FACT SHEET

Drones in Agriculture

OATS Organic Agronomy Training Service
Fiscal Sponsor: Organic Trade Association

SUMMARY

- Drones are a new tool in agriculture showing lots of promise.
- The technology is evolving rapidly, with drones becoming obsolete within 18 months.
- Drones are used both to map fields and to apply materials.
- Flying agricultural drones requires licensing from the FAA (Federal Aviation Administration).

THE BASICS

Drones are a promising addition to agriculture, with the ability to perform jobs that are otherwise impossible or very expensive. However, they are also a technology that is rapidly evolving. While some farmers are using drones, an increasing number of companies offer drone services to farmers.

In general, there are two types of drones, categorized by the task they perform: smaller, less expensive drones for mapping; and larger, more expensive drones for applying materials (pesticides, cover crop seed, etc.).

The basic process for using drones is:

1) Gather field data - Map the field with a remote sensing drone or existing maps.
2) Analyze field data - Import the field data gathered by the drone into a computer program and analyze it for use in making decisions. Or, use the existing maps to plan the route of the application drone.
3) Create a flight map for the application drone.
4) Apply material with an application drone.

FEATURES

REGULATIONS

Before engaging in any of these operations, be aware that all agricultural drones are regulated by the FAA. It is important for farmers who are considering doing their own field work to understand the required regulations, which continue to change rapidly.

- **Drones under 55 pounds** - A drone under 55 pounds that is used for fun is NOT regulated by the FAA, but any drone that is used for business (like farming) DOES fall under FAA regulations. Typically, drones under 55 pounds are those that are used for mapping/sensing. Operators of mapping drones need a Part 107 certification from the FAA. This process is similar to obtaining a pesticide applicator's license - get the study book, study, take the test, file paperwork with the FAA, and keep up with continuing education credits.
- **Drones over 55 pounds** - Drones that weigh over 55 pounds are typically used for applying materials. They require an oversize frame certificate from the FAA. This is a more involved process that requires more paperwork, more time for FAA approval, and a doctor's note certifying the operator's physical fitness.
- **Drones applying materials** - There are additional licenses required by the FAA for operators applying materials. According to the FAA, a drone operator "dispensing any other substance intended for plant nourishment, soil treatment, propagation of plant life, or pest control" needs a Part 137 exemption.
- **All drones must be registered with the FAA.**

QUICK TIP

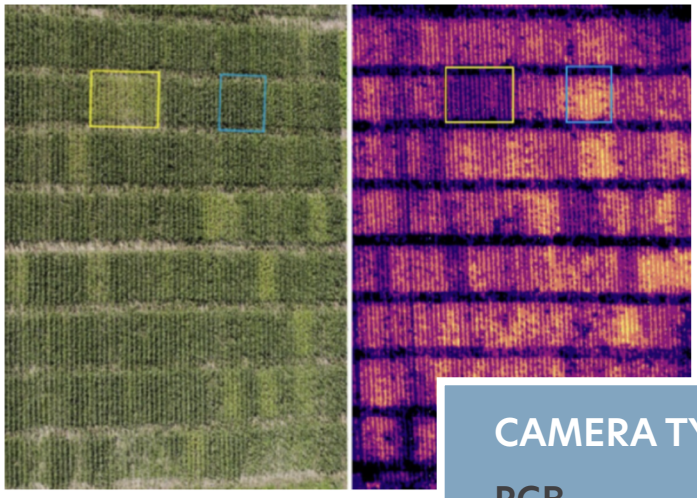
Because of the long process required to be certified to drone apply materials, it often makes little sense for a farmer to get this certificate, unless perhaps they want to start a custom applicator business. Also, many people find that working with a lawyer to get the Part 137 exemption is helpful to simplify the process.

Drone operators don't want to skip getting certified by the FAA - because the FAA requires that each manufactured drone has a transponder, like the black box in an airplane. This means that the FAA will know your drone is flying.

By Sam Oschwald Tilton, Designed by ideaFarm studios | Published April 2024

USING DRONES TO MAP
Cameras

Where as applying materials with drones is new and there are constantly new developments, crop mapping by satellite or airplane has been developing for more than 20 years. As a result, there is good existing information on the types of cameras and the programs used to interpret the data into usable field maps. A mapping drone can be fitted with a variety of camera types. Each type of camera 'sees' something different (see the table below). Camera models will be more or less expensive based on their resolution. For example, image quality could vary between one square inch per pixel to one square foot per pixel.



Here are images taken by different cameras of the same field where a nitrogen trial is being run. On the left is an image from an RGB camera, and on the right the image from an NDVI camera. Notice how the light spots, which are plants low in nitrogen, show up more clearly in the NDVI image, but the N-stressed plants can also be identified in the RBG image.

Source - University of Delaware, Types of Drones for Field Crop Production, by Jarrod Miller and James Adkins, Published January 19, 2018

EXAMPLE

What camera should we choose? An agronomist is working with a corn farmer to choose the type of camera they will use for drone mapping. They want to be able to map plant density early in the season, and estimate plant stress after canopy closure. RGB can do population counts early in the season, but for estimating plant stress after canopy closure, they choose NDRE because it is better at 'seeing' underneath the crop canopy.

CAMERA TYPE

RGB

This is a camera that generally sees what our eyes can see - red, green, and blue. It takes photos and can map things like stand counts (e.g. plant density, number of melons in a field) and elevation (helpful for irrigation and air drainage). These are the simplest and cheapest cameras.

RTK

Drones can be fitted with RTK guidance, which gives their maps sub-centimeter accuracy. The drone maps can be integrated with planting maps generated by a tractor's RTK - so that farmers can follow-up on variable seeding or fertilizer rates and see the effect on their crop later in the season.

NDVI, a.k.a. "Hyperspectral"

This camera measures the ratio between the different wavelengths of the visible and near-infrared light spectrum, and then compares those ratios to known values through complex algorithms. This camera can sense plant stress and track changes in plant growth by measuring the change in canopy volume, which can help predict yield.

While this camera is useful for identifying plant stress, it cannot identify the source of the stress. Farmers or scouts still need to go out and diagnose the problem. Also, NDVI becomes less useful with dense foliage because it can't accurately detect below the crop canopy.

NDRE, a.k.a. "Red-Edge"

This camera measures red wavelengths. It is able to penetrate the crop canopy and take more complete measurements of the crop stand. NDRE can sense chlorophyll content in leaves, variability in leaf size, and soil temperature. These measurements can be used to estimate crop nitrogen status, estimate soil moisture, and understand plant health.

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Making the Map

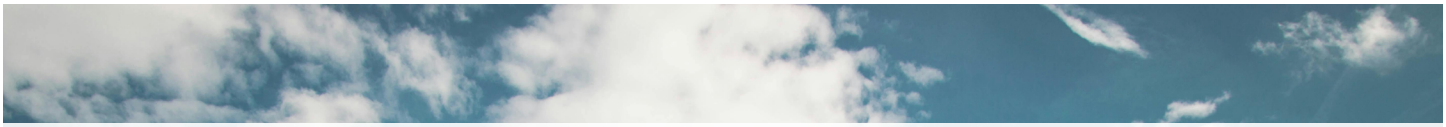
Buying and flying a drone is the glamorous part, but that is only 10% of the work. The other 90% is manipulating the gathered data to make accurate maps that provide actionable information. A drone operator might fly a 10 acre field in 30 minutes, but then spend three hours on the computer turning that data into a map, though with more experience that analyzing time might be reduced to 30 minutes. It takes training and experience to make each kind of map, and several maps may be made from a single drone flight, such as crop stand count, soil moisture, and nitrogen-stress.

Typically after a mapping flight, a drone operator will upload the data to the cloud in order to use big computing power to analyze it. A farmer's computer may not have the power needed to analyze the flight data, and farmers in rural areas may not have the internet connection needed to upload 20GB of data to the cloud. Farmers investigating doing their own drone work should consider this.

Flying a drone and making a map are two different skills, and most drone pilots are not agronomists. The pilot may make a field map for a farmer based on a flight which could be used to guide an application-drone, but often an agronomist will be needed to interpret the map and advise on management decisions.

To learn more, search the web for commercial mapping companies in your area.

90% of the work is manipulating the gathered data to make accurate maps



TAKE AWAY

Unless a farmer enjoys learning technology and working on computers, it generally makes more sense to hire a drone company to make maps. They have more experience and access to better algorithms so their maps are often more accurate.

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USING DRONES TO APPLY MATERIALS

Applying materials with drones is a newer practice, and the technology of drone-application is advancing rapidly, as are the capabilities of application drones.

Applying Pesticides and Fertilizers

Drones have several advantages over ground sprayers:

Field Access

Drones can fly and apply regardless of soil moisture which is a huge advantage over ground sprayers.

Precision Application

Unlike airplanes or ground sprayers, if a farmer has a 120 acre field with a pest problem in only three acres - drones can apply on just those three acres.

Minimized Drift

Whereas ground sprayers have to drive with the crop rows or on tramlines, drones can follow any pattern in order to minimize drift.

Considerations when spraying:

Droplet Placement

The goal is to get small droplets under the crop canopy to land on the underside of leaves. Droplets above the canopy will quickly evaporate while droplets under the canopy persist longer and are more effective.

Spray Volume

When tank-mixing multiple materials, do a jar test to check for compatibility of your materials, even if they have been mixed previously with a ground sprayer. Materials can act differently when drone-applied because drones do not have agitators, they use much higher concentrations of materials, and they use lower volume pumps.

QUICK TIP

Consideration for organic farmers - Organic pesticides are contact, not systemic, so coverage is crucial. Generally, sufficient contact is not possible below two gallons of liquid per acre. Be suspicious if an applicator says "Don't worry, I can spray your material at one gallon per acre", because they may not fully understand how to best drone apply organic plant protectants, or they may not be following the product's label.

Seeding cover crops

It is increasingly common to use drones to underseed cover crops into established cash crops. For example, farmers are drone-planting red clover into winter and spring wheat and other small grains. They are also planting many cover crops into established corn, such as clover, turnip, radish, rye, or mixes. Drone-seeding of cover crops is new and evolving, with new experience, techniques, and capabilities every season.

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WORKING WITH A DRONE COMPANY

There are new drone companies and pilots entering the industry all the time, each with varying levels of experience and capabilities. When choosing a drone company, consider:

- How many acres has the pilot sprayed and how many acres do they spray per season? For example, 800 acres is not a lot of experience for drone spraying. A rough rule of thumb from one drone professional is that drone-spraying between 3,000 to 5,000 acres per season is enough for a drone pilot to know what they are doing.
- How often has the company sprayed the crop under consideration and do they have experience with the chosen material?
- Is the pilot being contacted early enough in the season? Drone pilots are busy. Farmers can't expect to call them three days before they want the drone flight, so call at least one month in advance.

QUICK TIP

To learn a little bit more about a drone applicator's experience, take a material for which you know the label and ask questions to figure out if they follow the label rates. You don't want a company that is willing to apply off-label.

FINANCIAL CONSIDERATIONS

As a rule of thumb, drone-application prices should be similar to the price of ground application.

The price per acre will rise as the volume or weight applied increases, the distance from the drone pilot's base increases, or the number of obstacles in a field increases.

Customers often receive a price break when they contract for multiple applications. This is because the company has to make a field map whether they apply once or three times in the season, and they can often use the same field map for several applications.

FAST FINANCIALS

A) One drone pilot seeding cover crop seed at a rate of 50 lbs. per acre can plant 100 acres on an open field per day, on a good weather day. At the 2023 going rate in Minnesota of $30 per acre, it would cost a farmer $3,000 to spread cover crop seed on 100 acres.

B) A farmer is considering whether to buy their own drone or hire a drone company for field mapping. A mapping drone can cost $2,000 to $5,000, depending on the model, and an application drone around $46,000. Custom application hire should run about $30 per acre. It is important to keep in mind that drone technology is new, and current drones are often obsolete in 18 months, which should be a consideration before investment. Suppose the farmer buys a spray-drone for $46,000: This drone has a capacity for eight gallons of material and can spray up to a 35 feet wide swath in each pass. It can spray up to 25 acres per hour when applying at a rate of 2 gallons per acre. If the farmer charges $30 per acre to custom apply for their neighbors, they will need to custom-apply on about 1,600 acres in order to pay for the cost of the drone.

LEARN MORE

Using Drones for Management of Crops https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az2031-2023.pdf

Crop Monitoring - NDVI vs NDRE https://withleaf.io/en/blog/ndvi-vs-ndre/

Certificated Remote Pilots including Commercial Operators https://www.faa.gov/uas/commercial_operators

Dispensing Chemicals and Agricultural Products (Part 137) with UAS https://www.faa.gov/uas/advanced_operations/dispensing_chemicals

Field Scale Crop Assessment Drone Videos http://extension.msstate.edu/content/field-scale-crop-assessment-drone-videos

Drones for Spraying Pesticides—Opportunities and Challenges https://ohioline.osu.edu/factsheet/fabe-540

Research reported in this publication was supported by The Organic Center and the Foundation for Food & Agriculture Research under award number TOCFFAR-EXT-002. The content of this publication is solely the responsibility of the authors and does not necessarily represent the official views of The Organic Center and the Foundation for Food & Agriculture Research.

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