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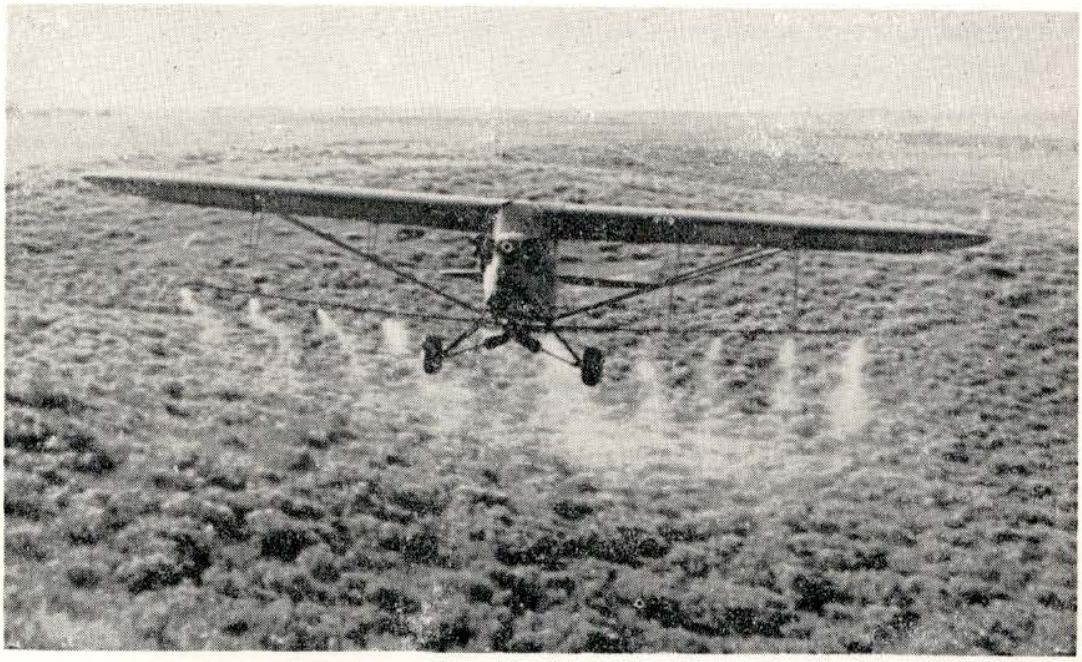

Aerial spraying of sagebrush in southwest Nebraska.

Agricultural Experiment Station and the Extension Service,
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Aircraft in Agriculture

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EARLY USES OF AIRCRAFT IN AGRICULTURE

Airplanes were first used in agriculture shortly after the close of World War I. They proved valuable for locating mosquito breeding areas, for forest fire patrol work, as an aid in locating outlaw cotton fields in the campaign against pink bollworm, and for surveying damage caused in large forested areas by the spruce budworm.

Probably the earliest experiment using the airplane for dusting or spraying of toxic chemicals was carried out in 1921. A six-acre catalpa grove with trees 25 to 30 feet high was dusted with lead arsenate for control of the catalpa sphinx. At least 99 per cent of the caterpillars were killed. Only 54 seconds elapsed during the actual flights over the grove in accomplishing what would have taken hours with ground equipment.

The start of a full scale effort aimed at the control of the cotton boll weevil took place in 1923 when calcium arsenate dust was applied by airplane. One year later mosquitoes in Louisiana and a locust plague in the Philippines received death-dealing poison dusts from low-flying airplanes. During 1924 and 1925, German and Russian workers adopted some of the methods used in America and began applying aerial dusts for the control of forest insects. The Bureau of Entomology reported excellent results in killing the gypsy moth in 1926. Applying 30 to 40 pounds of lead arsenate dust per acre by airplane gave the best results. About this same time the airplane was used in Oregon to dust insecticides for the control of alfalfa weevil.

The first use of airplane dusting in fruit orchards was reported in 1926 in an apple orchard and in peach orchards. Ground machines were compared with airplanes for dusting Georgia peach orchards. The airplane was found to be as effective as ground equipment in this case and many times faster. Also in 1926, several thousand acres of tomatoes and several hundred acres of peas were dusted by plane for the control of vegetable pests. Two pilots and a mechanic with one airplane were capable of doing the work previously requiring 1,500 to 2,000 men using ground equipment.

The airplane moved into the sugar cane fields in 1927 where approximately 5,000 acres were dusted for control of the sugar cane

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borer. At that time approximately 20 per cent of the Louisiana sugar cane was being destroyed each year by the sugar cane borer. Ground equipment could not penetrate the cane fields, so anything that could be done by airplane was advantageous. Sodium fluosilicate at 15 to 20 pounds per acre gave 60 per cent reduction in infestation.

Progress was slow but steady. In 1929 the first report of aerial dusting in citrus orchards came out of California. Sulphur was applied at 75 to 100 pounds per acre; a total of three applications gave good control on citrus thrips. This gave interest and impetus to the widening use of airplanes for pest control, and by 1931 about 140,000 acres of growing crops had been dusted by airplane. A previous report mentioned that in 1927 and 1928, 80,000 acres in Peru were dusted by airplane. About this time the Russians launched another five-year plan, and in 1930 reported 30,000 hectares in Dagestan and 10,000 hectares in North Caucasus (total of 98,000 acres) aerially dusted. In 1931, 230,000 hectares were dusted, or more than one-half million acres.

The earliest reported use of airplanes for spreading poison bran was in 1930 at Winner, South Dakota. Work done there in 1931 gave excellent kills at a cost of only 13.2 cents per acre with the possibility of lowering the cost to 10 cents per acre if operations were on a large scale. In 1932 the airplane was used for spreading poison bran for grasshopper control in Iowa. Approximately 10,000 acres were covered in this manner with good results and with greatly reduced danger of poisoning farm animals because of a lighter, more even application.

Some of the first applications of liquid sprays were made in 1932 and 1933; kerosene and distillates were sprayed on mosquito breeding areas and miscible oils were used on orchards, vineyards, and vegetable gardens. Centrifugal rotors which threw the liquid out at 2 to 15 gallons per acre at a cost of 25 to 30 cents per gallon were used. By 1936 it was thought that the airplane could be used in small eastern fields and that oil sprays could be used as soon as proper formulas were developed. In 1936 advantages of the autogiro over airplanes were cited for insect control in small fields such as the cranberry bogs of New Jersey. The low gallonage of a kerosene-pyrethrum mixture was compared with the bulk involved in dusting pyrethrum by airplane and autogiro.

The widespread grasshopper plague in the mid-thirties brought further attention to the use of the airplane for spreading poison bait. California reported satisfactory results. Nevada used the airplane on a large scale to control the Mormon cricket. From 1935 to 1941 about 600,000 tons of poison bait were distributed over 122 million acres for grasshopper control in the United States. An estimated $564,000,000 worth of food and feed crops were saved.

WORLD WAR II DEVELOPMENTS

With the entrance of the United States into World War II and the crowding together of millions of men into camps, the control of flies and mosquitoes became an immediate problem. Airplanes were soon pressed into service, and entire military installations were dusted or sprayed with DDT. Later, as fighting progressed from island to island in the South Pacific, the airplane became more important in fighting both mosquitoes and the enemy. On the other side of the world the U. S. Army Air Force was combating malaria mosquitoes in flooded areas on the Italian Peninsula, Sardinia, and Corsica by dusting with low-flying A-20 bombers. In fact, a Nazi malaria mosquito campaign in the form of deliberate flooding of land near Rome was defeated by using aerial dusting with DDT.

Since the war, many small towns and even entire cities have taken advantage of methods employed during wartime and have sprayed or dusted mosquito breeding areas or the mature mosquito with generally good results. Now airplanes are pressed into service whenever an insect or weed plague arises.

SUGGESTED USES OF AIRPLANES IN INSECT CONTROL

European corn borer. As early as 1944 DDT was applied by plane for corn borer control in Ohio with completely satisfactory results. The high value of the sweet corn crop justified the four applications needed to give 98 per cent control.

Compared with high volume and low volume ground equipment, airplane applications have been less effective, but their use is advocated when ground application is considered too slow or impossible. Time of application is more important than the method used. Use 1 to 1½ pounds of DDT per acre in 2 to 4 gallons of water. Swath width should be no greater than the wing span or rotor length.

In fields where corn measures 35 inches to the tips of the leaves and there are at least 50 egg masses per 100 plants, treatment for first generation borers should start four to seven days after the first hatch. If seven to ten days after treatment eggs continue at 50 or more masses per 100 plants and the weather remains cool and humid, then a second treatment should be made. Treat at the first hatch of the second generation borers if there are 100 egg masses per 100 plants. (See Extension Circular 1555.)

Corn rootworm. Very little has been done on this phase of control by using airplanes. The one exception is an experiment run at Wood River in 1948 where a cornfield was dusted about August 15. The idea was to kill the adult beetles before they began to lay eggs. The kill was very satisfactory; a survey the following spring showed no lodging, indicating that egg laying had been reduced to a minimum.

During August and early September, the Northern and Western corn rootworms lay their eggs in cornfields. These two can be treated aerially. Treat with 1 to 1½ pounds of DDT. In the spring the Southern or spotted corn rootworm lays its eggs in newly planted cornfields, and because of its long egg-laying season the chances of controlling it with an airplane are very remote.

Sweetclover weevil. This snout beetle that has caused so much trouble to Nebraska legumes can be fairly well controlled by airplane. One to 1½ pounds of DDT per acre dusted or sprayed when damage begins to show up has proved effective.

Grasshoppers. This is one of the biggest fields of operation for the aerial operator, whether he is putting on bait, spraying, or dusting for the government or for local farmers.

Apply 1 pound of chlordane or 1½ pounds of toxaphene to the acre in all crops except forage and pasture. In forage crops, trap strips treated with ground machinery are much better and much safer. In pastures, baiting or any other treatment where the insecticide is kept away from grazing animals is to be preferred.

In treating seed alfalfa for grasshoppers, do not apply the chemical beyond 10 per cent bloom. Either get the insecticide on ahead of this point or wait until the bloom period is over; otherwise, too much damage will be done to pollinating insects.

Lygus bugs. These insects can be killed at the same time treating is done for grasshoppers by adding some DDT to the spray mixture. When treating for lygus bugs alone, use 2 pounds of DDT to the acre. In mixing a spray for both insects, good control has been obtained with 1 pound of toxaphene and 1 pound of DDT. This was sufficient to handle both insects in 1949. Toxaphene by itself gives fair control of lygus bugs. The DDT treatment, however, is superior to either of the above sprays when lygus alone is to be treated.

Fly control in towns and cities. This is not recommended by the Entomology Department because too much territory not inhabited by flies is covered. An airplane should be used only in cases of emergency. Ground equipment is far superior.

Greenbugs. The Nebraska College of Agriculture recommends only benzene hexachloride for the control of the plant louse which attacks small grain. One-third pound of the gamma isomer of B.H.C. will do a good job in most cases. This is a little less effective than parathion but far less hazardous to the pilot, to the farmer, to livestock, and to the neighbors. Parathion *is not* recommended for any purpose in Nebraska.

Other insects. Aerial operators are occasionally called on for rather strange jobs. In some parts of the State airplanes have been used to

treat creek and river banks to control cankerworms and leaf beetles that are defoliating the trees. There are numerous other cases where insects can be controlled aerially. Keep in mind that the various departments at the University of Nebraska are always willing to identify any pests that may show up and will give the best information they have on how to control them.

SUGGESTED USES OF AIRPLANES IN WEED CONTROL

Small grain. Airplanes have probably been used more extensively for weed control in small grain than in any other weed situation. As early as the fall of 1946 work was initiated at the Nebraska Experiment Station using a Stearman PT-17. Pennycress, *Thlaspi arvense,* was eliminated 90 to 100 per cent by as little as 0.3 pound of 2,4-D butyl ester in 5 quarts of diesel oil per acre. The fall application seriously injured the wheat, causing rolled leaves, stunted growth, and incomplete head emergence which resulted in reductions in yield.

Best results have been obtained with 2,4-D on annual weeds in wheat, oats, and barley where spraying has been done moderately early in the season. This will ordinarily be the period after the small grain is fully tillered and before it enters the boot stage. Usually ¼ to ½ pound 2,4-D acid of the esters or ½ to ¾ pound 2,4-D of the amine salts is sufficient to control most weeds. Where adverse growing conditions exist, higher rates may be necessary. Wheat and barley are most subject to injury during the early boot stage. Serious injury may occur during the boot stage. Oats are more subject to injury from the seedling through the jointing stages. Fall-planted small grain should not be sprayed the same fall it is planted. At the low rates required for annual weeds, most grain can be profitably sprayed at any stage of spring growth if a serious weed problem exists.

Corn. Airplane applications of 2,4-D in corn have been successful although not extensive. Spraying should be done before the corn exceeds 24 inches in height to lessen crop damage such as brittle and bent stalks, root deformities, and leaf rolling. Use 2,4-D at the same rates as recommended for the control of weeds in small grain.

Injury to corn from 2,4-D is more likely to occur during periods of very rapid growth, especially during the two- to four-foot stage. Corn should not be sprayed when the silks are emerging. On newly emerged silks 2,4-D is likely to cause considerable sterility.

Such weeds as sunflower and cocklebur which are often a problem in corn after it is "laid by" may be sprayed by airplane any time after pollination. The airplane is especially adapted to work in tall corn or over wet fields where ground equipment cannot operate.

Grain sorghum. Small sorghum plants up to 4 inches high appear to be more susceptible to 2,4-D than larger plants when grain yields

are considered. Greater root damage may be expected when treating plants that are 10 to 12 inches high. Considerable root deformity may be noticeable without grain or forage yield reductions. If sorghum is to be sprayed during the heading stage, do not use over ½ pound 2,4-D acid per acre, and some floret sterility should be expected.

Flax. The margin of safety between dosages of 2,4-D that injure flax and dosages that give effective weed control is narrow. Flax should be sprayed with 2,4-D as soon as there is enough emergence of susceptible species of weeds to make spraying practical. Flax may be badly injured if sprayed in the bud to bloom stages. The amine salts are safer to use than the esters when spraying flax. Important differences exist in varietal tolerances of flax to 2,4-D. Consult local agricultural authorities for tolerances of varieties when aerial spraying is contemplated.

Irrigation and drainage ditches. Along steep ditch banks where susceptible crops can be avoided, aerial spraying has been successful in controlling many broad-leaved weeds. Clusters of nozzles or a single large venturi beneath the fuselage instead of a spray boom have been used to give a sharp, narrow spray swath for such specialized work. This narrow, concentrated spray swath gives the operator better control of the weed killer and also makes possible maximum coverage where plant cover is often quite dense. Use 2,4-D for annual broad-leaved weeds when the weeds are 6 to 8 inches high for safest, cheapest, and most effective weed control. A second application later in the season will usually be required to control those weeds which germinate intermittently throughout the season.

Ranges and pasture land. It has been estimated that control of brush and weeds in range and pasture land constitutes one of the largest potential fields for wide-scale aerial application. In Texas and Oklahoma alone there are approximately seven million acres of sand sagebrush. The sand sage can be controlled effectively by aerial applications of 2,4-D. On an acre basis, not less than ¾ pound and preferably 1 pound 2,4-D acid should be used. Spraying should not begin until the sagebrush reaches the bud stage and may be continued for three or four weeks thereafter. Final results should not be estimated until approximately one year later. Greatest benefits are realized where proper grazing management accompanies brush and weed control measures.

In many of the smaller pastures much improvement can be brought about by timely applications of 2,4-D. Some of the most common species which can be controlled are ragweed, sunflower, wild hemp, marsh elder, cocklebur, and gum weed. Buckbrush, willows, cottonwood, and wild plum can also be effectively controlled by 2,4-D. If wild rose, honey locust, currant, gooseberry, or poison ivy are treated

in solid stands, use 2,4,5-T. When species susceptible to 2,4,5-T are mixed with species susceptible to 2,4-D, then a mixture of 2,4-D and 2,4,5-T should be used. Use at least 1 pound acid per acre where the materials are used separately. Where a mixture of the two herbicides is to be used, let the amount required to control the most tolerant species be a guide to the upper limit of dosage required.

Livestock are not harmed by 2,4-D and 2,4,5-T; however, some species of plants which have some poisonous properties but are ordinarily not eaten by livestock may be eaten following treatment. Because of this possibility, it is suggested that the livestock owner keep all livestock from the sprayed pasture for one week.

SPECIALIZED USES OF AIRCRAFT IN AGRICULTURE

Seeding. Seeding rice by airplane into flooded seedbeds has become an established practice in the rice areas of Arkansas, Texas, Louisiana, and California. Aerial applications of 2,4-D in these same rice fields for weed control is also becoming commonplace.

The Forest Service has successfully used aerial seeding as a means of quickly establishing a cover of wild mustard on steep watersheds following a fire. Direct seeding of forest trees by seed from airplanes has not proved satisfactory. The same is true of seeding grasses on depleted range land (covering the seed by ground methods usually is required). Aerial seeding of grasses has been successful where seeding is done immediately following brush and timber burns. Sufficient ashes to permit good seed coverage is essential.

Fertilization. Aerial applications of fertilizers and fungicides have been accomplished with some degree of success in the fruit and vegetable areas of California, Washington, and Oregon.

Pollination. Aerial operation for the purpose of pollinating alfalfa by air turbulence is not an approved practice. The small amount of seed, if any, resulting from such operations probably would be self-pollinated. Seed produced as a result of self-pollination is undesirable because it produces less vigorous plants than cross-pollinated seed.

SPECIAL REFERENCES ON AERIAL EQUIPMENT

Since there is so much controversy on the type of equipment to use, some specific references in this particular field are listed below. Most of these publications are available from the issuing agency in Washington, D. C.

E. T. 228. "Equipment for the Dispersal of DDT Insecticides by Means of Aircraft," by C. N. Husman, O. M. Longcoy, and H. S. Hensley. U.S.D.A., Bureau of Entomology and Plant Quarantine.

"Aerial-Spray Equipment for a Piper Cub J-3 Airplane," by Orve K. Hedden. U.S.D.A., Bureau of Plant Industry, Soils, and Agricultural Engineering. Information Series No. 88, August, 1948.

"Aerial-Spray Equipment for a Stearman N2S Airplane," by D. A. Isler. U.S.D.A., Bureau of Plant Industry, Soils, and Agricultural Engineering. Information Series No. 87, August, 1948.

E. T. 262. "Equipment for Dispersing Insecticides from Aircraft," by Frank S. Faulkner and C. C. Deonier. U.S.D.A., Bureau of Entomology and Plant Quarantine.

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STATE REQUIREMENTS GOVERNING AERIAL APPLICATORS

Dusting and spraying by aircraft in the State of Nebraska may be done only by approved operators after a waiver of regulations and rules has been obtained from the State Department of Aeronautics. Such a waiver is issued for not more than one year and is subject to recall at any time for just cause. A seal evidencing such waiver shall be displayed on each aircraft registered under the waiver on the right rear window or just aft of the rear cockpit on the starboard side in the case of an open cockpit plane.

Such a waiver will be issued to Nebraska residents contingent upon compliance with the following requirements:

(1) Possession of a current waiver issued by the Civil Aeronautics Administration.

(2) Equipment used, including aircraft and spraying or dusting equipment, must have the approval of the Civil Aeronautics Administration and the Department of Aeronautics.

(3) Each aircraft must be inspected by a person authorized by the Department of Aeronautics to conduct such inspection.

(4) The inspector shall determine that the CAA Airworthiness Certificate is current, installation of spraying or dusting equipment has CAA approval, spraying rig is satisfactorily equipped with a positive shut-off device at each discharge nozzle, dusting rig is satisfactorily equipped with a positive shut-off between hopper and discharge orifice, and the entire rig is in good usable condition and free from any obvious points of leakage.

(5) Certificate of competency of personnel to be employed must be completed and submitted with application.

(6) A bond in the amount of $1,000 approved by the Director must be posted with the Department of Aeronautics and shall cover the period of time for which such waiver is sought or granted.

Aerial sprayers not residents of the State of Nebraska must meet the following additional requirements:

(1) Furnish evidence indicating current qualifications as aerial dusters or sprayers in their native state.

(2) After complying with all rules and regulations, make payment of any fees as charged by their state of residence to Nebraska dusting and spraying operators or pilots.

(3) Post bonds or insurance in such amount as that required by the state of residence if such amount is in excess of the amount required in this State.

These regulations governing aerial applicators in the State of Nebraska originated through the combined efforts of the Agricultural Committee of the Nebraska Air Trades Association, Attorney-General, State of Nebraska, State Department of Agriculture, and the Nebraska Department of Aeronautics. Such regulations were formulated in the interest of public safety, for the protection of persons contracting the services of aerial applicators, and also for the benefit and protection of this new industry which has developed only in the last three or four years. Contact the Department of Aeronautics to determine whether the operator you intend to engage has met all State and Federal requirements.

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