.84	30.32	0.095
14	25.67	20.22	0.011	9.57	12.25	0.03
21	11.36	6.31	0.0053	0.78	0.16	0.016
35	0.675	0.143	0.0039	0.164	0.022	0.009
49	ND**	ND**	ND**	0.052	ND**	ND**

* Samples were taken two hours after treatment.

** ND = Not detected (Limit of detection = 0.02 ppm for chlorpyrifos and 0.01 ppm for profenofos.

Residues in dates were investigated by many researches, in which supervised trials in Iraq, Mac Callum and Pascoe (1976) found that, a deposit of 125 mg per square meter was effective for the treatment of waxed paper liners. At these rates pirimiphos-methyl residues in the dates during the following six months were invariably small – i.e. less than 0.5 mg/kg. The residues of chlorpyrifos and its oxygen analog in dates was studied by Mansour (1985) who found that the oxygen analog was more persistent in dates than chlorpyrifos it self. Mansour and Al-Hassan (1985) determined the residues of pirimiphos-methyl and its degradation products in dates. They found that the oxygen analog of pirimiphos-methyl were found in trace amount while residues of pirimiphos-methyl found and declined slowly through the season. Degradation of the acarcides abamectin, flufenoxuron and amitraz on date palms, grown in Saudi Arabia was studied by Kamel et al (2007), during the pre-harvest interval (PHI) under the local weather and soil conditions. The initial deposit of abamectin residues on dates was 0.09 mg/kg, which declined to 0.03 (66%) loss and 0.02 mg/kg (88%) loss after 7 and 14 days of spraying, respectively (PHI = 10 days, MRL = 0.03 mg/kg). The initial deposit of flufenoxuron residues was 0.68 mg/kg and declined to 0.25 (68%), 0.07 (90%) and 0.03 (96%) loss after 16, 52 and 60 days, respectively (PHI = 50 days, MRL = 0.1 mg/kg). Finally, the initial deposit of amitraz was 0.34 mg/kg which declined to 0.02 mg/kg (95%) and was not detected (100%) after 21 and 30 days, respectively (PHI = 28 days, MRL = 0.01 mg/kg).

Unfortunately, No recommendations concerning the maximum residue limits for chlorpyrifos and profenofos in date fruits are yet available. But the lowest MRL for chlorpyrifos and profenofos established by CODEX in vegetables is 0.05 ppm (CODEX 2003), applying this limit on date fruits the PHI for chlorpyrifos is about 2 days and about 12 days for profenofos (provided that the injection device is used at 6 bars pressure through 2 holes in the palm tree

There are recommendations from the CODEX for fruits in particularly stone fruits which are in between 0.2 and 0.5 ppm for chlorpyrifos, and between 0.5 and 5.0 ppm for peppers in profenofos according to the Maximum Residue Levels of pesticides (2003).

Finally, a trunk injection device was developed and tested under some definite operating parameters. Data from this study recommended that it could be use the trunk injection device for

controlling RPW infestation in date palm trees as it reached 100% controlling efficiency accomplished with decreasing controlling time and costs without any harmful effect for the palm tree. From the obtained data, date palm fruits could be marketed safely after 2 and 12 days, from the injection with chlorpyrifos and profenofos, respectively, till the CODEX assign MRL for dates.

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تقييم أداء جهاز حقن ومكافحة سوسة النخيل الحمراء وتتبع حركة المبيدات داخل جزع وثمار نخيل البلح.

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تعتبر حشرة سوسة النخيل الحمراء من أهم وأخطر الآفات التى تصيب أشجار نخيل البلح على الاطلاق وقد زاد انتشار الآصابة لتشمل معظم محافظات الجمهورية. وحيث ان المكافحة الكيميائية باستخدام المبيدات مازالت هى الطريقه الوحيدة الفعالة فى مكافحة هذه الآفه حتى الان ونظرا لصعوبة استخدام المبيدات ضد الحشرة التى يعيش معظم اطوارها داخل جذع النخله لذلك كان جهاز حقن الجذع من الوسائل الحديثة المتطورة فى عملية العلاج والمكافحة فى مصر. لذا كان الهدف من البحث هو تقييم اداء جهاز الحقن للوصول إلى أفضل عوامل التشغيل التى تعطى أعلى كفاءة فى مكافحة حشرة سوسة النخيل الحمراء. وقد شملت المتغيرات المؤثرة فى عوامل الأداء: الحقن فى أعمار مختلفة من النخيل و ا ستخدام ضغوط مختلفة للحقن و عدد الفتحات \ موضع الأصابة.

شمل البحث ايضا دراسة الأثر المتبقى فى الجذع (اعلى واسفل منطقة العلاج) وكذلك ثمار البلح لمبيدى الكلوروبيروفوس و البروفينوفوس المستخدمين فى عملية العلاج ضد سوسة النخيل الحمراء.

تتلخص أهم النتائج المتحصل عليها فيما يلى:

يمكن الحصول على أقصى كفاءة علاجية بنسبة 100% ضد سوسة النخيل الحمراء عند الحقن خلال 2 فتحة \ موضع أصابة مع إستخدام ضغط 200KPa للأعمار الصغيرة و 300KPa لكلا من الأعمار المتوسطة والكبيرة من النخيل. اقصى أنتاجية لجهاز الحقن كان 6.25 ،4.10 و 3.80 نخلة \ ساعة عند الحقن من خلال فتحة واحدة وضغط 400KPa عند علاج النخيل الحديث ، المتوسط والقديم على التوالى. تلاحظ ايضا زيادة زمن العلاج بزيادة عمر النخلة وعدد الفتحات لكل موضع أصابة، حيث كان أعلى زمن للحقن والعلاج 27.6 ، 22.9 ، 18.3 دقيقة \ نخلة عند علاج النخيل القديم ، المتوسط والحديث على التوالى.

تم تقدير الاثر المتبقى من مبيدى كلوربيريفوس و بروفينوفوس فى لب جزع النخلة حول المنطقة التى تم الحقن بها سواء كان اسفل او اعلى منطقة الحقن وايضا فى ثمار البلح. ولم يستدل على اى متبقى للمبيدين بعد الحقن بساعتين، وكانت اقصى كمية للاثر المتبقى من مبيدى كلوربيريفوس و بروفينوفوس هى 0.052 و 0.42 جزء في المليون بعد 1، 3 يوم على التوالى من الحقن.

واثبتت دراسة المتبقيات انتقال المبيدات المستخدمة خلال الاوعية النباتية سواء اعلى او اسفل نقطة الحقن عقب استخدام جهاز الحقن (رغم ان هذه المركبات غير جهازية).