

WEATHER AND INSECT DISPERSAL

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Abstract

Agriculture in the vast majority of the United States has to manage around the winter weather. Winter synchronizes pest populations by creating a common starting point. Insect species unable to overwinter must rely on dispersal to reinfest northern areas or develop methods to exploit the overwintering area. The simple but useful formula: (Population = Birth – Death + $\pm$ Dispersal) is a tool to highlight the importance of dispersal. Pest populations are predictable due to the synchronization and common starting point of the crop and pest. Dispersal of adult stages is enhanced via high pressure cells that lift the insects upward and further enhanced via wind activity of a surface low level jet stream is created at the boundary of a western counter-clock flow of a low and a clockwise air movement of a high to the east. The cumulative effect of the wind directions around each of these pressure cells creates a strong current northward. An average northward airflow of approximately 15 MPH within the pump can move a pest from northern Texas to central Iowa in 2 days. The *Spodoptera frugiperda* (JE Smith) the fall armyworm, *Trichoplusia ni* (Huber) the cabbage loopers, *Helicoverpa zea* (Boddie) the corn earworm and *Aphis glycines* the soybean aphid adults are annual migration pests. These insects have high fecundity, large adult populations, large source regions, and have adapted a life cycle to fit annual weather patterns. Dispersal must have species survival value. Noctuid adults will fly south in the fall and avoid the winter kill.

Key words: dispersal, front, drop zone, frontal boundary, Noctuid adults.

Introduction

Agriculture in the vast majority of the United States has to manage around the winter weather. A cold winter season obviously prevents crops from growing, but it also produces a significant challenge for the pests that feed on these crops. Not only does their food source stop growing, but these pests are must somehow keep from freezing themselves. In order to survive the bitter cold, insects have one stage in their development (egg, larva, pupae or adult) that is especially adapted for winter conditions. The insect has mechanisms that reduce ice crystal formation, have fluids like antifreeze, or can freeze solid and still not be killed. Insects adapt. When the spring come the surviving stage will emerge and start a new cycle. Winter synchronizes pest populations by creating a common starting point.

Not all insect species are able to over-winter everywhere. Insects must rely on dispersal to re-infest northern areas or just develop methods to exploit the area they can survive the winter.

Understanding the impact of weather on insect population dynamics will enhance your pest management program. Through winter-synchronization and weather-driven migrations, pest management becomes a yearlong-process.

The Winter Season: Defining the Conditions that Synchronize Pest Populations

Winter might be a harsh season where you live, but it is not safe to assume severe winter weather equals high insect mortality. Sometimes, local conditions and over-wintering

sites protect a pest population and favor their survival. Conversely, those same conditions could kill a different pest population. For instance, snow cover might shield a pest from harsh conditions if the pest were underground, or be warm and moist in the debris and rot the insect. It has been very difficult to make blanket survival predictions. Insects are killed by free water expanding to form ice crystals within their exoskeletons. With this in mind, we have found that a period of four or more continuous days with minimum daily temperatures 0°F (or colder) provides a critical “winter kill” threshold (Figure 1).

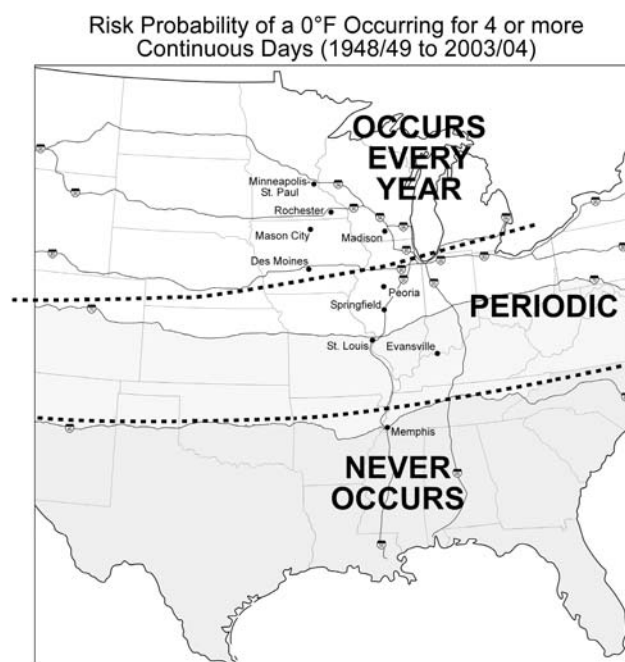


Figure 1. Annual winter probability of four or more consecutive days with a minimum temperature $\leq 0^{\circ}\text{F}$ (Data courtesy of the Midwestern Regional Climate Ctr. and NIU Cartography Lab).

The use of USA Interstate highways is a practical benchmark to characterize pest/weather patterns. Locations north of I-80 experience at least one “winter kill” event *every winter*, while those between I-80 and I-40 experience them *periodically*. South of I-40 severe “winter kill” *never* occurs.

Despite never reaching the “winter kill” threshold, cold weather and frost will synchronize the crops and the pests south of Interstate 40. This region rarely experiences heavy (greater than 4 inches/event) snowfall. Therefore, the insect pests in this region are more susceptible to a one-time hard freeze with a minimum temperature of 28°F or lower (Figure 2).

Probability of Experiencing a “Hard Freeze” During the Winter (28°F Low Temperature)

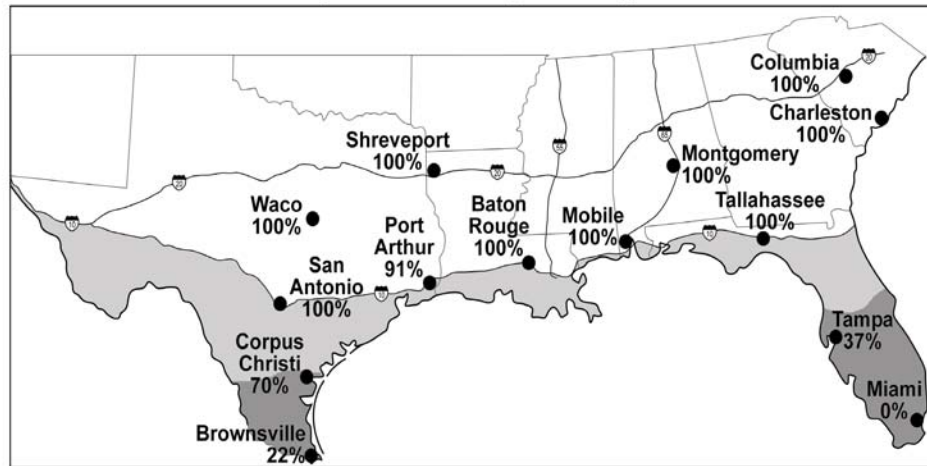


Figure 2. Probability of experiencing a ‘hard freeze’ during the winter (28F low temperature). (Data courtesy of the Midwestern Regional Climate Ctr. and NIU Cartography Lab).

The period of cold weather synchronizes the surviving pest stages. Based on this finding, pest insects will *always* be able to survive in extreme southern Florida and Texas, therefore, these regions are annual insect and disease pest source region.

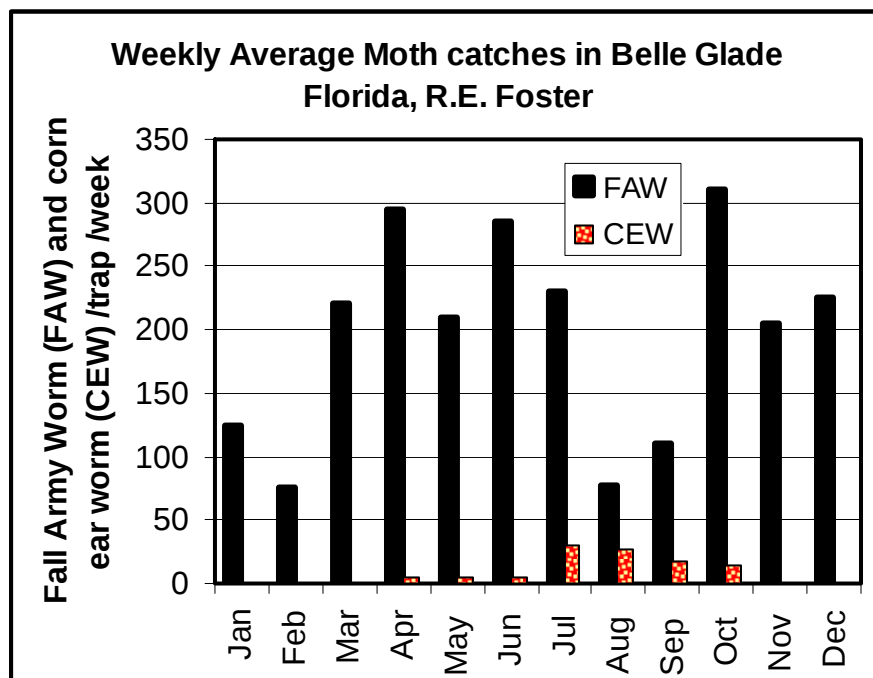


Figure 3. Fall army worm and corn earworm dispersal table from Belle Glade, Florida, USA.

Figure 3 shows the fall armyworm adults are present and dispersing year round while the corn earworm population is more seasonal, but at higher numbers when crops further north are more vulnerable. The fall armyworm is an annual pest along the eastern coastal areas.

Weather Patterns: Understanding How Pests Disperse and Migrate Northward

Insects will disperse locally and regionally (Figure 4). However, key issues facing much of the agricultural community in the upper Great Plains, Midwest, Ohio River Valley, Northeast and Eastern Coastal Plainses each growing season are the pests that migrate in from the south. The majority of these southern pest populations have been synchronized by frost, and so defined migration patterns can be estimated. In a 40-year recap of corn earworm black light catches in northern Illinois, a non-over wintering area, the average first significant flight varied by $\pm$ one week from the average night of the first significant flight. Figure 5 reflects a similar summer weather set-up that could during the summer months produce a dispersal flight from a source region.

There are several characteristic features of surface weather patterns. The first of these features is a “Low” pressure cell around which winds move in a counterclockwise direction (“into” the center of the Low). In the summer, “Lows” are usually located in the western Great Plains and sometimes have an associated frontal boundary located from its center eastward into the upper Midwest. The second feature is a “High” pressure cell of warm moist air. Winds move clockwise away from the center of the High. Highs can be located anywhere. Adult insects disperse in Highs. Within a High, the warm air creates convection currents that will move insects into the warm, moist air. A third weather feature is known as the frontal boundary. The frontal boundary represents the juncture between the cold, drier air moving in from the north and the warm, moist air from the High south of the front.

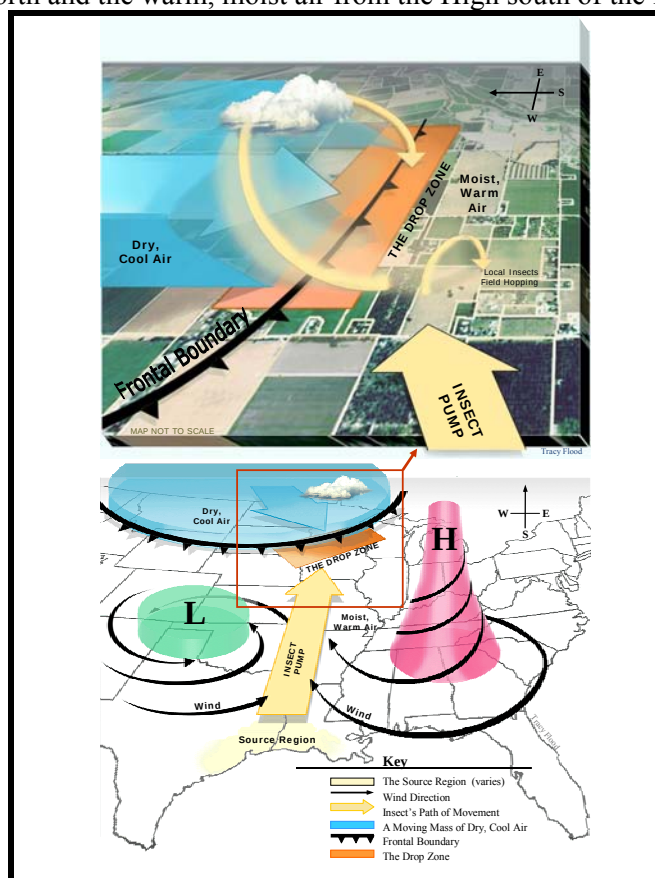


Figure 4. The primary weather patterns that impact dispersion both locally and regionally.

The Insect Pump

Local insect populations might not be the only pests dropping out of the sky. Frequently, during the growing season, weather conditions associated with a specific surface pattern cause widespread, northward migration of pests from their source regions. This migration occurs in a warm, moist air mass referred to as the “Pump”. The surface weather patterns associated with the “Pump” primarily involve an area of high pressure (a “High”) somewhere in the Southeast (See Figure 4) and a low pressure cell in the west. The cumulative effect of the wind directions around each of these pressure cells creates a strong current northward, low level jet stream.

The distance that these adult pests can travel within the pump (in the lowest levels of the atmosphere) is influenced by a number of weather-related factors including the wind speed within the pump, whether or not it encounters a “frontal boundary” (which will drop the pests out of the sky), and whether the s encounter rain that will flush them from the air mass. Typically, given an average northward airflow of approximately 15 MPH within the pump, a pest could move from northern Texas (I-20 corridor) to central Iowa (I-80 corridor) in approximately two days.

Local Field Hopping—(Inappropriate and Appropriate Landings per Dr. S. Finch et al)

The Drop Zone typically progresses into an area with hot and humid air. Before the cold air sets in, the insects actively move from field to field. The warm air lifts insects out of the crop canopy and into the air via convection currents. Local populations dispersing that are lifted by convection or flight are susceptible to the incoming frontal boundary. Once the frontal boundary passes, the cool, dry air passes over the fields. This cooler air encourages the insects to remain within the appropriate crop canopy.

The Drop Zone

The frontal boundary will have cloud cover, rainfall, thunderstorms, hail, snow and insects dropping out of the sky. The activity of the frontal boundary is one of the most important features in insect dispersal. First of all, the cold air behind the frontal boundary moves into an area like a wedge. This creates a lift upward and northerly. The warm, moist air of the High is pushed up over the cold air mass. Insects caught in the warm air are swept up as well. As it travels higher, the warm, moist air cools and the moisture in the air condenses into cumulus clouds (large and fluffy clouds). Eventually, air temperatures fall below 59°F and this causes insects caught in the “High” to drop out of the sky. We identify this area as the “Drop Zone”, the more stationary the drop zone the larger potential for increased insect numbers due to the accumulation effects of the air masses.

What to Watch for: When a Pump Feeds into a Drop Zone

Use weather maps and forecasts to predict a pest migration in conjunction with: 1) knowing the pests status in locally and regionally 2) determining if surface winds can move more pests into your region, and 3) determining whether or not there is a frontal boundary nearby that would force the pests to fall out of the sky and onto your crops. It is important to be aware of the local and regional weather patterns in order to develop an appreciation and understanding of the crop/weather/ and pest interactions.

You cannot change the weather, but you can manage your crops better by understanding it. Now enjoy the day and, for the sake of your pest management program, keep your eyes on the weather.

References

Foster, R, and Flood, B.R. 2005. Vegetable Insect Management. Meister Pro Publ.