JOURNAL OF SOUTH VALLEY UNIVERSITY
FOR
ENVIRONMENTAL RESEARCHES

Combined effect of applied equipment and formulation of pesticide on spray and dust drift in relation to harmful effects for honeybees in Libya.

Farg A.Jabail* and Al sherif A. Ahmed

Faculty of Agriculture, Al-Jabal Algharby University, Libya

Abstract In Elhamronia Zone, Tripoli, Libya, field and laboratory studies were conducted in summer 2008 to investigate drift of Cyanophos applied on potato fields onto adjacent maize plants. Drift deposits of Cyanophos was determined as µg/kg maize leaves. The determinations were conducted on leaves of maize grown at various distances from the edge of the treated potato fields (i.e. 5, 8, 14. up to 51 m). Distances travelled by drift in the 1st spray were farther than those of the 2nd spray. This result could be easily explained on the basis that wind speed was higher in 1st spray (wind speeds were 3.8 and 2.6 km/hr during time of application in the 1st and 2nd sprays, respectively). The farthest distance within maize field reached by drift was observed for the dust application followed by micron ULVA and mistblower spraying

++(the distances were 26, 35 and 44 m in the first spray when using the mistblower, micron ULVA and the mistblower as a duster, respectively). The corresponding values of drift deposits were 18.5, 13.6 and 28.4 µg/kg maize leaves, respectively. The potential drift emitted by micron ULVA compared with that of mistblower may be due to the smaller droplets of the former sprayer. Drift of Cyanophos released by each of the tested equipment caused 100% mortality of honeybees placed at the distances 5 and 8 m from the edge of treated potato field. For the dust application, 100% mortality was observed at longer distances (14 and 17 m). The study suggests that buffer zones (no spray zones) have to be established downwind of the treated field to avoid environmental contamination due to off-target deposition of pesticide drift. The model and specifications of these zones depend variably on quality of spray, release height, wind speed and other factors. Other measures of drift mitigation have to be considered.

Keywords: Pesticide; Spray and dust drift; Equipment; Bees

Introduction

Pesticide application is an important activity in agricultural production. Methods of application and use of pesticides include liquid sprays, dusts and fogs. The most commonly of these used are aerial and ground spray. Spray application methods are the final controllable event in most pest control programs. The resulting degree of mortality and the use of pesticide, the degree of success or failure, and many of the long-term ecological consequences of pesticide use are a function of spray application methods. Application of foliar sprays is a complex process that includes such events as spray atomization, transport to the plant, impaction on plant surfaces and retention (Reichard et al., 1998). These processes all influence spray effectiveness. Thus, precision spray application appears to be a primary objective of both physical and biological-oriented scientists concerned with pesticide use allover

* Tel.: +218912126447
Email address: f.jabel@yahoo.com

the world. This concern has been expressed for better control by increasing target contact efficiency but not to increase the exposure of non-target organisms appearing in a pesticide applicator area. The optimum size for insecticide spray droplet is one of the most important and most elusive factors affecting the efficiency of insecticide spray. When small droplets are applied, coverage of the target (e.g. plant) may be improved. However, the small droplets increase drift potential, thereby increasing the possibility of adverse effects on surrounding plants and animals. The majority of pesticides continue to be applied as formulations diluted in water and sprayed under pressure through hydraulic nozzles. These sprays consist of or very wide range of droplet size and in consequence, the larger droplets influenced by gravity are mostly deposited fairly close to the point of release (Matthews, 1995) and fail to attain the required coverage and distribution on the plant surfaces. As Cooke et al. (1985) pointed out, hydraulic nozzles although biologically effective, are wasteful because large droplets may bounce off foliage. Controlled droplet size application (CDA) is a familiar term for means of spraying a uniform cloud of droplets of the correct size to give effective control of a pest with the minimum amount of pesticide and carrying liquid (Matthews, 1979). Spinning disc droplet generators fall into this category. The hand-carried spinning disc sprayers (e.g. micron ULVA) are designed especially for application of pesticides at ultra low volume rates of 1-5 L/h (Oudejans, 1991) and introduced in Egypt for water-oil based application on potato fields at rate 9.5 L/H. (Osman et al., 1994). Another type of spraying systems applying reduced volumes is air-assisting spraying. Air-assisted sprayers (e.g. the motorized knapsack mistblower) use air jets to carry pesticide droplets to the target position, to displace the air inside the crop canopy and to assist a uniform deposition of the pesticide droplets on the targeted surface (Sidahmed and Brown, 2001; Delele et al., 2005; DaSilva et al., 2006). In addition to the precision spray, offered by such equipments problems arising from the availability and transport of water can be alleviated by reducing dosage volumes during application. Dust application may be of a great concern in this respect particularly for rain-fed crops (Gupta and Katiyar, 1987; Bodhade and Agalave, 1991). However, reduced spray volumes require smaller droplets which are prone to drift and environmental contamination. The aim of this study was to evaluate the effect of applied equipment and formulation of pesticide on spray and dust drift during application onto maize plants grown adjacent to the treated fields in relation to toxicity of this drift to honeybees, when Cyanophos applied by two methods of application, i.e. micron ULVA and the motorized knapsack mistblower.

Materials and methods

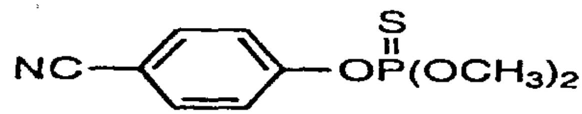
1. Insecticides used: Cyanophos:

Trade name: Cyanox 50% EC, Technical cyanophos 98.7% was used in the present study as well.

Manufacture: Sumitomo comp.

Source: provided by Founder of the Arab Federation For Agricultural Development.

Structural formula:



Chemical name: 0-4-cyanophenyl o,o-dimethyl phosphorothioate.

Molecular weight: 243

Rate of application: 2380 cm3/H.

2. Chemicals and other materials used:

Talc powder: Hydrated magnesium silicate, Mg3 SiO2 (H2O) 4. And aceton were provided by Founder of the Arab Federation for Agricultural Development.

3. Test organisms:

Honey bees:

Honey bees, Apis mellifera L. (first hybrid carniolan workers) were obtained from the special apiary of Elhamronia zone, Tripoli. Bees were directly transferred from the apiary to the site of experiments in small wooden boxes (each of 5 x 10 cm) covered with wire gauze.

4. Application equipments:

Two types of equipments each represented drift spraying were used, i.e. Micron ULVA and a motorized knapsack mistblower.To use the mistblower as duster, the inner part of the tank was thoroughly dried and the following components were removed: nozzle and spray tube, hose, plug and liquid strainer. The following parts were assembled: Ventilation distributor and the drainage socket. The powder flow was regulated by turning the dusting adaptor on the pleated hose.

5. Insecticidal formulations and their physico-chemical properties:

5.1. Preparation of Cyanophos in the laboratory as dust:

Cyanophos was prepared in the laboratory as 5% Dust. The impregnation method was used as described by Bishara and Hafez (1974) with minor modifications. The required amount of technical Cyanophos was dissolved in acetone (Technical grade). The solution was transferred gradually to the calculated amount of a talcum powder. This addition was carried out in a warring blender to ensure complete mixing and homogenization. The resultant slurry was quantitatively transferred and spread on a plain glass surface and left to dry at room temperature for ten hours. The semi-dried mass was then dried at 40oC for 24 hours by means of an oven, powdered and sieved through a 325 mesh standard sieve. The product was kept in tightly closed glass containers till use.

6. Drift studies:

Eight plots of potato, each of nearly (14 x 35 m) separated by non treated strips of potato cultivations each of (10 x 35 m) were designed to be adjacent to eight corresponding plots each of about (14 x 50 m) grown with maize and positioned downwind of potato field. The experimental plots of maize were also separated by strips of maize plants each of (10 x5 0 m). Cyanophos was applied on potato by three methods of applications i.e. micron ULVA, and the motorized knapsack mistblower as a sprayer and as a pulverizer. Two plats of potato corresponding to two plots of maize were specified for each type of application. The rest of plots were reserved as a control. Two applications of Cyanophos were performed, on 27/7 and 12/8. Heights of maize plants were 100-130 cm throughout the experimental period.

Samples of maize leaves (each of nearly 500 gm) were collected randomly from two rows of plants at each distance after each spray at various distances from the edge of treated potato and transferred to the laboratory in plastic bags. Cages of bees was allowed to stand in their positions during and 24 hours after pesticidal application, thereafter mortality counts were recorded. Weather conditions obtained by Tripoli Station, are shown in Table (1).

Table (1): Weather conditions during field application for drift studies.

Date	Time of application	Air temperature (oC)	R.H. (%)	Wind velocity (km/h)
1st spray; 27/7	7-9 a.m.	25-28	51	3.8
2nd spray, 12/8	7-9 a.m.	26-29	59	2.6

6. Analysis:

6.1. Initial drift deposits on maize:

Dislodgeabile drift deposits of Cyanophos on maize leaves were determined. Samples of maize leaves collected from the field were divided into 200 gm representative sub-samples, which were chopped to small pieces. The method of extraction and clean up of Cyanophos was that described by Mukherjee and Gopal (1992) with some modifications. Each sub-sample was transferred to round-bottom flask containing 800 ml of acetone. Stoppered flasks were vigorously shaken by means of a mechanical shaker for one hour. The extracts were decanted into other clean flask and the chopped maize leaves were reextracted by the same procedure. The extracts were combined and evaporated under reduced pressure to 10 ml which were transferred along with a saturated solution of sodium chloride (150 ml) to a separating funnel. The resultant solution was extracted with hexane (3 x 50 ml). The combined hexane extract was passed on anhydrous sodium sulphate and concentrated to 5 ml then cleaned up via passing through a column prewashed with 50 ml of hexane + acetone (9: 1 v/v). The column was filled with acidic alumina (5 gm) + sodium sulphate (2 mg) and was eluate with 100 ml of a mixture of hexane + acetone (9: 1 v/v). The elute was evaporated to dryness and the residue was dissolved in 10 ml methanol and then analyzed by HPLC.

6.2. Chromatographic analysis:

Analysis was done using HPLC apparatus, Peckman att: 5, WL: 236, A.F. U.S.;l UV detector model Peckman 110b; the mobile phase: methanol, flow rate: 0.7 ml/min.

7. Statistical analysis: Statistical analysis of variance of the data was carried out according to Duncan's multiple range test (Duncan, 1955).

Results and Discussion

1Drift studies:

2.1. Drift of Cyanophos into adjacent maize plants:

The drift into adjacent maize plants during application of Cyanophos on potato fields was studied. Drift deposits of Cyanophos was determined as µg/kg maize leaves. Values were corrected with percent of recovery, which was found to be 87%). The determinations were assayed on maize leaves positioned at various distances from the treated potato fields (i.e. 5, 8, 11, and 14 up to 50 m). Results are recorded in Table (2).

Nd = Not detected

It is apparent that, in all methods of application distances travelled by the drift in the first spray were further than those of the second spray. This result could be easily explained on the basis that wind speed in the first spray was higher than in the second one (3.9, 2.7 km/hr, respectively as previously mentioned). Wind speed plays an essential role for drift of pesticides (Briand et al., 2002; Gil and Sinfort, 2005). The farthest distance within maize field showing detectable residues was observed during dust application followed by that of micron ULVA and the mistblower spraying. At the first spray, distances reached by residues of Cyanophos to 26, 35 and 44 m when using the mistblower (sprayer), micron ULVA and the mistblower (duster), respectively. At the end of these distances, the corresponding values of mean deposits were 18.5, 13.6 and 28.4 µg/kg of maize leaves, respectively. At the second application, the distances were 20, 26 and 35 m corresponding to the initial deposits, 21.3, 12.6 and 43.2 µg/kg maize leaves respectively. At 5 m away of treated potato, the drift emission from the mistblower pulverizer was more potential than spray application (the mean of initial deposits was 124.3 or 215.1 µg/kg maize leaves for dust application versus 81.3-117.2 µg/kg maize leaves for spray application).

It is known that because dust particles are finely ground, they may drift long distances from the treated area and may contaminate off-target areas. In the current study it is obvious that spraying with micron ULVA is a greater contributor to drift than spraying with the mistblower. This is something logical because micron ULVA releases smaller droplets liable to drift. The relation between drift and droplet size was described by Niessen (1974) as shown in the table (3).

Table (2): Drift of Cyanophos into adjacent maize plants during its application on potato field by various methods.

Method of application	No. of spray	Mean initial deposit (µg/kg maize leaves) at distances (m) from potato field															
		5	8	11	14	17	20	23	26	29	32	35	38	41	44	47	50
Micron ULVA	1st	117.2	94.3	75.2	61.5	43.7	31.1	25.6	19.2	21.1	18.5	13.6	Nd	Nd	Nd	Nd	Nd
Micron ULVA	2nd	81.3	87.3	63.3	51.2	41.8	33.6	25.1	12.6	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Mistblower (sprayer)	1st	109.1	80.3	63.5	41.7	45.6	31.1	23.3	18.5	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Mistblower (sprayer)	2nd	118.2	64.5	44.3	23.9	19.8	21.3	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Mistblower (pulverizer)	1st	215.1	158.2	163.3	152.9	118.8	123.1	114.3	102.3	91.6	93.2	69.3	73.5	49.6	26.4	Nd	Nd
Mistblower (pulverizer)	2nd	124.3	105.1	84.3	73.5	89.3	101.0	75.1	78.3	83.2	64.2	43.2	Nd	Nd	Nd	Nd	Nd

Nd: Not detected

Table (3): Relation of drift to droplet size (Niessen, 1974).

Droplet diameter (µm)	Velocity of fall (cm/sec)	Drift distance (m)
10.0	30	20
96.6	28	21.4
93.8	26	22.7
[illegible]	18.9	31.7
[illegible]	[illegible]	111

From this table it is obvious that the distances travelled by the droplets as drift increases with decreasing their sizes. Droplets of smaller size can remain suspended in the air for long periods and drift long distances. Drift is not limited to liquid applications, light weight dusts are also very susceptible to drift. In all cases it is necessary to make non spray buffer zones with certain specifications to protect water courses and non target organisms whenever pesticides are applied.

2.2. Effect of Cyanophos drift on non-target organisms:

Simple test was designed to predict drift of Cyanophos following its application by various methods to bees and fish located on the ground under maize plants at various distances from the edge of the treated cotton fields. Cages of bees or containers of fish were allowed to stand in their positions during and 24 hr after pesticidal application, thereafter, mortality counts were recorded.

2.2.1. Toxicity of drift to honeybees:

Results are recorded in Table (4). It is evident that apart from the mistblower spraying, the application of Cyanophos released drift at a distance of 14 m away from the edge of treated cotton resulting in 100% mortality of bees. The drift emitted from dust application was more powerful, especially in the 1st spray where 24.5% mortality of bees was observed at a distance of 35 m. In the first spray, zero mortality was detected at distances 20, 32 and 41 m when using the

Table (4): Toxicity of Cyanophos drift against honey bees during and 24 h after application on potato field.

Methods of application	No.of spray	% mortality honey bees placed at distances (m) from potato field															
		5	S	11	14	17	20	23	26	29	32	35	38	41	44	45	49
Micron ULVA	1st	100	100	100	100	89.5	69.5	39.5	17	4.5	0	0	0	0	0	0	0
Micron ULVA	2nd	100	100	100	100	67.0	47.0	27.0	0	0	0	0	0	0	0	0	0
Mistblower (spray)	1st	100	100	64.5	42.0	17.0	0	0	0	0	0	0	0	0	0	0	0
Mistblower (spray)	2nd	100	84.7	29.5	7.0	0	0	0	0	0	0	0	0	0	0	0	0
Mistblower (pulverizer)	1st	100	100	100	100	100	100	77.0	74.5	54.5	47.0	24.5	4.5	0	0	0	0
Mistblower (pulverizer)	2nd	100	100	100	100	100	64.5	47.0	44.5	27.0	7.0	0	0	0	0	0	0
Control	1st	7.5	7.0	4.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Control	2nd	2.5	4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0

mistblower sprayer, and the mistblower (duster) respectively. In the second spray, these values were 17, 23 and 32 m, respectively. Thus, it seems that wind speed (higher in 1st spray) plays an important role as a contributor determining drift profile. The higher levels of drift observed for micron ULVA or the duster are easily explained based on their production of smaller droplets (or pine particles drifting longer distances. Davis and Williams (1990) estimated the distance at which bees would encounter an LD_{50} dose from spray drift during application by ground methods. They found that at a wind speed of 4 m/sec, maximum LD_{50} distances were ≤ 40 m. An unusual case was reported by Morse and Gunnison (1967) where poisoning of honeybees placed in area 1.25 miles from an area being air-sprayed with carbaryl. Death of bees may be caused by drift of chemicals on hives, crops or water. When drift occurs onto crops where bees are foraging the problems are similar to those for cases involving direct spraying. According to Peach (2006), drift occurs from nearly all spray or dust Applications of pesticides from a short distance to miles downwind. Pesticide dusts drift farther than sprays. Pesticides applied by plane usually drift farther than those applied by ground equipment. On the other hand dusts are usually more hazardous to bees [illegible]

usually significantly reduces injury to bees. Moving bees one mile away from the treated field reduces bee kill by 60%. Based on the earlier discussion, data of the present study reveal that equipments like mistblower and especially for micron ULVA, inspite of being advantageous and efficient for insect control, it may pose deleterious effects on non-target organisms due to their emission of a potential drift onto field boundaries. To make full use of these equipments, buffer zones (no sprayed zones) have to be set downwind of the treated fields. A buffer zone (also known as no spray zone) is an area in which direct application of the pesticide is prohibited; this area is specified in distance between the closest point of direct pesticide application and the nearest boundary of a site to be protected. The obtained data in the present study are considered insufficient to suggest the specifications of these zones. No theoretical basis exists to justify buffer zone at a given field (De Schampheleire et al., 2007).

Buffers may be based on many variables e.g. type and quality of spray, release height and others such as wind speed. De Snoo and deWit (1998) reported that the creation of a 3 m wide buffer zone may lead to a 95% reduction in pesticide deposition on the adjacent [illegible] for the protection of aquatic ecosystems. In some cases there is an obligation to use buffer zones (or conservation headlands) in combinations with other drift mitigation measures. The environmental contamination due to off-target of pesticide droplets can be minimized by using optimum design and operating parameters of sprayers Examples are drift reducing nozzles, shielded spraying (using shields or shrouds or so-called tunnel spraying) (Sidahmed et al., 2004). Strips of hedgerows are also effective (Longley et al., 1997).

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الملخص العربي

التأثير المشترك لآلة التطبيق وتجهيزه المبيد على انجراف المبيد وعلاقة ذلك بالتأثيرات الضارة لشغالات نحل العسل في ليبيا

فرج علي جبيل ، الشريف أبو القاسم أحمد
كلية الزراعة- جامعة الجبل الغربي بالزاوية

دراسات حقلية ومعملية أجريت في منطقة الحمر ونية- طرابلس- ليبيا- في صيف 2008 لدراسة انجراف رذاذ أو حبيبات مبيد السيانوفوس إلى نباتات الذرة المنزرعة بجوار حقول البطاطا المعاملة على مسافات مختلفة . أوضحت النتائج اكتشاف رواسب الانجراف الأولية على نباتات الذرة على مسافات أطول في حالة الرشة الأولى عن مثيلتها في الرشة الثانية وربما يرجع ذلك إلى زيادة سرعة الرياح أثناء الرشة الأولى عنها في الرشة الثانية. ولوحظ أن أطول مسافة لوصول انجراف السيانوفوس كانت نتيجة لتطبيقه في صورة تعفير ثم تقل مسافة الانجراف بعد ذلك باستخدام الرشاشة ميكرون أولفا ثم المضخة ذو الحامل الهوائي وكانت هذه المسافات 44، 35، 26 متر على التوالي. وكانت كميات الرواسب الأولية للانجراف عند هذه المسافات هي على التوالي 28.4، 13.6، 18.5ميكروجرام لكل كيلو جرام من أوراق نبات الذرة. وبصفة عامة وجد أن الإنجراف المنبعث من أي من الآلات المستخدمة يؤدى إلى 100 % قتل لأفراد حشرات النحل الموضوعة على مسافات 5 أو 8 متر من حافة حقول البطاطا المعاملة، وكانت هذه المسافة أطول بالنسبة لمسحوق التعفير(14 و 17 متر) . وتقترح الدراسة أن المضخة الحقلية ذات الحامل الهوائي تمثل الوسيلة الملائمة لتطبيق المبيدات على محصول البطاطا ويمكن التقليل من المخاطر الناجمة عن استخدامها بإتباع تدابير الأمان المعروفة . وبخصوص الانجراف أثناء التطبيق فإنه يقترح تحديد مناطق غير مرشوشة بجوار الحقول المعاملة ويتوقف تحديد مواصفات هذه المناطق على عوامل عديدة منها سرعة الرياح وارتفاعات الغطاء الأخضر في المنطقة ونوع آلة الرش المستخدمة وخلافه.

الكلمات المفتاحية:

مبيد ، إنجراف السائل والمسحوق ، الآلة ، نحل العسل.