CHEMICAL CARRIER COVERAGE - SOUTHWESTERN CORN BORER[1/] CONTROL IN CORN AND CROP OIL SPREADING ON VARIOUS CROPS[2/]

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ABSTRACT

Field studies were conducted to evaluate spray deposition and efficacy of pyrethroid and chlorpyriphos insecticides aerially applied using different carriers. The treatments included ultra-low-volume (ULV), 2.3 l/ha, applications with cottonseed oil (CSO) or soybean oil (SBO) and conventional applications using water at 28.0 l/ha or water plus a nonemulsified petroleum oil (NEPO). Droplets from ULV and conventional applications penetrated the canopy similarly, but there were more and larger droplets on plants sprayed with water or water-NEPO. In spite of the difference in droplet deposition, Southwestern corn borer (SWCB) control with ULV-pyrethroid applications using vegetable oil carriers were equal to chlorpyriphos and pyrethroid applications in water.

Laboratory data showed CSO and SBO drops spread similarly on a leaf surface. The manner and degree of spreading was influenced by the leaf venation and leaf structure. Droplets on leaves of cotton and soybean (dicot) and sorghum (monocot) increased ca. 1.6 times their original size, but droplets on corn leaves were increased 60 to 100 fold. The spreading ability of oil drops on a leaf surface may be a key factor contributing to the equivalent control with ULV-vegetable oil or water carrier applications.

INTRODUCTION

The economic situation of agriculture has prompted producers and aerial applicators to re-evaluate pesticide usage and make decisions based on the ever changing economic environment. To minimize expenses and/or to improve application efficacy, some applicators are using different chemicals, reducing spray volume (liters per hectare), and incorporating adjuvants with the insecticide carrier.

Aerial application of ultra-low-volume (ULV) and emulsifiable concentrate (EC) formulations of insecticides

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[1/] Lepidoptera: Pyralidae

[2/] Approved for publication as TA no. 21755 by Director, Texas Agricultural Experiment Station

were extensively researched during the late 1960's. The studies indicated that ULV applications improved chemical activity by providing better coverage, longer chemical persistence on the crop, and more efficient insecticide absorption by the pest (Wolfenbarger and McGarr 1971, Awad and Vinson 1968, Awad et al. 1967). Factors limiting ULV usage include poor spray deposition and nontarget contamination from drift (Smith and Burt 1970, Yates et al. 1967). Recently, there has been renewed interest to aerially apply insecticides ULV, particularly with cottonseed oil (CSO) or soybean oil (SBO) as the carrier of pyrethroid insecticides (Anonymous 1983). Matthews (1979) reported that the carrier utilized affects application efficacy and that vegetable oils were desirable carriers because of low volatility and low phytotoxicity. Currently, information regarding insecticidal activity, application deposits, and drift from ULV-vegetable oil applications is extensive for cotton and soybean crops (Hutchins and Pitre 1984, Ware et al. 1984, McDaniel et al. 1983, Southwick et al. 1983, 1986). ULV application with a vegetable oil has potential use in controlling Southwestern corn borer (SWCB) infestations with pyrethroid insecticides.

Application of other insecticides may require use of water as the chemical carrier. But, investigations have shown that spray evaporation (Amsden 1962) and drift (Ware et al. 1972, 1984) reduces a large portion of the spray from reaching the target crop. Research has shown that equipment adjustments and adjuvants can minimize these losses (Bouse et al. 1976, Yates et al. 1974, 1976). However, the greater height of corn and dense canopy can severely restrict penetration of the aerially applied sprays (unpublished data) which may limit the efficacy of insecticides applied either ULV with vegetable oils or conventionally with adjuvants. Studies from 1982 to 1984 were conducted to: 1) examine spray deposition on field corn with aerial ULV application of pyrethroids using vegetable oil (CSO and SBO) carriers and conventional (28.0 l/ha) application of chlopyriphos using water with and without a nonemulsified petroleum oil (NEPO), Sunspray® 11N, as the carrier and; 2) evaluate SWCB control with these applications. In addition, a laboratory study was designed to identify spreading of vegetable oil drops on leaf surfaces of cotton, soybeans, sorghum, and corn.

MATERIALS AND METHODS

Spray deposition and SWCB efficacy studies were conducted using aerial application of either a pyrethroid or chlorpyriphos with water, water plus petroleum oil, or ULV vegetable oil from 1982 to 1984. In 1982, Pioneer 3186 corn was planted on 0.76 m row spacing in a field at Hart, Tex. between 20 and 25 April 1982. On 1 March, 112 kg/ha of 18-46-0 fertilizer was preplant incorporated and on 10 May 269 kg/ha of N was sidedressed as anhydrous ammonia. Eradicane® at 6.6 kg (AI)/ha and atrazine at 0.56 kg (AI)/ha were preplant incorporated on 1 April. In 1983, Pioneer 3186 corn was planted 10 April in 1 m row spacings at

Sunnyside, Tex. Fertilizer was applied prior to planting using 224 kg/ha of 10-35-5 and then sidedressed with 336 kg/ha anhydrous ammonia. A pre-emergence application of atrazine at 2.24 kg (AI)/ha was applied for weed control. On 20 April 1984, Stauffer 7759 corn hybrid was planted on 1 m row spacings. Prior to planting, nitrogen was incorporated at 235 kg/ha, and on 10 May a postemerge application of atrazine was applied at 1.96 kg (AI)/ha. All fields were furrow irrigated with a minimum of six 7-10 day interval irrigations during the growing season.

Spray Deposition. A fluorescent pigment, Blaze orange Ax-15N or HiViz G-3014 yellow orange, was incorporated into each insecticide mixture at 12 gm/l to facilitate evaluation of spray deposition. Pigment was mixed with all insecticides on 3 August 1982 and with cypermethrin-water, cypermethrin-SBO, and chlorpyriphos-water (1.12 kg (AI)/ha) with and without a NEPO on 8 August 1983. Prior to each chemical application six water or oil sensitive papers (2.6 x 7.6 cm), attached to clothes pins with double stick tape, were placed on each of 10 corn plants per treatment. The six papers per plant were clipped onto the top, ear, and bottom leaves. Two papers per leaf were positioned over the upper and lower leaf surface mid-rib on the inner 1/3 of the leaf length. Plants were selected at random from the middle of each spray area. Shortly after spraying, papers were collected and taken to the laboratory to quantify spray deposition. Water or oil droplets from three 1-cm^2 areas per paper were counted and measured with the aid of an ocular micrometer in a microscope.

SWCB Efficacy. Insecticide treatments were applied to tasseled corn in 4.05 ha blocks (1982 and 1983) or in 3.23 ha blocks (1984). On 3 and 13 August, 1982, a Turbo Thrush airplane sprayed two swaths (26 rows/swath) while flying 3 m above the corn canopy at 225 kmph. Permethrin (2E) at 0.112 kg (AI)/ha was applied in water at 28.0 l/ha through a sprayboom at 2.1 kg/cm^2 equipped with 33 D8 nozzles. Permethrin (2E) and (4E) formulations were applied at 0.112 kg (AI)/ha in once-refined cottonseed oil (CSO) at 2.3 l/ha using 18 Teejet® 8002 nozzles at 2.8 kg/cm^2.

Aerial applications in 1983 were made on 8 and 17 August. Cypermethrin (0.045 kg (AI)/ha) was applied with water at 28.0 l/ha and with once-refined SBO at 2.3 l/ha. Chlorpyriphos (1.12 and 0.56 kg (AI)/ha) was applied in water in 28.0 l/ha with and without 2.3 l/ha of NEPO. Fenvalerate (0.14 kg (AI)/ha) was applied with 28.0 l/ha water and at 0.14 and 0.08 kg (AI)/ha in 2.3 l/ha SBO. The 0.14 kg (AI)/ha rate of fenvalerate in 2.3 l/ha SBO was applied only on 8 August. A Turbin Air Crusher airplane flying at 217 kmph, 3 m above the corn, sprayed two swaths (24 rows/swath) with chemical-SBO mixtures at 2.95 kg/cm^2 through a spray boom fitted with 22 Teejet® 8002 nozzles. A Cessna Ag Truck airplane flying at 185 kmph sprayed the chemical-water mixtures in three swaths (13 rows/swath) using 20 Teejet® 45 swirl nozzles with #12 orifices at 1.96 kg/cm^2.

Aerial applications in 1984 were fenvalerate (0.14 kg (AI)/ha) and chlorpyriphos (1.12 kg (AI)/ha) with 28.0 l/ha water, and chlorpyriphos (1.12 and 0.56 kg (AI)/ha) in water with 2.3 l/ha NEPO. On 29 July and 4 August, chemical mixtures were aerially sprayed to three swaths 16 rows wide using a Piper Bravo 300 flown at 177 kmph, 3 m above the crop through 36 D7 multijet nozzles at 1.75 kg/cm^2.

SWCB control was evaluated from four plots within each sprayed area on 22 and 23 September 1982, on 30 September 1983, and on 14 September 1984. Evaluations were made by splitting twenty-five corn stalks per plot and determining the presence of larval tunneling, live larvae, and girdling damage.

Droplet Spread. A laboratory study was conducted to compare droplet spread of SBO and CSO on different crops and at different temperatures. A thin wire probe was dipped into the oil to form a capillary droplet on the probe. Oil drops were placed on the upper and lower surface of corn, sorghum, soybean, and cotton leaf sections. This produced rather large drops, ca. 450 µm, but the method permitted preliminary comparison of the vegetable oils without expensive equipment. Leaf sections were placed in environmental chambers at 21.1°, 32.2°, and 43.3°C. Droplet spread was determined by measuring droplet diameters with an ocular micrometer at 0, 1, 4, 6, and 24 hrs.

Data for spray deposition (droplets/cm^2, droplet size, and % area covered) and control efficacy (SWCB infestation and damage) were analyzed by analysis of variance and means separated with Duncan's multiple range test (Duncan 1955). A studentized t-test analysis compared SBO and CSO droplet spread. To correlate the influence of time and temperature on droplet spread, data were analyzed with a linear regression analysis.

RESULTS AND DISCUSSION

Spray Deposition. In 1982, ULV-vegetable oil and conventional aerial applications were sprayed from mid-to late afternoon when temperatures were fairly high, 32.2°C, relative humidity was low, 28%, and winds moderate, ca. 12.9 kmph. In 1983, conditions were warm, dry and relatively calm at 23.9°C, 35% RH, and wind ca. 12.9 kmph. These environmental conditions may have been conducive to droplet evaporation when using only a water carrier. Even though these conditions existed, significantly more droplets/cm^2 were deposited on papers within the corn canopy when insecticides were applied with water or water plus NEPO than when applied ULV with either CSO or SBO (Table 1). This could be attributed to higher spray volumes with conventional (28.0 l/ha) vs ULV (2.3 l/ha) applications.

Droplets on the water and oil sensitive papers confirmed that spray deposition from ULV-vegetable oil and conventional applications were distributed similarly on the leaf surfaces of corn each year (Table 1). The erect structure of the flag leaf at the top of the corn plants allowed droplets to be deposited on both leaf surfaces, but drops on any given flag leaf were primarily on only one side of a leaf. This would indicate that spray droplets during the aerial application were not being swirled within the

TABLE 1. Average Number of Droplets per cm^2 Area from Water and Oil Sensitive Papers Placed at Designated Leaf Location on Corn Plants.

	Average number of droplets[a/]						
	Upper surface			Lower surface			
Application[b/]	Top leaf	Ear leaf	Bottom leaf	Top leaf	Ear leaf	Bottom leaf	Total
			1982				
permethrin 2E/ H_2O	20.63 a A	4.17 a BC	1.77 a C	15.57 a AB	0.03 a C	0.03 a C	42.2 a
permethrin 2E/ CSO	10.23 a A	2.43 ab B	0.93 a B	6.97 ab AB	0.23 a B	0.00 a B	20.8 b
permethrin 4E/ CSO	8.23 a A	0.60 b B	1.03 a B	1.73 b B	0.00 a B	0.07 a B	11.7 b
			1983				
chlorpyriphos 4E/ H_2O	13.10 ab AB	18.47 ab A	3.53 b CD	8.63 a BC	0.03 a D	0.07 a D	43.8 ab
chlorpyriphos 4E/ H_2O + NEPO	21.13 a A	21.10 a A	10.43 a AB	5.23 a B	0.07 a B	0.10 a B	58.1 a
cypermethrin 2.5E/ H_2O	8.37 ab AB	8.13 bc AB	2.37 b BC	9.97 a A	1.70 a BC	0.30 a C	30.8 b
cypermethrin 2.5E/ SBO	2.87 b A	2.07 c AB	0.33 b BC	0.13 a C	0.03 a C	0.00 a C	5.4 c

a/ Means followed by different letters within a column (lowercase) and within a row (uppercase) for each year are significantly different at the $p \leq 0.05$ level (Duncan's [1955] multiple range test).

b/ Aerial applications of insecticide - water mixtures were at 28.0 l/ha and insecticide - vegetable oil (CSO and SBO) mixtures were at 2.3 l/ha. CSO, SBO, and NEPO designate cottonseed oil, soybean oil, and nonemulsified petroleum oil, respectively.

canopy and were deposited on the leaf surface facing the spray plane.

Droplets were more evenly distributed on the leaves within the canopy in 1983 than in 1982 (Table 1). This could be attributed to differences in plant population, corn variety, environmental conditions, and row spacings. The row spacing in 1982 (0.76 m) was narrower than that used in 1983 (1 m) which would have caused a more dense canopy and restricted droplets penetrating into the corn. Hutchins and Pitre (1984) reported fewer droplets penetrating the soybean canopy when soybeans were planted on narrower row spacings. The similarity of droplet penetration for ULV-vegetable oil and conventional applications indicate droplet density differences at a leaf location (Table 1) was due to more droplets reaching the canopy when water (28.0 l/ha) was used for the insecticide carrier. The addition of NEPO to insecticide-water mixtures may have reduced droplet evaporation which possibly resulted in improved droplet penetration within the canopy. But, further studies are needed to substantiate this improved distribtuion.

The mean droplet size showed the drops from ULV-vegetable oil applications were significantly smaller than the water droplets (Table 2). These measurements only represent the size of a droplet after impact and do not indicate what spreading would have occurred on the leaf surface. Differences in the chemical:carrier ratio for permethrin in CSO and use of either SBO or CSO did not affect droplet size. In 1982 and 1983, drops on the upper leaf surface of all leaves and on the lower surface at the top leaf were larger in the pyrethroid-water applications than the pyrethroid-vegetable oil treatments. Drops in both chlorpyriphos-carrier applications had similar droplet diameters to those for cypermethrin-water at any leaf location except at the lowest leaf, upper surface. Collectively the mean diameter for drops from all water carrier applications were significantly larger than ULV-SBO drops. These differences between water and ULV-vegetable oil carriers illustrate how the droplet atomization from a spray application was affected by the carrier and volume of application.

The droplet density and droplet size affect the area covered by the insecticide spray. Placement of water and oil sensitive paper in the canopy showed that regardless of the carrier utilized, only a small portion of any leaf surface was actually covered with the insecticide spray (Table 3). The coverage within the canopy was similar to the droplet distributions each year (Table 1). Generally, coverage was better at the top leaf in 1982; while in 1983, surface coverage was similar at the top and ear leaf. With an application having relatively similar droplet sizes at all leaf locations within the canopy (Table 2), these data indicate that leaf surface coverage within the canopy was primarily a function of droplet density. Coverage and droplet density reductions within the corn canopy may be attributed to leaf foliage intercepting droplets penetrating the canopy. Similar decreases in droplet density and coverage were related to canopy interception in cotton and

TABLE 2. Average Size of Droplets per cm^2 from Water and Oil Sensitive Papers Placed at Designated Leaf Locations on Corn Plants.

Application[b/]	Average droplet size (µm)[a/]						
	Upper surface			Lower surface			
	Top leaf	Ear leaf	Bottom leaf	Top leaf	Ear leaf	Bottom leaf	Mean/leaf
1982							
permethrin 2E/ H_2O	297 a AB	310 a AB	371 a A	272 a B	123 a C	62 a C	292 a
permethrin 2E/ CSO	125 b A	137 b A	103 b AB	128 b A	149 a A	0 a B	127 b
permethrin 4E/ CSO	141 b AB	157 b A	145 b AB	135 b AB	0 a B	123 a AB	141 b
1983							
chlorpyriphos 4E/ H_2O	251 ab AB	282 a AB	283 b A	240 a AB	185 a B	246 a AB	265 a
chlorpyriphos 4E/ H_2O + NEPO	286 ab A	259 ab A	268 b A	236 a A	92 a B	82 a B	268 a
cypermethrin 2.5E/ H_2O	299 a B	311 a AB	445 a A	244 a B	323 a AB	301 a B	296 a
cypermethrin 2.5E/ SBO	174 b A	180 b A	197 b A	185 a A	62 a B	0 a B	177 b

a/ Means followed by different letters within a column (lowercase) and within a row (uppercase) for each year are significantly different at the $p \leq 0.05$ level (Duncan's [1955] multiple range test).

b/ Aerial applications of insecticide - water mixtures were at 28.0 l/ha and insecticide - vegetable oil (CSO and SBO) mixtures were at 2.3 l/ha. CSO, SBO, and NEPO designate cottonseed oil, soybean oil, and nonemulsified petroleum oil, respectively.

TABLE 3. Percent Coverage of Droplets per cm^2 from Water and Oil Sensitive Papers Placed at Designated Leaf Locations on Corn Plants.

	Percent coverage[a/]					
	Upper surface			Lower surface		
Application[b/]	Top leaf	Ear leaf	Bottom leaf	Top leaf	Ear leaf	Bottom leaf
			1982			
permethrin 2E/ H_2O	1.29 a A	0.31 a BC	0.19 a BC	0.80 a AB	>0.001 a C	>0.001 a C
permethrin 2E/ CSO	0.13 b A	0.04 b B	0.01 b B	0.09 ab AB	>0.004 a B	0.000 a B
permethrin 4E/ CSO	0.13 b A	0.01 b B	0.02 b B	0.02 b B	0.000 a B	>0.001 a B
			1983			
chlorpyriphos 4E/ H_2O	0.58 a B	1.11 a A	0.22 b CD	0.380 a BC	>0.001 a D	>0.003 a D
chlorpyriphos 4E/ H_2O + NEPO	1.29 a A	1.09 a A	0.59 a AB	0.190 a B	>0.001 a B	>0.001 a B
cypermethrin 2.5E/ H_2O	0.56 a A	0.58 b A	0.34 b AB	0.460 a A	0.130 a AB	0.020 a B
cypermethrin 2.5E/ SBO	0.07 a A	0.05 c AB	0.01 b BC	0.004 a BC	>0.001 a C	0.000 a C

a/ Means followed by different letters within a column (lowercase) and within a row (uppercase) for each year are significantly different at the $p \leq 0.05$ level (Duncan's [1955] multiple range test).

b/ Aerial applications of insecticide - water mixtures were at 28.0 l/ha and insecticide - vegetable oil (CSO and SBO) mixtures were at 2.3 l/ha. CSO, SBO, and NEPO designate cottonseed oil, soybean oil, and nonemulsified petroleum oil, respectively.

soybeans (Smith and Burt 1970, Hutchins and Pitre 1984). Also, these researchers reported similar spray penetration within the canopy with each application method as we found within corn.

The surface area covered with applications using water as a carrier for the insecticide should be greater than ULV-vegetable oil applications due to differences in droplets/cm^2 and droplet size. The permethrin-water application did have more area of the papers covered at the upper surface of the top, ear, and bottom leaves (Table 3). Differences in area covered for the applications were not as evident in 1983 when droplets were more evenly distributed within the canopy. The coverage was only better with water carriers for the upper surface on the ear leaf and on the bottom leaf upper surface when NEPO was added to the water carrier. Only a slight percentage of a paper surface was ever covered with any application if papers were positioned across the lower surface of the ear and bottom leaves.

Placing water and oil sensitive papers within the canopy documented the spray deposition on corn with ULV-vegetable oil carrier (2.3 l/ha) sprays and for water carrier applications (28.0 l/ha) with and without a mineral oil (NEPO) adjuvant. Identifying the coverage will help determine the importance of an applications spray deposition, droplet density (droplets/cm^2), solution concentration (liters/ha), chemical dosage (kg/ha), and the behavior of the pest on chemical activity. Young et al (1972) showed that Heliothis zea (Boddie) moth control was reduced significantly when moths were caged at the ear of sweet corn than when caged at the corn tassel. Interception of spray droplets in narrow row spacings of soybeans were shown to reduce both total droplets/cm^2 and mean percent coverage within the canopy and was correlated with reduced pest control (Hutchins and Pitre 1984). Studies by Fisher and Menzies (1976) showed that the exposure of lepidoptera larvae, Grapholitha molesta (Busck), to carbaryl residues was directly related to droplets/cm^2. The larvae were poisoned in less time and with fewer contacts when droplet number and percent area covered were increased. Therefore, considering the spray deposition within the corn canopy, control in our studies could possibly have been affected by application coverage. Differences in canopy penetration for applications in 1982 as compared to applications in 1983 suggest chemical activity could have been less effective in 1982. The similarity of droplet penetration for ULV-vegetable oil (2.3 l/ha) and conventional water (28.0 l/ha) applications would indicate that any differences in control could be due to: droplet density and coverage at a leaf location or; the concentration of active ingredient within the application droplet. The addition of NEPO could possibly improve conventional water application control by increasing droplet density and droplet penetration.

SWCB Efficacy. SWCB infested corn stalks were relatively similar regardless of the insecticide carrier and application rate (Table 4). All insecticide applications, except in 1984, equally reduced larval numbers and damage below those in the untreated check. In 1983 the SWCB

TABLE 4. Southwestern Corn Borer Control for Insecticides Aerially Applied with Water and ULV - Vegetable Oil Carriers.

Application [b]	Rate kg (AI)/ha	% Stalks [a] Infested	Tunneled	Girdled	Lodged	Live larvae
1982						
permethrin 2E/ H_2O	0.112	8 b	3 b	5 b	2 b	1 c
permethrin 2E/ CSO	0.112	16 b	7 b	9 b	4 b	12 b
permethrin 4E/ CSO	0.112	8 b	4 b	4 b	2 b	0 c
Untreated	-	74 a	30 a	44 a	27 a	54 a
1983						
chlorpyriphos 4E/ H_2O + NEPO	1.12	12 bc	10 bc	2 b	1 b	7 bc
chlorpyriphos 4E/ H_2O + NEPO	0.56	15 bc	11 b	4 ab	1 b	12 b
chlorpyriphos 4E/ H_2O	1.12	17 b	13 b	4 ab	1 b	9 bc
chlorpyriphos 4E/ H_2O	0.56	13 bc	9 b	4 ab	0 b	7 bc
cypermethrin 2.5E/ H_2O	0.04	2 bc	2 b	0 b	0 b	2 c
cypermethrin 2.5E/ SBO	0.04	7 bc	5 b	2 b	0 b	4 bc

TABLE 4. (Cont'd.)

Application[b]	Rate kg (AI)/ha	% Stalks[a] Infested	Tunneled	Girdled	Lodged	Live larvae
			1983			
fenvalerate 2.4E/ H_2O	0.14	4 bc	4 b	0 b	0 b	0 c
fenvalerate 2.4E/ SBO	0.14	1 c	1 b	0 b	0 b	0 c
fenvalerate 2.4E/ SBO	0.08	10 bc	8 b	2 b	0 b	5 bc
Untreated	-	39 a	29 a	9 a	4 a	26 a
			1984			
chlorpyriphos 4E/ H_2O + NEPO	1.12	11 bc	9 c	2 b	0 a	11 bc
chlorpyriphos 4E/ H_2O + NEPO	0.56	36 b	24 bc	12 ab	3 a	34 b
chlorpyriphos 4E/ H_2O	1.12	67 a	54 a	13 ab	0 a	67a
fenvalerate 2.4E/ H_2O	0.14	5 c	5 c	0 b	0 a	5 c
Untreated	-	78 a	50 ab	21 a	5 a	73 a

a/ Means followed by different letters in a column for each year are significantly different at the $p \leq 0.05$ level (Duncan's [1955] multiple range test).

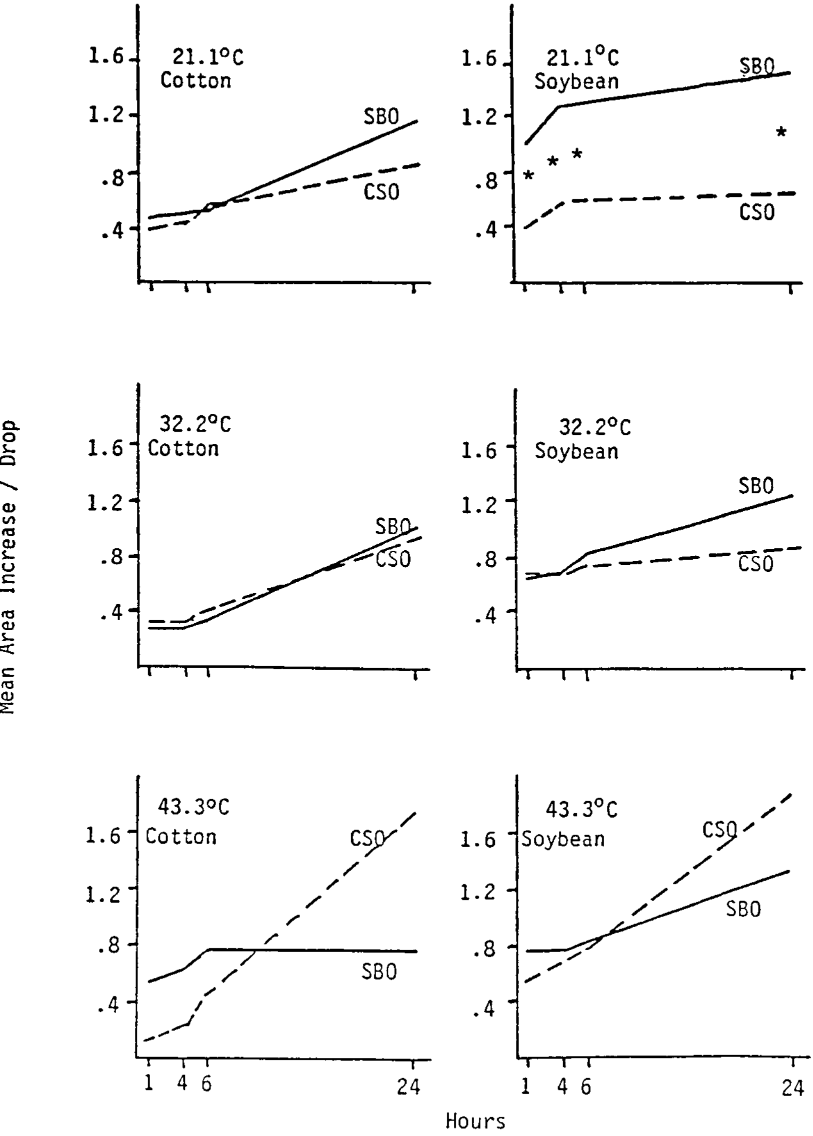
b/ Aerial applications of insecticide - water mixture were at 28.0 l/ha and insecticide - vegetable oil (CSO and SBO) mixtures were at 2.3 l/ha. CSO, SBO, and NEPO designate cottonseed oil, soybean oil, and nonemulsified petroleum oil, respectively.

infestations were low. With this infestation level, there was no difference in control for chlorpyriphos applications in water with and without NEPO. But, with a heavier infestation (1984) control from chlorpyriphos at 1.12 and 0.56 kg (AI)/ha was improved by adding NEPO to the water carrier. Neither vegetable oil (CSO and SBO) carrier nor the ratio of pyrethroids (2E and 4E permethrin formulations) in oil prevented ULV applications from controlling SWCB even though water applications had better spray coverage. Also, the reduced fenvalerate rate (0.08 kg (AI)/ha) and the single ULV application at 0.14 kg (AI)/ha in 1983 were effective.

The effectiveness of the ULV-vegetable oil and conventional insecticide applications show that control was not restricted by the droplet penetration of the corn canopy, droplets/cm^2, and droplet size. The high toxicity of the pyrethroids and their high photostability (Elliott 1977) may explain why both ULV and conventional pyrethroid applications were effective. Equally effective SWCB control from pyrethroids applied with ULV-vegetable oil (2.3 l/ha) as compared to the water (28.0 l/ha) carrier could be attributed to greater concentrations of insecticide in the vegetable oil spray droplets. Brazzel et al. (1968) reported recovering more insecticide (malathion) from ULV applications on cotton even though there were fewer drops per square inch of the leaf surface. Also, ULV formulations have been shown to enhance residual life of the insecticide (Awad et al. 1967, McDaniel 1980) and improve the chemical absorption by the pest (Awad and Vinson 1968, Polles and Vinson 1969). Another factor contributing to ULV-vegetable oil control could be the carriers ability to spread toxicant over a leaf's surface.

Droplet Spread. Studies were conducted in the laboratory to determine if droplet spread of SBO and CSO differed on several leaf surfaces. These studies revealed some interesting insights into spread characteristics of vegetable oil spray droplets. Droplet spread by SBO and CSO was similar, but considerable variation occurred among individual drops (Fig. 1 and 2). The way droplets spread on a leaf's surface was influenced by the physical structure of the leaf venation. Droplet spread is only presented for the upper surface because spreading characteristics on the lower surface were similar.

Droplets on the upper surface of cotton and soybean leaves (dicotyledon plants) spread along the vein labyrinth. The mean area increase of CSO and SBO drops on cotton and soybean leaves correlated better with time than with increasing temperature (Table 5). Both CSO and SBO droplets increased to no more than 1.6 times its original size after 24 h (Fig. 1). Although the circular droplet size increased 1.6 times, the movement along veins outside the circular area was substantially larger and would increase the total area that insects could come in contact with the insecticide. At the lower temperature (21.1°C) SBO droplet spread was significantly greater than CSO droplets on soybeans. Increasing the temperature to 43.3°C did improve CSO spread on the leaf surface.



g. 1. Mean increase in soybean oil (SBO) and cottonseed oil (CSO) roplet area on the upper leaf surface of cotton and soybean at different emperatures. Significant difference between spread at $P \leq 0.10$ (*).

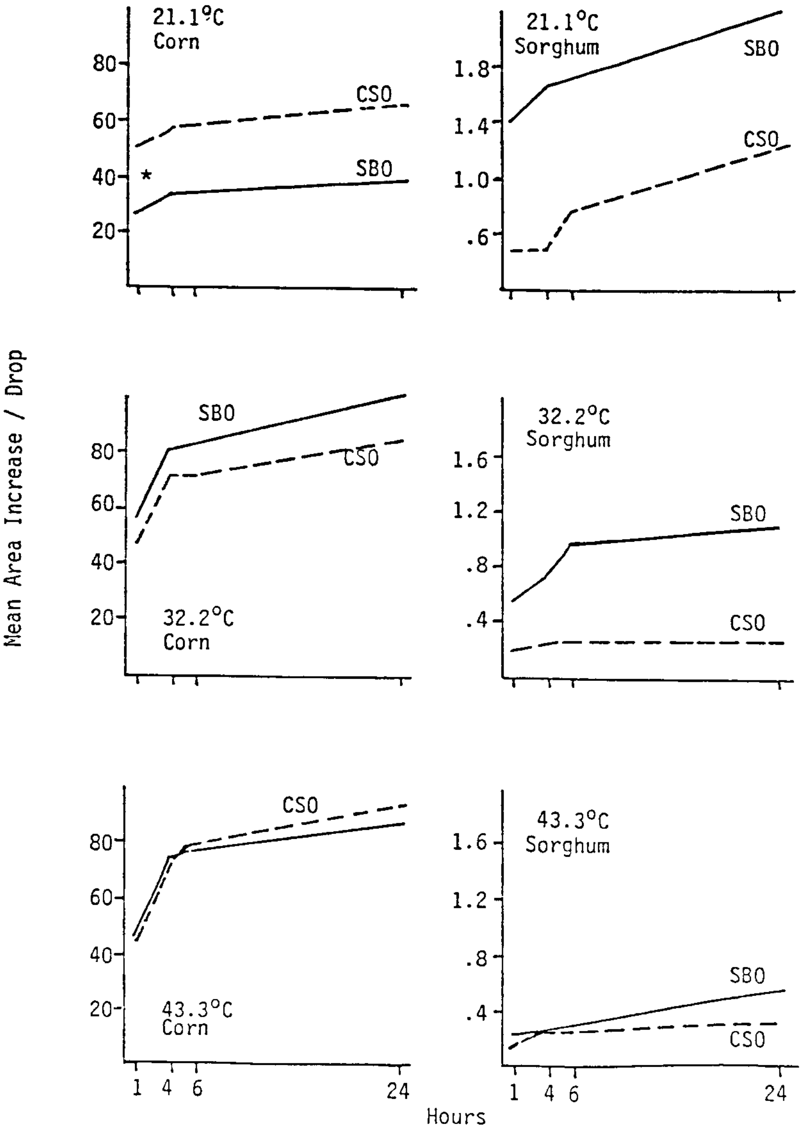


Fig. 2. Mean Increase in soybean oil (SBO) and cottonseed oil (CSO) droplet area on the upper leaf surface of corn and grain sorghum at different temperatures. Significant difference between spread at $P \leq 0.10$(*).

TABLE 5. Correlation of Soybean Oil and Cottonseed Oil Droplet Spread with Time (hours) on the Upper Leaf Surface and with Temperature Increase.

	Correlation coeficients (r)[a/]			
	Soybean oil		Cottonseed oil	
Leaf	Time	Temp.	Time	Temp.
Cotton	.827**	.036	.859**	.110
Soybean	.715**	-.504*	.636*	.453
Corn	.398	.646*	.675*	.440
Sorghum	.368	-.903**	.537*	-.559*

a/ Correlation coefficient (r); * = significant at 5% level of probability, ** = significant at 1% level of probability.

The vegetable oil droplets on corn and sorghum leaves also spread along the vein configuration but never spread very far across the veins. On sorghum leaves the mean area increase of CSO and SBO droplets was similar to increases on dicotyledon leaves (Fig. 2). However, SBO and CSO droplet spreading on sorghum was negatively related to temperature (Table 5). The higher temperature may have altered the sorghum leaf surface condition which inhibited droplet spread. The greatest droplet spreading occurred on corn plants. After 1 h droplets of both vegetable oils increased the surface area covered from 40 to 60 times their original size and most spreading occurred within the first 4 h (Fig. 2). In many instances, the moment droplets, particularly with CSO, touched the leaf surface spreading occurred. This influenced the effect time and temperature had on SBO and CSO spreading on corn (Table 5). The laboratory study indicates the spreading characteristic of ULV, CSO and SBO carriers in the field should be relatively similar on the two dicotyledon and monocotyledon plants tested. The spreading along the vein labyrinth on dicotyledon leaves and down the horizontal venation on monocotyledon leaves, particularly corn, may have contributed to the good ULV pyrethroid control in spite of poor leaf surface coverage.

ACKNOWLEDGEMENT

We thank Leesa Smart-Gray for technical assistance in analysing droplet deposition on the water and oil sensitive papers. We are grateful to Don Moore, Jackie Clark, and Lonnie Bell, our cooperators, who allowed us to conduct this work on their farms, and Olan Moore, private crop consultant, helped locate fields and coordinated aerial application services. We appreciate B&W Aerial, Jones Spraying Service, Triple A Spraying Service, and their aerial applicators for providing aerial and ground services. This research was supported in part by grants from the American Soybean Association, Dow Chemical Co., FMC Chemical Co., ICI Chemical Co., and Shell Chemical Co.

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