

Equipment Setup for Aerial Application of Liquid Pesticides



Aerial application of liquid pesticides is an important operation, especially over forests and large crop areas and when speed of treatment and field access are keys to a successful treatment. Some diseases such as the Asian Soybean Rust spread so quickly and aggressively that aerial application is the only effective way to deliver treatment to large areas in very short time.

Types of Aircraft

Both fixed-wing and rotary-wing aircraft are used for the application of pesticides. Several companies have designed specific aircraft for crop spraying. Air Tractor Inc. (www.airtractor.com), Thrush Aircraft Inc. (www.thrushaircraft.com) and Bell Helicopter (www.bellhelicopter.com) are among the most popular manufacturers of spraying aircraft in the United States. Desirable characteristics of spraying aircraft are:

- High-performance engine to lift a heavy payload from an unpaved strip.
- Airframe capable of frequent landings and takeoffs.
- High payload to low gross weight ratio.
- Light and responsive controls to reduce pilot fatigue.
- Cockpit with good overall visibility.
- Pressurized and air-conditioned cockpit to reduce the risk of contamination of pilot.
- Tank design allowing fast loading and easy cleaning, as well as special provisions for rapid dumping of a load in case of emergency.

SPRAY EQUIPMENT

Spray Tank

Tank should provide a translucent zone at the rear, when mounted on the fuselage, to permit the pilot to inspect the remaining volume. The shape of the tank should allow complete drainage. A dump valve should be strategically located to effectively eliminate a full load in less than 5 seconds in case of an emergency. A bottom loading point usually is used to pump a load from a ground mixing unit.

Pump

Centrifugal pumps usually are used. Pumps may be driven by a fan mounted on the slipstream of the propeller of the aircraft, usually between the landing wheels. Hydraulic drive systems and electrically operated pumps are sometimes used, as well. The pump should always be mounted below the tank level to ensure it remains primed. Many helicopter systems use one or two electrically driven centrifugal pumps.

Spray Boom

In the United States, spray booms on fixed-wing aircraft cannot extend more than 70 percent of the wing span to reduce off-target drift. Spray droplets close to the wing tip area usually are caught in vortexes and carried away from the intended deposit area. Spray booms usually are mounted at least 10 inches vertically and 6 inches horizontally away from the wing's trailing edge. There are measurable advantages in lowering the spray boom to avoid turbulence. Hoffmann and Tom (2000) fabricated and tested a spray boom system that was lowered in flight by 1.5 feet and moved forward by 1.2 feet. Effective swath width was increased by 3.6 percent, and off-target drift was lowered by 26 percent at 33 feet downwind and 56 percent at 1,000 feet downwind.

Check Valves

Check valves are required to provide positive shutoff of the nozzles and prevent them from dripping. AeroFlow Systems (www.aeroflow.com) are the manufacturers of the AFS valve, a popular check valve among aerial applicators.

Spray Nozzles

Hydraulic nozzles used in aircraft are similar in design to nozzles used in ground-based sprayers. The fundamental difference is that nozzles for aircraft need to have high volume output because of the high operating speed of the aircraft. Hydraulic nozzles used on an aircraft are affected by air shear caused by the high-speed slipstream. The angle at which liquid is discharged from the nozzle relative to the slipstream changes the droplet spectra. Nozzles angled forward and downward into the slipstream produce smaller droplets and a wider range of sizes than nozzles directed backward.



A typical hydraulic nozzle used in American aircraft is the CP nozzle manufactured by the CP Products Company Inc. (www.cproductsinc.com). CP nozzles such as the CP-09 offer the versatility of multiple orifices so the pilot can quickly change flow rates. It also offers three different angles of deflection. The CP-11TT flat fan nozzle is CP's newest nozzle and can hold up to three different flat fan nozzles and still provide shutoff. The USDA-ARS Areawide Pest Management Research Unit located in College Station, Texas, has developed several computer models users can access to learn more about setup effects of the CP nozzles in the production of small droplets. The models can be accessed at www.ars.usda.gov/spa/sparc/apmru.

A different aircraft nozzle is the rotary-centrifugal-energy Micronair manufactured by Micron (www.micron.co.uk). These nozzles offer great versatility and droplet control. Six to eight units are usually enough for an airplane in contrast to 40 to 60 regular nozzles. An electric version of this nozzle provides the pilot with more control over the droplet size produced,

since the nozzle rotation is independent from aircraft forward speed. These nozzles are difficult to clog, since small orifices are not required to break up the liquid. Wettable powders and suspensions are more easily applied. Higher application volumes (greater than 5 gallons per acre) usually are harder to obtain when using these nozzles, however. Other manufacturers of similar nozzles are Davidon Inc. (www.davidononline.com) and Curtis Dyna-Fog Ltd. (www.dynafog.com).

FLIGHT PLANNING

Aircraft Flying Height

According to the literature, the distance between the aircraft and the crop should not exceed half the wingspan if full use of the downwash turbulent air is to be made. Recommendations are made for pilots to fly 8 feet to 12 feet above the crop canopy. Spray deposition and off-target drift are extremely sensitive to changes in release height.

Swath Width

The swath used by an aircraft is a function of the type of aircraft, flying height, droplet size and wind conditions at the time of spray. The best method to learn what is the optimal swath width for a particular aircraft is to participate in a calibration clinic. During the clinic, a cotton string is used to capture spray, and computer software calculates the optimum swath width based on the coefficient of variation. Dr. Dennis Gardisser, retired professor of the Cooperative Extension System at the University of Arkansas, lists the typical swath widths (in feet) expected for several Air Tractor aircraft as:

Aircraft	1 GPA	2, 3 GPA	5 GPA	8 GPA	10 GPA
AT 402	69	66	63	60	57-60
AT 502	72	70	66	63	60-63
AT 602	78	75	72	66	66-70
AT 802	90	85	80	75	72-78



Guidance Systems

Global positioning system (GPS) receivers are widely used in aerial application today. Most receivers will record data for later viewing and retrieving. This data can be used to verify pattern and coverage during the application. Dedicated software will guide the pilot during the application at the selected swath width. Hemisphere GPS (www.hemispheregps.com), Ag Nav (www.agnav.com) and Dyna Nav (www.dynanav.com) are among the most popular systems used in the United States.

Flight Pattern

Pilots often will choose between racetrack and back-and-forth methods of spraying. In a racetrack mode, pilots fly in the same direction for each spray pass and this may provide a more even spray coverage. A racetrack method provides a left-on-right deposition. In a back-and-forth application method, pilots fly a field progressively back and forth, producing a left-on-left and right-on-right deposition.

Flow Control

Flow control is becoming more popular than ever in the United States. Flow control systems usually are comprised of a ball valve (to adjust flow), flow meter, GPS receiver and a computer console. The computer matches flow requirements to the groundspeed of the aircraft, thus minimizing upwind or downwind application rate differences. Smith (2000) calculated that for an air speed of 135 mph, an aircraft facing a headwind of 10 mph would produce a groundspeed of 125 mph but would produce groundspeed of 145 mph on a downwind leg under the same conditions, a difference of 14.8 percent.

FORMULAS

Aircraft Productivity in Acres per Minute (APM):

$$APM = \frac{AIR\ SPEED\ (IN\ MPH) \times SWATH\ WIDTH\ (IN\ FEET)}{495}$$

Aircraft Flow rate, in gallons per minute (GPM) needed, based on productivity:

$$GPM = APM \times GPA$$

Number of nozzles (NN) needed:

$$NN = \frac{GPM}{NOZZLE\ FLOW\ RATE, in\ GPM}$$

EXAMPLES:

Aircraft speed is 155 miles per hour (MPH); desired swath width is 70 feet. Aircraft productivity in acres per minute will be:

$$APM = \frac{155\ MPH \times 70\ FEET}{495} = 21.9\ ACRES\ PER\ MINUTE$$

For an application rate of 5 GPA, aircraft flow rate needed is:

$$GPM = 21.9 \times 5\ GPA = 109.5\ GPM$$

The minimum number of nozzles needed, based on the flow rate of 2.454 GPM per nozzle is:

$$NN = \frac{109.5}{2.454} = 44.6\ or\ 45\ nozzles$$



REFERENCES

Hoffmann, W.C., Tom, H.H. 2000. Effects of Lowering Spray Boom in Flight on Swath Width and Drift. Applied Engineering in Agriculture. Vol 16(3): 217-220.

Mathews, G.A. 2000. Pesticide Application Methods. 3rd Edition. Blackwell Science.

Oseki, Y. 2006. Manual de Aplicacao Aerea. Sao Paulo. www.spraytec.com.br. (In Portuguese).

Smith, L.A. 2000. Automatic Flow Control for Aerial Applications. Applied Engineering in Agriculture. Vol. 17(4): 449-455.



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