

When drones started showing up in the orchard and the pasture, they brought promise and headaches in equal measure. Promise because a 10 to 40 kilogram aircraft can cover rough ground fast, place droplets exactly where you want them, and reduce worker exposure. Headaches because the spray physics change the moment you shrink boom width, cut water volumes, and push air down with props. The adjuvants that worked behind a ground rig do not always behave the same in a moving downwash a few meters off the canopy. That is where mixing matters, not just the order you pour into the tank, but the way you pick and tune adjuvants to match drone platforms, nozzles, chemistry, and the crop you are trying to protect.

Across a few seasons of flying Agricultural Drone missions for Agricultural Spraying in row crops, specialty orchards, and pasture weeds, I have found that adjuvant choice often decides whether a drone beats a ground rig by a mile or merely equals it. It shows up in the drift pattern on a water-sensitive card, in the residue tests that come back from the lab, and in the re-scout two weeks later when the second flush of pigweed breaks through. The details matter, and they start with how drone spraying is different.

Drone physics change the droplet story

A ground boom lives in a relatively stable airflow. Drones fly inside their own wind. Prop wash shears droplets, induces recirculation, and can either drive spray down through dense foliage or kick it outward into drift if the settings are wrong. Two other realities distinguish drones:

- Low to ultra-low volumes. Many platforms run 5 to 20 gallons per acre, and specialty work routinely drops to 1 to 3. When you reduce carrier, you raise active ingredient concentration and put a larger burden on the adjuvant to manage coverage, retention, and evaporation.
- Narrow swaths and variable overlap. Even with RTK and a good flight plan, overlap at headlands, crosswinds, and terrain changes can be uneven. Adjuvants that stabilize droplets and help coverage at the leaf surface give you some margin against those inconsistencies.

The same herbicide that behaves acceptably at 15 GPA with a ground boom can drift excessively from a drone at 2 GPA if you do not adjust the adjuvant. Conversely, a well-chosen mix can produce better deposition in the lower canopy than a ground rig, especially in tall soy or dense berries, because the prop wash drives droplets into the understory.

What adjuvants actually do in drone work

Most adjuvant labels read like a grab bag: surfactant, penetrant, drift reduction, defoamer, water conditioner, humectant. Under a drone, these functions split into three jobs.

First, modify droplets in the air. You want a volume median diameter that balances coverage and drift control. The platform, nozzle, pressure, and flight speed frame the window. Drift reduction agents and polymer thickeners raise viscosity and increase droplet size. Oil-based adjuvants can do the same, but they also change evaporation rates. This matters more at low volumes.

Second, manage the spray at the leaf. On waxy leaves or hairy velvetleaf, surface tension fights coverage. Nonionic surfactants and organosilicone super-wetters lower surface tension, which spreads the droplet and increases contact area. For contact herbicides and many fungicides, that spread is a direct yield on efficacy at low GPA.

Third, handle the water. Hard water robs chelated actives and weak acids. At pH above 7, some actives degrade quickly. Water conditioners like ammonium sulfate pre-bind cations. Buffers and acidifiers adjust pH. In low volume

work, there is less water to dilute the problem, so one cup of calcium in a nurse tank can ruin your morning if you are not conditioning up front.

Matching adjuvants to nozzle and platform

Nozzle choice comes first. Most Agricultural Drone platforms ship with two options: a compact air induction style that yields coarser droplets and resists drift, and a fan or hollow cone style that yields finer droplets and better coverage. Each style responds differently to adjuvants.

Air induction nozzles and polymers complement each other. The nozzle entrains air to create coarser, air-filled droplets that resist drift and still shatter at impact. Add a moderate drift reduction polymer and you can tame fines at 2 to 4 GPA without losing too much coverage. Push the polymer too far and the spray sheet becomes elastic, which can cause streaking at high speeds.

Fan and cone nozzles lean on surfactants. If you are aiming for contact fungicides or desiccation where fine droplets matter, a low-foam nonionic surfactant or a silicone blend helps spread on leaves when volume is limited. If wind picks up, you may need to trade down to a heavier droplet class and substitute a mild polymer to keep fines in check.

The platform adds quirks. Multi-rotors with eight props produce stronger downwash directly under the airframe and a pressure gradient at the edges. A high solids mix with too much polymer can rope into strings in those gradients, especially at high flight speed and low altitude. That shows up as striping on water-sensitive cards. In those cases, a lighter polymer dose paired with a humectant often smooths the sheet. Fixed-wing VTOL platforms have more forward velocity and less vertical wash, so they benefit from slightly finer droplets with stronger drift control from the adjuvant side.

The core adjuvant families for drone spraying

Most jobs fall into four families of adjuvants. A fifth, anti-foam, is the quiet helper that keeps your tank from turning into cappuccino during mixing.

Nonionic surfactants. These lower surface tension and improve spread. They are the default for many herbicides, fungicides, and insecticides. In drone work, look for products that specifically mention low volume performance. The dose often sits in the 0.125 to 0.25 percent v/v range, but can go higher with heavy wax cuticles. Watch label limits with carbamates and certain sulfonylureas that can burn foliage if the surfactant is too hot under high temperature.

Organosilicone surfactants. These super-wetters can drop surface tension dramatically, creating fast spread and stomatal infiltration. Great for contact fungicides on tight canopies like strawberries. Risk comes with runoff at very low GPA, especially on vertical plant surfaces. For Agricultural Spraying by drone, dial doses low, around 0.05 to 0.125 percent v/v, and test on a dozen plants before a full field.

Drift reduction polymers. Think of these as spray sheet stabilizers. They raise viscosity a touch and reduce the fraction of droplets under 100 microns. Good fits include dicamba or 2,4-D scenarios near sensitive crops, and any low GPA work when wind runs 6 to 10 miles per hour. Pair with air induction nozzles for buffer strips and headland passes. The trade-off is coverage. You will need to compensate with a surfactant or a higher GPA if the chemistry is strictly contact.

Oil-based adjuvants. Crop oils, methylated seed oils, and high surfactant oils increase leaf cuticle penetration and reduce evaporation. For systemic herbicides like clethodim, an oil adjuvant can be the difference on drought-stressed grass. Under a drone, oils can help maintain droplet size at low volume. They also add weight to the

spray, which can work with downwash to push into canopy. On sensitive crops or in heat, dial back the rate to limit burn.

Humectants and retention aids. At 1 to 3 GPA in arid air, droplets can flash dry before they spread. Humectants hold water a few extra seconds. That window adds coverage and uptake for contact fungicides and desiccants. Look for glycerol or sugar alcohol blends. They are often bundled with surfactants in multi-function adjuvants.

Anti-foam. Drone tanks are small, and agitation is often continuous with recirculation pumps. A half milliliter of silicone defoamer per gallon can save you from cavitation alarms and false low-level alerts. Add early, then top off after powders.

Water quality and pH, the quiet saboteurs

I have flown perfect weather with a great mix and come back to patchy control, only to find later that the nurse tank pulled from a well at 18 grains hardness with pH 8.4. At 2 GPA, the concentration of calcium and magnesium ions relative to active ingredient was enough to bind a weak-acid herbicide. A quick jar test with ammonium sulfate fixed it. That experience made me a lifelong believer in testing the water before season and spot-checking throughout.

A simple protocol pays for itself. Check hardness with a field strip or a handheld meter. If hardness runs above roughly 150 parts per million as CaCO_3 , plan to condition. Ammonium sulfate at 8 to 17 pounds per 100 gallons handles many weak acids. For pH, aim for a target that matches the chemistry. Some insecticides prefer neutral to slightly acidic. Many herbicides like a pH around 5 to 6. Avoid over-acidifying mixes that include copper fungicides or sulfonylureas that become too soluble and can injure crops. If you must blend, build the solution carefully and follow label incompatibility notes.

Mixing order and the drone tank reality

A drone tank is not a 1200-gallon sprayer. There is little room to correct mistakes. Many operators load a 30 to 80 liter hopper that feeds directly into the system with recirculation. If you create sludge or a cottage cheese layer, you will be flushing lines for an hour while your window closes. The standard W-A-L-E-S framework still holds true, but with drone-specific tweaks.

W stands for water. Start with a third to half the tank, conditioned and pH adjusted. With drones, I prefer preconditioning in a nurse tank so the small onboard pump does not have to mix everything.

A is agitate. Turn on low recirculation. Avoid full throttle, which can entrain air and create foam in small volumes.

L is dry formulations, but with caution. Water-dispersible granules can take long to dissolve at low temperatures. Pre-slurry them in a bucket with warm water, then screen into the drone fill to prevent clumps. Wettable powders are risky at very low GPA unless the label allows, **Drone Spraying** and many drone operators simply avoid them.

E is emulsifiable concentrates and flowables. Add slowly. Watch for inversion if the water is too cold or salty.

S is surfactants, oils, and drift reducers. Add last. The drone's small tank makes foaming from surfactants more likely, and polymers thicken the mix, which you want to do after everything else is in. A final dash of defoamer is cheap insurance.

Before first flight, draw a cup from the tank bottom. If you see strings or clots, do not fly. Recirculate or dilute, then test again. Better to lose 10 minutes than to spend the afternoon purging filters.

Calibration and droplet verification in the field

Adjuvants do not live in a vacuum. They interact with nozzle pressure, flight speed, and altitude. If you change any one of these, confirm droplet size and distribution. A quick routine with water-sensitive paper mounted at different canopy heights tells you more than hours of desk research. Place cards at three heights on a stake in the target row. Fly a pass at intended settings. Review card coverage and droplet size with a magnifier or a phone app. If the top card shows high coverage with many fines and the lower card is sparse, add polymer or switch to an air induction nozzle. If coverage looks blotchy with large droplets but misses small targets like grass tillers, step down in droplet size and add a surfactant.

For ultra-low volume fungicide work in berries and grapes, I target a deposition count above 80 droplets per square centimeter at the fruiting zone with even distribution. For contact herbicides on broadleaf weeds, I aim for uniform spread without coalescence, which often points to a nonionic at modest dose paired with a humectant on hot days.

Weather windows and how adjuvants stretch them

Drone pilots often squeeze work into short windows around wind and temperature inversions. Adjuvants help, but they have limits. A polymer can tame fines up to a point. Past about 12 miles per hour wind, downwash becomes asymmetric and the spray sheet leans, making drift control more a function of flight path and altitude than chemistry. Similarly, in dry air with relative humidity under 30 percent and temperatures above 90 Fahrenheit, droplets can evaporate before they hit the leaf. A humectant helps only if you have enough volume for it to matter. In those conditions, increasing GPA from 2 to 3 or 4 often gives better returns than more adjuvant. I keep two mixes on hand for such days, a standard and a hot-weather version with a bit more humectant, slightly larger droplets, and a touch more oil for systemic herbicides.

Regulatory realities and neighbor risk

The rise of sensitive crops and residential buffers has made drift headlines. Labels for certain actives require drift reduction adjuvants and nozzle classes. Under a drone, you must meet those requirements while still getting coverage. I plan buffer passes with a heavier drift setup, then swap to a coverage setup once I turn into interior rows. Many platforms let you switch nozzle sets or pressure presets on the ground in a few minutes. It is tedious but cheaper than complaints. For near-vineyard or near-tomato work, I avoid volatile formulations outright and keep a log with weather data, droplet class, adjuvant brand and rate, and flight tracks. If there is ever a question, that log speaks for you.

Specialty use cases

Herbicides on tough perennials. Quackgrass and johnsongrass under heat will shrug [Agricultural Drones](#) off a skinny rate if the adjuvant is wrong. An MSO at the high end of the label paired with a low dose nonionic spreads and penetrates without running off. Keep droplet size in the medium to coarse range to cut drift and allow uptake time. If the canopy is dusty, add a small amount of wetter to break surface tension and push through the dust layer.

Fungicides in dense canopies. Strawberries and cucurbits respond well to organosilicone at low rates when disease pressure is building. The drone's downwash can place droplets below the top leaves. The risk is run-off at low GPA. Dial the silicone low and consider a humectant. If leaves are hydrophobic, test on a single bed and look for beading. If beading persists, a different silicone blend or a nonionic with lower surface tension might do better.

Insecticides against piercing-sucking pests. For aphids and whiteflies on the underside of leaves, coverage at the lower canopy is king. Run a slightly slower flight speed, drop altitude carefully while watching prop wash, and use a balanced nonionic. Drift control polymers can be added if you must fly near sensitive areas, but do not overdo them or you will lose fine droplets that reach the underside of leaves.

Plant growth regulators and desiccants. Uniformity matters more than raw coverage in these jobs. A mild polymer stabilizes the sheet, and a nonionic ensures spread without hotspots. Calibrate to consistent swath width and overlap. Water-sensitive cards at several points across the boom help identify if the props at the ends over or under-deposit, which can happen with some arm geometries.

The economics of adjuvants in drone operations

Adjuvants often run two to eight dollars per acre in the volumes common to drone work. That looks steep until you factor in re-sprays and missed control. At low GPA, the adjuvant is not optional. The question is which one and how much. I look at cost in three parts: efficacy, workflow, and risk.

Quadrotor Services Greenwood Nursery
Birkenhead Rd
Willaston
Neston
CH64 1RU

Tel: +44 151 458 5160

Efficacy drives re-sprays. A one dollar per acre bump that lifts control from 85 percent to 95 percent often avoids the second pass. Workflow includes the time you lose to foam, clogs, or mixing delays. A quality defoamer and a dust mask for pre-slurrying dry products pay back in hours saved. Risk is liability. Drift complaints and off-target injuries are costly. A mandated drift reduction adjuvant costs less than a single angry call from a neighbor with grapes.

Practical checkpoints before takeoff

Below is a short preflight checklist that has saved me from avoidable problems. Keep it on a laminated card at the fill station.

- Verify water hardness and pH, then add conditioner and buffer as needed before actives.
- Confirm nozzle type, pressure, and intended droplet class match the job and adjuvant plan.
- Pre-slurry dry formulations, add oils and polymers last, and use defoamer early.
- Run a jar test with the full ingredient list anytime you change one component.
- Fly a single test pass with water-sensitive paper at canopy height and review deposition.

Agricultural Seeding by drone, a quick note on adjuvants

Most people hear adjuvants and think only of sprays, but coating and sticking agents play a similar role in Agricultural Seeding from drones. For cover crops broadcast into standing corn, a tackifier or a clay-based coating helps seed flow, improves spread pattern in downwash, and promotes soil contact once on the ground. Humectant-coated seed can buy a little time in dry conditions, keeping the coat pliable until a light shower. Rates are modest, a few ounces per 100 pounds of seed, but the benefit shows up in stand counts. Test flow through

the drone's spreader with the actual coated product. Some tackifiers that work well in ground seeders clump under prop wash and humidity in the hopper. If you see bridging, a lighter coat or a different carrier like diatomaceous earth may solve it.

Building your own adjuvant playbook

Labels are your first stop, but the last word often comes from your own field trials. I keep a binder broken out by crop and pest, with a page per mix. Each page lists water quality, GPA, nozzle, flight speed, adjuvant brand and rate, and a few notes on weather and outcome. If a mix fails or underperforms, I write what I would change. Over a couple of seasons, patterns emerge. For example, I learned that a light polymer paired with an MSO was my best hedge against afternoon gusts on pasture thistle, while organosilicone at very low rates became my standard for early-season berry fungicide passes when humidity is higher and run-off risk is low.

Drone manufacturers and nozzle makers now publish guidance for droplet classes and spray heights. Marry that guidance with your own notes and you will avoid most pitfalls. When in doubt, fly a small test strip and adjust. The drone's strength is agility. Use it to tune rather than trusting a mix designed for 60 foot booms running 15 GPA across flat ground.

Edge cases and judgment calls

Tank mixes with multiple actives. The temptation to stack herbicide, insecticide, and nutrition is strong when flight time is precious. Compatibility and pH windows overlap only sometimes. Put a priority on the most pH-sensitive component and check the others. Some micronutrients precipitate in the presence of phosphates if pH swings. If you cannot satisfy all, split the pass.

Leaf burn in heat. Oils and silicones can scorch on hot, dry days, especially on tender leaves. Dial back rates, fly earlier, and consider a nonionic with humectant instead of a silicone. When a label allows, add a small amount of urea ammonium nitrate to help uptake without the same burn risk as oil.

Odd crops and waxy leaves. Cabbage and onions are notorious for shedding droplets. Here, a silicone or a specialized vegetable adjuvant at low rate helps. You may also benefit from a slightly higher GPA, even if it costs you a few more battery swaps. The time beats a re-spray.

Night spraying. Drones make this tempting, especially in heat waves. Cooler air reduces evaporation, which helps low GPA work. Dew, however, dilutes droplets and can cause run-off. Use less aggressive wetters and avoid oils that could spread too far on wet leaves. Flight planning must account for wildlife and legal lighting requirements.

Closing thoughts from the field

The drone is a tool that amplifies good decisions and punishes sloppy ones. Adjuvants sit right at that junction. They are not magic, but they let you bend physics in your favor. When the tank is small, the air is moving, and the window is tight, the right adjuvant turns a marginal pass into a solid one.

The habits that matter most are simple. Know your water. Choose adjuvants to match the chemistry and the nozzle. Mix in the right order. Verify deposition with cards, not just gut feel. Keep a record, then adjust based on what the field tells you. Respect the soft edges, like neighbor risk and heat stress. And do not skimp on defoamer.

Drones will keep evolving. Pumps will get smarter, nozzles more tailored, flight planners more weather aware. Even then, a quart of the right adjuvant in the right place will still be worth the lift.