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Comparison between electrostatic spraying and traditional ground spraying techniques by using certain insecticides on *Thrips tabaci* (Thysanoptera: Thripidae) infesting onion in Qalubiya Governorate

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Abstract:

The present work was carried out to determine quality, spray deposited on the plant, lost spraying by drift and lost spraying on ground between plants. As well as the biological efficiency produced with possibility of using the least amount of pesticides to reach the highest efficiency against controlling *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) on onion crop. The used ground equipment were knapsack motor mist blower sprayer with shear unit (79 L/fed.), knapsack blower sprayer with electrostatic charging unit (42 L/fed.), rotary hand held sprayer (18 L/fed.), knapsack hydraulic hand held sprayer (56 L/fed.) and conventional ground motor sprayer with two spray guns (578 L/fed.). Marshal insecticide was used for controlling onion thrips (*T. tabaci*) infesting onion fields with recommended dose during season 2017. In the second season 2018 marshal and chinook insecticides were used with recommended doses and 3/4 recommended dose during season 2018. In the second season 2018 experimental results showed that, the highest mortality rate for *T. tabaci* infesting onion was revealed by knapsack motor mist blower with electrostatic unit spraying 95 % followed by knapsack mist blower motor sprayer with its shear unit, rotary hand held sprayer, knapsack hydraulic hand held sprayer and conventional ground motor sprayer with spray gun were 93, 91, 77 and 72 %, respectively. The lowest drift spray was done from electrostatic knapsack motor sprayer 42 L/fed. and the highest drift spray was done from rotary sprayer 18 L/fed. Conventional ground motor sprayer revealed the worst equipment in lost spraying in ground about 44% from spraying volume was lost on ground, but the best equipment saving lost spraying on ground was electrostatic Agrimondo 15.5% from spraying volume; also revealed 20% from droplets deposition on both sides of onion leaves, also pneumatic knapsack sprayer with electrostatic unit revealed a lowest drift spray but the highest equipment revealed drift spray was rotary spinning disk matabi.

Introduction

Onion had been one of the most important crops grown in Egypt for domestic use and exportation. The total area of onion were (113118 fed.) with a total production of (1504081) tons with an average of (13.3) tons per fed. Economic Affairs Sector Ministry of Agriculture (2010/2011). The volume of exports of onion crop was 669,358 thousand tons, which was equivalent to 19.4% of the total exports of the European Union as the average period (2009-2013) (Abdel- Hamid *et al*., 2016). Onion had been one of the important crops in the medical industry. Onion was important source of the rapetic agents containing active principles mainly in the form of cysteine derivatives. It contains enzymes acting possess and diabetic (Augusti, 1996). Onion thrips *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) had been a key insect pest of onion and other *Allium* species in many parts of the world (Lewis ,1997). *T. tabaci* was destructive, polyphagus pest of agricultural and other economically important crop plants (Sathe and Mithari, 2015). Thrips had been among the most important agricultural pests globally because of the damage inflicted by their oviposition, feeding and ability to transmit plant viruses (Stuart *et al.*, 2011). High populations of onion thrips can damage the leaves of onions (*Allium cepa* L.) in the field resulting drastic reducing in crop yields (Edelson *et al*., 1989). The climate condations played major role in increasing or decreasing the number of onion thrips in the field (Domiciano *et al.*, 1993). Thrips population correlated negatively with relative humidity and positively with temperature. A population of 10 thrips/plant and temperature around 29ºC coupled with dry season could cause serious damages to the onion crop. Due to climate changes occurring in the world, the temperature in Egypt during the onion season exceeds 30 ºC as the average temperature during the season so we can say that thrips is permanent pest according to our climate condations. Farmers were using chemical control as an integrated pest control against onion thrips. The using chemical control without awareness caused pollution to the environment, humans and farm animals (Foqué *et al*., 2012). Many growers also erroneously believing that high spray volumes and pressures had been need to obtain good plant protection. Therefore, we should studied the traditional and modern spraying machines to determine the optimum droplet size of the appropriate spray volume and the ideal spray coverage on the onion crop. The reasons to be achieved to ensure proper chemical control with less spray volume, reduced the loss as of pesticides on the ground and drifting spray, through testing certain recent ground equipment with comparison of traditional ground sprayers.

Materials and methods

1. Qualitative spraying techniques:

1.1. Field experiment and sampling:

Field experiments were conducted over two sucssive seasons. Second season field experiments were carried out during season 2018 on 16th March in private onion field located at Qaha, Qalyubiya Governorate. The onion cultivated was (*Allium cepa* L.). The experiments were done under local meteorological conditions of 22ºC temperature, relative humidity 75% RH. and 2 m/sec.wind velocity. The selected areas of 2.0 feddans were split into 20.0 plots and control plot. The areas of each plot were about 400m², spraying operations have not been done with any insecticides before execution the field experiment. The experimental field was divided into ten plots were sprayed with recommended dose rate, ten plots were sprayed with ¾ recommended dose rate and one treatment left without spraying as a control with two insecticides (Marshal 25% WP) common name carbosulfan were sprayed at the recommended rate (150 gm. / 100 L.) and 3/4 recommended rate (112.5 gm. / 100 L) and (Chinook 35% SC) common name imidacloprid were sprayed at the recommended rate (250 cm. / 100 L.) and 3/4 recommended rate (187.5 gm. / 100 L) . The spraying equipment were rotary hand held sprayer (Spinning-disc, MATABI)® (18 L/fed), knapsack motor mist blower sprayer with electrostatic (Spectrum electrostatic 3010 head)® (42 L/fed.), knapsack hydraulic hand held sprayer (MATABI)® with the nozzle types, 4 holes hollow cone nozzles (56 L/fed.), knapsack mist blower sprayer (AGRIMONDO)® with (shear nozzle) i.e normal unit (79 L/fed.) and conventional ground motor sprayer with spray gun (Wisconson)® ground motor (578 L/fed.), respectively.

1.2. Calibration and performance adjustment of the tested equipment:

The calibration of the equipment used in spraying application was done in the laboratory to fulfill the technical needs of the required field tests, the program of calibration tests for ground spraying equipment suggested by **Gabir (1995)** was applied as follows:

$$Q = \frac{T \times Rw \times Vo}{252}$$

Where:

Q=Flow rate (L/ min.).
T=Spraying Volume (L/ fed.).
Rw=Effective run width (m.).
Vo=Working speed (Km/h)
252=Constant value

and measure the swath width, using water sensitive papers (Novartis cards)® , with a minimum spot diameter of 100 micron (VMD) was calculated with each of the tested sprayers at 0.5 meter as spray height and average walking speed 2.4 km/h i.e 40.0 meter/min. Daily rate of performance fed. /day was counted as the following equation by Hindy (1992).

$$\text{productivity (fed/h.)} = \frac{60 \times \text{swath width}(m) \times \text{working speed (m/min)}}{4200}$$

Where:

4200 (m²) = the area of one feddan.
60= Constant number to turn the values from minutes to hours.

Rate of performance (fed. /day.) =Productivity (fed. /h.)×*2/3×*6 hours.

Where:

*2/3= The time of actual spraying minus from it the time consumed in going and returning to the field during the spraying and the time consumed in feeding spray solution in spray tank
*6 hours = number of daily spraying working hour.

I.3. Quantity of insecticides:

Out of Techno- operational data of ground application techniques used in Table (1) determined the quantity of insecticides (Marshal 25% WP) and (Chinook 35%SC) with recommended doses and 3/4 recommended doses per feddan for each unit to applied spraying on onion field to control the (*T. tabaci*) data in Tables (2 and 3).

Table (1): Techno- operational data of some ground application techniques used against controlling *Thrips tabaci* on onion crop during season 2018.

Equipment	Tank capacity(L)	Spray volume (L/fed)	Flow rate (L/min)	Swath width (m)	Productivity (fed/h)*	Rate of performance (fed/day)*
Rotary sprayer	1	18	0.172	1.0	0.57	2.3
Knapsack motor sprayer with electrostatic unit	20	42	2.0	5.0	2.9	11.6
Hydraulic sprayer	20	56	0.807	1.5	0.86	3.4
Knapsack blower sprayer with normal unit	20	79	3.75	5.0	2.9	11.6
Conventioal ground motor sprayer	600	578	11	2.0	1.1	4.4
Type of Spraying	**Target spraying in all treatments**					

***Calculations of productivity and rate of performance after Hindy (1992).**

Table (2): Quantity of insecticide for used (Marshal 25% WP) with recommended doses and 3/4 recommended doses used against controlling *Thrips tabaci* on onion crop during season 2018.

Equipment	Quantity of insecticide (gm. / fed.) recommended doses	Quantity of insecticide (gm./ fed.) 3/4 recommended doses
Rotary sprayer	30	22.5
Knapsack motor sprayer with electrostatic unit	66	49.5
Hydraulic sprayer	84	63
Knapsack blower sprayer with normal unit	120	90
Conventional ground motor sprayer	**882**	**661.5**

Table (3): Quantity of insecticide used (Chinook 35% SC) with recommended doses and 3/4 recommended doses used against controlling *Thrips tabaci* on onion crop during season 2018.

Equipment	Quantity of insecticide (cm. / fed.) recommended doses	Quantity of insecticide (cm. / fed.) 3/4 recommended doses
Rotary sprayer	53	40
Knapsack motor sprayer with electrostatic unit	105	79
Hydraulic sprayer	136.5	102
Knapsack blower sprayer with normal unit	210	158
Conventional ground motor sprayer	1449	1087

I.4. Collection and measurement of lost spray on ground:

Before spraying each onion field treatment, a sampling line was consisted of five wire holders fixed in diagonal line with distance (2.0) meters between each holders inside each treatment to collect spraying chemicals between plants; each wire holder top has a water sensitive paper (Novarits cards)® on it. Also each five onion plants, was put at distances the water sensitive paper cards at the same height as the onion plant and on the ground to calculate the spray droplets slipping from the leaves of the onion plants. Receptors were fixed in the experiments were designed after Hindy (1989). Number and size of blue spots (deposited droplets) on water sensitive papers were measured with a special scaled monocular japanese lens (Struben)® with a magnification power of 15x with an accuracy of ±25 micrometers. The diameter data of the spots were corrected with the knowledge of the spread factor, and converted to actual volume mean diameter (VMD), and the number of droplets in one square centimeter according to Gabir (1995).

I.5.Collection and measurement of spray drift:

During spraying each onion field treatment, a sampling line was constructed of eight wire holders fixed in straight line with down wind trend outside each treatment to collect spraying drift; each wire holder top has two water sensitive paper (26 x 76 mm) (Novartis cards)® on it one horizontal position the other at vertical position. The holders were placed in straight line with a distance of 50 cm between the each others by a long distance of 4 meter. All cards were collected and transferred carefully to the laboratory for measuring and calculated the drift droplets in all treatments by a special scaled monocular Japanese lens (Struben)®

1.6.Bioassay procedure:

Filed experiment was conducted on onion field highly infested with insect *T. tabaci*. Insects were active on onion leaves and their number exceed the critical economic limit. In order to evaluate the tested compounds on onion thrips, pre-treatment count was recorded at onion field. Plants at random for each treatment, each treatment was divided into four replicates, in which five plants were randomly examined to calculate the number of moving thrips individuals fallen from the plant on white paper and posttreatment count was recorded after 1,7 and 12 days after treatment onion thrips and control treatment. These calculations were done before and after the treatment.In the field experiment results were calculated according to **Henderson and Tilton (1955).**

Results and discussion

1. Spray coverage and mortality:

Data from Table (4) and Figures (1 and 2) were revealed that, relationship between spray coverage of certain ground equipment and reduction percentages of onion thrips sprayed by marshal recommended dose insecticide during season (2018). It was noticed that, no significant difference between initial spraying and mean of residual spraying mean at rotary matabi sprayer 18 L/fed., knapsack motor sprayer with charging unit 42 L/fed and knapsack motor sprayer with normal unit 79 L/fed. the initial and mean residual were 98, 96, 91, 94, 93 and 95%, respectively. But a drastic efficiency of marshal recommended dose the low value of reduction percentages were mortality with conventional ground motor sprayer (578 L/fed.) and hydraulic matabi sprayer 56 L/fed. The initial and mean residual were 63, 76, 67 and 68% respectively. Data on Table (4) and Figures (3 and 4) showed that, the relationship between spray coverage of certain ground equipment and reduction percentages of onion thrips sprayed by marshal ¾ recommended dose during season (2018). It was found that, no significant difference between initial spraying and mean of residual spraying at rotary matabi sprayer 18 L/fed., knapsak motor sprayer with charging unit 42 L/fed. and the same equipment with shear unit 79 L/fed. The initial and residual mean were 93, 94, 87, 89, 90 and 92%, respectively, with droplet spectrum ranged between 55-62µm (VMD) droplets sizes and (222-265) droplets/cm². But it was noticed that, the same initial and mean residual was reaveled in hydreulic matabi was 76% and 76%. But in case of conventional ground motor sprayer initial and mean residual were 63% and 76% respectively the droplet spectrum was differantly distribution than recent sprayers which ranged 116-385 µm (VMD) as droplet sizes and 52-68 droplets/cm² . these phenomena of asmmitrical droplet distrbution lead to the poor results in bio-residual activity of marshal ¾ recommended dose with hyduralic equipment.

Table (4): Relationship between spray coverage of certain ground equipment and reduction percentages of onion thrips *Thrips tabaci* sprayed by marshal insecticides recommended dose and 3/4 recommended dose during season 2018.

Days after spraying / Equipmet	Insecticides	Spray volume (L/fed)	Initial spraying after 24 hours	Residual spraying mean	VMD	N/cm²
Rotary sprayer	Marshal recommended dose	18	98 %	96 %	58	228
	Marshal ¾ recommended dose		93 %	94 %	60	222
Electrostatic sprayer	Marshal recommended dose	42	91 %	94 %	47	265
	Marshal ¾ recommended dose		87 %	89 %	55	241
Hydraulic sprayer	Marshal recommended dose	56	67 %	68 %	119	60
	Marshal ¾ recommended dose		76 %	76 %	116	68
Knapsack blower sprayer	Marshal recommended dose	79	93 %	95 %	53	280
	Marshal ¾ recommended dose		90 %	92 %	62	265
Conventional ground motor sprayer	Marshal recommended dose	578	63 %	76 %	370	50
	Marshal ¾ recommended dose		63 %	76 %	375	52

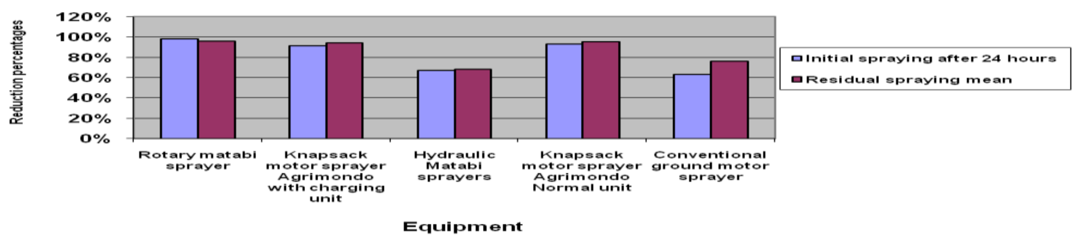
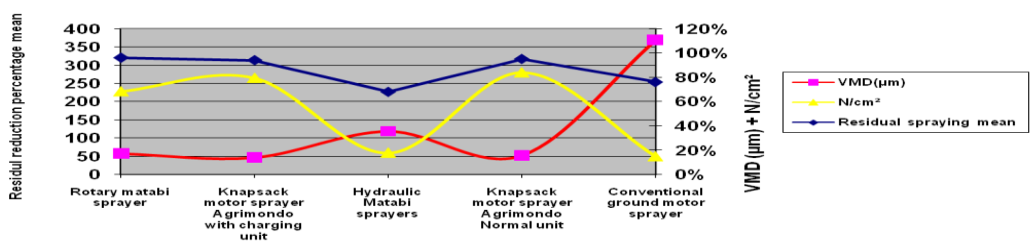


Figure (1): Relationship of reduction percentages and different spraying volume of certain ground equipment for insecticides marshal recommended dose during season 2018.



Figue (2): Relationship between percentage reduction means and distribution coverage of certain ground equipment for insecticides marshal recommended dose during season (2018).

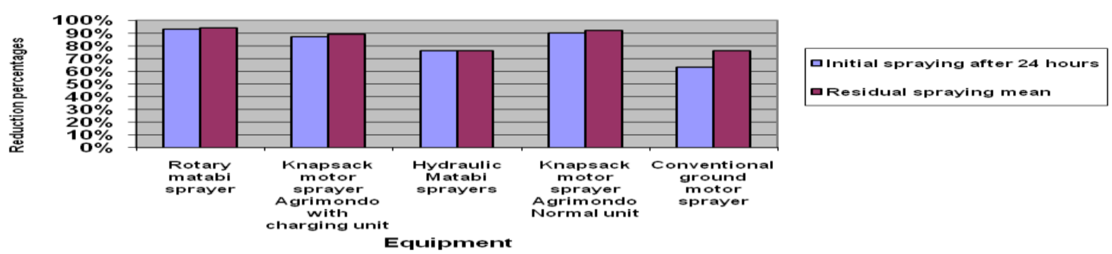


Figure (3): Relationship of reduction percentages and different spraying volume of certain ground equipment for insecticides marshal 3/4 recommended dose during season 2018.

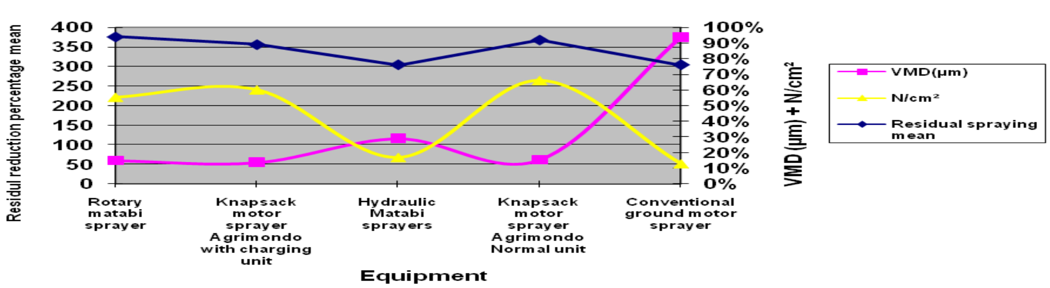


Figure (4): Rrelationship between percentage reduction means and distribution coverage of certain ground equipment for insecticides marshal 3/4 recommended dose during season 2018.

Data in Table (5) and Figures (5 and 6) illustrated that the relationship between spray coverage of certain ground equipment and reduction percentages of onion thrips sprayed by chinook recommended dose during season (2018). It was found that in recent sprayers like rotary matabi sprayer 18 L/fed., initial spraying and residual spraying mean were 99 and 96%, respectively. But knapsack motor with charging unit and normal spraying mean 92, 93, 95 and 95%, respectively. On other hand, hydraulic matabi 56 L/fed. and conventional ground motor sprayer reaveled initial spraying and residual spraying mean as 88, 77, 65 and 80% respectively. Data in Table (5) and Figures (7 and 8) illustrated the relationship between spray coverage of certain ground equipment and reduction percentages of onion thrips sprayed by chinook ¾ recommended dose during season (2018), in recent equipment rotary sprayer and knapsack motor sprayer with charging unit and normal unit there was no significant differences between initial spraying and residual spraying means the reduction percentages were 96, 93, 94, 90, 93 and 92%, respectively. But in hydraulic matabi and conventional ground motor sprayr the reduction percentages were 90, 75, 63 and 75%, respectively.

Data in Tables (4 and 5), illustrated that, there was no significant differences between recommended dose and ¾ recommended dose with resent equipment. It was mean that, it could be sawed 25% of the price of insecticides used in controlling *T. tabaci* and save the agriculture environment from pollution with using recent machine to control thrips pests. Data also showed that, there were no significant results between initial spraying after 24 hours and residual after 7 days and 12 days after spraying in recent sprayers. But a drastic differences between initial and residual spraying in both of conventional ground motor sprayer and hydraulic matabi sprayer these data agree with Smith and Goodhue, 1945), Potts and Garman (1950) and Gabir (1975 and 1995).

Table (5): relationship between spray coverage of certain ground equipment and reduction percentages of onion thrips sprayed by chinook insecticides recommended dose and 3/4 recommended dose during season 2018.

Days afterspraying Equipment	Insecticides	Spray volume (L/fed)	Initial spraying after 24 hours	Residual spraying mean	VMD	N/cm²
Rotary sprayer	Chinook recommended dose	18	99 %	96 %	55	230
	Chinook ¾ recommended dose		96 %	93 %	61	220
Electrostatic sprayer	Chinook recommended dose	42	92 %	93 %	50	258
	Chinook ¾ recommended dose		94%	90 %	52	260
Hydraulic sprayer	Chinook recommended dose	56	88 %	77 %	120	66
	Chinook ¾ recommended dose		90%	75 %	125	70
Knapsack blower sprayer	Chinook recommended dose	79	95 %	95 %	60	271
	Chinook ¾ recommended dose		93 %	92 %	65	264
Conventional ground motor sprayer	Chinook recommended dose	578	65 %	80 %	375	58
	Chinook ¾ recommended dose		63 %	75 %	380	60

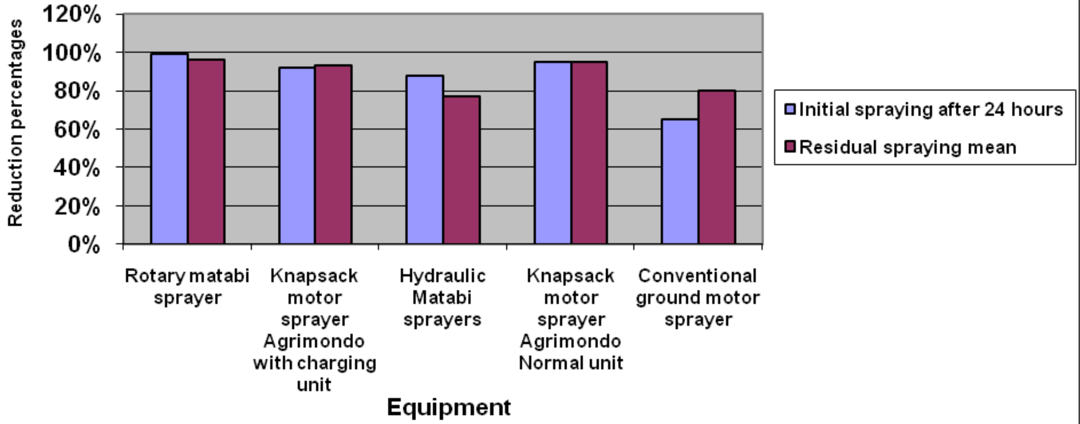


Figure (5): Relationship of reduction percentages and different spraying volume of certain ground equipment for insecticides chinook recommended dose during season 2018.

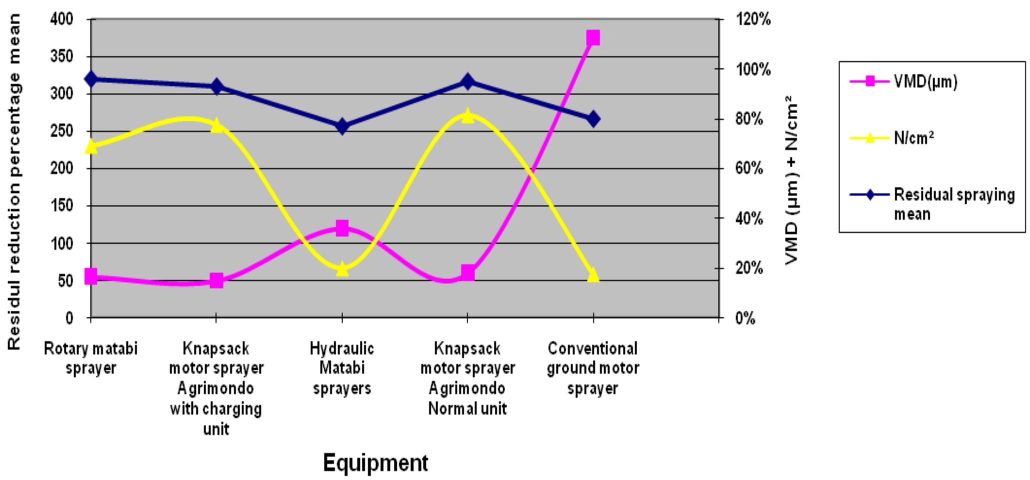


Figure (6): Relationship between percentage reduction means and distribution coverage of certain ground equipment for insecticides chinook recommended dose during season 2018.

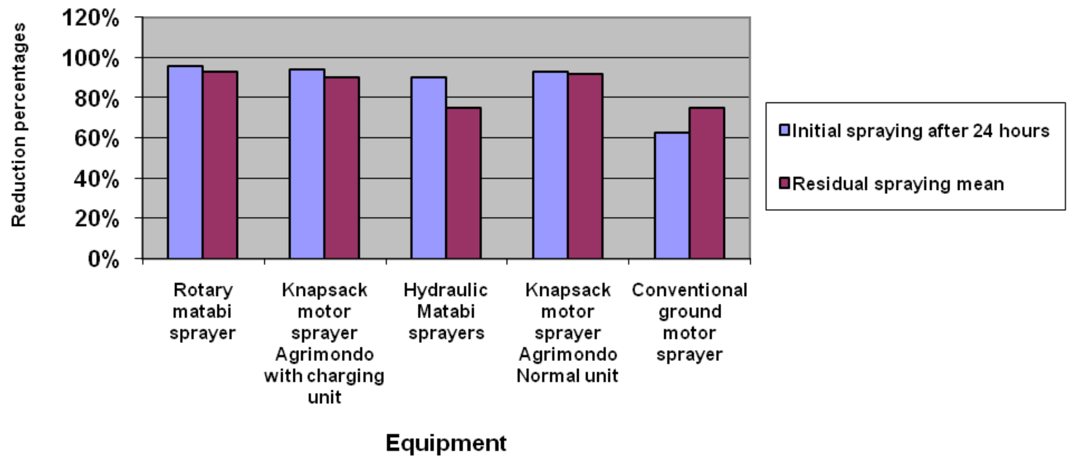


Figure (7): Relationship of reduction percentages and different spraying volume of certain ground equipment for insecticides chinook ¾ recommended dose during season 2018.

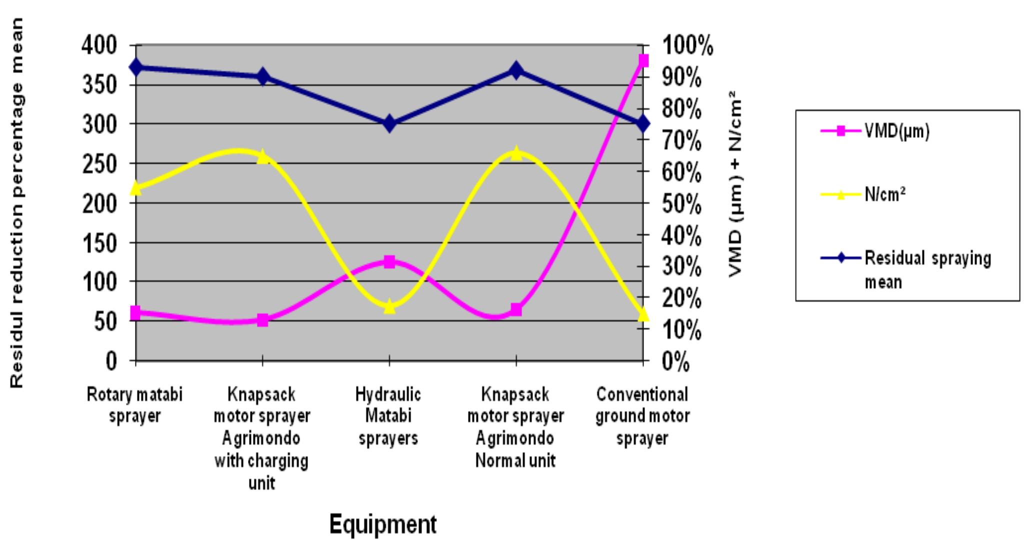


Figure (8): Relationship between percentage reduction means and distribution coverage of certain ground equipment for insecticides chinook 3/4 recommended dose during season 2018.

2. Drift:

Drift spray measurements for certain equipment under field conditions during season 2018 as shown in Table (6) and Figures (9-14), the front of at each treatment with down wind direction watery sensitive papers were put at 0.5m until 4.0 meter to collect the drift spray resultant from each tested ground sprayers, data showed that, the highly drifted sprayer was rotary matabi (spinning disk) sprayer 18 L/fed. drift distance was 3.5m down wind of the treatment. But the lowest drift spray distance was in case of knapsack motor sprayer with charging unit, the drift distance was 1.0m from spraying treatment, the short distance of drift due to the electrostatic foresees which controlled the movement of droplets sizes and captured its at the target spraying and the effect of wind was weak effect due to the charging power of droplets keep its on target spray directly. This results agreed with Mattwes (1989), Celen *et al.* (2009), Gitirana Neto *et al.* (2015) and Jaferi *et al.* (2018). Drift spray measurements were hydraulic matabi sprayer and knapsack motor sprayer Agrimondo with normal unit (Sheear nozzle). The drift distances were 3.0m down wind and the conventional ground motor sprayer was 1.0 m from treatment the short distance due to the of drift spray was big volumes droplets falls terminal velocity of vertically and the wind velocity could not easily to horizontal direction down wind. Therefore the big amount of lost spray of conventional motor sprayer was between the plants on ground and contaminated the local area treated with lost spray on ground. This data agreed with Gaber (1975) and Hindy *et al*. (1991).

Table (6): Spray drift of certain ground equipment during season 2018.

Equipment	Spray volume (L/fed)	Drift distance (m)	General mean	
			VMD (µm)	N/cm²
Rotary sprayer	18	3.5	46	35
Electrostatic sprayer	42	1	50	8
Hydraulic sprayer	56	3	109	56
Knapsack blower sprayer	79	3	50	73
Conventionalground motor sprayer	578	1	150	177

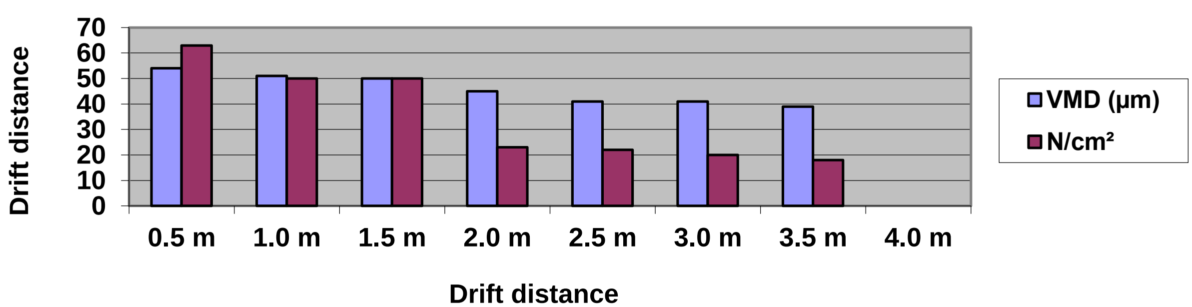


Figure (9): Drift rotary matabi sprayer.

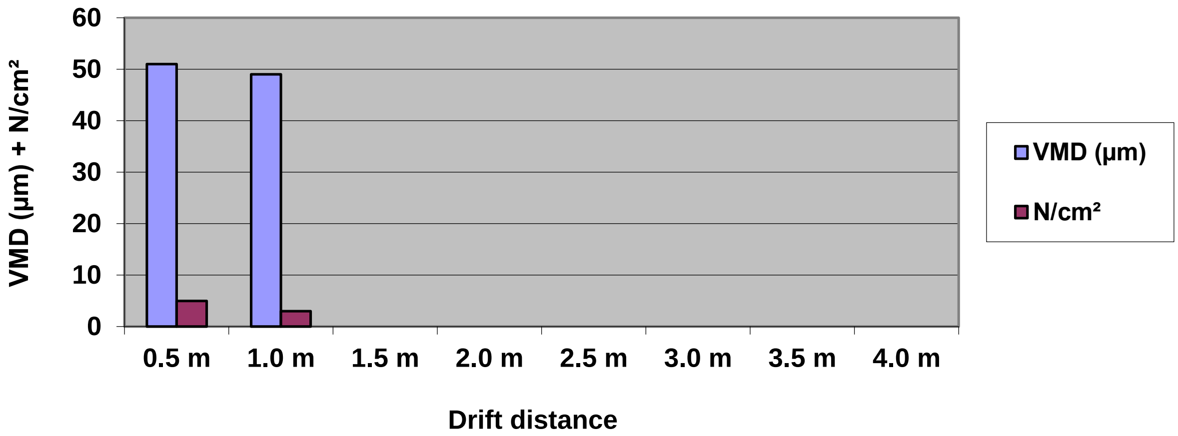


Figure (10): Drift knapsack motor sprayer Agrimondo with charging unit.

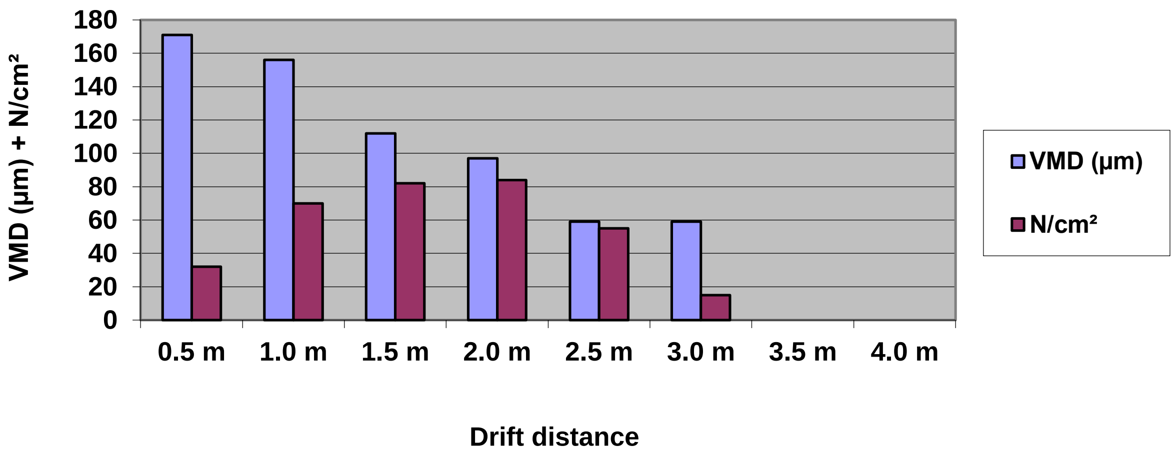


Figure (11): Drift hydraulic matabi sprayers.

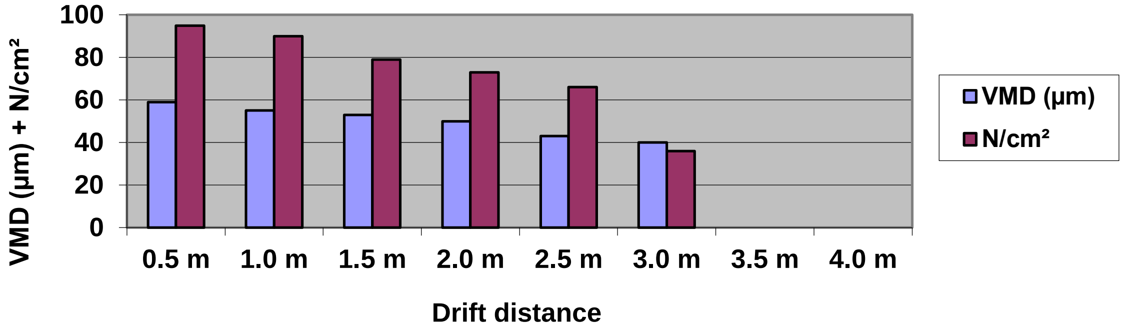


Figure (12): Drift knapsack motor sprayer Agrimondo normal unit.

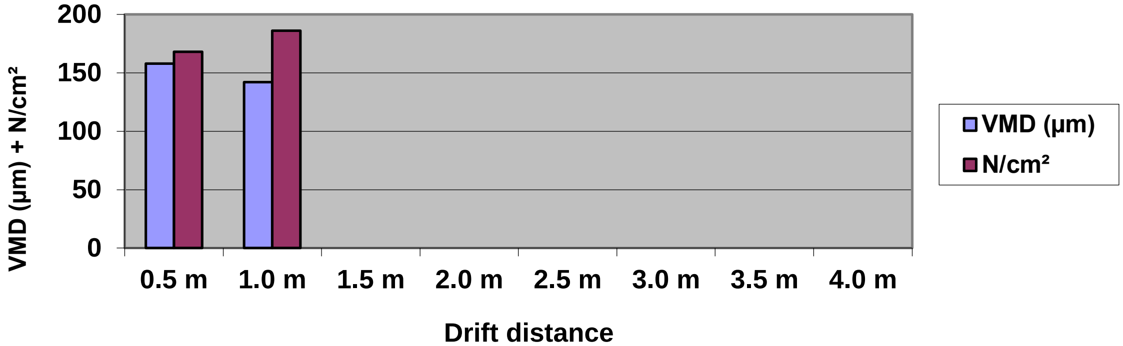


Figure (13): Drift conventional ground motor sprayer.

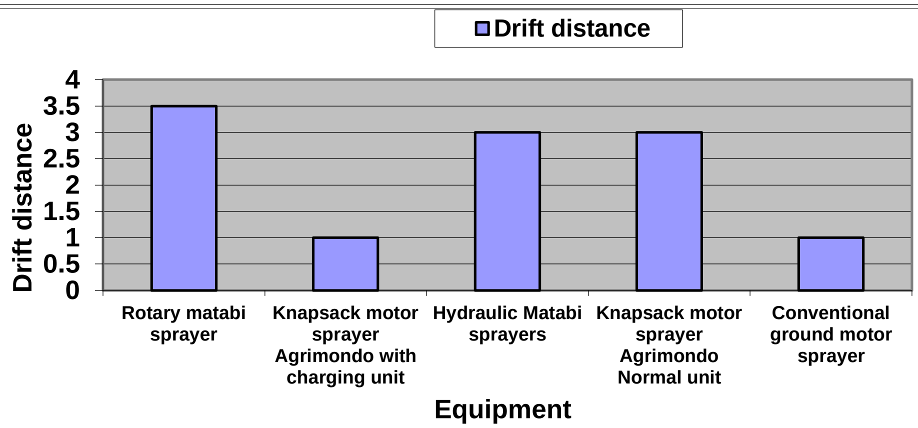


Figure (14): Relationship of drift distance between equipment.

3. Spray mass:

Data in Table (7) and Figures (15 a,b,c,d and e) illustrated that, percentages of spray mass on onion plant, lost spray on ground and the drift by using marshal and chinook recommended and ¾ recommended doses by certain ground equipment during season 2018. The range of spray coverage on the onion plant was ranged from 79% by Agrimondo® with charging unit (24 L/fed.) and 26% by conventional motor sprayer (587 L/fed.). But in case of rotary matabi® sprayer (18 L/fed.) the coverage on the onion plant was 43%. On other hand the Agrimondo® with normal unit the coverage spray on onion plant was 51% and the hydraulic matabi® sprayer (56 L/fed.) the coverage spray on onion was 31%.

Table (7):Relationship between deposit on plant, lost spray on ground and lost spray by drift for sprayer equipment during season 2018.

Spray mass / Equipment	% of the spray mass on the plant	% of the lost spray mass on ground	% of the lost drift mass
Rotary matabi sprayer	43 %	52 %	5 %
Knapsack motor sprayer Agrimondo with charging unit	79 %	19 %	2 %
Hydraulic Matabi sprayers	31 %	46 %	23%
Knapsack motor sprayer Agrimondo Normal unit	51 %	38 %	11 %
Conventional ground motor sprayer	26 %	42 %	32 %

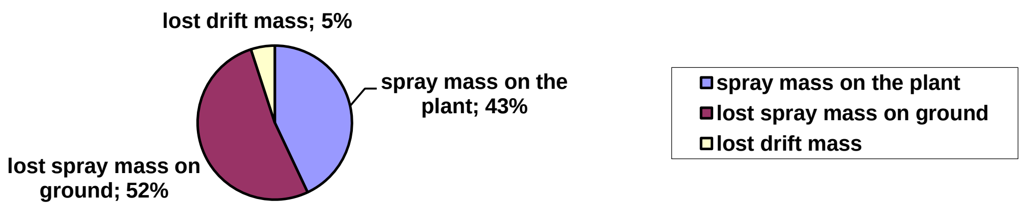


Figure (15a): Distribution of spray mass on the plant, lost on ground and the drift spray forrmatabi sprayer (18) L / fed.

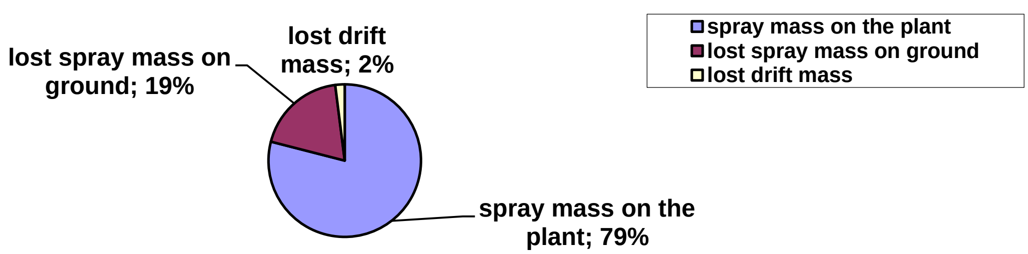


Figure (15b): Distribution of spray mass on the plant, lost on ground and the drift spray for knapsack motor sprayer Agrimondo with charging unit (42) L / fed.

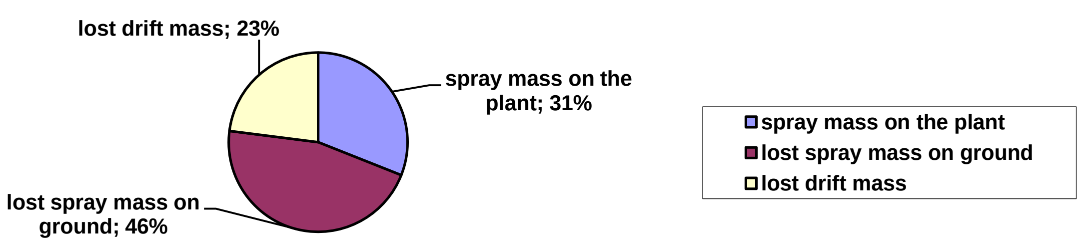


Figure (15c): Distribution of spray mass on the plant, lost on ground and the drift spray for hydraulic matabi sprayers (56) L / fed.

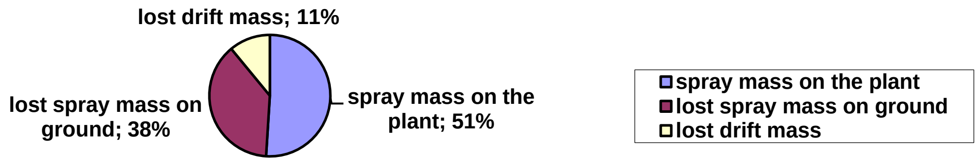


Figure (15d): Distribution of spray mass on the plant, lost on ground and the drift spray for knapsack motor sprayer Agrimondo Normal unit (79) L / fed.

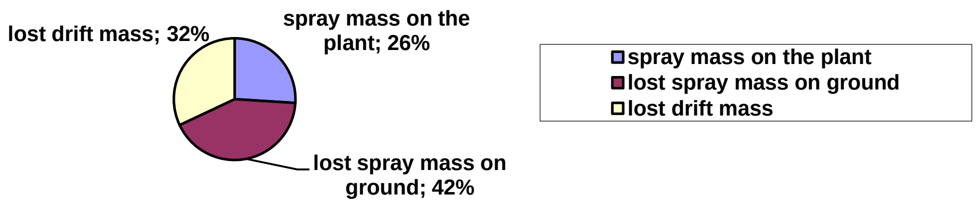


Figure (15e): Distribution of spray mass on the plant, lost spray on ground and the drift spray for conventional ground motor sprayer (578) L /fed.

Data showed that, there was great relationship between droplet (i.e. decreasing droplet sizes (VMD) and increasing number of s given a high efficiency of insecticides used against thrips on onion. It must be controlled with low volume spraying machines reneged from 18-42 L/fed. Through using electrostatic and pneumatic energy or both of them or by using centrifugal energy by spinning disc sprayer the worst bad quality spray and a poor efficiency of bio residual activity of insecticides sprayed had been revealed through using hydraulic energy through ground motor spray or hand held hydraulic spray. Data also showed that, there was no significant differences between recommended doses and ¾ recommended doses with recent equipment. It could saved 25% of the insecticides prices used in controlling thrips and saving agricultural environment from pollution on land and air.

From another side, data found that, there was no significant results between initial spraying after 24 hours and residual spraying after spraying 7 days and 12 days by resent sprayer and hydraulic matabi sprayer. Also, data showed a lowest drift spray was resulted from electrostatic sprayer, but the biggest drift spray was resulted from rotary matabi spinning disc. Similar result had been obtained from using two insecticides with recommended and ¾ recommended dose with using the same five tested spraying techniques. So, a sati's factory spray coverage, as well as lost spray on ground between plants and drift spray outside the treatment with down wind were determined. Data showed that the ideal spray quality on onion crop, and a highest reduction of lost spray on ground was about 15.6%. and a least spray drift out side the treatment was electrostatic Agrimondo sprayer, but the worst equipment was conventional ground motor sprayer was 44.6% as lost spray on ground due two a big droplets, amount of water and a high operational pressure used.

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