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CENTRAL

How weather affects pesticide applications

By Matt Smith

Editor's note: This article grants one continuing education unit (CEU) in the Core category toward the renewal of a Florida Department of Agriculture and Consumer Services restricted-use pesticide license when the accompanying test is submitted and approved.

Weather affects what pests you might be spraying for and the worker doing the spraying. There are environmental safety risks that pesticide applicators should consider before starting the day. Heat, wind, rain, and humidity are all important factors in determining the safety of a pesticide application.

We'll go over some of the invisible forces at work that determine the weather, how temperature inversions can cause pesticide drift with calm winds, the dangers of heat stress and the effect of rain on pesticide movement. We'll also try to force as many lame puns as possible from a certain 1980s naval aviation film with an upcoming sequel, because I think it makes things more fun. I still can't believe how much I got away with last time with the Point Break references (see Citrus Industry, August 2021, page 44).

AIR CIRCULATION

Pesticide drift is the airborne movement of pesticides to non-target areas. To understand drift, it helps to understand how air moves throughout the day.

Under normal conditions, the temperature of the air gets colder at higher altitudes. When the sun shines, it warms up the air and the ground. The air doesn't hold heat very well, but the ground does. The ground soaks up solar radiation and then radiates that heat upward. However, radiation isn't enough to push heat very far into the sky. Instead, another force at play, called convection, moves the air further aloft.

When the sun rises, energy from the sun is transferred into the ground. The cool air next to the ground conducts this energy and warms it. Warm air is full of very excited, fast-moving atoms, and these atoms want to spread out. When atoms spread out in a parcel of air, the pressure of that air begins to drop and can rise. The cool air aloft, which is denser,

moves downward to fill the space, conducts heat from the ground and rises. When spraying pesticides in these conditions, the convection helps lift any drifting pesticide upward.

This circulation continues throughout the day and increases in intensity as the sun gets higher in the sky. This is why the strongest winds of the day are more likely to occur midday, and pesticide applications should be avoided when wind speeds exceed 10 miles per hour. During days with strong convection, the convection can reach high up into the atmosphere. If the air being forced up is moist, the moisture in the air can condense and form clouds and even storms.

The best time to spray pesticides is generally in the early morning or late evening when wind speeds are lower, convection is light but still present, and the spray droplets move slowly upward. Later in the day, the increased convection and wind makes pesticide drift more likely.

STABLE AND UNSTABLE ATMOSPHERES

How easily convection can climb in the sky depends on the stability of the atmosphere. In stable atmospheric conditions, the air resists vertical motion. In unstable atmospheres, the air is in an excited state, and vertical motion is encouraged. There are some visual clues you can use to identify if the atmosphere is stable or unstable.

Stable air is characterized by flatter, stratiform clouds and fog, continuous and steady precipitation, smooth air, and fair to poor visibility if haze, smoke or pollution is unable to move out of the area. Stable atmospheres are calm, predictable and steady.

Unstable air is characterized by vertically developed cumuliform clouds, showery precipitation, turbulent air, and good visibility unless the wind blows visual obstructions into the area. Unstable atmospheres also tend to occur in hot and humid conditions. Unstable atmospheres are chaotic and only happy when they're going Mach 2 with their hair on fire.

BECAUSE I WAS INVERTED

Sometimes, a layer of cool air gets trapped underneath a layer of warm air. This is called a temperature inversion. The layer of warm air forms a cap where the air at ground level, and anything in it, can no longer rise and disperse. Convection at the surface continues, dispersing air molecules vertically until they reach the cap and then spill laterally as if they'd hit an invisible roof.

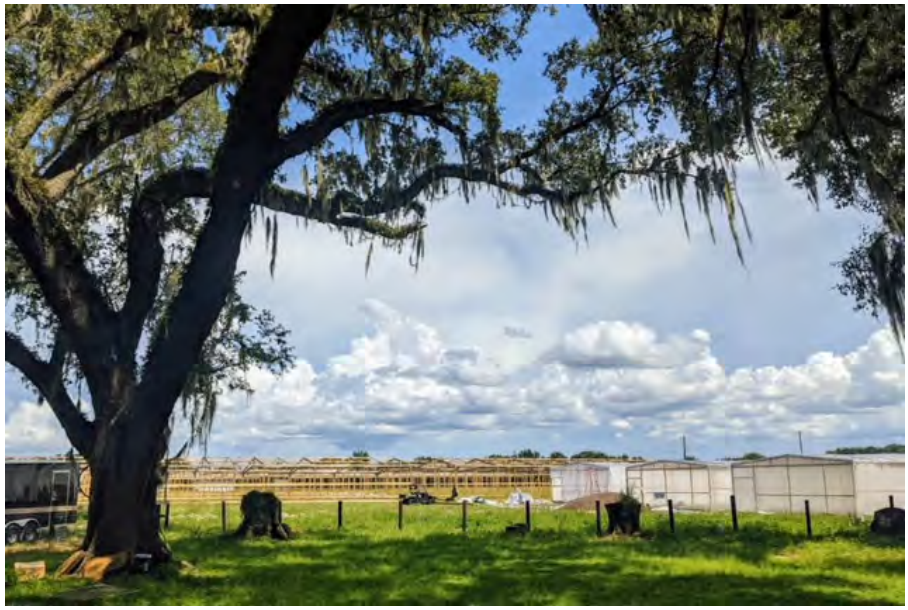

Photo by Matt Smith

Vertically developing cumuliform clouds on a hot, humid Florida day

If you've ever tailgated at a late-season football game in the evening, you've likely witnessed a temperature inversion. The smoke from the grills rises maybe 30 feet, stops and spills right back down. It stings your eyes a bit, but it smells like beer brats, so nobody cares.

When an inversion occurs during spraying, pesticide droplets can drift off-target even when wind conditions are below the normal threshold where applicators would refrain from spraying. Long-range drift incidents exceeding 1 mile are often the result of spraying under stable atmospheric conditions like temperature inversions.

Several factors influence whether a temperature inversion will develop. Moist soil holds heat better than dry soil, so dry conditions can be one factor. Clouds very effectively reflect heat radiating from the ground back down to Earth. So, if there are few or no clouds, then ground heat radiates unimpeded into the atmosphere. Even with clear skies and dry ground, the wind blowing at 5 miles per hour is usually enough to keep the air mixed and prevent the cool air settling at ground level. But if the wind is calm and the other conditions are present, the chances of an inversion forming increase. Temperature inversions are most likely to be present in the early morning or evening.

Without any visual obstructions present like smoke, fog or pollution, temperature inversions are invisible. So how do you know when one is present? The most direct way is to get a weather report from a weather station that has thermometers at both eye level and near ground level. A weather station housed at your farm is ideal, but if you do not have one then you can access the University of Florida's Florida Automated Weather Network (FAWN) service (see fawn.ifas.ufl.edu). All FAWN stations give temperature readings at 2, 6 and 30 feet in the Graphical Weather Data section. If the temperature at 2 feet is cooler than the temperature at 6 feet, a temperature inversion is occurring.

RESULTS OF RAIN

Rain is something Florida growers are very familiar with. At a certain point in May, it seems like someone in the sky turns on the faucet and forgets to turn it off until October. In the Florida peninsula, the wind coming from almost any direction passes over either the Gulf of Mexico or the Atlantic Ocean. These cool, dense sea breezes move inland like a wedge and push the warm land air high into the sky.

In summer, the Florida atmosphere tends to be very unstable, and vertical

motion is encouraged. Warm air is also able to hold more moisture than cold air. Daily thunderstorms occur when all these factors are combined. Sometimes competing sea breezes from both the Gulf and the Atlantic meet over land and result in particularly spectacular storms.

Rain can play a factor in two forms of off-target movement: runoff and leaching.

Runoff is the surface movement of a pesticide in water from the treated site. This occurs when pesticide residue is carried by rainwater or irrigation water laterally along the surface. Runoff risks carrying pesticides to non-target crops and also risks contaminating surface water, the source of 38% of Florida's freshwater withdrawals.

Leaching occurs when water from rain or irrigation transports pesticides downward through the soil. Leaching risks damage to groundwater reserves, which provide the other 62% of Florida's freshwater withdrawals and drinking water to about 90% of its residents.

For a pesticide to successfully leach, it must resist binding to soil particles — a process called adsorption — and resist breaking down into chemical compounds that are no longer toxic. Pesticide chemistries vary in how likely they are to bind to soil or break down, and those that carry an enhanced risk of leaching often contain a statement of that risk on the pesticide label. Pesticides bind better to organic matter and clay or silty soils than sandy soils. As such, sandy soils with low organic matter give the greatest potential for leaching, though leaching can happen in any type of soil.

GREAT BALLS OF FIRE

During periods of hot temperatures, the risks of heat exhaustion and heatstroke increase. Heatstroke and heat exhaustion occur when the amount of heat the body is subjected to is greater than it can cope with. This heat comes not only from the sun and the outside air, but also from the heat created by the body while it is working.

Wearing lightweight, breathable, loose-fitting clothing can shade the body from the sun while allowing the body's natural cooling mechanisms, like sweating, to work with minimal obstruction. However, many forms

of personal protective equipment are anything but lightweight and breathable and will decrease the body's ability to efficiently remove heat. Therefore, pesticide applicators can be at an increased risk of heat-related illness and injury compared to other agricultural employees.

Heat stress affects both physical and mental performance because it affects blood flow to muscles, internal organs and the brain. Physical effects include weakening of the muscles and feeling tired quicker than usual. Mental effects include impaired judgment and a loss of alertness.

Because there is no pain associated with these symptoms, workers may be unaware they are suffering the effects of heat stress. It only takes a 2-degree increase in body temperature above normal to start feeling mental effects, and those mental effects may make it even more difficult for the affected applicator to recognize the more serious signs of heatstroke, which can occur if the initial heat stress is not managed. An increase in body temperature of 5 degrees above normal can result in serious illness or even death.

As we enter the warmer months, it is a good idea to acclimatize yourself and other workers to the heat to reduce the risk of heat stress. When warm temperatures become the norm, assign lighter workloads with longer rest periods while ensuring that workers work in the heat for at least 100 minutes per day for a five- to seven-day period. Monitor workers closely during this period for signs of heat-related illness.

Heat exhaustion symptoms include fatigue, headache, nausea, chills, dizziness, fainting, clammy skin and heavy sweating. Heatstroke occurs when the body's natural cooling system shuts down. As a result, heatstroke victims will have hot, dry skin and will no longer be sweating. Victims of heatstroke need immediate medical attention.

PESTICIDE VAPORIZATION

High temperatures can also increase the risk of pesticide vaporization. Pesticide vaporization occurs when a liquid pesticide transforms into a gas that is capable of drifting extremely far away from the target site. Pesticides vary in how likely they are to vaporize. The tendency of a pesticide to turn into a gas or vapor is called volatility. Particularly volatile pesticides tend to carry vaporization warnings on the pesticide label and should not be applied when temperatures are above or expected to reach 85 degrees.

The risk of vaporization increases in the presence of higher temperatures, stronger winds and lower humidity. These conditions are common midday in Florida, and for that reason, midday is one of the times pesticide drift is likely to occur.

END CREDITS

Weather plays an important role in determining what we spray. Certain conditions give rise to greater pest pressure. As spring moves to summer, keep in mind that weather should also play a role in when and if you spray on a given day. Unless a temperature inversion is present, the best time to spray pesticides is in the morning or evening when wind speeds are below 10 miles per hour, and it is not raining or about to rain. If the product is especially volatile, don't spray if the temperatures is 85 degrees or is expected to reach 85 degrees.

Sources: "Applying Pesticides Correctly, 7th Edition" by F. Fishel, "Managing Pesticide Drift" by F. Fishel and J. Ferrell, "Florida Sea Breeze Thunderstorm Climatology" from the National Weather Service Tampa Bay Area Office, "Air Temperature Inversions Causes, Characteristics and Potential Effects on Pesticide Spray Drift" by Thonstenson et al.

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'How weather affects pesticide applications' test

To receive one Core continuing education unit (CEU), read "How weather affects pesticide applications" in this issue of Citrus Industry magazine. Answer the 20 questions on the magazine's website (www.CitrusIndustry.net/ceu) or mail the answers and application information to the address at the end of the article. You must answer 70% of the questions correctly to receive one Core CEU. The article and test set are valid for up to one year from the publication date. After one year, this test will no longer grant a CEU.

Select one answer per question. T = true and F = false.

1. Under normal conditions, the temperature of the air gets warmer as elevation increases. **T F**
2. In a stable atmosphere, vertical motion is consistently encouraged. **T F**
3. Unstable atmospheres tend to occur in hot and humid conditions. **T F**
4. Pesticide drift is impossible when wind speeds are below 5 miles per hour. **T F**
5. Temperature inversions are most likely to occur in early morning or late evening. **T F**
6. Runoff is the surface movement of a pesticide in water from the treated site. **T F**
7. It only takes a 2-degree increase in body temperature above normal to start feeling the mental effects of heat stress. **T F**
8. Heatstroke victims have clammy skin and sweat profusely. **T F**
9. Leaching occurs when water from rain or irrigation transports pesticides downward through the soil. **T F**
10. An increase of body temperature of 5 degrees above normal can result in serious illness or even death. **T F**
11. Pesticide drift is the movement of pesticides to non-target areas through
    A) Water **B)** The air **C)** The soil **D)** Tokyo
12. The strongest winds of the day are more likely to occur during
    A) Early morning **B)** Midday **C)** Early evening **D)** Night
13. The best time to spray pesticides occurs when
    A) Wind speeds are low **B)** Convection is present **C)** Spray droplets move slowly upwards **D)** All of the above
14. Unstable air is characterized by
    A) Stratiform clouds and fog **B)** Continuous precipitation and smooth air
    C) Cumuliform clouds and showery precipitation **D)** A and B
15. A temperature inversion occurs when
    A) Warm air gets trapped under cold air **B)** Cold air gets trapped under warm air
    C) Warm air and cold air mix equally **D)** Iceman pulls a 4G negative dive with a Mig-28
16. These soil characteristics give the greatest potential for leaching
    A) Sandy and low organic matter **B)** Clay with high organic matter
    C) Sandy with high organic matter **D)** Clay with low organic matter
17. When acclimatizing yourself and workers to warming temperatures,
    A) Assign lighter workloads **B)** Provide longer rest periods
    C) Ensure workers work at least 100 minutes each day **D)** All of the above
18. The process by which pesticides bind to soil particles is called
    A) Hydrolysis **B)** The Wingman Effect **C)** Absorption **D)** Adsorption
19. The tendency of a pesticide to turn into a gas or vapor is called
    A) Volatility **B)** Vaporware **C)** Convection **D)** Solubility
20. Pesticides with a high chance of vaporization should not be applied when temperatures are above or expected to reach
    A) 75 degrees **B)** 85 degrees **C)** 95 degrees **D)** 105 degrees

Please circle the number below to rate this article and test:

Not very useful	1	2	3	4	5	6	7	8	9	10	Very useful

Pesticide Applicator CEU Form

First Name: _____ **Last Name:** _____

E-mail: _____ **Phone:** _____

Pesticide License Number: _____

Address: _____

City: _____ **State:** _____ **Zip:** _____