Drift residues on alfalfa hay

A progress report on investigations of pesticide drift from nearby aircraft applications

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During the past two seasons a series of aircraft spray drift tests has been run on properties of the S. A. Camp ranch near Bakersfield. These runs were made on fields upwind, and immediately adjacent to, alfalfa which was 12 to 18 inches high at the time, and about 2 weeks from cutting. Several pesticide chemicals, some in combination and some singly, were applied as emulsion sprays for these runs. Certain tracer dyes were also added to each spray test and were evaluated for the amount of drifting spray drops caught on plastic sheets and filter papers. These were correlated with the pesticide residues taken from alfalfa samples which were processed and evaluated by spray residue laboratories of the participating chemical companies, and others.

The series were as follows: (1) June 23, 24, 1960; (2) October 3, 4, 1960; (3) June 15, 16, 1961 and (4) August 15, 16, 1961. Not all data is available from all of these tests as yet, but sufficient information has been obtained, both from the pesticide residue and the tracer correlation, to enable a limited evaluation of the extent of drift under the type of weather, amount and formulation of chemicals applied, and the type and manner of operation of application equipment used.

Under good weather conditions, the safe upwind distance from alfalfa hay is 600 feet when an application of 1½ pounds per acre of active DDT is to be made, if the treatment is made at least one week before the alfalfa is to be cut. However, when the weather is either windy, or very calm, and particularly under a strong inversion, the residue can increase 3 to 10 times. Safe distances would also be increased in relation, but not necessarily in direct proportion. It is planned to continue to investigate the effects of weather factors on the drift of chemicals to determine more accurately what part these play on the drift of agricultural pest control chemicals.

Each of the tests consisted of two runs on successive days, the June, 1960 runs were also dual applications with two aircraft spraying on two separate fields at the same time. This was done to obtain as near similar application and weather conditions to compare a fine spray system with a medium spray.

All aircraft used were Stearman type with 450 horsepower engines. The nozzling systems were set for fine sprays (with exceptions as noted) using disc insert type hollow cone nozzles. This produced a spray of arithmetic average drop size ($\Sigma ND/\Sigma N$) between 100 and 150 microns. The exceptions to this system were two runs in June of 1960 (simultaneous fine and medium spray) using medium spray atomization (150 to 300 microns, using jet nozzles aimed down and back 45 degrees) to compare with fine spray drift. Drift samples were taken downwind to one mile from the treatment area. Ground fallout samples were caught on plastic sheets, 6 × 18 inches, and also on 3¼ × 4-inch glass slides. The latter were used to obtain drop-size data while the first were stripped and analyzed in the laboratory for the tracer material which had been added to the spray.

Airborne samples

Airborne samples were taken at specified stations with Staplex air samplers and Casella cascade impactors. The Staplex filter papers were stripped and analyzed as were the plastic sheets, while the Casella devices which impinge drops on 4 glass slides or stages were examined under a microscope for drop size information. Alfalfa samples were taken at each station and replicated 3 to 5 times (on different runs). These samples were analyzed for residue data for each of the insecticides applied.

In each case 40 acres (or equivalent) were treated on the upwind side of the alfalfa. A 10-gallon per acre application rate was aimed for but was usually less as noted. All spray formulations were emulsions.

Weather data was taken throughout the summer months and special high accuracy equipment was used during the tests to obtain specific information on (a) wind direction, (b) wind velocity, (c) temperature and temperature lapse rate, and (d) relative humidity. The temperature lapse rate indicates the turbulence or vertical mixing taking place, while the relative humidity gives an indication of the evaporation rate of the spray.

Test data

The tests run thus far cannot in any sense be termed conclusive. Each test was under different weather conditions and other variations in the applications. Thus, while an attempt was made to hold application rates, treatment acres, spray atomization, and weather conditions as nearly the same as possible, considerable variation occurred which cannot be entirely corrected to standard conditions in the data presentation.

The specific objectives of these runs were (1) to obtain data on the extent and amount of pesticide drift residue and the influence of spray atomization, rate of pesticide application, weather conditions, and certain other variables affecting drift residue; and (2) to obtain a correlation of the tracers (several were used which can be analyzed cheaply and quickly and with high degree of accuracy) and the actual pesticide chemical residue. The pesticide analysis is costly and frequently is not of sufficient accuracy in analysis for drift studies. Under many circumstances it may also be hazardous to use pesticide chemicals for the number of tests needed for this evaluation.

The first objective was not intended to be completed with pesticide materials, but in lieu of little knowledge on possible correlation it was thought best to obtain as much data as possible using actual pesticides, while working also toward the correlation data needed to make valid the use of tracers alone. This second objective appears to be well satisfied in all of the tests run on alfalfa. Thus, future runs will shift toward tracers only, when the other variables of formulation, atomization, rate of application and weather conditions will be examined in greater detail. It is expected that additional actual pesticide residue data will be needed, particularly if runs are made on other crops.

Weather

Test results are shown in Table 1. Under the micro-weather columns are shown the wind velocity at 8 feet height, the temperature in degrees F. at 8 feet, the temperature difference at 32 feet minus 8 feet (a plus indicates inversion or stable air and minus indicates lapse or turbulent air) and the relative humidity.

The next columns indicate the degree of spray atomization and pounds of active chemical used. The remaining columns show the parts per million of chemical residue, at downwind distances as noted, which were found on zero days after the application. Note that these are for green alfalfa samples. Various factors immediately start reducing the chemical residue, such as physical weathering, chemical degradation, and growth of the alfalfa which reduces the relation of chemical weight to alfalfa weight on which the "parts per million" is based. These continue to decrease the residue with time, while curing and drying the hay tends to increase the parts per million residue as water weight is removed.

The June 23, 1960 runs were made with fine and medium spray simultaneously. These were run with materials at 0.5 lb., 1.5 lbs. and on the 24th with 4.5 lbs. of active chemical. The differences show about a 2-times increase in residue when fine is compared with medium. The average drop size change was from fine at 95 to 150 microns to medium at 150 to 300 microns.

Active materials

Although on June 23, 0.5 and 1.5 lbs. active materials were run simultaneously the residue does not follow a 3-times relationship. Under other tests (June 15, 1961) they do, hence it is assumed that residue analysis problems caused the difference here, and that under identical weather and application conditions the amount of drift residue should be in direct proportion to that applied, within reasonable limits, with an emulsion formulation.

The runs of June 23, 24, 1960 and June 15, 1961, were similar as to weather conditions. An inversion is indicated for June 15, 1961, but this is localized and unique being produced by high evaporation of water from the recently irrigated alfalfa. High air temperatures also acted to increase this evaporation rate. The run of October 3, 1960, is considered a strong, true inversion with high relative humidity and the high drift residue resulting is indicative of this also. It would appear that the inversion at 10 to 20 feet height placed a "cap" on the field that allowed

Drift sampling layout showing Cascade impactors, Staplex samplers and ground fall-out sheets.

no normal upward diffusion and hence a high residue downwind.

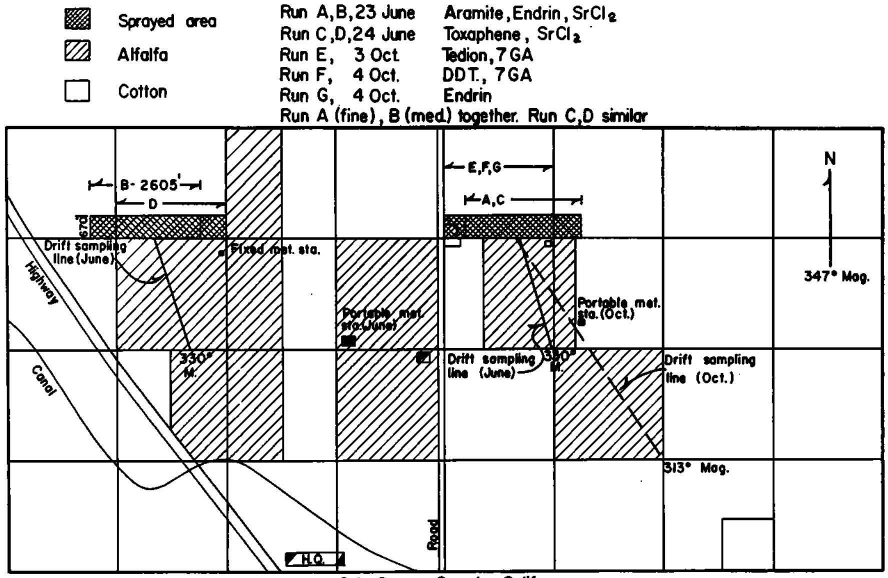
Air samples

The air samples taken by Staplex devices during the October 3, 1960 run indicate 85 times more material traveled past a given station in the air than settled out on the alfalfa. This is similar to other runs under better weather where amounts of the order of 40 to 80 times that of the ground fallout were found in the air.

Although no complete dust runs were made, data of other investigators indicates dust drift residue will be several times higher than with fine sprays. It seems evident that dust drift will always be higher than spray, but runs will be made later to obtain more clarification of dust drift.

Table II is a more generalized form of Table I and unlike Table I it is a composite of several runs rather than specific run data. Here the drift residue is all based on 1 pound active chemical per acre. For other rates of ½, 2 or 3 pounds multiply the residue obtained from the table by the pounds used.

Also in Table II is the effect of a larger field of 80 acres (40 swaths on a ½ mile run), and 160 acres (80 swaths) as related to the basic field size of 40 acres or 20 swaths on a half-mile run. This appears to follow a changing relation with



S.A. Camp Cawelo, Calif.
Layout for drift runs

little increase in the residue for the larger fields at 100 feet downwind from the start of the aircraft swaths, but increasingly more residue at greater distances downwind as the number of swaths increases.

The effect of the strong inversion and strong windy, turbulent conditions as significant weather changes should be noted. The strong inversion with low wind appears to cause greater increases in residue as the distance downwind from the start of the aircraft runs is increased. These cannot be stated precisely at this time but are roughly from 3-times the values under the 100-foot station for the good weather runs to 10 times the values of the good weather runs at the 2,000-foot station. For example, at the 100-foot station, and downwind from a 40-acre treatment, a residue of 1.36 ppm is indicated for the good weather conditions. For the inversion conditions, 1.36 times 3 equals 4.08 ppm.

The strong wind condition causes a

TABLE I

Spray Drift Residue and Weather Data Taken During Runs as Noted at S. A. Camp Company, Shafter

Drift from 20 Swaths or 40 Acres on a ½ Mile Run

Date	MICRO-WEATHER DATA				SPRAY DATA		ACTUAL CHEMICAL RESIDUE PPM ON GREEN ALFALFA 12-18" HIGH						
							Feet downwind						
	Velocity mph at 8'	Temp. 8 ft. F°	Temp. diff. 32'-8'	RH %	Spray atomization	Pounds active per acre	100	200	400	600	1000	2000	4000
23 June 1960	3.5-6.4 ave. 4.7	101 to 103	0 to normal lapse	22	Fine (under 150 microns)	0.5	0.5	0.3	0.14	0.08	0.04	....	....
					Med. (150-300 microns)	0.5	0.28	0.16	0.07	0.04	0.02	....	....
3 Oct. 1960	3-4 ave. 3.5	83 to 85	+4°F Strong inversion	50	Fine	0.5	0.95	0.84	0.69	0.55	0.38	0.18	0.06
15 June 1961	ave. 5	101 to 105	+4°F (Localized inversion)	40	Fine	0.5	0.68	0.3	0.15	0.09	0.05	0.016	0.007
23 June 1960	Run at same time as 23 June above				Fine	1.5	0.9	0.55	0.3	0.19	0.11	....	....
					Med.	1.5	0.5	0.3	0.14	0.08	0.05	....	....
15 June 1961	Run at same time as 15 June above				Fine	1.5	2.0	0.9	0.45	0.27	0.15	0.05	0.02
24 June 1960	6-7 ave. 5	90 to 91	0 to normal lapse	25	Fine	4.5	7.0	4.5	2.5	1.6	0.8	0.31	....
					Med.	4.5	4.0	2.5	1.3	0.75	0.35	0.1	....

Material, 7-8 total gal/acre, applied by Stearman, 450 hp aircraft, 3-5 feet above crop flying on a ½ mile run for 20 passes or 40 acres. Fine sprays: 36, D-8 (June 61, D-10) tips with No. 46 whirl plates (one case 3 October without plates) aimed straight down. Medium spray with 38, D-8 tips only, aimed down 45 degrees and back. Pressures 20-30 ps at boom.

TABLE II

Approximate Drift Residue in PPM to Be Expected on 12 to 18 Inch Alfalfa at Downwind Distances as Noted

Emulsion Formulation Applied at Total of 10 Gallons with One Pound Active Chemical Per Acre

MICRO-WEATHER DATA				SPRAY DATA		CHEMICAL RESIDUE PPM ON GREEN ALFALFA IMMEDIATELY AFTER SPRAYING					
						Feet downwind					
Velocity mph at 8 feet	Temp. F° 8 ft.	Temp. diff. 32-8 feet F°	RH %	Spray atomization	Pounds active per acre	100	200	400	600	1000	2000
BEST WEATHER CONDITIONS FOR APPLICATION											
3 to 5	70 to 95	zero to normal lapse	20 to 50	Fine (under 150 microns)							
Drift from 80 swaths, or 160 acres on a ½ mile run					1.0	1.76	0.84	0.46	0.32	0.198	0.094
Drift from 40 swaths, or 80 acres on a ½ mile run					1.0	1.63	0.74	0.38	0.26	0.144	0.046
Drift from 20 swaths, or 40 acres on a ½ mile run					1.0	1.36	0.6	0.3	0.18	0.1	0.032
CALM, STRONG INVERSION WEATHER											
2 to 3	70 to 100	+2 to +5	40 to 50	Fine	1.0	The ppm varies from 3 to 10 times the above residue values. It appears that the larger multiplier should be used for the greater downwind distances.					
STRONG WIND, TURBULENT WEATHER											
8 to 10	70 to 110	0 to −5	20 to 40	Fine	1.0	The ppm varies from 3 to 6 times the residue values in columns above.					

For two pounds active chemical, double ppm data in above tables. For 0.5 pound active, divide by two. Other amounts of active chemical would be taken proportionally for emulsion formulations.

For medium atomization sprays (150 to 300 microns) divide ppm residue by two in the tables above.

All data above is in ppm on green hay basis. Curing the hay (water loss) tends to increase residue, while degradation (chemical and physical loss during curing) tends to reduce this residue.

higher residue at all stations downwind. From Table II under windy, turbulent conditions it is indicated that 3 to 6 times (or an average of 4.5 times) the good weather condition residue might occur from 100 to 2,000 feet downwind. Additional factors which would affect drift residues are type of crop or cover, drop size, and formulations which evaporate more slowly than the usual normal low oil content emulsions.

The drift residue to be tolerated at any given point is not only a function of the residue shown here, but also of the type of chemical material used, its degradation rate, and its feeding toxicity and retention or passing through by the animal being fed.

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Participating chemical companies were: Naugatuck Chemical Co., Hercules Powder Co., Shell Chemical Co., and Niagara Chemical Div. Hazleton Laboratories and the Pesticide Residue Laboratories at the University of California, Riverside, also ran certain of these analyses.

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Data from Table II may be used in the following manner: The California State Department of Agriculture regulations permit a residue tolerance of 0.5 ppm DDT on alfalfa. If we start with this tolerance level on the alfalfa we can determine from our data the distance upwind that an application can be made without exceeding this tolerance. First, we will assume that an 80-acre field is to be treated with one and one-half pounds of DDT. If the alfalfa were harvested immediately after the drift exposure, or zero days, we would find that the curing process would cause the apparent residue to increase by 2 to 3 times. This is due to the loss of water during curing which increases the apparent residue, while at the same time chemical degradation of the DDT causes a decrease in apparent residue. If 2½ times the increase in residue occurs during curing we would have to reduce the maximum acceptable on the green hay from 0.5 to 0.2 ppm. At zero days we would have to be 1,200 feet upwind to stay below 0.2 ppm residue. Note that Table II is for one pound of active DDT. If one and one-half pounds are used the residue data has to be multiplied by one and one half.

If we now take an average half life of 6 days for DDT on alfalfa we can say that in 6 days only one half as much residue would be found as at zero days. This means that if the alfalfa were not harvested until 6 days after drift occurred the initial residue could be twice as much, or 0.4 ppm. Thus, by waiting 6 days, we could reduce the minimum upwind distance to 600 feet and stay below the 0.5 ppm on the cured hay. Similarly, if 12 days is allowed before harvesting we can reduce the safe distance from an upwind treatment to 300 feet.

TABLE III

Minimum Safe Distances Upwind from an Alfalfa Field That an 80-acre Application of 1½ Pounds of DDT Per Acre Can Be Made, as a Fine Emulsion Spray, Without Producing More than an 0.5 PPM Residue on the Alfalfa

Weather	Days After Drift Exposure Alfalfa Harvested	Safe Distance, Feet
Good weather conditions	0	1200
	6	600
	12	300
Strong inversion	12	1100 to 1900
Windy, turbulent	12	1100 to 1500

Table III indicates the approximate safe distance that applications, as noted, can be made upwind from an alfalfa field at various days from harvest, and for different weather conditions. Note that under inversion conditions, or windy, turbulent conditions the safe distance even 12 days after drift exposure is similar to zero days for good weather conditions. It should be apparent that attempting to work under poor weather conditions will increase the drift hazard by many times.

If determinations for materials other than DDT are to be made, the proper half life and feed through characteristics for these materials must be used.