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Evaluation of two different pesticides sprayer equipment techniques on squash plants

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Abstract:

The main experiments were carried out during 2017 and 2018 seasons at the New Salheia, Sharkia Governorate to investigate and evaluate two techniques (pressure or hydraulic atomization and centrifugal atomization) to apply pesticides and their effect on volume median diameter, number of droplets/cm², L and loss and drift outside treatment or contamination of applicator, pesticides efficiency. This work was tested three equipment, the equipment used were ULVA sprayer, electric battery sprayer fitted with flat fan nozzle Ss-83 and conventional motor sprayer with variable spraying rates. In addition, pesticides buprofezin and imidacloprid against the aphid *Aphis gossypii* Glover (Hemiptera: Aphididae) and the tomato whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) and pests infested squash plants where be used. Current study was determined the effect of each technique and pesticide of reduction of pests and determined the contamination of applicator, L and loss and Drift outside treatment caused by each technique. The result obtained during the two seasons showed that the spray with high volume was gave low percent reduction of pests and high contamination of applicator or Losses on land if compared with low volume spraying. No drift spray was recorded by ULVA sprayer and electric battery sprayer fitted flat fan (Ss-83) nozzle, while there is drift spray was occurred with the use conventional motor sprayer on distance 1m, 2m and 3m.

Introduction

Squash is one of the most important vegetables in Egypt, it cultivates under summer and winter conditions, although still not widely used by the food industry, squashes are consumed worldwide. Fruits are consumed as vegetables or dessert (pie) and seeds as nuts and, to a lesser extent, as cooking oil (Lazos, 1986 and 1992). Because of their resistance to drought and the high protein (23-35%) and oil (25-55%) contents of their seeds, squashes

have attracted the attention of many growers and plant breeders within the past 50 years (Curtis, 1946; Bemis *et al*., 1978 and Scheerens *et al*., 1991). According to Food and Agricultural Organization (FAO) (2012), the Egyptian production for squash was 658.234 metric tons. The cultivated area with this crop increased during the last two decades especially in new reclaimed regions in both open and protected plantation. Throughout the growing season, cucumber plants are suffering from severe infestation with different phytophagous insect pests such as the aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae) and the tomato whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) , which considered the most common and dangerous insect pests of cucumber plants. In case of heavy infestation, these pests are causing serious damage to plants, leading to great reduction in the final yield (Hanafy, 2004). Squash crop is infested by many pests, these are aphid, *A. gossypii*., whitefly, *B. tabaci* and thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) (Mohamed ,2011).

Therefore, pest control through chemical spraying in highly needed in Egypt to reduce the annual losses in crops caused particularly by pests. Two types of insecticides have been recommended to control sucking aphid and whitefly. The insecticide effect of droplets sprayed is dependent on spectrum droplets (Palti and Ausher, 1986). The performance of pest control dependent on the proper choose of suitable technique to use of spraying. So, this study compared with two techniques centrifugal atomization technique(ULVA sprayer) with 18.4L/fed., pressure or hydraulic atomization (Electric battery sprayer fitted with flat fan nozzle Ss-83) with 89.3 L/fed. and pressure or hydraulic atomization (Conventional motor sprayer) with 330L/fed. Therefore, the main objective of this study is to evaluate some techniques (pressure or hydraulic atomization and centrifugal atomization) used to apply pesticide in Egypt and their effects on spraying efficiency volume median diameter, number of droplets/cm², L and loss and drift outside treatment or contamination of applicator, pesticides efficiency were also conducted.

Materials and methods

1. Squash crop:

The variety was used in this study for manual planting were planted in ridges the distance between each ridge was 80 cm and row spacing between the plants was 50 cm. this variety is recommended in Egypt.

2. Field layout:

The experiment was carried out in a rectangular shape area about 2 Feddans. Squash area were planted by hand in ridges. The experiment area divided into nine plots area of plot 1056m² (44x24m) and left between each plots (treatment) and the other (44 x 8m) for measure the drift sprayer has two plots, as shown in Tabel (1). Six plots for treatment and one for control.

Table (1): Designed showing the field experiment.

3kerates	6kerates	ULVA Sprayer		Electric Battery Sprayer fitted with flat fan nozzle (Ss-83)		Conventional Motor Sprayer		3 kerates
		Buprofezin	Imidacloprid	Buprofezin	Imidacloprid	Buprofezin	Imidacloprid	
		6 kerates	6 kerates	6 kerates	6 kerates	6 kerates	6 kerates	

3. Pesticide used:

3.1. Buprofezin (Applaud 25% SC) suspension concentrate with recommended rate 600cm/fed.

3.2. Imidacloprid (Avenue 70%WG) water dispersible granules with recommended rate 120gm/fed.

4. Equipment Used:

Spraying machinery used in this investigation and specification of equipment as follow:

4.1. ULVA sprayer (Centrifugal atomization technique):

The sprayer has aluminum tube 1.30m long contain five batteries 1.5 volt located in the section of the tube and connected via an on/off switch to a 7.5-volt motor located at the rear of the tube. The sprayer has one-liter plastic bottle concentrate liquid (pesticide) which was fed by gravity to reach the spinning disc. The sprayer attached with back tank ten liters and is led to the spinning disc through plastic pipe (food house) to increase performance. The sprayer made in England.

4.2. Electric battery sprayer (Pressure or hydraulic atomization) with flat fan Ss83 nozzle:

The electric battery sprayer has 20-liter liquid tank capacity, and diaphragm pump motor operated without air chamber. The power consumption for 4.5-hour continuous operation is Battery12 volt, motor speed 2800- 3200 rpm., and operating pressure is 3 bar.

4.3. The Conventional motor sprayer (Pressure or hydraulic atomization):

This equipment is local manufacturing, it consists of 600 liters tank capacity, spray gun connecting with the pump by 40 – 80m long rubber house, reciprocating pump with air chamber, the power is 5 hours while, the operating pressure is 3 bar. This equipment works with hydraulic agitation, with cooled air.

5. Measurements instrument:

5.1. Tape: For measuring the distance cut by operator of each replicate.

5.2. Stopwatch: It used to calculate the average forward speed and flow rate with accuracy too sec.

5.3. Graduated cylinder: Graduated Cylinder was used to calibrate the volume of the spraying solution.

5.4. Water sensitive paper: Ciba Geigy sensitive paper (76 x 26mm) to receive spray droplets from sprayers during their operation.

5.5. Wind meter: Wind meter was used to measure the wind velocity (m/s).

5.6. Strubin® lens (X15)**:** This lens used to measure the number and volume of deposited droplets on sensitive paper.

6. Measurements: -

6.1. Flow rate (L/min):

Flow rate was the first test made to calibrate the equipment. The researcher was filled the sprayer tank with water and regulated the required pressure and height of nozzle. The flow rate was measured by collecting the water in a graduated cylinder for one minute, and repeated this step for three times, and calculated the average to achieve accurate result. Then we consider the flow rate was achieved as expressed the sprayer.

6.2. Swath width of the sprayers (m):

The Patternation test by means of only one nozzle, as well as the pass of ground sprayer over sensitive cards. The sensitive cards technique was found to be less accurate but easier and quicker technique than the former one. Therefore, the pass spray technique will be selected to determine the swath width of the tested sprayer, at two spray heights and two walking speed with the use of water and sensitive cards calculated are presented in Table (2).

Table (2): Laboratory technical data of sprayer techniques used by three tested sprayers.

Item	ULVA Sprayer	Electric battery sprayer with flat fan nozzle(ss83)	Conventional motor sprayer
Type of sprayer	Rotary	Hydraulic	Hydraulic
Spray tank, (L).	10	20	600
Flow rate, (L/min.)	0.175	0.850	2.36
Rate of application, (L/fed.)	18.4	89.3	330
Spray height, (m)	0.50	0.50	0.50
Swath width, (m)	1	1.00	0.75
Working speed, (Km/h.)	2.4	2.4	2.4
Type of spray used	Target	Target	Target
Productivity, (fed/h.)	0.57	0.57	0.43
Rate of performance (fed/day.)	2.28	2.28	1.72

Productivity, (fed/h.) = $\frac{60*speed*swaghwides}{4200}$ **Rate of performance/day= Productivity, (fed/h.) * (6 and 8) *** $\frac{2}{3}$**).**

7. Description of sampling line:

Six plots were sprayed, and one was left for control. The sampling line consisted of 5 wires holders fix at one (m). In diagonal line inside each treatment to collected sprayer chemicals. Sensitive paper cards double with the wire holder were fixed in "L" shape on the top of wire holders to measure the distribution ratio on the upper and lower surface of the sensitive paper. Three sensitive paper cards double were distribution on some plants (right, middle, left) at distance of one meter to measure the distributed on the upper and lower surface at five plants. In addition to, one sensitive paper card was placed under each plant to measure loss of land. While, sensitive paper cards were fixed on the applicator (Head, Thorax, abdomen and legs (right and left)) for measure the contamination deposit. All cards were numbered, collected and transferred carefully to the laboratory for measurement the volume and number of deposited droplets per cm^2 by the above-mentioned Strobing lens. Therefore, calculate the VMD of droplets. Results were then recorded, in ten successive classes with a range of 50microns. Volume Median Diameter (VMD) value was calculated according to the following equation **(Gabir, 1978).**

V.M. D= $[\Sigma_i^n = 1(nixi3)/\Sigma_i^n = 1ni]\frac{1}{3}$

Xi= droplet diameter for a given size class (1) µm

$\sum^n i$ = total number of droplet, in all droplets categories

8. Laboratory coverage for used equipment:

The table (3) is conducted the laboratory coverage of used equipment.

Table (3): Spray coverage on artificial targets as produced by electric battery sprayer and ULVA sprayer.

Equipment				Electric Battery Sprayer (Ss-83)			ULVA Sprayer		
Spray Volume (L/fed)				89.3			18.4		
Droplets spectrum / Spray parameter				VMD µm	N/cm²	% N	VMD µm	N/cm²	% N
Working Speed (2.4km/h)	Spray height	0.30 m	Upper	170	55	69	99	93	72
			Lower	73	25	31	87	36	28
		0.50 m	Upper	174	63	70	107	97	69
			Lower	78	27	30	81	43	31
Working Speed (3.0 km/h)		0.30 m	Upper	174	55	75	91	72	65
			Lower	88	18	25	90	39	35
		0.50 m	Upper	128	53	76	118	81	59
			Lower	80	17	24	93	56	41

9. Weather conditions:

Weather conditions during the experimental periods were measured, measurements will be taken by the method described by **(Barry, 1978)** Table (4). A simple anemometer has a pith ball which moves up at vertical tube according to the strength of the wind "Dwyer's anemometer"

Table (4): Average of meteorological conditions during experiments execution.

Experiments	Season	Date of Experiment	Governorate	A.T (°C)*	R.H (%)**
In Laboratory	2017	28. 2.2017 5. 3.2017	Spray technology Departement, EL- Dokki, Giza	24.0 27.0	68.0 71.0
Insecticides on squash plants fields	2017	3. 6. 2017	New Salhia, Sharkia	31.0	68.0
	2018	10. 5. 2018		34.0	73.0

Notations: * Air Temperature (ºC). ** Relative Humidity (R. H.%).

10. Experimental treatments:

The chemical pest control treatments were conducted during squash cultivated seasons 2017&2018**.** Chemical applications were started 37days at season 2017 and 39 days at season 2018 after the sowing of squash plants.

11. Determination of spray deposit

Number and size spots (droplets) on sensitive cards will be measured with a special scaled monocular lens (**Struben®**) with a magnification of X 15. This is a hand lens which gives a direct measurement because it magnifies both the spot and scale at the same rate, scales 6 mm in 60 parts, and diameter 7 mm. The area of its field *=0.432 cm².* Obtained data was corrected (by knowledge of the spread factor) and is calculated to obtain the Volume Median Diameter of droplets (VMD) and the number of these droplets in one square centimeter (N/cm²), according to **Gabir (1975/95).**

The volumetric diameter droplets on Ciba-Geigy sensitive paper can be calculated as follows:

Actual droplet diameter= $\frac{\text{stain diameter of droplet}}{\text{spraed factor}}$ µm.

12.Spread factor:

The values of spread factor cited from Ciba Geigy Company, were followed here (Table,5) **(Gehan, 2000).**

Table (5): The values of spread factor.

Stain diameter of droplet in (µm)	Spread factor	Droplet diameter actual in (µm)
100	1.7	050
200	1.8	100
300	1.9	155
400	2.0	200
500	2.0	243
600	2.1	285

13. The wind velocity:

Face the wind hold meter in front of you in vertical position and with scale side toward. Do not block bottom holes. Height of ball indicates wind velocity for high scale, cover hole at extreme top with finger.

14. The Drift:

Outside treatment of squash plants only wire holders were fixed in the distance 1, 2, and 3 m to measure drift spray lost by air.

15. Biological whitefly and Aphids infesting:

Imidacloprid and buprofezin evaluated at a recommended rate (120gm/fed. and 600cm³/fed.), respectively, against squash plants insects. Samples of 25 plants were chosen at randomly from each replicate before treatment and at 1, 3, 7 and 15 days after pesticides application. The number of target insects was counted. Percentage of the insect population was calculated according to Henderson and Tilton (1955). Comparing differences mean, the main effect and Independent factors interaction were analyzed throughout Spss version 19.

Results and discussions

The data obtained from the field experiment with the purpose of evaluating some techniques (pressure or hydraulic atomization, centrifugal atomization) to apply pesticides in Egypt and their effect on spraying efficiency (droplet size and spray distribution pattern), environmental pollution.

1. Field performance:

The performance of some techniques (pressure or hydraulic atomization, centrifugal atomization) with two types of pesticides were tested and evaluated according to the following aspects: a. Volume medium diameter. b. Number of droplets. c. Land loss. d. Drift. e. Contamination of applicator. f. Pesticides efficiency.

2. The evaluation of techniques:

The evaluation of techniques was based on volume median diameter (VMD) (µm) and number of droplets (N/cm²), this well be on both a horizontal card (on wire and the cards on the surface of leaves for the plant right, middle and left, (is calculated as follows upper and lower of surface the card while on the land (is calculated as follows upper surface the card).

2.1. ULVA sprayer (Centrifugal atomization technique):

Generally, were the obtained results showed that the volume medium diameter and number of droplets there was discrepancy between the two surfaces upper and lower for artificial and plants when using avenue 70% WG (Imidacloprid), while when using applaud 25% SC (Buprofezin), the volume medium diameter and number of droplets decreased on lower surface and increasing on upper surface for artificial and plants, meanwhile increases the volume medium diameter and decreased the number of droplets on the land loss with two types pesticides.

2.1.1. Effect using ULVA sprayer on volume median diameter and number of droplets with avenue 70% WG (Imidacloprid):

Table (6) showed that the effect using ULVA sprayer on volume median diameter (µm) and number of droplets (N/cm²) at 18.4 L/fed. spray rate. The volume median diameter and number of droplets on upper and lower surface for the card on artificial was (72 and 88 µm) and (106 and 48 N/cm²), respectively. While, the upper and lower surface for the cards on leaves of the plant (right, middle and left) was (82, 78 and 84µm), (86, 77 and 75 µm) and (62, 59 and 58 N/cm²), (42, 44 and 44 N/cm²), respectively. Meanwhile, the volume median diameter and number of droplets on upper surface for the card on the land 131µm and 33 N/cm², respectively.

Table (6): The effect using ULVA sprayer on volume median diameter (VMD) and number of droplets (N/cm²) with avenue 70% WG (Imidacloprid).

Spray receptors	Spray direction	Place the spray card	VMD (µm)	N/cm²	N %
Wire	Artificial	Upper	72	106	69
		Lower	88	48	31
Plants	Right	Upper	82	62	59
		Lower	86	42	40
	Middle	Upper	78	59	57
		Lower	77	44	43
	Left	Upper	84	58	57
		Lower	75	44	43
Land			**131**	**33**	**100**

2.1.2. Effect using ULVA sprayer on volume median diameter and number of droplets with applaud 25% SC (Buprofezin):

Table (7) showed that the effect using ULVA sprayer on volume median diameter (µm) and number of droplets (N/cm²) at 18.4 L/fed. spray rate. The volume median diameter and number of droplets on upper and lower surface for the card on artificial was (78 and 78 µm) and (81 and 53 N/cm²), respectively. While, the upper and lower surface for the cards on leaves of the plant (right, middle and left) was (89, 76 and 90µm), (63, 73 and 54 µm) and (64, 76 and 54 N/cm²), (40, 48 and 44 N/cm²), respectively. Meanwhile, the volume median diameter and number of droplets on upper surface for the card on the land 109 µm and 26 N/cm² respectively.

Table (7): The effect used ULVA sprayer on volume median diameter (VMD) and number of droplets (N/cm²) with applaud 25% SC (Buprofezin).

Spray receptors	Spray direction	Place the spray card	VMD (µm)	N/cm²	N%
Wire	Artificial	Upper	78	81	60
		Lower	78	53	40
Plants	Right	Upper	89	64	62
		Lower	63	40	38
	Middle	Upper	76	76	61
		Lower	73	48	39
	Left	Upper	90	54	55
		Lower	54	44	55
Land			**109**	**26**	**100**

2.2. Electric battery sprayer (Hydraulic atomization technique):

Generally, the obtained results showed that the volume medium diameter and number of droplets decreased on lower surface and increasing on upper surface for artificial and plants, while increases the volume medium diameter and decreased the number of droplets on the land loss with two types of pesticides.

2.2.1. Effect using electric battery sprayer technique on volume median diameter and number of droplets with avenue 70% WG (Imidacloprid):

Table (8) showed that the effect using electric battery sprayer technique (Battery –operated knapsack motor sprayer) on volume median diameter (µm) and number of droplets (N/cm²) with using flat fan nozzle at 89.3 L/fed. spray rate. The volume median diameter and number of droplets on upper and lower surface for the card on artificial was (171 and 89µm), (58 and 30 N/cm²). While, the upper and lower surface for the cards on leaves of the plant (right, middle and left) was (165, 132 and 154µm), (80, 106 and 85 µm) and (58, 54 and 55 N/cm²), (27, 26 and 25 N/cm²), respectively. Meanwhile, the volume median diameter and number of droplets on upper surface for the card on the land was 215µm and 28 N/cm².

Table (8): The effect of using electric battery sprayer with flat fan nozzle (Ss83)) on volume median diameter (VMD) and number of droplets (N/cm²) at use Avenue 70% WG (Imidacloprid)

Electric Battery sprayer fitted flat fan nozzle (Ss83)					
Spray receptors	**Spray direction**	**Place the spray card**	**VMD (µm)**	**N/cm²**	**N%**
Wire	Artificial	Upper	171	58	66
		Lower	89	30	34
Plants	Right	Upper	165	58	67
		Lower	80	27	33
	Middle	Upper	132	54	68
		Lower	106	26	32
	Left	Upper	154	55	69
		Lower	85	25	31
Land			**215**	**28**	**100**

2.2.2. Effect using Electric Battery sprayer technique on volume median diameter and number of droplets with applaud 25% SC (Buprofezin):

Table (9) showed that the effect using hydraulic atomization technique (Battery–operated knapsack motor sprayer with flat fan nozzle) on volume median diameter (µm) and number of droplets (N/cm²) 89.3 L/fed. spray rate. The volume median diameter and number of droplets on upper and lower surface for the card on artificial when using flat fan nozzle was (163 and 80µm), (64 and 33 N/cm²) respectively. While, the upper and lower surface for the cards on leaves of the plant (right, middle and left) was (152, 154 and 158µm), (87, 85 and 85 µm) and (58, 53 and 56 N/cm²), (31, 31 and 36 N/cm²) respectively. Meanwhile, the volume median diameter and number of droplets on upper surface for the card on the land was 224 µm and 20 N/cm².

Table (9): The effect of used Electric sprayer atomization with flat fan nozzle (Ss83) on volume median diameter (VMD) and number of droplets (N/cm²) at use applaud 25% SC (Buprofezin).

Electric Battery sprayer fitted and flat fan nozzle (Ss83)					
Spray receptors	**Spray direction**	**Place the spray card**	**VMD (µm)**	**N/cm²**	**N%**
Wire	Artificial	Upper	163	64	66
		Lower	80	33	34
Plants	Right	Upper	152	58	65
		Lower	87	31	35
	Middle	Upper	154	53	63
		Lower	85	31	37
	Left	Upper	158	56	61
		Lower	85	36	39
Land			**224**	**20**	**100**

2.3. Conventional motor sprayer (Hydraulic atomization technique) with rate spray 330 L/fed.:

2.3.1. Effect using conventional motor sprayer on volume median diameter and number of droplets at use Avenue 70% WG (Imidacloprid):

Table (10) showed that the effect using Conventional Motor Sprayer technique on volume median diameter (µm) and number of droplets (N/cm²).The volume median diameter and number of droplets on upper and lower surface for the card on artificial was (520 and 162 µm) and (28 and 21 N/cm²), respectively. While, the upper and lower surface for the cards on leaves of the plant (right, middle and left) was (483, 459 and 460 µm), (135, 156 and 148µm) and (28, 24 and 27 N/cm²), (18, 20 and 17 N/cm²) respectively. Meanwhile, the volume median diameter and number of droplets on upper surface for the card on the land 518 µm and 19 N/cm², respectively.

Table (10): The effect used conventional motor sprayer technique on volume median diameter (VMD) and number of droplets (N/cm²) at use avenue 70% WG (Imidacloprid).

Spray receptors	**Spray direction**	**Place the spray card**	**VMD (µm)**	**N/cm²**	**N%**
Wire	Artificial	Upper	520	28	57
		Lower	162	21	43
Plants	Right	Upper	483	28	61
		Lower	135	18	39
	Middle	Upper	459	24	55
		Lower	156	20	45
	Left	Upper	460	27	61
		Lower	148	17	39
Land			**518**	**19**	**100**

2.3.2. Effect using conventional motor sprayer on volume median diameter and number of droplets at use applaud 25% SC (Buprofezin):

Table (11) showed that effect using Conventional Motor Sprayer technique on volume median diameter (µm) and number of droplets (N/cm²). The volume median diameter and number of droplets on upper and lower surface for the card on artificial was (504 and 167 µm) and (30 and 21 N/ cm²), respectively. While, the upper and lower surface for the cards on leaves of the plant (right, middle and left) was (478, 474 and 494 µm), (170, 184 and 152 µm) and (26, 18 and 28 N/cm²), (19, 21 and 21 N/cm²), respectively. Meanwhile, the volume median diameter and number of droplets on upper surface for the card on the land 519 µm and 18 N/cm², respectively.

Table (11): The effect used conventional motor sprayer technique on volume median diameter and number of droplets at use applaud 25% SC (Buprofezin).

Spray receptors	Spray direction	Place the spray card	VMD (µm)	N/cm²	N%
Wire	Artificial	Upper	504	30	59
		Lower	167	21	41
Plants	Right	Upper	478	26	58
		Lower	170	19	42
	Middle	Upper	474	18	46
		Lower	184	21	54
	Left	Upper	494	28	57
		Lower	152	21	43
Land			**519**	**18**	**100**

3. Drift:

The drift into adjacent land during application different techniques atomization on squash field was studied. Drift deposits of pesticide determined by volume median diameter (µm) and number of droplets (N/cm²). The determination was assayed on the cards land positioned at various distances from treated squash field (1, 2, and 3m). These results could be easily explained on the basis that wind speed during spray was 4 m/sec, relative humidity was (68-73%) and air temperature was (31-34°C). Tables (12 a and b) show that the greater drift within adjacent land showing detestable residues was observed during spray application followed by that of Hydraulic atomization (Conventional Motor Sprayer) and no drift ULVA Sprayer and Electric Battery sprayer with Ss83 with two types pesticides. Also, note that the drift tends to be greater with smaller droplets than with large droplets.

Table (12a): Effect used sprayer technique on drift work experiences at use avenue 70% WG (Imidacloprid).

Techniques	Equipment	Drift outside treatment								
		1m			2m			3m		
		VMD µm	N/cm²	% N	VMD µm	N/cm²	% N	VMD µm	N/cm²	% N
Centrifugal atomization	ULVA sprayer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hydraulic atomization	Electric battery sprayer with Ss83	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Conventional motor sprayer	80	33	51	76	18	28	35	14	21

Table (12b): Effect used sprayer technique on drift work experiences at use applaud 25% SC (Buprofezin).

Techniques	Equipment	Drift outside treatment								
		1m			2m			3m		
		VMD µm	N/cm²	% N	VMD µm	N/cm²	% N	VMD µm	N/cm²	% N
Centrifugal atomization	ULVA sprayer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hydraulic atomization	Electric Battery sprayer with Ss83	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Conventional Motor Sprayer	95	29	48	88	22	37	46	9	15

4. The amount of pesticide deposits of the applicator:

The evaluation of the amount of pesticide deposits operator body for spray techniques was based on number of droplets on the operator body legs, chest (right and left) and head.

4.1. Effect using spray techniques on the amount of pesticide deposits of the operator's body with Avenue 70% WG (Imidacloprid).

Results obtained in Table (13) indicated that, the highest average number of droplets per cm² operator's head was 21 N/cm² for hydraulic atomization (Conventional motor sprayer), while the other machines are zero N/cm². While, the highest average number of droplets per cm² operator's chest (right and left) was (32 and 58 N/cm²) and (11 and 20 N/cm²) for hydraulic atomization (Conventional Hydraulic Sprayer), (Electric Battery sprayer with Ss83), respectively. The obtained results showed also, the highest average number of droplets per cm² on applicator legs, right and left were 53 and 45 droplets respectively by Electric Battery sprayer with Ss83. In case of the ULVA sprayer were 35 and 40, respectively. While, the Conventional Motor Sprayer (right 28 and left 30).

Table (13): Contamination of applicator produced by spray different techniques with avenue 70% WG (Imidacloprid) at (2017 – 2018) seasons.

Equipment	Spray Volume (L/fed)	N/cm² (on head)	N/cm² (on chest)		N/cm² (on legs)	
			Right	Left	Right	Left
Electric battery sprayer with Ss83	89.3	0.0	11	20	53	45
		0.0%	8.53%	15.51%	41.08%	34.88%
ULVA sprayer	18.4	0.0	0.0	0.0	35	40
		0.0%	0.0%	0.0%	46.67%	53.33%
Conventional motor sprayer	330	21	32	58	28	30
		12.43%	18.93%	34.32%	16.57%	17.75%

4.2. Effect using spray techniques on the amount of pesticide deposits of the operator's body with applaud 25 % SC (Buprofezin):

Results obtained in Table (14) indicated that, the highest average number of droplets per cm² operator's head was 15 No./cm² for hydraulic atomization (Conventional Motor Sprayer) while the other machines are zero No./cm². While, the highest average number of droplets per cm² operator's

chest (right and left) was (33and 68 N/cm²) and (0.0 and 11 N/cm²) hydraulic atomization (Conventional Motor Sprayer), (Electric Battery sprayer with Ss83) respectively. The obtained results show also, the highest average number of droplets per cm² on applicator legs, right and left were 48 and 59 droplets respectively by Electric Battery sprayer with Ss83. In case of the ULVA sprayer were 44 and 37 respectively. While, the Conventional Motor Sprayer (right 31 and left 33).

Table (14): Contamination of applicator produced by spray different techniques with applaud 25 % SC (Buprofezin) at (2017 – 2018) seasons.

Equipment	Spray Volume (L/fed)	N/cm² (on head)	N/cm² (on chest)		N/cm² (on legs)	
			Right	Left	Right	Left
Electric battery sprayer with Ss83	89.3	0.0	0.0	11	48	59
		0.0%	0.0%	9.3%	40.7%	50%
ULVA sprayer	18.4	0.0	0.0	0.0	44	37
		0.0%	0.0%	0.0%	54.3%	45.7%
Conventional motor sprayer	330	15	33	68	31	33
		8.3%	18.3%	37.8%	17.2%	18.3%

5. Comparison between spray techniques:

Reviewing the obtained results for the tested spray techniques, cleary show that the spray was mainly number of droplets (spray deposit) on the upper surface of the leaves, while the lower surface the least received number of droplets (spray deposit) comparing between three spray techniques had values of percentage spray coverage on squash plants, loss on land, drift and contamination. Results obtained in Table (15) indicated that, the highest percentage coverage squash plants were 57.5 and 47 for centrifugal atomization (ULVA sprayer) and hydraulic atomization (Electric battery sprayer with Ss83) respectively. While, the highest percentage of drift with Conventional Motor Sprayer was 13.6 % the percentage of contamination was 14.3 and 32.2 % for centrifugal atomization (ULVA sprayer) and hydraulic atomization (Electric battery sprayer with Ss83) respectively.

Table (15): Percent of number of droplets /cm² on targets produced by ground sprayer with applaud 25 % SC (Buprofezin) insecticide against whitefly and aphid at (2017 – 2018) seasons.

Equipment	ULVA Sprayer		Electric Battery sprayer with Ss83		Conventional Motor Sprayer	
Spray volume (L/fed)	18.4		89.3		330	
Dose rate	Recommended rate					
Droplets spectrum / Target	N/cm²	% N	N/cm²	% N	N/cm²	% N
Artificial	134	23.6	97	17.2	51	11.5
Plants	326	57.5	265	47	133	30.1
Loss of land	26	4.6	20	3.6	18	4.1
Drift	-	0.0	-	0.0	60	13.6
Contamination	81	14.3	182	32.2	180	40.7

Results obtained in Table (16) indicated that, the highest percentage coverage squash plants were 54.1 and 50% for centrifugal atomization (ULVA sprayer) and hydraulic atomization (Electric battery sprayer with Ss83)

respectively. While, the highest percentage of drift with conventional motor sprayer and electric battery sprayer with Ss83 was 14.9 and 0% respectively. Meanwhile, the lowest percentage of contamination was 13.1 and 26.3% for centrifugal atomization (ULVA sprayer) and hydraulic atomization (Electric battery sprayer with Ss83) respectively.

Table (16): Percent of number of droplets /cm² on targets produced by ground sprayer with Avenue 70% WG (Imidacloprid) insecticide against whitefly and aphid at (2017 – 2018) seasons.

Equipment	ULVA Sprayer		Electric battery sprayer with Ss83		Conventional motor sprayer	
Spray Volume (L/fed.)	18.4		89.3		330	
Dose rate	Recommended rate					
Droplets spectrum / Target	N/cm²	% N	N/cm²	% N	N/cm²	% N
Artificial	154	27	88	18	49	11.2
Plants	309	54.1	245	50	134	30.7
Loss of land	33	5.8	28	5.7	19	4.4
Drift	-	0.0	-	-	65	14.9
Contamination	75	13.1	129	26.3	169	38.8

6. Efficiency of the applied insecticides against aphids and whitefly infesting squash plants:

Data in Table (17) showed that applaud 25% SC (Buprofezin) and avenue 70% WG (Imidacloprid) exhibited the same trend. The two insecticides achieved similar reduction present against aphid *A.gossypii*. In addition, Buprofezin showed slight increase in reduction percent compared to imidacloprid. Table (17) showed that the initial effect (after 24 hours) conducted the least reduction percent compared to the other periods. While the greatest effect was obtained after 7 days of application, followed by 15 day and 3 day, respectively. Similar trend was observed with *B. tabaci* whitefly, two tested insecticides showed similar reduction percent profile. With the least reduction percent initial and greatest reduction percent after 7 days. Table (18) illustrated the significant difference between buprofezin and imidacloprid in both *gossypii* and *B. tabaci*. The date in the table clarified that, there were no significant difference between the applied insecticides in both insects (at level. 0.05).

6.1. Effect of the used equipment on insecticides efficiency:

Based on the mean effect of the tested insecticides with reference to the used equipment, the obtained data were tabulated in Table (19). The results clarified that, ULVA sprayer was the most efficiencies sprayer and proved the heighted reduction percent. followed by electric battery sprayer with Ss83 nozzle and finally the conventional motor sprayer. The previous finding was consistent with the two applied insecticides with either A *gossypii* or *B. tabaci*: our finding gave a similar trend in relation to the impact of application equipment.

Table (17): Effect of applaud 25% SC (Buprofezin) on aphid *Aphis gossypii* and whitefly *Bemisia tabaci* infesting squash plants with various ground application techniques during Seasons (2017/ 2018).

Pesticide	Date	ULVA Sprayer	Electric battery sprayer with Ss83	Conventional motor sprayer
Avenue 70% WG (Imidacloprid)	**Aphids**			
	1 day	54.30± 3.79	47.73±7.03	46.6± 2.70
	3 day	76.95± 2.19	69.40± 5.68	67.1±1.34
	7 day	91.75± 1.11	85.51 ±4.25	82.6±2.62
	15 day	82.50± 3.88	73.31±5.20	62.0±5.83
	Whitefly			
	1 day	52.71±9.49	46.88±4.67	44.43±5.48
	3 day	73.67±7.47	64.46±12.26	66.38±5.93
	7 day	87.97±3.71	75.83±13.50	80.63±3.08
	15 day	81.16±3.83	78.79±8.93`	61.03±6.07
Applaud 25% SC (Buprofezin)	**Aphid**			
	1 day	54.01±3.34	47.69±10.16	46.38±6.75
	3 day	74.99±8.15	70.13±5.39	69.07± 4.77
	7 day	88.46±4.39	88.54±2.92	82.84±2.90
	15 day	80.98±3.34	73.79±7.39	64.52±3.34
	Whitefly			
	1 day	51.56±9.56	46.54±7.40	43.73±7.23
	3 day	72.80±7.84	68.60±5.32	68.60±5.32
	7 day	86.83±4.64	80.06±3.93	80.06±3.93
	15 day	80.43±4.17	61.05±2.28	61.05±2.28

Table (18): Significant difference between buprofezin and imidacloprid.

Pests	Pesticide		Sig*
Aphid	Avenue 70% WG (Imidacloprid) 71.47(70.25-72.69)	Applaud 25% SC (Buprofezin) 72.43(71.12-73.64)	0.27
whitefly	Avenue 70% WG (Imidacloprid) 70.14(68.65-71.63)	Applaud 25% SC (Buprofezin) 70.68(69.20-72.16)	0.61

Table (19): Interaction between buprofezin pesticide and equipment on the mortality.

Pesticide	Equipment	Mean ± S. E	95% Confidence Limit
Applaud 25% SC (Buprofezin) aphid	ULVA Sprayer	74.61±1.33	(71.96-77.25)
	Electric Battery sprayer with Ss83	70.04±1.37	(67.32-72.75)
	Conventional Motor Sprayer	65.70±1.37	(62.99-68.42)
Applaud 25% SC (Buprofezin) whitefly	ULVA Sprayer	72.90±1.67	(69.59-76.22)
	Electric Battery sprayer with Ss83	68.03±1.67	(64.72-71.35)
	Conventional motor sprayer	63.36±1.67	(60.05-66.68)
Avenue 70% WG (Imidacloprid) aphids	ULVA Sprayer	76.62±1.33	(73.98- 79.27)
	Electric battery sprayer with Ss83	68.99±1.37	(66.27-71.70)
	Conventional motor sprayer	64.55±1.37	(61.83-67.26)
Avenue 70% WG (Imidacloprid) whitefly	ULVA sprayer	73.88±1.63	(70.64-77.11)
	Electric battery sprayer with Ss83	66.49±1.67	(63.18-69.81)
	Conventional motor sprayer	63.12±1.67	(59.80-66.43)

Table (20) explained the significant difference between the used equipment the statistical analysis explained that, there were significance difference between all the tested equipment. As a result, to the previous finding, the used equipment's affect and contribute significantly in the success of pest control.

Table (20): Significant difference between the used equipment.

(I) equipment	(J) equipment	Sig.[b]	
		Aphid	whitefly
Conventional motor sprayer	Electric battery sprayer with Ss83	.002	.018
	ULVA sprayer	.000	.000
Electric battery sprayer with Ss83	Conventional motor Sprayer	.002	.018
	ULVA sprayer	.000	.000
ULVA sprayer	Conventional motor sprayer	.000	.000
	Electric battery sprayer with Ss83	.000	.000

6.2. Significance of the main factors:

Table (21) showed that in either aphids or whitefly the tested pesticides exhibited non-significance difference with P value of 0.276 and 0.611 for aphids and whitefly, respectively.

Oppositely, equipment exhibited high significance difference with P value of 0.00 and 0.00 for the insects. Similarly, Time showed the same degree of significance with both insects.

The interaction between pesticides, equipment and time Table (21) exhibited non-significant difference with both aphid and whitefly with P value of 0.10 and 0.24 for aphids and whitefly, respectively.

Table (21): Significant difference between machines, time and pesticide.

Pesticide	0.276	0.611
Equipment	0.000	0.000
Time	0.000	0.000
Pesticide * Equipment * Time	0.10	0.24

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