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EVALUATION OF SPRAY COVERAGE OF MISCIBLE OIL ON CITRUS TREES BY MEANS OF AERIAL AND GROUND APPLICATIONS

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Abstract

The present work was carried out to evaluate the quality of spray produced by Mi-2 helicopter and conventional motor sprayer using rates of application 40.0 and 2400 L/fed, respectively. A summer oil (Masrona super oil) was used for controlling red scale insect, Aonidiella aurantii (Order : Homoptera Fam : Diaspididae) and the white fly, Dialeurodes citri (Fam : Aleyrodidae) on sweet orange trees. Due to sufficient down wash created by the helicopter, good spray coverage coinciding to a great extent with the distribution of infestation on the treated trees resulted. The spectrum of oily droplets deposited on citrus trees was bigger in size with 11% and with about 50% less in number than the watery droplets that were recorded under airstrip conditions due to the viscosity factor. The average size and number of droplets collected under airstrip and orchard conditions were 340, μm-60 droplets/cm2 and 443, μm-33 droplets/cm2, respectively. The C.V. % of droplets distribution number on spray collectors was 48%.

The total spray lost on ground with aerial and ground application was 15% and 75%, respectively. A positive correlation was found between aerial spray coverage and the control of red scale insect wher mortality percentage increased 1% more by increasing the droplet size with 4.0 μm. The daily performance of motor sprayer and Mi-2 helicopter was about 3.0 and 500 fed./day, successively. The price of aerial spraying of one feddan by aerial means was cheaper by about 56% than the price of motor sprayer. In additon to reducing dose amount with low volume spray by helicopter to the fifth in comparison with motor sprayer. In general the helicopter was superior in controlling red scale insect on citrus than ground motor sprayer.

INTRODUCTION

Adjustment of spraying equipment to operate with proper parameters is one of the vital factors responsible for obtaining successful application and satisfactory biological and economical results. Due to washing of citrus trees, big amount of chemical, time, expenses and effort were lost (Carman, 1975).

The use of helicopter with lower rates in spraying orchards was tested and recommended by many authors such as Johnstone (1978), Witkowski (1978), Mochida et al. (1981), Helmy *et al.* (1984), Amsden (1986), Gabir (1991), and Helmy *et al.* (1994) where they confirmed the superiority of helicopter in comparison with fixed-wing aircraft.

In Egypt, big orchards are suffering from shortage of manpower required to operate ground equipments, thus encourged the interference of helicopter for compensation.

The present work is a comparative study to evaluate the spray coverage of a miscible oil on sweet orange trees Citrus sinenses using a (Mi-2) helicopter and a conventional motor sprayer. As well as, to assay the control results of both the red scale insect, Aonidiella aurantii (Mask.), and the white fly, Dialeurodes citri, (Ashmead). Amin (1970) and Helmy (1982) revealed that, the highest population of red scale insect occurred in the north east direction of the tree during August and the lowest in the south-east direction during May, where lower shady zone and central core of trees tend to harbour higher population, while the lowest population accumulated always on the upper most exposed zone of the tree. The photonegative reaction of the insect seems to be the most important factor regulating such distribution. Hall and Ford (1933) found that the red scale insect distribution was more dense on the dusty citrus leaves. Dickson and Lindgreen (1947) reported that, in winter the red scale insect prefered the southern side of citrus trees than the northern.

Oviposition and development of immature stages of white fly occurred underside the young leaves of citrus (Bullock and Brooks, 1975).

Helmy *et al.* (1996) found that, the distribution percentages of A.aurantii scouted and examined before spraying were 45%, 35%, and 20% on the upper, middle and lower levels of the orange tree, on both periphery and core. Most of the examined samples were found on the upper surfaces of leaves and orange fruits. Also, they found that the distribution percentages of Dialeurodes citri - before spraying - were 25%, 35%, and 40% on upper, middle and lower levels of orange trees. Majority of adults and nymphs on the tree periphery were observed on lower surfaces of leaves only.

MATERIALS AND METHODS

Two spraying tests were applied on sweet orange plantations in Sharkeya governorate, during December 1994. The percentage of green area to the total orchard area was about 70% and distances of cultivation was 3 x 7m.

The mean height and diameter of trees was 4.0 and 1.5 meters. A (Mi-2) helicopter was calibrated to deliver 40.0 l/fed. of summer light oil (Misrona super oil), with a dosage of ten litres of such oil emulsified in thirty litres of water. The obtained spectrum of droplets ranged between 180-550 micrometers (VMD) with a number not less than 30.0 droplets/cm2. Techno-Operational data of helicopter, and motor sprayer, as well as, the applied spray parameters are recorded in Table 1. Spray quality of helicopter's swath was determined under both airstrip and orchard conditions.

In airstrip, dyed watery spray-with Nigrosine 0.5% was collected on glossy white paper "Bendakote mounted on fifty receptors of 1.4 m. heigh consistuting the samping line. In orchard treatments, three cards of "Bendakote paper were fixed as a sandwich covering each leaf on the upper, middle and lower levels of three trees in a diagonal line. At each level, cards were mounted inside and outside the tree. Eight wire holders of 30.0 cm heigh, furnished with Bendakote cards were fixed on the ground surrounding each tested tree. The mean meteorological conditions during tests were suitable for spraying according to Yates et al (1963), and Trayford et al (1977). Measurements of the sprayed spots were done by a special scaled mono cular. Necessary corrections and calculation of droplets were carried out on basis of that given by Gabir (1993). Aerial spray coverage obtained under airstrip and orchard conditions were presented in Tables 2 and 3, respectively and the spray lost on ground between citrus trees was shown in Table 4.

RESULTS AND DISCUSSION

1. Qualitative determination of spray coverage

1.1 Standard aerial spraying of water in airstrip

Data in Table 2 showed that the oily droplets deposited on citrus leaves were sufficient in number and suitable in size to control both the red scale insect, Aonidiella aurantii and the immature stages of white fly, Dialeurodes citri. The mean number size of droplets (NMD/VMD) were 60.0/350 µm and 21.0/197 µm on the upper and lower cards surfaces, respectively. On the upper surface, there was a

Table 1. Techno-Operational data of Mi-2 helicopter and motor sprayer.

Mi-2 Helicopter			Conventional Motor Sprayer	
Item	Value	Remarks	Item	Value/Specification
Call sign	CCC P-2334		Model	Genar
Main rotor diameter, m	14.56		Nozzle Type	Spray gun-hollow cone
Operational speed, Km/h.	40.0 Km/h.	during test ± ~3	Spray Angle	Narrow angle
Rate of application 1/fed	40.0		Effective swath width (m.)	Washing technique
Run width, m.	30.0	Spray Height =3-6m.	Mean. flow rate, (1/min)	30.0
Nozzle type	D3-1.2	Hollow cone	Average working speed, (km/h)	1.2
No. of Nozzles	(21) front right (22) front left,		Spraying volume, (lit/fed)	2400.0
	(13) rear, (Tatal 56)1	Various spacing.	Operational pressure, Kg/cm2	20-30
Mean flow rate, 1/min	190.50		No. of Nozzle	two
Mean rate of performance (Fed / day).	500	For one pilot	Recommended oil dose/fed	48.0 1/fed
Quantity of oil/one load	150 lit.		Quantity of oil/one load (L).	24.0
Quantity of water/one load	450 lit.		Quantity of water / one load (L)	1176.0
Quantity of oil/fed	10.0		Mean rate of performance, fed/day	2.5-3.0
A/C flight direction	Head wind south west.		The cost of spraying. L.E./Fed.	25.0
Price of spraying LE/Fed.	14.0			

Table 2. Distribution of aerial watery spray on artificial collectors under airstrip conditions.

Receptor level Card position	Upper surface	Droplet spectrum			Lower surface	Droplet spectrum		
	Card position	N/cm2 (1)	% N/cm2	(2) µm.	Card position	N/cm2 (1)	% N/cm2	VMD µm (2)
Upper	Anterior vertical	70	19.4	425	Posterior vertical	20	18.9	230
	Upper horizontal	75	20.7	347	Lower horizontal	24	22.6	200
Middle	Anterior vertical	62	17.1	400	Posterior vertical	18	17.0	215
	Upper horizontal	51	14.1	326	Lower horizontal	23	21.7	180
Lower	Anterior vertical	53	14.6	350	Posterior vertical	21	19.8	158
	Upper horizontal	51	14.1	250	-----------	---	---	----
Average.		60		350		21		197

(1) N/cm 2 : Number of droplets/cm2

(2) VMD : Volume Mean Diameter, (µm).

Table 3. Distribution of aerial oily-spray on orange trees.

Tree Coverage	Tree periphery						Tree core					
	Upper surface			Lower surface			Upper surface			Lower surface		
	N/cm2	% N/cm2	VMD µm.	N/cm2	% N/cm2	VMD µm.	N/cm2	% N/cm2	VMD µm.	N/cm2	% N/cm2	VMD µm.
Upper North	44	33	462	21	38	260	27	31	400	10	30	250
South	34	26	300	18	32	250	25	29	350	12	36	180
East	33	25	500	8	15	270	20	23	450	6	18	200
West	22	16	511	8	15	190	15	17	550	5	15	280
Middle North	21	29	380	13	24	220	20	33	300	9	30	220
Sourth	14	19	365	19	35	156	17	29	380	12	40	200
East	21	28	480	7	13	300	14	23	500	3	10	220
West	18	24	460	15	28	150	10	15	530	6	20	180
Loer North	15	22	290	4	12	210	19	43	220	12	60	190
South	13	19	380	13	39	200	11	25	231	—	---	---
East	22	32	320	10	29	285	8	18	180	8	40	200
West	19	27	300	7	20	207	6	14	145	—	---	---
Mean Upper	33		443	14		243	22		438	8		228
Mean Middle	19		421	14		207	15		428	8		205
Mean Lower	17		323	9		226	11		194	10		195
Grand Mean	23		396	12		225	16		353	9		209

great tendency to catch bigger droplets allover the spray receptors, where one fourth of the total number of droplets were deposited on the lower surface with a significant reduction of 56% in their sizes.

The coefficient of variation (c.v. %) of droplets distribution number on spray collectors was 48%.

1.2 Aerial spray of miscible oil solution deposited on sweet orange trees

On basis of data recorded in Table 3 a significant decrease in number of droplets was found on citrus trees, in comparison to airstrip receptors. The average diameter of droplets deposited on citrus trees was bigger with about 11% than those collected on the airstrip receptors. This result could be attributed to the added viscous oil which alter the atomization process to create such spectrum of droplets.

The maximum number of droplets was recorded at the periphery of the trees, then it decreased gradually towards its center. About 55.0, 34.0 and 28.0 droplets/cm2 were deposited on the upper, middle and lower levels, respectively with average size (VMD) of 441.0, 425.0 and 259.0 μm, at the same arrangement. Both number and size of droplets found on the upper, middle and lower levels tends to decrease allover the trees.

Data in Table 4 showed that total aerial spray lost on ground was 15%. With helicopter application a successful control was achieved for pests that spent their lives on the tree canopy. The spray coverage was coincidental to a great extent with the distribution of infestation of red scale insects and white flies as mentioned by Amin (1970) and Bullock and Brooks (1975), respectively. A positive correlation was found between aerial spray and the control of citrus insects A.aurantii and D.citri, where mortality percentage increased by 1% more by increasing the droplet size with 4.0 μm.

1.3 Ground spray coverage on sweet orange trees

The diluted washing of trees obtained by motor sprayer was found to be non homogeneous due to such sort of drizzling and irregular ground speed. For scale insect control, the mature citrus tree required a spraying volume equal to its height (in feet) plus five litres. (Carman 1975).

Therefore, the spray gun should be adjusted to direct two thirds of the spray bulk to the upper half of the tree. It was difficult to determine the number and size of drizzles produced by the spray gun, as the majority of mounted cards were completely washed with the sprayed solution.

Table 4. Aerial spray lost on ground surrounding citrus trees.

Card Position	Horizontal level			Vertical level		
	N/Cm2	% N/cm2	VMD µm.	N/Cm2	% N/cm2	VMD µm.
North	15	27.2	347	13	37.1	268
South	23	37.0	292	6	17.2	292
East	14	22.5	583	4	11.4	437
West	10	16.3	362	12	34.3	434
Average	16	---	418	9	---	357

About one fourth of this bulk was composed from shapeless spots of 16 spots/cm2 ranged between 550-1200 µm in diameter. The main spray bulk was composed of big drizzles of more than 875 µm. The majority of spray bulk was subject to leakage from the tree to the ground. This trend agreed with findings of Carman (1975) and Helmy *et al.* (1994). Fig. 1 illustrated the aerial spray distribution of oily droplets on orange tree, the distribution percentage of infestation of pests and lost spray on the ground. Tabulated data and illustration indicates a certain conicidence between the distribution of oily droplets and the distribution percentage of infestation of *Dialeurodes citri* and *Aonidiella aurantii.*

2. General performance of (Mi-2) Helicopter and motor sprayer

Data presented in Table 1 indicated that, the mean daily performance of motor sprayer and Mi-2 helicopter was about 3.0 and 500.0 feddans successively under the tabulated techno-operational conditions. The price of spraying of one feddan by helicopter was cheaper than cost of ground spraying with 56% approximately.

CONCLUSION

It was evident that, low-volume application with helicopter offered tangible benefits in comparison with conventional ground application, as air-borne equipment having less general cost than ground spray units. With motor sprayer, about one

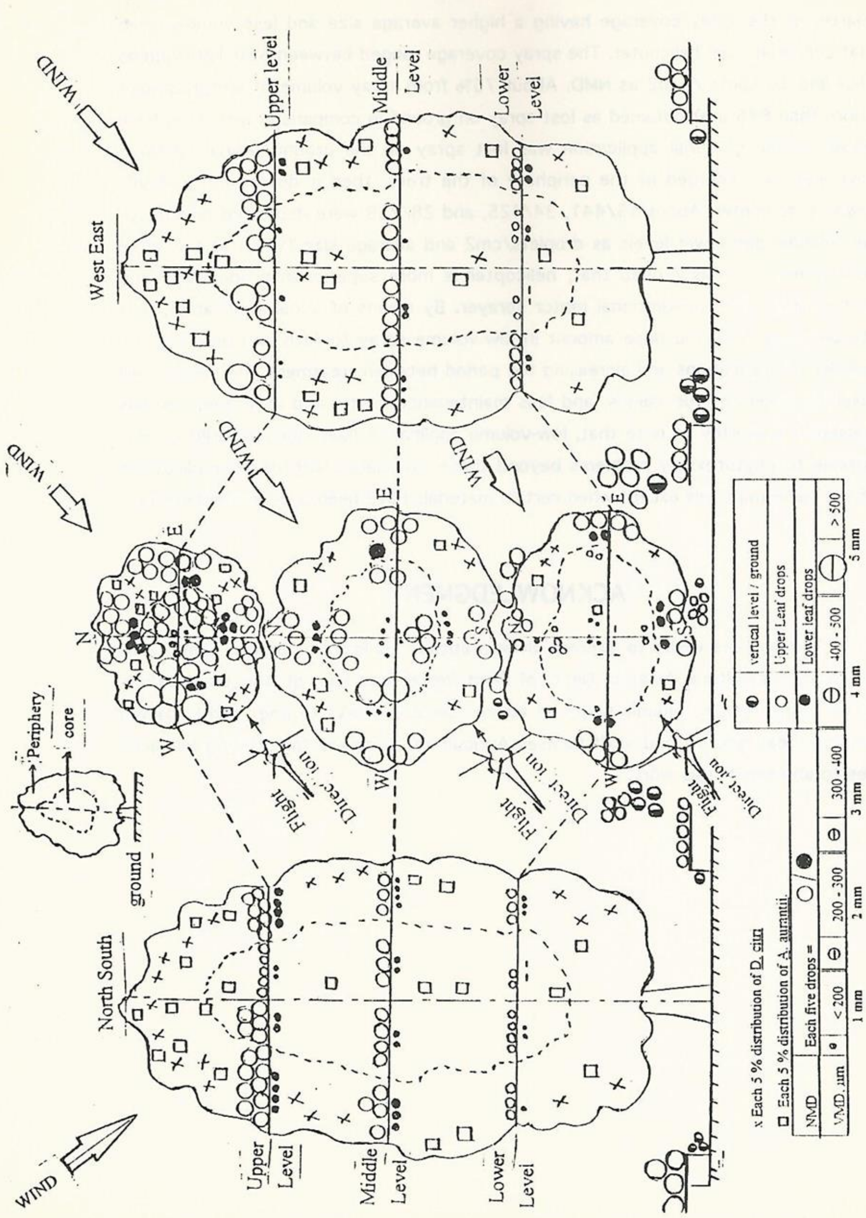

Fig. 1. Aerial spray distribution of oily droplets on orange tree, lost spray on ground and the distribution percentage of pests infestation.

quarter of the spray coverage having a higher average size and less number than that collected from helicopter. The spray coverage ranged between 550-1200 μm as VMD and 16 spots / cm2 as NMD. About 75% from spray volume of motor sprayer (more than 875 μm) obtained as lost spray on ground in comparison with 15% from spray volume of aerial application was lost spray on the ground. Aerial spraying coverage was recorded at the periphery of the trees, then it decreased gradually towards its center. About 55/441, 34/425, and 28/259 were deposited on the upper, middle, and lower levels as droplets/cm2 and average size (VMD) at the same arrangement. It was proved that, helicopter is more superior in productivity and performance than conventional motor sprayer. By means of aerial application, it is obvious that, reducing dose amount in low-volume spray to fifth and reducing the number of applications and increasing the period between treatment and harvest will result in lower residue values, and less maintenance costs, and less chemical was applied. It is worthy to note that, low-volume application have not appeared to predispose to phytotoxicity problems beyond those associated with dilute applications of the same materials except when certain materials have been used in combination.

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تقييم غطاء الرش بالزيت الصيفى الخفيف على اشجار الموالح بالوسائل الجوية والارضية

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تم تقييم كفاءة غطاء الرش الجوى الناتج من الطائرة العمودية (مى - ٢) بالمقارنة مع الرش الناتج من الموتور الارضى التقليدى وذلك باستخدام احجام رش ٤٠ ، ٤٢٠٠ لتر/فدان على التوالى من محلول الزيت الصيفى (سوير مصرونا) لمكافحة كل من الحشره القشرية الحمراء والذبابة البيضاء على اشجار الموالح فى مصر.

لقد تطابقت التغطية بالرش مع توزيع الاصابة على الاشجار المعاملة بالطائرة العمودية وذلك بسبب قوة اندفاع تيار الهواء المحمل بالرش بدرجة كافية والتى سمحت بعمل تقليب جيد للافرع وللاوراق مما أدى إلى الحصول على تغطية مرضيه على كل المستويات المختلفة للاشجار المعاملة.

كان طيف القطيرات الموجودة على اشجار الموالح اكبر فى الحجم بمقدار ١١٪ وأقل فى العدد عما سجل تحت ظروف المهبط باستخدام الماء ويرجع ذلك لزيادة نسبه لزوجة الزيت المعدنى المستخدم.

وجد أن متوسط أحجام واعداد القطيرات المجمعة تحت ظروف المهبط والحقل كما يلى ٣٤٠ ميكرون ، ٦٠ قطيرة / سم٢ ، ٤٤٣ ميكرون ، ٣٠ قطيرة / سم٢ على التوالى .

كانت النسبة المئوية لمعامل الاختلاف لتوزيع اعداد القطيرات ٤٨٪ فى حالة قطيرات الرش على مستقبلات الرش بالمهبط.

أما الفاقد من الرش على الارض تحت وحول الأشجار المعامله بالوسائل الجوية والأرضية فقد قدر بحوالى ١٥٪، ٧٥٪ من إجمالى حجم الرش لكل منهما على التوالى .

ظهر ارتباط موجب فى العلاقة بين الرش الجوى ومكافحة افات الموالح تحت هذه الدراسة حيث زادت النسبة المئوية للموت بمعدل ١٪ مع زيادة احجام القطيرات ٤ ميكرون .

وجد أن معدل الأداء اليومى فى التشغيل لكل من موتور الرش والطائرة العمودية مى - ٢ حوالى ٣ ، ٥٠٠ فدان / يوم على التوالى.

من الناحية الاقتصادية فان سعر رش الفدان الواحد بطائرات الهيلكوبتر يقل بمقدار ٥٦٪ من تكلفة رش الفدان بموتور الرش التقليدى.

باستخدام الطائرة العمودية امكن تحقيق خفض فى الجرعة المستخدمة من الزيت الى حوالى الخمس مقارنه بالجرعة العادية المستخدمة مع الوسائل الارضية مع تفوق الكفاءة الأبادية للحشرات لصالح الطائرة العمودية عن الموتور الارضى.