An Apple Grower's Experience Using a Drone to Manage an Orchard's Spray Program

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Considerations for Spraying Tree Fruit with a Drone

This report is intended to address growers' questions about the experience of using a drone to manage an orchard's spray program. The report addresses "boots on the ground" experience with a drone but does not cover other key questions related to using a drone in an orchard such as drone selection, nozzle calibration, and best practices.

This guide reflects my experience with one particular drone, a DJI Agras T30, at one particular orchard. The T30 has an eight-gallon tank. I have three batteries and an indoor charger. Battery life is about ten minutes, which is a brief enough period of time to be fairly inconvenient. DJI does make a generator-powered charger that charges the batteries quickly. Indoor charges takes about 40 minutes per battery.

There are a number of characteristics of my situation that made drone spraying appear to be an attractive option for me:

- My acreage is relatively small – only about six acres
- My orchard has short rows set up in different orientations – some rows are east-west, some are north-south, some are northeast-southwest.
- I am okay not driving a tractor
- I have an affinity for digital technology versus engines and hydraulics
- In the spring, my orchard tends to be wet
- My orchard has some elevations that are challenging for traversing with a tractor

Bottom line: if you spray with a tractor and are happy with that approach, keep taking that approach. There is no research yet to suggest that orchard spraying with a drone is superior to orchard spraying with a tractor and an airblast sprayer. At the same time, there is no research to suggest drone spraying is inferior to tractor/airblast spraying. In my particular case, tractor spraying took an inordinate amount of time due to short rows with different orientations and so I was interested in exploring the feasibility of using a drone to spray.

Starting Your Spray Day
I discovered that my "home base" wasn't conducive to efficient drone spraying since it used valuable battery life just to get from my charging station to the start of the spray area, so I generally left the drone out in the orchard and transported the following out to the drone on a utility vehicle:

- Spray materials
- Measurement devices (scale/volumetric measuring container)
- Water jugs
- Mixing container (a five-gallon container with a screw-top opening)
- Drone batteries, fully charged
- Remote, fully charged
- PPE

Mixing
When you are spraying at a small scale, your mixing technology needn't be expensive or fancy. I have a designated mixing container that I use to combine materials. I add water first and then add the spray materials in the designated order, mixing between each addition. Agitation is provided by manually shaking/inverting the mixing container. I then add the contents of my mixing container to the drone's tank, alternating with water.

Applying
Researchers at Penn State and Michigan State are engaged in establishing best practices for drone spraying fruit trees; those best practices are beyond the scope of this guide. It is important to be aware of this research because it will ultimately provide useful information about spray nozzle types, spray volumes, and spray patterns. I found that the minimum gallons per acre specified by product labels sprayed at 18' feet from the ground in roughly alternate rows parallel to the tree rows provided adequate coverage on spray paper placed at three different heights in the canopy. My drone's speed was set according to the gallons per acre I wanted to spray, so I did not treat speed as a variable.

The advice coming out of those two research programs is to spray 15-25 gallons per acre and to treat the label guidance for gpa as minimal. Given short battery life and a small tank, it will be tempting to use those minimums. I haven't found those minimums to be problematic. What I have found to be more problematic are materials and spray area perimeters.

Because the drone does not have built-in agitation, dry spray materials – especially powders – are prone to settling and clogging; therefore I suggest modifying your drone-based spray program to use liquids to the extent possible. If liquids are not possible, use a water-dispersable granule rather than a wettable powder. See the attached spreadsheet for aerial-application-approved pesticides and growth regulators and their characteristics of dry versus liquid.

I've also found issues with spray area perimeters, namely that coverage on perimeters has been less than optimal. There are a couple of ways to address perimeter challenges:

- Use larger spray areas to reduce spray area borders. I have used large areas and small areas. In large areas, the challenge is battery life; however, I will trade challenges associated with interrupted sprays due to battery life for insufficient pesticide coverage.
- Pay careful attention to wind direction and speed and modify your spray area to accommodate those differences from one spray day to the next.

Clean-Up
After spraying, I rinse the tank and spray lines out, much as you would for your airblast sprayer.

Conclusions
In conclusion, for orchardists trying to decide if drone-based spraying is right for them: there is no single correct answer. Consider the factors I listed above (access in wet conditions, spray time on a tractor, material selection, comfort with tractors versus digital technology, equipment investment) to determine if drone spraying is an option for you. If you are unsure about the results associated with using a drone to spray, stay tuned for research coming out of Penn State and Michigan State within the next year.

Commonly-Used Pesticides in Tree Fruit Production Approved for Aerial Application

Category	Product	Restricted Use?	Formulation	Aerial GPA
Insecticide/Miticide	Altacor 35WDG	No	Dry	5
Insecticide/Miticide	Asana XL 0.66EC	Yes	Liquid	10
Insecticide/Miticide	Assail 30SG	No	Dry	10
Insecticide/Miticide	Avaunt 30WDG	No	Dry	10
Insecticide/Miticide	Baythroid XL 1EC	Yes	Liquid	10
Insecticide/Miticide	Beleaf 50SG	No	Dry	10
Insecticide/Miticide	Besiege	Yes	Liquid	10
Insecticide/Miticide	Agree 3.8WS	No	Dry	2–10
Insecticide/Miticide	Deliver 18WG	No	Dry	10
Insecticide/Miticide	Dipel 10.3DF	No	Dry	3
Insecticide/Miticide	Javelin WG	No	Dry	3
Insecticide/Miticide	Centaur 0.7WDG	No	Dry	5
Insecticide/Miticide	Delegate 25WG	No	Dry	
Insecticide/Miticide	Intrepid 2F	No	Liquid	20
Insecticide/Miticide	Zylo	No	Liquid	20
Insecticide/Miticide	Lambda-Cy 1EC	Yes	Liquid	5
Insecticide/Miticide	Leverage 360	Yes	Liquid	10
Insecticide/Miticide	Magister SC	No	Liquid	10
Insecticide/Miticide	Movento 240SC	No	Liquid	10
Insecticide/Miticide	Mustang Max	Yes	Liquid	10
Insecticide/Miticide	Neemix	No	Liquid	3–5
Insecticide/Miticide	Azatin XL	No	Liquid	3
Insecticide/Miticide	Onager 1EC	No	Liquid	10
Insecticide/Miticide	Surround 95WP	No	Dry	10
Insecticide/Miticide	Transform WG	No	Dry	3

Category	Product	Restricted Use?	Formulation	Aerial GPA
Insecticide/Miticide	Verdepryn 100SL	No	Liquid	5
Insecticide/Miticide	Versys	No	Liquid	10
Insecticide/Miticide	Warrior II 2.08CS	Yes	Liquid	5
Fungicide/Bactericide	Aprovia	No	Liquid	5
Fungicide/Bactericide	Actigard 50WG	No	Dry	5
Fungicide/Bactericide	Captan 80WDG	No	Dry	5–20
Fungicide/Bactericide	Captan Gold 4L	No	Liquid	5–20
Fungicide/Bactericide	Cevya	No	Liquid	10
Fungicide/Bactericide	Badge SC	No	Liquid	10
Fungicide/Bactericide	Badge X2	No	Dry	10
Fungicide/Bactericide	Champ Formula-2 4.6F	No	Liquid	10
Fungicide/Bactericide	C-O-C-S WDG	No	Dry	10
Fungicide/Bactericide	Cueva	No	Liquid	5–40
Fungicide/Bactericide	Cuprofix Ultra 40 Disperss	No	Dry	10
Fungicide/Bactericide	Kocide 3000	No	Dry	10
Fungicide/Bactericide	Kocide 3000-O	No	Dry	10
Fungicide/Bactericide	Double Nickel LC	No	Liquid	3
Fungicide/Bactericide	EcoSwing	No	Liquid	5–20
Fungicide/Bactericide	Flint Extra	No	Liquid	10
Fungicide/Bactericide	Indar 2F	No	Liquid	10
Fungicide/Bactericide	Inspire Super	No	Liquid	10
Fungicide/Bactericide	Manzate Pro-Stick	No	Dry	10
Fungicide/Bactericide	Penncozeb 80WP	No	Dry	10
Fungicide/Bactericide	Penncozeb 4FL	No	Liquid	10
Fungicide/Bactericide	Merivon	No	Liquid	10
Fungicide/Bactericide	Miravis	No	Liquid	10
Fungicide/Bactericide	Oso 5% SC	No	Liquid	
Fungicide/Bactericide	Pristine 38WDG	No	Dry	10
Fungicide/Bactericide	Trionic	No	Liquid	10
Fungicide/Bactericide	Regalia	No	Liquid	2–10
Fungicide/Bactericide	Rhyme	No	Liquid	5
Fungicide/Bactericide	Topguard	No	Liquid	5
Fungicide/Bactericide	Scala	No	Liquid	15
Fungicide/Bactericide	Serenade Opti	No	Dry	3-20

Category	Product	Restricted Use?	Formulation	Aerial GPA
Fungicide/Bactericide	Sovran 50WDG	No	Dry	5
Fungicide/Bactericide	Syllit FL	No	Liquid	10
Fungicide/Bactericide	Tesaris	No	Liquid	10
Fungicide/Bactericide	Torino	No	Liquid	10
Fungicide/Bactericide	Vangard WG	No	Dry	20
Fungicide/Bactericide	Vacciplant	No	Liquid	
Insecticide/Miticide	Brigade 10WSB	Yes	Dry	10
Insecticide/Miticide	Brigade 2EC	Yes	Liquid	10
Insecticide/Miticide	Enkounter	No	Dry	10
Insecticide/Miticide	Entrust 2SC	No	Liquid	
Insecticide/Miticide	M-Pede	No	Liquid	3
Insecticide/Miticide	Checkmate CM-F	No	Liquid	
Insecticide/Miticide	Checkmate OFM-F	No	Liquid	
Fungicide/Bactericide	Cabrio EG	No	Dry	10
Fungicide/Bactericide	Howler	No	Dry	10
Fungicide/Bactericide	Luna Experience	No	Liquid	10
Fungicide/Bactericide	OxiDate	No	Liquid	
Fungicide/Bactericide	Serenade ASO	No	Liquid	3-20
Fungicide/Bactericide	Vivando	No	Liquid	10
Growth Regulator	Fruitone N	No	Dry	
Growth Regulator	Kudos	No	Liquid	10
Growth Regulator	PoMaxa	No	Liquid	5
Growth Regulator	PRO-HEX	No	Dry	10
Growth Regulator	Refine 6.25L	No	Liquid	5
Growth Regulator	Refine 3.5L	No	Liquid	5
Insecticide/Miticide	Admire Pro 4.6SC	No	Liquid	25
Insecticide/Miticide	JMS Stylet-Oil	No	Liquid	
Fungicide/Bactericide	Wettable sulfur	No	Dry	