REPORT NO. 80-4

SPRAY CHARACTERIZATION TRIALS FOR THE 1979 MAINE SPRUCE BUDWORM CONTROL PROGRAM

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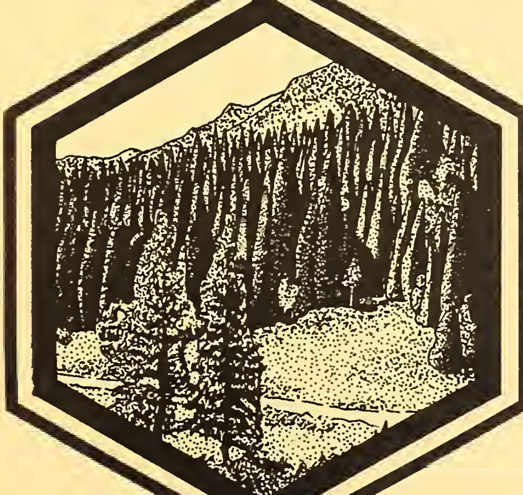

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SPRAY CHARACTERIZATION TRIALS FOR THE 1979 MAINE SPRUCE BUDWORM CONTROL PROGRAM

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ABSTRACT

Spray trials were conducted at Mesa, Arizona, during May 1979 to determine the atomization of several pesticide tank mixes for use in Maine during 1979 to control spruce budworm. The trials were a joint effort which involved the State of Maine, the Forest Service, pesticide manufacturers, and the applicator. Results of the spray deposit assessment are provided.

INTRODUCTION

Atomization is a critical factor in the quality of aerial spray application which affects efficacy of insect control. A spray that is too coarse will insure placement of a relatively high proportion of the pesticide volume on the target area but, in all probability, will provide inadequate surface coverage. Fine atomization, on the other hand, will result in considerably less total volume delivered to the target area but with a higher number of droplets. To illustrate this point, a 400 µm drop would make 8,000 drops 20 µm in diameter. Finer droplets, however, are more susceptible to air movement, drift, and loss through evaporation. Canopy penetration also is a consideration. If the atomization is too fine a droplet may meander through the canopy, being too small to deposit or impact the host plant or target insect. Too large a droplet, with less of a fall angle, may have a low probability of contacting a leaf or insect.

Another factor in selecting the optimum atomization for a particular spray is the physical nature of the carrier. Water-base sprays should be atomized more coarsely due to rapid reduction of drop size caused by evaporation. Oil-base sprays and those with additives designed to reduce spray volatility, can be atomized in smaller droplets.

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Physical factors which influence atomization include such items as nozzle type and size, nozzle orientation on the spray boom, boom pressure, and aircraft speed.

In selecting appropriate atomization the project officer must consider the above factors, select the combinations which show promise of providing the desired atomization, and test to insure that the spray system produces the desired droplet size.

Since 1976 the Maine Forest Service has specified spray atomizations of less than 150 μm volume median diameter (VMD) and low volume applications in the range of less than 64 oz/A.[2] To facilitate this, the Maine Forest Service has annually conducted both calibration and spray characterization evaluations prior to launching spruce budworm control projects. In 1979 the Maine Forest Service and its cooperators conducted calibration and characterization trials at Mesa, Arizona, with contract aircraft for this purpose prior to the operational control project.

This data report addresses only the characterization trials. Maine personnel were responsible for other aspects of contract administration and aircraft calibration.

OBJECTIVE

The objective of this project was to obtain information on the atomization of several insecticide tank mixes which were under consideration for operational use in Maine during 1979 to control the spruce budworm, *Choristoneura fumiferana* Clemens.

METHODS

Characterization trials were conducted at Mesa, Arizona, from May 1 to May 3, 1979. Site selected for these trials was approximately one mile north of Falcon Field on the Salt River Indian Reservation. Trials were conducted during evening and morning hours when conditions are generally more favorable for spraying.

Several formulations and tank mixes of carbaryl (Sevin), acephate (Orthene), and trichlorfon (Dylox) were evaluated (Table 1). Carbaryl trials are designated by the letter prefixes A through J; acephate trials by letters M through W; and the trichlorfon trials W and X. Other letters in the trial designator code are "T" for TBM aircraft; "P" for Pawnee Brave aircraft; "X" for crosswind spray trials, and "I" for inwind spray trials.

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2 Personal communication. John Chadwick, Maine Forest Service.

Table 1. Parameters for spray aircraft characterization trials with carbaryl (Sevin), Mesa, AZ, May 1-3, 1979.

Trial	ATI	BTX	BTI	CTX	CTI	DLX	DLI	ELX	ELI
Trial Date	May 1	May 1	May 1	May 1	May 1	May 2	May 2	May 2	May 2
Chemical	Sevin 1:4	Sevin 1:4	Sevin 1:4	Sevin 1:2.33	Sevin 1:2.33	Sevin Kerosene 6:14	Sevin Kerosene 6:14	Sevin Kerosene 1:2.33	Sevin Kerosene 1:2.33
Aircraft	TBM	TBM	TBM	TBM	TBM	Pawnee Brave	Pawnee Brave	Pawnee Brave	Pawnee Brave
Aircraft speed (mph)	165	165	165	165	165	120	120	120	120
Application rate oz/A[a]	20	20	20	20	20	20	20	20	20
Release height (ft)	100	100	100	100	100	75-100	75-100	75-100	75-100
Nozzle type	8008	8008	8008	8008	8008	Beecomist 350	Beecomist 350	8006	8006
Number nozzles	24	24	24	24	24	4	4	18	18
Boom pressure (psig)	40	40	40	40	22-25	22-25	22-25	40	40
Sampler spacing (ft)	25	100	1-17=25' Others=100'	100	100	100	100	100	100

a Pre-planned application rate.

Table 1 (cont). Parameters for spray aircraft characterization trials with carbaryl (Sevin and UCSF-1), Mesa, AZ, May 1-3, 1979.

Trial	FLX	FLI	GLX	GLI	HLX	HLI	JLX	JLI
Trial Date	May 2	May 2	May 2	May 2	May 3	May 3	May 3	May 3
Chemical	Sevin/Orchex 1:2.33	Sevin/Orchex 1:2.33	Sevin/Orchex 6:14	Sevin/Orchex 6:14	UCSF-1 1:2.33	UCSF-1 1:2.33	Sevin/Orchex 6:14	Sevin/Orchex 6:14
Aircraft	Pawnee Brave	Pawnee Brave	Pawnee Brave	Pawnee Brave	Pawnee Brave	Pawnee Brave	Pawnee Brave	Pawnee Brave
Aircraft speed (mph)	120	120	120	120	120	120	120	120
Application rate oz/A[a]	20	20	20	20	20	20	20	20
Release height (ft)	100	100	100	100	75	25	100	100
Nozzle type	8006	8006	Beecomist 350	Beecomist 350	8006	8006	8006	8006
Number nozzles	18	18	4	4	20	20	18	18
Boom pressure (psig)	40	40	40	40	22-25	22-25	22-25	40

a Pre-planned application rate.

Table 1 (cont). Parameters for spray characterization trials with acephate (Orthene), Mesa, AZ, May 3, 1979.

Trial	M	N	P	Q	R	S	T	U	V
Trial date	May 3	May 3	May 3	May 3	May 3	May 3	May 3	May 3	May 3
Chemical	Orthene 75S	Orthene 75S	Orthene 75S	Orthene 97%	Orthene 97%	Orthene 97%	Orthene 97% w/Nalco Trol	Orthene 97% w/Nalco Trol	Orthene 97% w/Nalco Trol
Release time	0558	0620	0640	0735	0745	0749	0803	0807	0814
Aircraft speed (mph)	120	120	120	120	120	120	120	120	120
Application rate oz/A[a]	64	64	64	64	64	64	64	64	64
Release height (ft)	25-30	25-30	25-30	25-30	25-30	25-30	25-30	25-30	25-30
Nozzle type	8006	8006	8006	8006	8006	8006	8006	8006	8006
Number nozzles	18	18	18	18	18	18	18	18	18
Sampler spacing (ft)	10	10	10	10	10	10	10	10	10
Length sampling	400	400	400	400	400	400	400	400	400

a Pre-planned application rate

Table 1 (cont). Parameters for spray characterization trials with trichlorfon (Dylox), Mesa, AZ, May 3, 1979.

Trial	W	X
Trial Date	May 3	May 3
Chemical	Dylox 4	Dylox 4
Release Time	1830	1835
Aircraft Speed (mph)	120	120
Application Rate	32 oz/A	32 oz/A
Release Height (ft)	50	50
Nozzle Type	8006	8006
Number Nozzles	9	9
Sampler Spacing (ft)	10	10
Length Sampling	400	400

For example a trial designated ATI consisted of:

A	T	I
Sevin 1:4 mix		
	TBM aircraft	
		Inwind trial

Sampling lines were established perpendicular to the flight line of the spray aircraft being characterized. Both crosswind and inwind releases were conducted with the various tank mixes of carbaryl. Inwind trials only were conducted with acephate and trichlorfon. Rhodamine B powdered dye (1 lb/100 gals) was added to the water-base mixes and Automate Red dye (1 gal/100 gals) was added to the oil-base sprays to aid in deposit assessment.

Kromekote cards were placed on the ground in standard yellow card holders. These were picked up 10 minutes after spraying following standard procedures (Barry et al. 1978). Assessment of the cards was performed by Los Alamos Scientific Laboratory (LASL) on the Quantimet Image Analyzer. LASL also analyzed the Quantimet data using the automatic spot counting and sizing program (ASCAS) (Young et al. 1977). No attempt was made to evaluate drop size (VMD) in the field as described in the D-max method (Barry et al. 1978).

Meteorological observations were made during each trial. These included temperature, relative humidity, wind speed, and wind direction (Table 2).

A Pawnee Brave agricultural spray aircraft was used to apply all the tank mixes except the carbaryl and diesel. For the latter a Grumman TBM was used. Each aircraft flew at operational spraying speeds, i.e. 120 mph for the Pawnee, and 165 mph for the TBM. Tank mix application rates were 20 oz/A for the carbaryl trials, 32 oz/A for the trichlorfon trials and 64/A for the acephate trials (Table 1). Data on the specific gravity and viscosity were available only for the carbaryl tank mixes (Table 3).

Spraying System Co. flat fan 8006, 8008 nozzle tips and the Beecomist 350 nozzle were used. One combination of nozzle sizes and configurations was used for each tank mix. Although it would have been desirable to evaluate the affects of several nozzle sizes on atomization, the scope of the project precluded more intensive evaluation. Nozzle type and size selected for each tank mix was our best estimate of the nozzle which would produce a VMD below 200 µm.

Table 2. Meteorological data, spray aircraft characterization trials, Mesa, AZ, May 1-3, 1979.

Trial	Chemical	Time	Wind Direction	Wind Speed (mph)	Temp. (°F)	RH%
M	Orthene 75 S,	0558	E	1	45	57
N	"	0620	E	1	45	48
P	"	0640	E	2	48	56
Q	Orthene 97%	0735	E	2	65	52
R	"	0745	E	2	66	36
S	"	0749	E	1	66	40
T	Orthene 97%	0803	E	1	67	40
U	"	0807	SE	2	68	38
V	"	0814	SE	3	68	34
W	Dylox 4	1830	SW	1	80	26
X	Dylox 4	1835	SW	1	81	22
AT	Sevin	0545	SE	6	66	28
BT	Sevin	0615	SE	6	61	33
CT	Sevin	0710	SE	5	67	33
DL	Sevin	0537	SE	2	56	50
EL	Sevin	0610	SE	-	-	-
FL	Sevin	0712	SE	4	63	37
GL	Sevin	0725	S	5	63	37
HL	Sevin	0620	E	2	54	48
HI	Sevin	0640	E	2	56	56
JI	Sevin	0700	E	2	57	46
JX	Sevin	0715	E	2	60	40

Table 3. Viscosity and specific gravity for carbaryl tank mixes. Spray aircraft characterization trials, Mesa, AZ, May 1-3, 1979.

Tank Mix	Viscosity	Specific Gravity
Sevin:Carrier		
4:16 Diesel	12.0	0.8780
4:14 Diesel	12.5	0.8783
4:16 Orcheck	28.	0.8569
6:14 Orcheck	32.0	0.8650
4:16 Kerosene	7.5	0.8421
6:14 Kerosene	9.5	0.8597
Diesel oil	8.0	0.8490
Kerosene	6.0	0.78 to 0.80
Orchex oil	15.0	0.8480

RESULTS

Carbaryl

The smallest drop sizes were achieved on the Sevin 4-oil/diesel oil trials using 8008 nozzles where VMD ranged from 176 to 194 μm. This small drop size is probably due to the high speed of the aircraft, which aided in break-up of the spray. The kerosene carrier applied by the Pawnee with 8006 nozzles resulted in VMD's of over 200 μm. On those trials with Orchex as a carrier the VMD's were the highest of the carbaryl trials. Orchex applied with the Pawnee and a Beecomist system still produced VMD's of over 300 μm. The water-base UCSF-1 tank mix applied by the Pawnee with 8006 nozzles also produced a large VMD of 300 and 339 μm. The large VMD's and the low application rate (20 oz/A) resulted in drops per square centimeter ranging from only 1 to 7 drops (Table 4).

Acephate

The Orthene 75S trials with application by the Pawnee at 64 oz/A resulted in VMD's ranging from 340 to 371 μm. These VMD's seem consistent with those observed previously with water-base sprays but larger than the 236-245 μm VMD's reported by Flavell (1977). The Orthene (97 percent technical) produced a smaller VMD which ranged from 263 to 298 μm. Of particular note is the increase in VMD to 439 to 553 μm on those acephate trials which used Nalco Trol additive. Nalco Trol is a polymer which reportedly reduces the number of small droplets. The larger VMD's were achieved with only a reduction in droplet density from 9.6 to 8.4 drops/cm^2 (Tables 5, 6, and 7).

Trichlorfon

Only two triclorfon trials were conducted. Application was with the Pawnee equiped with 8006 nozzles. The VMD's were 200 and 226 μm, and droplet densities were 13 and 29 drops/cm^2 (Table 8). Equipment failures precluded additional trials with trichlorfon.

CONCLUSIONS

1. Dilution of carbaryl with Orchex generally leads to larger spray droplet size and correspondingly higher recovery of the spray. However, the coverage expressed as drops/cm^2 appears to be somewhat lower than is obtained with diesel.

2. Application with TBM's generally leads to better droplet break-up and spray coverage/cm^2 than with Pawnee's.

3. The use of diesel or kerosene diluents, or the proportion of Sevin 4-oil to diluent, does not appear to appreciably affect spray deposit recovery under the conditons of this test.

Table 4. Spray deposit data for carbaryl trials, application rate 20 oz/A. Spray aircraft characterization trials, Mesa, AZ, May 1-3, 1979.

Sevin:Diluent	Chemical Carrier	Trial/Nozzle	Aircraft	Drop Diameters (μm) Volume Median	Drop Diameters (μm) Mass Mean	Drop Diameters (μm) Number Median	Number Mean	Drops/ sq. cm.	Volume Recovered/A gal.	Volume Recovered/A oz.	Recovery oz. active/A
4:1	Sevin/Diesel	ATI-8008	TBM	194	199	119	128	7	0.133	17	6.7
4:1	Sevin/Diesel	BTX-8008	TBM	176	182	104	112	2	0.023	2.9	1.1
4:1	Sevin/Diesel	BTI-8008	TBM	179	185	114	120	3	0.045	5.8	2.3
2.33:1	Sevin/Diesel	CTX-8008	TBM	190	200	115	124	2	0.036	4.6	1.6
2.33:1	Sevin/Diesel	CTI-8008	TBM	184	190	108	117	4	0.059	7.6	2.6
6:14	Sevin/Kerosene	DLX-Beecomist	Pawnee	162	170	96	104	4	0.037	4.7	0.7
6:14	Sevin/Kerosene	DLX-Beecomist	Pawnee	263	278	138	153	4	0.153	19.6	2.9
2.33:1	Sevin/Kerosene	ELX-8006	Pawnee	243	260	113	128	1	0.033	4.2	1.4
2.33:1	Sevin/Kerosene	ELI-8006	Pawnee	259	276	131	146	2	0.064	8.2	2.8
2.33:1	Sevin/Orchex	FLX-8006	Pawnee	368	415	134	158	2	0.094	12.0	4.1
2.33:1	Sevin/Orchex	FLI-8006	Pawnee	543	529	165	214	1	0.068	8.7	3.0
6:14	Sevin/Orchex	GLX-Beecomist	Pawnee	332	333	178	195	2	0.175	22.4	3.3
6:14	Sevin/Orchex	GLI-Beecomist	Pawnee	304	339	135	153	2	0.079	10.1	1.5
2.33:1	UCSF-1	HLX-8006	Pawnee	300	312	79	136	1	0.018	2.3	0.8
2.33:1	UCSF-1	HLI-8006	Pawnee	339	343	165	182	3	0.245	31.4	10.8
6:14	UCSF-1	JLX-8006	Pawnee	455	469	179	204	2	0.152	19.5	2.8
6:14	UCSF-1	JLI-8006	Pawnee	480	468	123	151	-	-	-	-

Table 5. Spray droplet data for acephate (Orthene) tank mixes sprayed by Pawnee Brave with 8006 nozzles. Spray aircraft characterization trials, Mesa, AZ, May 1-3, 1979.

Trial	Chemical	Drop Diameters (μm) [3] Volume Median	Mass Mean	Number Median	Number Mean	Deposition Density drops/sq. cm	Recovery Rate gals/acre
M	Orthene 75 S 64 oz/A	340	357	102	138	12	0.602
N	"	350	352	102	135	8	0.361
P	"	371	375	104	138	7	0.349
Q	Orthene 97% tech 64 oz/A	298	308	104	131	10	0.378
R	"	276	298	114	135	9	0.338
S	"	263	280	108	129	10	0.306
T	Orthene 97% tech 64 oz/A with 0.078125% Nalco Trol	553	586	113	146	8	0.654
U	"	431	477	91	127	7	0.347
V	"	439	448	130	163	10	0.857

3 Volume Median Diameter (VMD). The drop diameter at which 50% of the volume is in drops larger and 50% of the volume is in drops smaller than the VMD. Also referred to as mass median diameter (MMD).

Volume Mean Diameter. The diameter associated with that drop, not necessarily in the population, for which the average drop volume is found.

Number Median Diameter. The drop diameter which divides the total drop population in half with half the drops larger and half the drops smaller.

Number Mean Diameter. Average diameter of the drop population, independent of volume.

Table 6. Summary of droplet distribution of acephate (Orthene) trials M, N, P, U, and V with Spraying Systems, Inc., 8006 flat fan nozzle tips and Pawnee aircraft. Spray aircraft characterization trials, Mesa, AZ, May 1-3, 1979.

SUMMARY

Diameter (μm)				Deposition	Recovery
Volume Median	Mass Mean	Number Median	Number Mean	Density drops/sq. cm	Rate gal./A
382.466	406.91	105.37	139.27	8.222	.469

Summary by Drop Size Category

Drop Size Category	Drop Size Upper Limit μm	Counts in Category drops/sq. cm	Mass Recovered gm/sq. m	Cumulative Mass gm.	Percent Mass	
					Category	Cumulative
1	85.8	3.48962	$.2882x10^{-2}$	.001284	.69	.69
2	163.1	2.45250	$.2713x10^{-1}$	.013371	6.45	7.14
3	246.4	1.14914	$.5379x10^{-1}$	.037331	12.79	19.93
4	328.9	.60588	$.7707x10^{-1}$	.071661	18.33	38.26
5	403.9	.26534	$.6905x10^{-1}$	.102419	16.42	54.69
6	502.2	.17936	$.8834x10^{-1}$	.141771	21.01	75.70
7	571.3	.03861	$.3139x10^{-1}$	.155754	7.47	83.17
8	656.0	.02671	$.3248x10^{-1}$	.170222	7.73	90.89
9	741.0	.00786	$.1407x10^{-1}$	.176492	3.35	94.24
10	826.3	.00449	$.1135x10^{-1}$	.181547	2.70	96.94
11	911.8	.00135	$.4640x10^{-2}$	.183614	1.10	98.04
12	989.9	.00045	$.2024x10^{-2}$	.184515	.48	98.53
13	1076.1	.00045	$.2596x10^{-2}$	.185672	.62	99.14
14	1156.0	.00022	$.1636x10^{-2}$	.186400	.39	99.53
15	1218.5	.00022	$.1968x10^{-2}$	.187277	.47	100.00
16	1334.9			.187277	0.00	100.00

Table 7. Summary of droplet distribution of acephate (Orthene 75S) trials Q, R, S, and T with Spraying Systems, Inc., 8006 flat fan nozzle tips and Pawnee Brave aircraft. Spray aircraft characterization trials, Mesa, AZ, May 1-3, 1979.

SUMMARY

Volume Median	Diameter (μm) Mass Mean	Number Median	Number Mean	Deposition Density drops/sq. cm	Recovery Rate gal./A
314.737	387.50	109.11	133.66	9.239	.398

Summary by Drop Size Category

Drop Size Category	Drop Size Upper Limit μm	Counts in Category drops/sq. cm	Mass Recovered gm/sq. m	Cumulative Mass gm.	Percent Mass Category	Percent Mass Cumulative
1	85.8	3.74973	$.3097 \times 10^{-2}$	.001156	.87	.87
2	163.1	2.88189	$.3189 \times 10^{-1}$	.013056	8.94	9.80
3	246.4	1.66735	$.7804 \times 10^{-1}$	.042183	21.87	31.67
4	328.9	.62080	$.7896 \times 10^{-1}$	.071654	22.13	53.80
5	403.9	.19479	$.5069 \times 10^{-1}$	.090573	14.21	68.01
6	502.2	.08199	$.4038 \times 10^{-1}$	.105643	11.32	79.32
7	571.3	.01634	$.1329 \times 10^{-1}$	.110603	3.72	83.05
8	656.0	.01286	$.1564 \times 10^{-1}$	.116438	4.38	87.43
9	741.0	.00429	$.7679 \times 10^{-2}$	.119304	2.15	89.58
10	826.3	.00295	$.7449 \times 10^{-2}$	.122085	2.09	91.67
11	911.8	.00188	$.6461 \times 10^{-1}$	.124496	1.81	93.48
12	989.9	.00188	$.8456 \times 10^{-2}$	.127652	2.37	95.85
13	1076.1	.00080	$.4647 \times 10^{-2}$	.129387	1.30	97.15
14	1156.0	.00107	$.7811 \times 10^{-2}$	.132302	2.19	99.34
15	1218.5	.00027	$.2349 \times 10^{-2}$	.133179	.66	100.00
16	1334.9			.133179	0.00	100.00

Table 8. Spray droplet data, trichlorfon (Dylox) spray characterization trials with Pawnee aircraft and 8006 nozzles. Mesa, AZ, May 1-3, 1979.

		Drop Diameters (µm)				Deposition	Recovery
Trial	Chemical	Volume Median	Mass Mean	Number Median	Number Mean	Density drops/sq. cm	Rate gals/acre
W	Dylox 4 32 oz/A	200	205	70	85	13	0.117
X	Dylox 4 32 oz/A	226	234	63	76	29	0.229

4. The Beecomist do not appear to provide any consistent differences in atomization compared to 8006 nozzles.

5. The additive Nalco Trol seems to affect atomization. Although only three replicates were conducted with and without Nalco Trol, it appears that the additive results in larger VMD's but does not affect the number of spray droplets ultimately depositing on the target.

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