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DEVELOPMENT OF A LOCAL SPRAYING MACHINE FOR CROIPS AND ORCHARD

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ABSTRACT

This research was to manufacture a local high clearance tractor. One of its applications, which was studied in this research, was to carry a spraying system for insects and pest causing diseases. One of its advantages is that it suited spraying both crop and orchard fields. Field and laboratory experiments were carried out to study the distribution of droplet numbers, and size of the spray solution, bioassay and residual effect of Cascade (IGR) pesticide against cotton leaf worm by using tested machine and control machine, percentage of damaged plants, and field efficiency. Results indicated that insecticidal activity of Cascade which was sprayed with the tested machine and control machine had two different trends according to their insecticidal efficiency. The self-propelled sprayer gave a high insecticidal efficiency for the two larval instars with a significant differences compared with the control machine. Also, it could be concluded that the optimum forward speed and operating pressure were 2.5 km/h and 1961.3 kpa, respectively. The developed machine was proven to be run by on operator. Also, it reduced the used amount of pesticides, consequently, reduced the spraying costs and the environmental pollution.

INTRODUCTION

Pesticides are a group of agrochemicals that is composed of a large number of chemicals used in various aspects of agricultural production. Pesticides are used in large amounts all over the world to reduce the losses, which are often tremendously high in food and fiber production caused by weeds, insects, and other agricultural pests (Emara, 1986). Improvements of application equipments and techniques for the effective use of smaller dosage of chemicals and to reduce drift and harmful residues became increasingly important (El-Gendy, 1999). The effective, economical and safe method of using pest control machines depends up on various factors including knowledge of the principle structure and performance of machines, now available, selection of an appropriate formulation of pesticides timing and method of application and adequate percolation against toxic hazards to men and animals. There are many types of pest control machines such as sprayers, dusters, mist sprayers, granular applicators, air blast sprayers, and soil disinfectors (kaburki *et al.*, 1982). Sprayers are the most commonly used pesticide application equipments. Mboob (1975) mentioned that when insecticides were applied with high-volume sprayers, droplet size was not considered as an important aspect. When large volumes of liquid are used, coverage is far from continuous, also, droplets coalesce and run off occurs. UK and Courshee (1982) found that the deposits of the underside of the leaves rarely exceed 40 to 50 % or less for the upper leaves and can be as low as 5 % or less for the lower leaves. Emara et al (1995) mentioned that, there are differences in spray deposition (No/cm^2) between the top and the two lower levels (middle and bottom). In the last decade low-volume sprays have become increasingly popular; growers have realized that spraying with droplets of indiscriminate size can be both wasteful and inefficient. There are many types and sizes of sprayers ranging from small hand held sprayers, for home and garden, to large tank models for spraying crops, golf courses, greenhouses, nurseries, orchards, roadways ,tall trees, and vineyards. Proper spraying requires skill and accuracy. Moreover, it is expensive therefore; more attention should be paid to selecting the proper equipment to do an effective job. In addition, proper care and maintenance of valuable spray equipment is a necessary component of efficient application. A large sprayer for commercial use is a long-term capital investment. It should be selected carefully based on the following considerations:

- Does the size and design of the sprayer fit its intended use?
- Is the designed sprayer easy to fill, clean, handle, operate, and adjust?
- What is the quality of material and construction of the tank, pump, agitator, and strainers?
- Are spare parts and repair services available?
- How many people are needed to operate the sprayer at what is the maximum efficiency?

For proper and safe operation, a sprayer must be in good condition in the hands of a well-trained operator. To keep a sprayer at peak performance, it must be serviced and adjusted before each use. Sprayers are subjected to hard use, and they are exposed to corrosive and abrasive chemicals (Lucas et al, 1985). The primary task of sprayers is to deliver the spraying fluid to the target surface. The operating process of any sprayer consists of delivering the spraying fluid either by pump or by air pressure from the reservoir to the spraying device (nozzle) which atomizes it into fine droplets and forms the desired spray (klenin *et al.*, 1985). In the present study, a self-propelled sprayer tool was manufactured to be use in spraying operation for insects and pest disease control. The objective of the present study was manufacturing and evaluating of a local self-propelled sprayer tool (that was called a self-propelled sprayer) to suit spraying operation on crop and orchard fields, which was achieved through the following:

1. Developing a high clearance tractor capable of carrying a spraying system or any other agricultural implements.
2. Determining the relationship between spray droplet size (Droplets/cm^2) with spraying pressure and forward speed, on the upper and lower surfaces of cotton leaves, using water sensitive paper technique.
3. Evaluation of the pesticidal efficiency of cascade, insect growth regulators (IGRs) against cotton leaf worn, *spodoptera littoralis*.

MATERIAL AND METHODS

The present investigation could be divided into two main tasks. The first task was to construct the research device in a private local workshop at Samanoud, Gharbia. Then, the second task was to evaluate it in a series of laboratory and field experiments at Etay Al-Baroud Agriculture Research Station, Behaira Governorate.

Research Device:

It is a self-propelled sprayer, figure1, which was designed to be run by only one operator. It consists of two main parts; the power unit and the spray system. Its general specifications are shown in table 1.

1. Nozzle.
2. Boom sprayer.
3. Corona
4. Chain.
5. Rear wheel.
6. Steering wheel
7. Engine.
8. Front wheel.
9. Spring load.
10. Solution tank.
11. Engine fly.
12. Suction hole.
13. File in hole.
14. Front axle
15. Gear box.
16. By-bass hole
17. Discharge hole
18. Spray.
19. Pedal flue.
20. Corona axle.

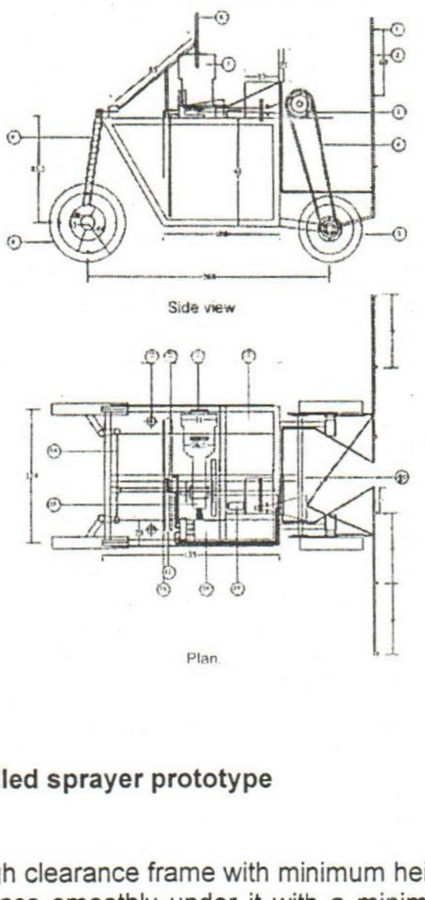

Figure 1: Self propelled sprayer prototype

The power unit

The power unit consists of a high clearance frame with minimum height of 910 mm to permit the plants to pass smoothly under it with a minimum quantity of plant damage analogous to the standard high clearance tractors. The distance between the wheel tracks was adjustable to allow running in a different spaced furrows and different grown plants

The steering system

The steering system consists of a steering wheel and a scatra of a 128 FIAT car in close proximity to the constructed machine. These are joined together by steel bar and were connected with the front wheels by means of spring loaded chock absorber to reduce vibrations at the front of the frame

Table 1: General specifications of the self-propelled sprayer

Specifications		
Overall length (mm)		2250
Overall width (mm)		1240-1500
Overall height (mm)		1500
Machine clearance (mm)		910
Forward Speeds- km/h	First	2.5
	Second	5.0
	Third	15
Rear speed (km/h)		2
Boom height(mm)	Min.	350
	Max	1500
Boom width(mm)	Min	1500
	Max	3600
Type of nozzle		Tee jet
Number of nozzles on boom		6
Capacity of two spraying solution tanks (L.)		250L
Capacity of fuel tank (L.)		12

Engine and transmission system

It consists of a 14 hp diesel engine with its gearbox of a Lambordeny cultivator to allow different levels of speeds. This component was taken as is to allow re-assembling the cultivator after the experiment was achieved. A differential system was installed and the power was transmitted from the hub through a universal joint to the differential system that in turn drove the two rear wheels. As the differential system reduced the speed to 1/4, the normal speed, two gears were installed in the transmission system to enlarge the rear wheel speed to the normal rotating speed. The motion was transmitted to the rear wheels by means of two pairs of sprocket and chain.

A pair of lug type tires was used as rear wheels to drive the spraying unit to assure good traction efficiency while working in the field under the worst soil conditions. However, another pair of motorcycle tires was used in front as; their pressure on soil did not exceed 10 N /cm^2

Spray device

The spray device consisted of two tanks, pump with air chamber, pressure regulator, spraying boom and nozzles assembly with hoses.

Knapsack hand sprayer

The knapsack hydraulic sprayer (CP3), 20 L vol. and 1 L pressure chamber, was used in the present study as a control. It is commonly used in broadcasting in Egypt.

Insecticide

Cascade, known as Fluefenoxuron, is an insect growth regulator produced by Cyanamid Company. It was used to control cotton leaf worm spodoptera littoralies on cotton and other vegetable crops. It has a 10% DC formulation and it was applied at 200 cm^3 per feddan.

Tested insect:

In the present study, 2^{nd} and 4^{th} instar larvae of cotton leaf worm, spodoptera littoralies were taken from a colony reared in laboratory according to the method by EL-Defrawi *et al.*, 1964 for the bioassay tests.

Collection and measurement of spray droplet:

The experiment was designed to study the effect of two levels of forward speed, three levels of spraying pressure, and their interactions on spray droplets depositing on upper and lower leaf surfaces of cotton plants under green-house conditions. The tested self-propelled sprayer tool and knapsack sprayer CP3 were used in this experiment. Plastic pots 200 mm diameter and 300 mm length was filled with 4 kg air dried clay from a soil that was free from pesticides in the station farm at Etay El-Baroud. The plastic pots were saturated for two days before cultivation. Then, each plastic pot was seeded with 10 seeds of cotton Giza 89 in the first of April 2000 then the plastic pots were grouped in seven groups. Each one contained ten plastic pots. All plastic pots were strictly irrigated every two days during the experiment. After approximately 3 weeks, the plants were thinned to two plants per pot. When the plants reached the flowering stage, at the end of June, special cards (26x55mm) of water sensitive papers were located randomly on upper and lower cotton leaf surfaces at each group. The paper cards were distributed on three pots of each group. Every treatment contained 18 paper cards for upper surface and 18 for lower surfaces. The treatments were SP1, S1P2, S1P3, S2P1, S2P2, S2P3, and the CP3 treatment as a control. Then the spray solution was applied using the tested sprayer and CP3 as a control. After the application and the water sensitive papers got dry the cards were collected and transferred to laboratory to evaluate the spray droplet numbers per square centimeter by computer and a microscope (S&ST series of wide field microscope) as a common method in this respect and personal computer as prose method to compare between the two methods.

Calculation of spray droplet numbers

a. Computer method

A proposed method was used to calculate the spray droplet number on water sensitive cards using a computer program as the following:

1. Water sensitive cards were scanned for every one of the seven treatments by a scanner and set of computer programs and they were inserted to the MS Word program.
2. One square centimeter was cut randomly from every card, it was magnified 14 times from the actual size, and it was printed to calculate droplet number for every card.

b. Conventional microscope method

The conventional microscope was used to calculate droplet numbers on the water sensitive card for every treatment. S&ST series of wide field droplet numbers that were taken from area of the field microscope were calculated for one square centimeter. The spray droplet numbers of the microscope method were compared with that resulted from the computer.

Droplet surface mean diameter

Droplet surface mean diameter (DSMD) is the mean of longitudinal and horizontal diameters of droplets. It was measured according to the method adopted by NOOR (1997) with the slight modifications. Micrometry slit was used to measure the longitudinal and lateral diameters of spray droplets. Then the droplet surface mean diameter (DSMD) was calculated using the following equation:

$$DSMD = \frac{D_x + D_y}{2}$$

Where:

DSMD = droplet surface mean diameter (μm)
D_X = the longest distance in the longitudinal direction (μm)
D_Y = the longest distance in the lateral direction (μm)

Field and laboratory Experiments

a. Field Experiment

Field experiment was conducted in the farm of Etay El-Braroud Research Station at cotton season 2000. An experimental area of half fedden was divided into three parts, and cultivated with Giza 89 cotton variety April1st, 2000. Then, in the 30th of July 2000, Cascade, as an Insect Growth Regulator (IGR) 10% DC, was applied at 200cm^3/ feddan against cotton leaf worm, spedooptera littoralis using the self-propelled sprayer, CP3 as a control. The three treatments, self-propelled sprayer, CP3, and untreated area (blank), were distributed in three parts of the experimental area. Each part had an area of 100 x 7.2 m^2, 720 m^2, with a furrow width of 600 mm. Every treatment consisted of five plots, where each one was 144 square meter divided into12 rows. The self-propelled sprayer was operated at 2.5 km/h forward speed and 1970.6 kpa operating pressure.

b.Bioassay determination of residual effect of sprayed insecticide on cotton leaves

The cotton leaf worm, spodoptera littoralis egg masses were collected from the area of experiment and reared under laboratory condition to the method adopted by El-Defrawi *et al.* (1964). The second and fourth instar larvae were used to evaluate the pesticidal efficiency of the Cascade which was sprayed with the tested machine and CP3 as a control. After spraying, the cotton leaves were dried, sample of cotton leaves from the three treatments were collected at random and transferred within paper pages to laboratory. The initial and bio-residual activities of the tested insecticide against the second and fourth larval instar of cotton leaf worm were studied in the laboratory. In this respect, 2nd and 4th Instars were subjected to the feeding technique according to the method adopted by the Egyptian Ministry of Agriculture for evaluating the efficiency of chitin synthesis inhibitors (CSI). In such technique, the feeding period was started immediately after insecticidal application and extended for pupating stage. The feeding period was divided into two successive intervals; 5 days for the first period and after the 5^{th} day until pupating stage for the second period. The larvae were fed on treated cotton leaves for 2 days, and then the alive larvae were fed on untreated leaves for 3 more days. Mortality count in each treatment was recorded after the first period (5 days) which represent the initial activity. Then the surviving larvae were fed on untreated leaves daily until pupating stage and the mortality count was recorded daily. The larvae of each selected stage were divided into batches of 50 larvae each (5 replicate with 10 larvae). All the mentioned above were at different time intervals from spraying, zero time (directly after spraying), 7, 14, and 21 days from spraying

Mortality count in each treatment was recorded daily and the total number of dead larvae was calculated at the end of each period. Also, pupating larvae and adult emergency counts were recorded. Then all counts were corrected and assessed as percentage using Abbot's formula (1952) as follow:

$$Mortality\% = \frac{Alive\ larvae\ in\ blank - alive\ larvae\ in\ treatment}{Alive\ larvae\ in\ blank}$$

RRSULTS AND DISCUSSION

Spray droplet numbers

a. Calculated using computer

The results in figure 2 represented the total spray deposit and intensity ratio throughout the whole plant. The upper surface received higher number of deposits than the lower surfaces throughout the whole plant with both of two tested sprayers. The data showed that the numbers of droplets lower surfaces were very poor compared with numbers of droplets on upper surfaces. For the tested machine, with both of two tasted speeds, it can be concluded that the average spray droplet number on upper surfaces increases with the spray pressure increasing. But with the lower this relation was not clear. Also the data showed that the average spray droplets number on upper surfaces for the control machine was less than as compared with the tested machine, but it was more on lower surfaces for the control machine (93.67) as compared with the tested machine. For the two tested speeds (2.5 and 5 km/h) it can be concluded that with (5 km/h) the average spray droplets number (droplets/cm^2) on upper surfaces was slightly high as compared with the other speed. For the lower surfaces, the trend was not constant. The intensity ratio (λ), which was calculated through the relation between the average droplet number for the lower surface / droplets/cm^2 of upper surface, it can be concluded that this ratio for the control machine was higher than that with tested machine. This may be due to the higher droplets number on lower surfaces for the control machine (93.67) as compared with the tested machine. Also, the spray deposits at upper surfaces of leaves were more intensive than that at lower surfaces for the three levels with all tested sprayers.

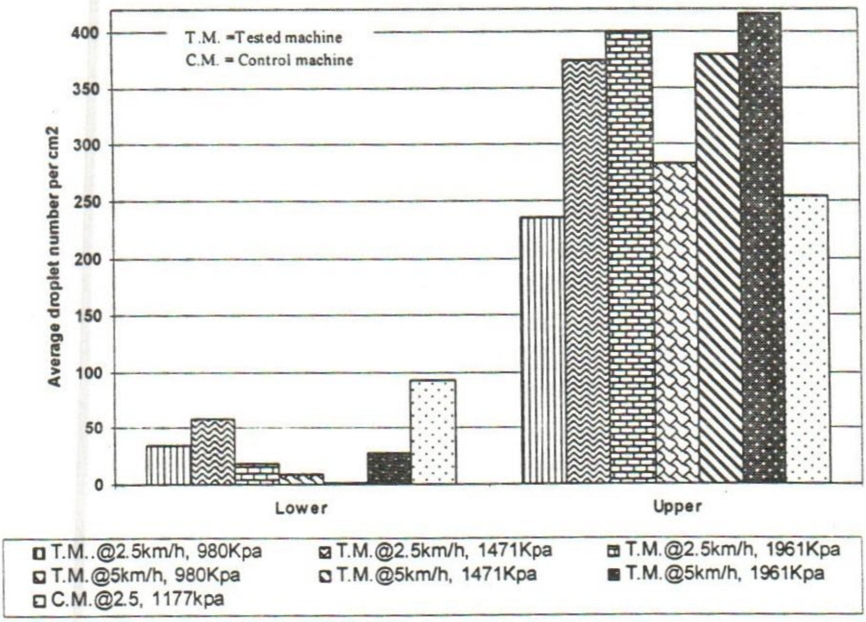

Figure 2: Average spray droplet numbers (droplets/cm^2) on upper and lower leaf surfaces throughout the entire plant using computer

b. Calculated using microscope

Figure 3 represented the average of the spray droplets number on upper and lower leaves surfaces for the two tested machines. Results showed that the average of spray droplets number took place mainly on upper side of the leave. It was 210.11 for the control machine, while it ranged from 235 to 320 droplets /cm^2 with the tested machine. Spray pressure effect in this respect was clear, while the speed factor was not. For the lower surfaces, average of the spray droplets was more with 2.5 km/h speed than that with 5 km/h.

To compare between two methods, it can be concluded that, the spray deposit on upper surfaces at all cases was higher with the computer than that will microscope, except at a speed of 2.5 km/h and a pressure of 980.1 kpa. But with lower surfaces the microscope gave bigger number of droplets than that with the computer, except with control machine at a speed of 5 km/h and a pressure of 1961.3 kpa. Also, intensity ratio (λ) with microscope was more than that of the computer at most cases.

Droplet surface mean diameter

Droplets surfaces mean diameter (DSMD) is the longitudinal and lateral diameter of droplets. Micrometry slit was used to measure the lateral and longitudinal diameter of the spray droplets. Then the droplets surface mean diameter was calculated

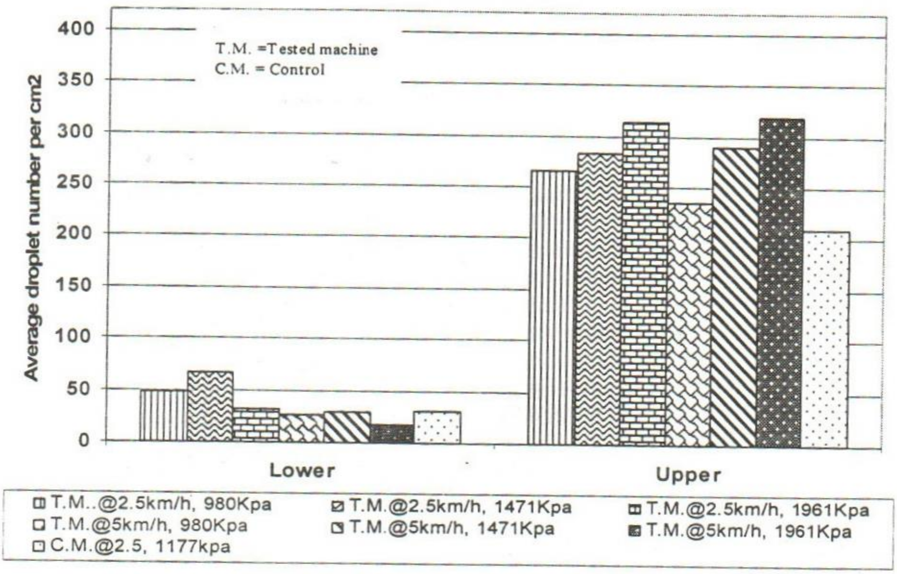

Figure 3: Average spray droplet numbers (droplets/cm^2) on upper and lower leaf surfaces throughout the entire plant.

Results of the droplet surface mean diameter are represented in figure 4. The maximum values of (DSMD) were observed with the tested machine, which ranged from 190.5 to 397.5(μm), while the smallest value, 162.5 μm, was observed with the control machine on the upper surface.

According to the results, it can be concluded that the optimum forward speed and operating pressure were 2.5 km/h and 1961.3 kpa, respectively.

Bioassay study

The initial and bio-residual activities of Cascade against the second and fourth larval instar of cotton leaf worm were studied in the laboratory. Corrected mortality percentages of 2nd and 4th instar larvae, pupating larvae, and emergency adults after different time intervals of Cascade spraying using the tested spray machine and hand-knapsack sprayer .The accumulative data of the pesticidal efficiency as initial effect, mean of residual effect, and general mean directly, one week, two-weeks, and three weeks after spraying are given in table 2 and figure 5. It is clear that the self-propelled sprayer had higher initial effect than that of the hand-knapsack sprayer at all tested periods with 2nd and 4th larval instar. In this respect, the tested spray machine gave initial effects gradually decreased with time after spraying increase. The initial effect was 100, 97.9, 89.4 and72.9 % for 2nd larval instar at directly, one-week, two-weeks, and three weeks after application respectively. For the 4th instar, it was 95.6, 89.6, 87.8 and 89.9 % at the same periods, respectively.

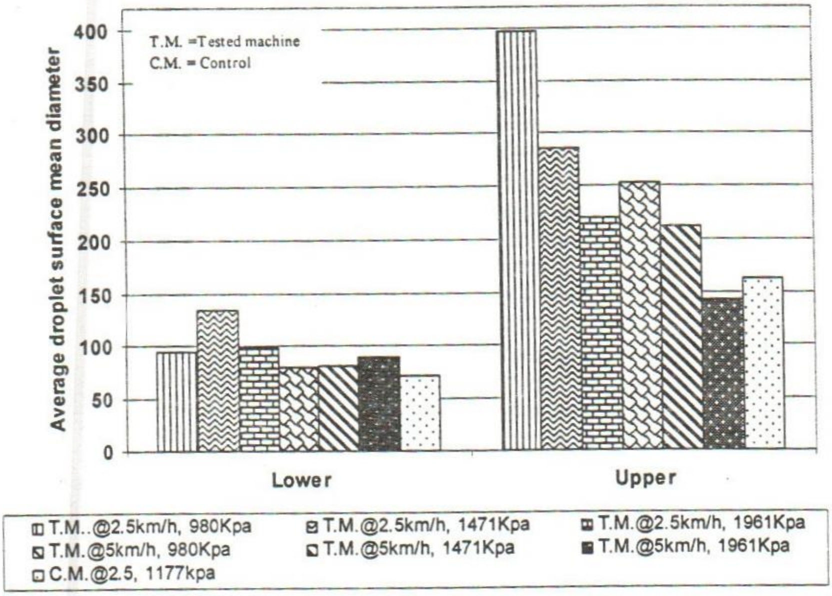

Figure 4: Droplet surface mean diameter (µm) for the upper and lower leaf surface at different forward speeds and spraying pressures

The initial effects of hand-knapsack sprayer were drastically decreased with time after spraying increase. It was 94, 81.3 29.8 and 29.17 for the 2nd larval instar and 87.2, 66.7, 53.1, and 18.4 for the 4th larval instar with the fourth periods, respectively. There are highly significant differences between the self-propelled sprayer and hand-knapsack sprayer with the second and fourth larval instars and at all the indicated periods.

Data also clearly indicated that the spray machine gave excellent effects, represented by high percentages of 86.7 and 90.05 % for the initial effect with the residual and general mean, respectively for the second larval instar. The equivalent values for the fourth instar were 89.07, and 90.07 % for the initial effect with the residual and general mean, respectively, which are considered high values too. In this respect, hand-knapsack sprayer gave lower values, which were 46.8, 58.6% and 46.07, 56.4% for the 2nd and 4th larval instars, respectively, as the initial effects of the residual and general means.

In general, insecticidal activity of Cascade which was sprayed with the tested machine and control machine had two different trends according to their insecticidal efficiency. The self-propelled sprayer gave a high insecticidal efficiency for the two larval instars with a significant differences compared with control machine. It may be due to receiving higher number of droplets on the upper surface with the tested machine than that was received with the control machine.

Table 2: Efficacy of Cascade (IGR) at different periods of application on cotton plant against cotton leaf worm *Spodoptera Littoralis* using the tested spraymachine, hand-knapsack sprayer

Larva Inst	Treatments	Directly after spraying		One week of spraying		Two weeks of spraying		Three weeks of spraying		Residual effect mean		General mean	
		Initial effect	Larvae failed in pupation	Initial effect	Larvae failed in pupation	Initial effect	Larvae failed in pupation	Initial effect	Larvae failed in pupation	Initial effect	Larvae failed in pupation	Initial effect	Larvae failed in pupation
2nd	Check	0.0	16	0	10	0	0	0	0	0	3.3	0	6.5
	Tested machine	100	100	97.9	100	89.4	95.5	72.9	77.8	86.7	91.1	90.05	93.3
	Hand-knapsack p	94	95	81.3	88.9	29.8	69.05	29.17	37.8	46.8	65.25	58.6	72.7
4th	Check	0.0	10	0	8	0	0	0	0	0	2.7	0	4.5
	Tested machine	95.7	97	89.6	100	87.8	91.3	89.9	93.6	89.07	94.7	90.7	95.5
	Hand-knapsack p	87.2	91	66.7	78.3	53.1	41.3	18.4	31.19	46.07	94.79	56.4	66.6
B.L.S. D.	2nd at 0.05	1.5		1.02		1.8		1.7					
	4th at 0.05	1.92		1.47		1.4		1.2					

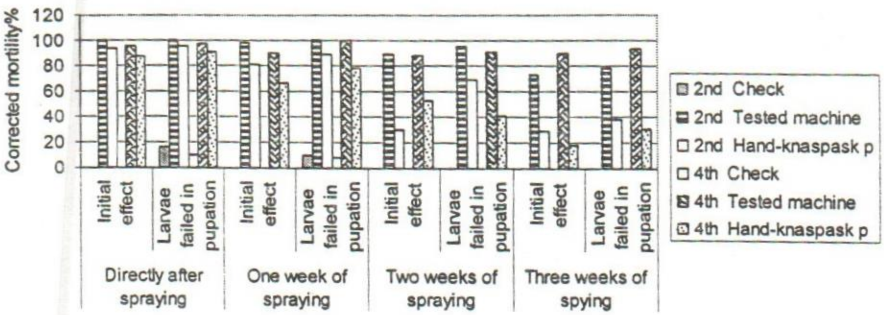

Figure 5: Efficacy of Cascade (IGR) at different periods of application on cotton plant against cotton leaf worm *Spodoptera Littoralis* using the tested spray machine, hand-knapsack sprayer

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تطوير آلة محلية تدار بواسطة الإنسان أو المحرك لرش المبيدات في حقول المحاصيل والبساتين

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تعتبر عمليات تطبيق مبيدات الآفات عنصرا هاما من عناصر الإنتاج الزراعي و ان نجاح التطبيق لها يحكمها عدة عوامل لعل من أهمها الآلة المستخدمة في التطبيق.

ويتناول هذا البحث تصنيع وحدة قدرة ذات خلوص مرتفع تدار بمحرك ديزل ١٤ حصان و ملحق بها وحدة لرش مبيدات الآفات في المحاصيل الحقلية والبستانية وذلك لتحقيق الأهداف التالية :

١. أداء عملية الرش بواسطة عامل واحد.
٢. تحقيق انتظامية وتجانس لمحلول الرش على المحصول المرشوش .
٣. خفض تكلفة الرش مع زيادة السعة الحقلية للآلة .
٤. الحد من التلوث البيئي عن طريق خفض حجم محلول الرش لوحدة المساحة

تضمن البحث أجراء تجارب معملية و حقلية لإبراز و توضيح النتائج المقدمة. التقيم المعملي و الحقلي اشتمل على تجميع قطرات الرش ودراسة متوسط أعدادها وأقطارها ، والتقيم الحيوي للكفاءة الابادية (تأثير أولى ، تأثير أثر باقي) لمنظم نمو حشري (كاسكيد) مطبق بالآلة موضوع الدراسة والرشاشة الظهرية CP3 للمقارنة ضد العمر الثاني والرابع لدودة ورق القطن.