Drift of 2,4-D Applied by Plane

better knowledge of wind direction and velocity as factors in drift contributes to reduction in number of damage suits

H. B. Schultz, N. B. Akesson, W. E. Yates, and K. H. Ingebretsen

The use of 2,4-D and related compounds to control weeds competing with grain and rice has resulted in an increased value of those crops to growers; but also it has resulted in damage suits filed by growers of crops susceptible to 2,4-D—cotton, grapes, tomatoes, and others—grown near rice or grain fields.

Formulations of 2,4-D for application by aircraft were limited to sprays—eliminating dust formulations—by early action of the Civil Aeronautics Authority. Furthermore, State regulation barred the highly volatile ester types of 2,4-D, leaving the low volatility esters and amine salt formulations available.

Investigations on aircraft equipment features such as nozzle pressures, types and placement, and control valves resulted in the recommendation that specific equipment be used to reduce formation and discharge of the small spray droplets so highly subject to drift. Cylindrical jets aimed with the air stream will produce the greatest part of the spray in large quickly deposited drops.

From studies on the air wake pattern from low-flying aircraft it was observed that fine spray droplets in the vicinity of the wing tip were lifted high into the air to be carried by whatever winds or thermal lifts existed. Also, because the wing generates the wake, it was found that keeping the boom away from the wing reduced the movement of droplets to wing vortices.

There are several basic weather factors which appear to control the movement of fine sprays in the air:

1. Horizontal air motion and direction which controls the distance downwind the spray may be carried toward or away from susceptible crops. Also involved with air motion would be the rapidity of dispersion or thinning out of the spray cloud.

2. Vertical air motion, principally effecting dispersion of the spray cloud, and primarily a function of the temperature gradient.

3. Spray evaporation, a function of the spray formulation on the one hand, and saturation deficit on the other hand which can be determined when air temperature and relative humidity are known. Saturation deficit is the amount of water vapor pressure needed to be added to the actual vapor pressure to bring the air to the saturation point, at which no more water vapor could be taken on and condensation would begin.

Weed spraying in rice fields is done from June to August, which are the hottest and driest months of the year and therefore the most favorable for chemical drift.

Two portable spot-climate stations were operated during the summer of 1954 near Grimes in the center of the Sacramento Valley rice area. Station No. *1* was installed over a rice plot to register continuously the air temperature, wet bulb temperature, temperatures of the rice water and the black globe—an instrument that furnishes information on radiation conditions and cloud cover. Included in the data collected was the continuous recording of wind direction and velocity by attachments developed as standard components of the spot climate recorders. Station No. *2* was located one mile to the northwest of Station No. *1* in a dry field—left fallow during the summer months in 1954—thus offering the opportunity for comparison of the rice paddy and fallow fields during July and August.

The fallow field station compared very well with the surrounding United States Weather Bureau Stations. There were small differences due to the different oceanic influences at the locations. Davis, the coolest of the four Weather Bureau Stations, is the nearest to the San Francisco Bay area; and Williams, the warmest—in the daytime—is the farthest from the bay area. Thus, the fallow field location can be considered standard exposure, and the comparison with the rice field station shows how a rice field modifies the climate. The temperature difference was especially pronounced in the daytime when the rice field was about 5°F cooler than the dry land station. This was the result of the ground conditions. The 1″ soil temperature at the dry land station was 30°F to 40°F higher in the daytime than the temperature of the rice water.

As an example of the daily course of the various temperatures on August 6, 1954, an especially calm day was chosen. During the day the air temperature differences rose even higher than 5°F and—with the higher evaporation rate over the rice water—resulted in a relative humidity over the rice field that was up to 20% higher than at the dry land station. The average humidity values at 4:00 p.m. were also significantly higher over the rice paddy. Using the moisture data with the air temperatures, the vapor pressure saturation deficit was calculated to be 0.85″ at 4:00 p.m. over the rice field in July. That deficit is low when compared with 1.32″ over the fallow stations. The corresponding figures for August 1954 were 0.68″ and 0.96″.

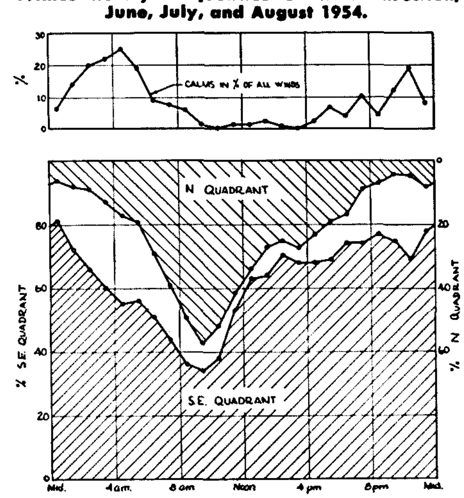
This reduction in saturation deficit is favorable because it diminishes spray evaporation. The lowering of the air temperature over the rice is also favorable because it might delay the beginning of early morning instability conditions which normally tend to disperse the spray. Special tests in this regard are planned.

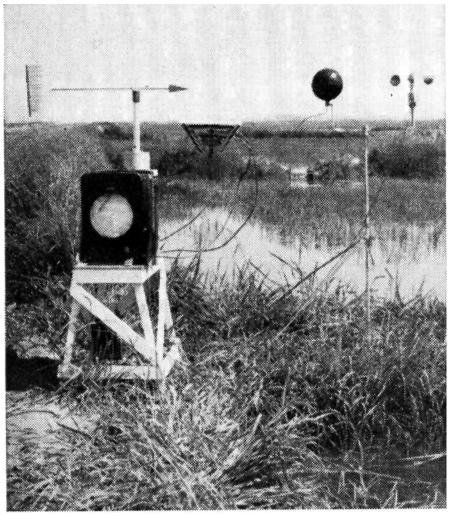
There are several indications that

Air Temperatures Measured with Spot Climate Recorder at Grimes Compared with Surrounding Standard Stations.

	Davis	Marysville	Grimes (fallow field)	Williams
Ave. Max. July 1954	96.4	97.5	97.9	98.5
Ave. Min. July 1954	57.7	61.5	61.8	60.9
Ave. Max. Aug. 1954	87.8	89.1	88.7	89.4
Ave. Min. Aug. 1954	53.2	57.0	57.1	55.6

Grimes hourly frequencies of wind direction, June, July, and August 1954.





Spot climate recorder over rice paddy near Grimes.

2,4-D spray damage to adjacent fields was caused by horizontal air movement. A detailed analysis of the wind recordings—at the field stations and eight years at Davis—was undertaken.

The graph in columns 2 and 3 shows the hourly frequency distribution of low wind velocities. On all three curves the expected maximum at sunrise is extremely high whereas the secondary maximum in the evenings is low. When judged by the curve, which includes the velocities up to 3mph, the hours in the late morning appear to be even quieter than most of the night hours. This is very unusual but encouraging for spraying operations which preferably are begun at dawn and continue for about six hours. When records of velocities up to 3mph and number of hours duration were compiled, it was found that six hours duration below 3mph would occur on only eight days in June, 10 days in July, and 12 days in August. The spraying conditions improve with the progressing season, but even August—with 12 days—is scarcely enough for the aircraft operators who need to be able to work at least on half of the days in a month. Consequently, there is considerable spraying being done during higher wind velocities. The law permits up to 5mph wind velocity measured at 10′ height and the wind direction must be taken into account.

In a compilation of wind directions for the months of June, July, and August, southerly winds prevail in the study area. In the 1954 average, about 70% of all hourly determined directions were southerly due to a monsoon-like pressure distribution. The higher pressure over the cooler ocean forces the marine air through the Golden Gate and into the interior valleys, approaching Davis as a south wind and Grimes as a southeast wind. However, these directions are shifting slightly during a daily period. At Davis the movement is from southwest in the afternoon and turns slowly toward southeast during the night. At Grimes, the southeast winds of the afternoon turn toward east-southeast, sometimes east. Around sunrise, a great number of calms appear, but shortly after sunrise a completely reverse flow from the north was registered on many days.

A detailed study was done of the specific morning wind conditions occurring when pilots wish to extend their spraying time. The described daily cycle is presented in a summarized form in the chart on page 4 by sorting all winds at Grimes between south and east into a group—the southeast Quadrant—and all winds between northwest and northeast into the north Quadrant. There is hardly a gap left from another direction; the space in between would mainly be filled by the calms which were plotted separately for the sake of clearness. There is a sharp increase of northerly directions toward a maximum of 60% at 10 a.m., and—to a great extent—they increase with a decreasing frequency of calms. Whenever a calm of one or more hours occurred around sunrise—which happened on 40% of all days—a temporary northerly flow always followed. On an-

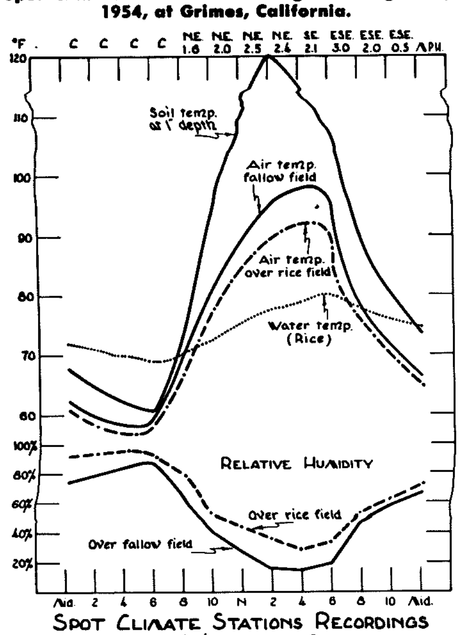
Concluded on page 14

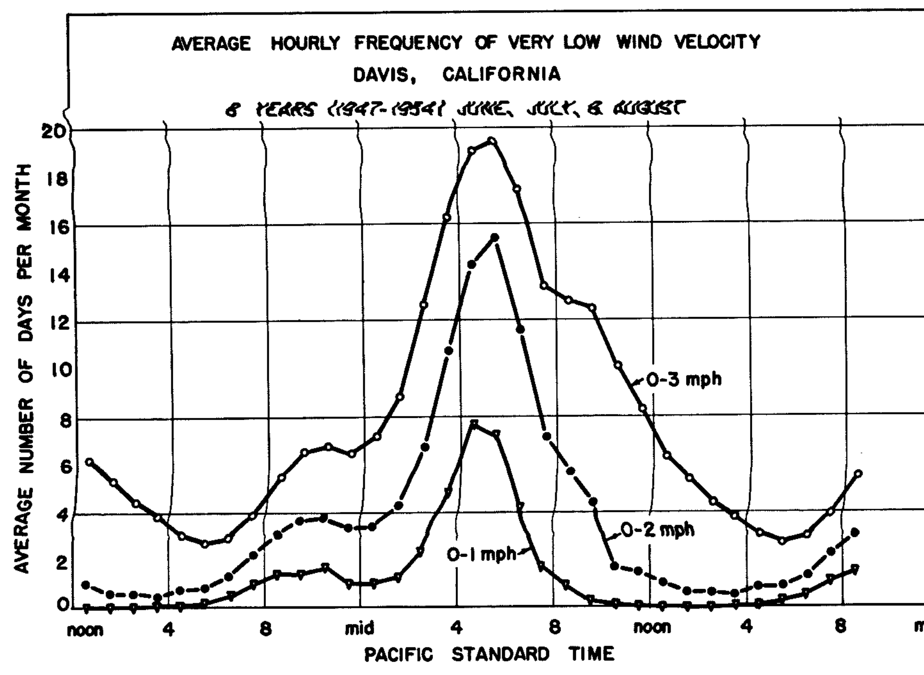
Comparison of Grimes Rice Field Station with Grimes Fallow Field Station.

	Air temp. Max.	Air temp. Min.	1″ soil or water temp. Max.	1″ soil or water temp. Min.	4 p.m. relative humidity	4 p.m. dew point temp.
July 1954						
Fallow field	97.9	61.8	120.1	68.3	26%	58°
Rice field	92.3	61.3	84.0	72.7	42%	67°
August 1954 (unusually cool)						
Fallow field	88.7	57.0	108.4	62.4	29%	52°
Rice field	84.0	56.1	76.3	66.7	42%	58°

* Only 25 days available. (July 1954: 4 p.m. relative humidity* and 4 p.m. dew point temp.*)

Spot climate stations recordings on August 6, 1954, at Grimes, California.





REJUVENATION

Continued from page 3

difference in fruit size was principally a difference in water content of the fruit. However, the percentage juice content of the fruit does not substantiate this suggestion, as there was no detectable difference in juice content.

There are indications that more frequent—and possibly smaller—irrigations might be beneficial in some of the orchards. The greatest reduction in production and fruit size and the greatest increase in soluble solids of fruits from furrow irrigated trees were in the two orchards which had the largest fluctuations in moisture between irrigations. The majority of the tensiometers in these two orchards exceeded the maximum reliable reading—750 centimeters of water —preceding each irrigation in 1954, whereas the tensiometer readings of the other orchards seldom reached the 750 centimeter limit between irrigations. The loss from split fruit was much more severe in the orchards which were dry before each irrigation, and the number of split fruits was approximately 25% higher in the furrow irrigated portion of these orchards than in the sprinkler irrigated portion.

There was visual evidence that the vegetative condition of orange trees in at least three of the orchards was improved by sprinkler irrigation. The sprinkled trees produced a more vigorous spring flush than those irrigated with furrows and in at least one of the orchards there was a marked difference in type of bloom. The furrow irrigated trees produced a very profuse bloom, most of which was borne on very short spring growth, often with no new leaves adjacent to the fruit; whereas the bloom on the sprinkled trees was sparse—predominantly a single terminal blossom on a 4″–6″ leafy shoot. The average diameter of fruit was larger and production averaged at least one field box per tree higher in these sprinkled plots than in the furrow irrigated plots.

Fumigation of the soil on one side of established orange and lemon trees with 70 to 120 pounds of the nematocide DD per acre was expected to reduce production temporarily even though the fumigant was applied at least 5′ from the tree trunk. A few months after fumigation, soil auger samples showed that roots in the middles—between tree rows—1″ or more in diameter, were black and decaying. Nematode counts showed that the fumigation had effectively reduced the population of the citrus nematode in the fumigated area. One year after fumigation, a small amount of root regrowth—about 6″–8″—into the fumigated soil had occurred.

The first year's records show that the fumigated trees were affected sufficiently to reduce the average production by 0.9 of a field box, as compared to nonfumigated trees. This difference in production was statistically significant. After the first year the fruit from fumigated trees tended in most plots to be smaller than fruit from nonfumigated trees but these differences were not significant.

Some of the trees in the fumigated plots appeared to have a less dense canopy of foliage one year after fumigation than other nonfumigated trees; yet this difference was not consistent in all plots.

The use of sprinkler irrigation in conjunction with soil fumigation appeared to reduce the injurious effects of the fumigation. This would appear to emphasize the importance of applying irrigation water in such a manner as to make use of as many roots as possible in order to obtain the maximum production from the trees.

The physical and biological soil properties associated with a wood shaving mulch may have a considerable influence on the trees by providing a better environment and, as a result, a better root system. Not only may the mulch be promoting a condition that favors the growth of beneficial organisms but it may also be producing healthier roots which can better compete with pathogenic organisms. However, the mulch as yet has produced no detectable effect on production or general condition of the aboveground portion of the trees.

In July 1955, new root growth was observed extending—several inches in some cases—up into the lowest layers of mulch. Most new root growth was at the inside edge or bottom of the furrow nearest the tree.

If the declining condition of the orchards is due to poor roots, it is probably too early to expect differences in the aboveground portions of the trees until they have had an opportunity to improve their root systems.

The results reported here are only preliminary and do not suggest any changes in orchard practices.

O. C. Taylor is Assistant Horticulturist in Citrus Grove Rejuvenation Research, University of California, Riverside.

G. A. Cahoon is Assistant Horticulturist in Citrus Grove Rejuvenation Research, University of California, Riverside.

The above progress report is based on Research Project No. 1612, a station-wide project administered by R. C. Baines, Plant Nematologist; H. D. Chapman, Professor of Soils and Plant Nutrition; J. C. Johnston, Farm Advisor, Riverside County; L. J. Klotz, Professor of Plant Pathology; R. L. Metcalf, Entomologist; P. W. Moore, Specialist in Citrus Grove Rejuvenation Research; S. J. Richards, Associate Irrigation Engineer; and W. B. Sinclair, Professor of Biochemistry—all of the University of California, Riverside.

Lewis H. Stolzy, Assistant Irrigation Engineer, University of California, Riverside, cooperated in the irrigation studies.

The application of the soil fumigant and evaluation of citrus nematode control were made by R. C. Baines, Plant Nematologist, University of California, Riverside.

DRIFT

Continued from page 5

other 20% of the days with this short time reversal, the calms preceding the wind shift were shorter than one hour and did not show up in the compilation of hourly directions, but a conspicuous low velocity slowdown at sunrise was registered.

The pattern of a weak air flow from the north in the early morning on about 60% of all days—and with velocities never exceeding 4mph—can be put to good use by aircraft operators. Because the occurrence of a north wind following the early lull is so frequent, aircraft spraying should begin on the south border of a field with the pilot working north into the developing wind. If susceptible crops are located on the north border of the field being sprayed, the pilot should stop the northward passes over the field shortly before the northerly air flow will be overcome by the dominant southerly flow. According to observations made in the summer of 1954, the temporary north winds last as follows: about 90% until 10 a.m., PST, and about 80% until 11 a.m. Only about 50% of them last till noon. The rest of the summer days when this phenomenon did not occur, about 35% of the winds were southerly and 5% northerly throughout a 24-hour period.

Data obtained during one summer period must be considered preliminary. However, spot climate stations were operated again during the 1955 season near Grimes and at other places in the rice area, and further information will be gathered in 1956. A three-year period will permit more reliable conclusions.

H. B. Schultz is Associate Specialist in Agricultural Engineering, University of California, Davis.

N. B. Akesson is Assistant Professor of Agricultural Engineering, University of California, Davis.

W. E. Yates is Assistant Professor of Agricultural Engineering, University of California, Davis.

K. H. Ingebretsen is Farm Advisor, Colusa County, University of California.

Personnel of Agricultural Engineering made the studies and recommendations of aircraft spray equipment and also developed the continuous wind direction and velocity attachments for the spot climate recorder.