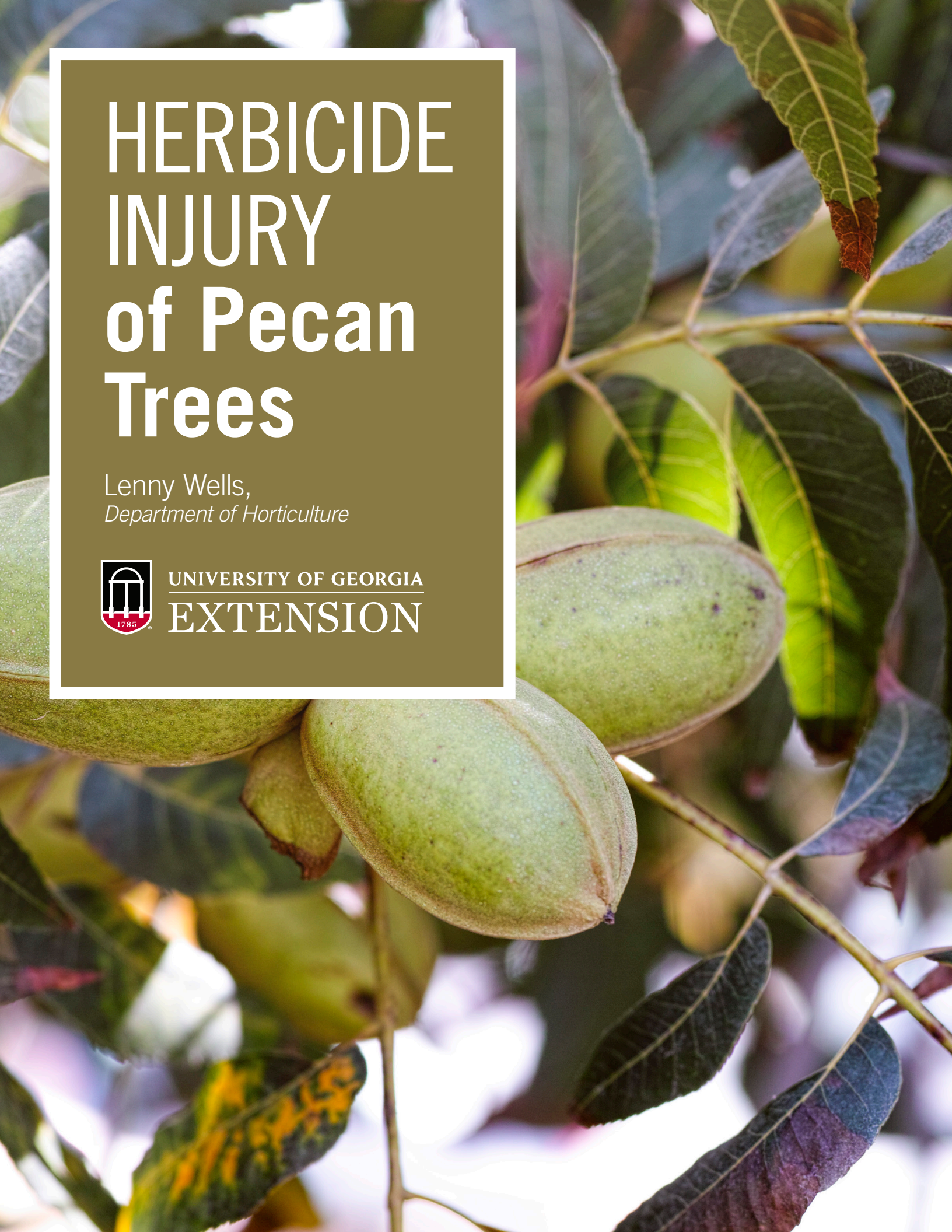

HERBICIDE INJURY **of Pecan Trees**

Lenny Wells,
Department of Horticulture

UNIVERSITY OF GEORGIA
EXTENSION

Georgia has a very diverse agricultural landscape consisting of row crops, pastures, hay fields, timber, vegetables, and orchard crops. Each of these agricultural systems plays a vital role in Georgia's agricultural economy. Georgia is the top producer of blueberries, broiler chickens, peanuts, pecans, and spring-season onions, and the state ranks second in production of cotton, rye, and various vegetables. The value of the state's pecan production is estimated at over $270 million. Georgia's pecan industry continues to grow at a rapid pace with over 140,000 acres of trees in production and an additional 30,000-35,000 acres of newly planted trees within the last five to seven years. Much of this production comes from the Coastal Plain region of the state, where most of the row crop acreage is also located. When a variety of crops are established within close proximity of each other, the potential for conflicting management practices can cause unintended damage.

Pecan orchards in the region are often found growing adjacent to fields of annual row crops. As a result, the tree canopies of these orchards are susceptible to injury from herbicide drift from neighboring row crop fields, particularly when herbicide applications are made under conditions that are unsuitable for spraying. This normally occurs from April through June as weeds are eliminated from fields in preparation for planting or soon after planting. Drift may also occur when cotton fields are sprayed with chemical defoliants in the fall. In addition, the roots of mature pecan trees can extend to a length twice the width of the tree canopy. Pecan tree roots often extend into an adjacent row crop field and can compete with the row crop for available soil, water, and nutrients. Under these conditions, trees may also absorb residual herbicides from the soil in these fields.

During herbicide application, very fine droplets or products of volatilization can find their way to areas where application was not intended and, as a result, trees can show herbicide injury symptoms. The extent to which a herbicide will drift from its intended target depends on several factors, such as the type of herbicide, the environmental conditions (e.g., wind speed) at the time of application, and the sensitivity of surrounding plants.

The most common cause of accidental herbicide contamination is particle drift, which occurs when small droplets are blown off-target by the wind. Damage from this type of drift is usually quite proximate to the herbicide application site and can be significantly reduced or prevented using proper application techniques. Injury symptoms resulting from these droplets may be obvious and consistent on the trees nearest the application area. Symptoms often decrease in severity the further one moves from the site of herbicide application.

Plant damage from volatilization of herbicides is much less common and harder to diagnose. It is also difficult to prove or consider pesticide misuse. Damage has been known to occur miles from the application site, depending on the herbicide involved and the sensitivity of damaged plants.

What to do when drift occurs

Pecan growers should be aware of crops planted in adjacent fields and the herbicide practices used for that crop. Since adjacent land may be owned by other farmers, cordial conversations with neighbors are an important first step in the prevention of accidental herbicide injury. Producers of agronomic crops often are not aware of the potential injury and value of pecan trees and the pecan crop.

If growers suspect accidental herbicide damage to one or more of their orchards, an orderly series of steps should be taken. When damage occurs, the damage should be documented. Important information to note will be the date injury or application was noticed and the number of trees or the acreage damaged. A summary of the symptoms on damaged plants should be written down. As quickly as possible, a combination of photos and plant samples should follow. University of Georgia Cooperative Extension agents can help to document symptoms, but they do not perform residue testing. The Georgia Department of Agriculture must take plant samples for residue testing if a formal complaint is filed.

After ruling out one's own negligence, including the use of a herbicide-contaminated sprayer to apply other pesticides or herbicide drift from within the orchard, attention should be turned to "off-farm" sources. If the damage is most severe in trees adjacent to a recently sprayed field and wind conditions were favorable for drift,

there is often fairly strong evidence that the neighbor's action caused the injury. Patterns in a planting can help determine the source of contamination. A change in the intensity of symptoms in the orchard may indicate the direction from which the herbicide originated.

Many herbicide drift incidents do not result in economic loss, but economic loss can occur if the injury is severe enough. Often the severity of damage cannot be determined initially and only time will tell the extent to which the trees and crop recover. As a result of the pecan tree's physiological processes, injury after July 1 will be more damaging to the following year's pecan crop than injury occurring earlier in the growing season. Therefore, documentation is the first step and should occur in all cases. If there is strong evidence that the action of a neighbor or chemical applicator hired by a neighbor is the cause of herbicide damage to a crop, then normal economic loss resolution procedures should be followed.

Procedures

When seeking compensation or, at least, recognition of the problem, the following approaches may be taken:

1. Make every effort to work directly with the neighbor, the pesticide application service acting on the neighbor's behalf, and/or the neighbor's insurance provider to bring about awareness of the incident.

2. Contact your local county Extension agent for documentation of the incident. Provide a detailed description of the timing of the application (to the best of your knowledge), symptom expression, and the extent of injury (i.e., how many trees, tree rows, or acres are affected). Take photographs of the injury. The Georgia Department of Agriculture will take tissue samples for their own investigation. Growers may take their own tissue samples for detection of herbicide residue at the University of Georgia Soil, Plant, and Water Laboratory or at a private laboratory. Bear in mind that these analyses may cost over $100 per sample depending on the herbicide in question. Samples for certain herbicides/chemicals must be taken within two to three weeks of exposure to be easily detected, and these samples are rarely used in any drift case. They usually offer little more than the producer's peace of mind. Samples taken by Georgia Department of Agriculture are necessary when a dispute occurs.

3. Contact the Georgia Department of Agriculture to report the incident as quickly as possible. The Georgia Department of Agriculture will likely conduct their own investigation. Contact the Georgia Department of Agriculture directly for information on procedures for investigating possible pesticide misuse and submitting a pesticide incident report. An investigator will likely visit the farm to ask questions and conduct the investigation, and the Georgia Department of Agriculture will pull their own tissue samples for residue detection.

Symptoms of herbicide drift

Depending upon the environmental conditions at the time of application, the herbicide used, rate, timing, and coverage, the trees may vary in their response to herbicide drift. Table 1 provides a quick reference and description of injury symptoms and risk of long-term damage. The most common herbicides involved in drift injury to pecan in Georgia are glyphosate, glufosinate, paraquat, and flumioxazen. With the recent release of 2,4-D- and dicamba-resistant crops, injury from these herbicides may become more common. Regardless of the herbicide in question, it may take time to determine the extent of the damage. It may be necessary to harvest damaged trees separate from undamaged trees in order to document any economic losses. Insurance companies often use a comparison of crop yields in the year of damage with the previous three-year average, which emphasizes the importance of keeping good farm records. Descriptions of the herbicides mentioned above and typical symptoms of their injury to pecan is provided on the following pages.

Glyphosate: Glyphosate commonly causes damage to pecan trees when the chemicals contact the foliage, and in the case of young trees (less than 3 years old), when chemicals contact green bark. In most isolated incidents, trees suffer some damage, leaf deformation, and defoliation, but they usually refoliate with only minor long-term effects and subsequent growth usually returns to normal. Glyphosate is a systemic herbicide and thus can potentially affect the trees for more than one year and yield may be reduced. The severity of damage is usually dependent on the rate of herbicide applied and the extent of its coverage. In very severe cases, glyphosate can kill limbs, but this is rare and would be evident within the first year or two following application. Repeated applications would have more significant, long-term effects, which could eventually result in death of the tree. Primary symptoms of glyphosate injury are thin, strap-like leaves and often some chlorosis or yellowing (Figure 1). Heavy concentrations can cause dieback.

Paraquat: Paraquat is a contact herbicide that only burns the tissue it touches. The extent of damage will be dependent upon the concentration of herbicide in the spray mix and the coverage on the pecan tree. Usually within 24-48 hours after contact, the affected leaves will develop yellow areas where contact was made (Figure 2). If only a few yellow spots are observed on leaves, the damage is most likely not significant. However, if a large percentage of the leaf or leaves turn yellow, the damage may be severe. The yellowed areas of the leaf turn brown and necrotic with age (Figure 3). Where a large percentage of the leaf surface is contacted, the foliage will die and drop from the tree. The same is true for pecan flowers, nuts, or any other green tissue which is contacted by the herbicide. In most cases, when paraquat is applied to a mature tree, the tree will refoliate and it will not suffer long-term injury. Paraquat applied to the thin bark of young trees (less than 3 years old) can girdle the tree, resulting in tree death.

Glufosinate: Glufosinate is a contact herbicide and its injury looks very similar to that of paraquat, but symptoms take longer to appear after application than they do for paraquat. Yellowed areas appear a few days after application and turn necrotic with age. Again, as with paraquat, the severity of the injury depends on the herbicide concentration and coverage. Trees generally recover without long-term damage.

Figure 1. Glyphosate injury vs. zinc deficiency of pecan. Note the thin, strap-like leaves of glyphosate-exposed leaves at left and center and the wavy/curly leaf edges of zinc deficient foliage on the right.

Figure 2. Paraquat drift injury to pecan foliage. Damaged areas turn yellow or chlorotic initially and then as the affected tissue dies, damaged areas turn brown. Glufosinate injury may appear similar.

Figure 3. Older paraquat injury of pecan.

Flumioxazen: Flumioxazen is used primarily as a preemergence herbicide, but it does have some postemergence activity. It is often tank-mixed with one or more of the herbicide chemistries listed previously. Injury symptoms are similar to that of glufosinate and paraquat. Trees generally recover quickly.

2,4-D: 2,4-D is a systemic auxin herbicide used to kill broadleaf weeds. A member of the phenoxy family of herbicides, 2,4-D was one of the first successful selective herbicides developed and has been used for more than 70 years. Injury symptoms first appear as a folding/curling of foliage (Figure 4). Wrinkling, cupping, curling or twisting of foliage along with some chlorosis or yellowing of the foliage continues within a few days of contact (Figure 5). Affected tissue will turn necrotic and dieback, often leaving a curled leaf stem if the concentration or coverage is great enough (Figure 6). We have observed serious injury, including death of foliage and limbs, experimentally, at leaf tissue concentrations of 25 parts per million, or ppm (Figure 7). 2,4-D can also arrest nut development at the stage at which contact with the herbicide occurred (Figure 8). Limbs or tissue receiving full coverage of a concentrated solution or full rate of 2,4-D will most likely die. We generally do not see evidence of translocation within pecan trees, so if only a small portion of the tree is affected or if the tree receives a low concentration of the material, it is not likely that the tree will be damaged long-term. The larger the percentage of coverage on the tree and the higher the concentration of the material, the more severe the damage will be. Full exposure of auxin herbicides to an entire tree or to a large percentage of a tree at full rates can kill the tree.

Dicamba: Dicamba is another selective herbicide in the phenoxy family of herbicides designed to kill broadleaf weeds. Symptoms are similar to that observed for 2,4-D.

Figure 4. Early symptoms of auxin herbicide injury to pecan exhibiting folding and curling of leaflets.

Figure 5. Auxin injury symptoms of pecan. Note twisting, cupping, and curling of leaflets.

Figure 6. Older auxin herbicide injury of pecan.

Figure 7. Severe auxin injury to pecan. The entire limb has died after exposure to direct application of herbicide to limb.

Figure 8. Arrested nut development resulting from contact with auxin herbicide.

Table 1. Symptoms and potential injury risk from various herbicides drifted onto or absorbed by pecan trees.

Herbicide	Symptoms	Long-term injury risk[a]
Glyphosate	Thin, strap-like leaves Dieback at high rates Repeated exposure can result in limb/tree death	4
Paraquat	Exposed areas turn yellow initially, then brown Dieback at high rates Repeated exposure can result in limb/tree death	2
Glufosinate	Same as paraquat above	2
Flumioxazen	Same as paraquat above	2
Auxins (Dicamba, 2,4-D)	Folding/cupping of leaflets Twisting, curling of leaflets Chlorosis Dieback Limbs/trees with complete coverage at full rates may die	8
Cotton Defoliants (Ethylene)	Leaf drop Depending on date of occurrence, quality or return crop may be affected Defoliation after November 1 rarely causes significant damage	5
Diuron	Necrosis between leaf veins Some limb dieback in severe cases	2
Imazapic	Root uptake results in unfilled kernels Planting young trees into fields to which imazapic has been applied can result in repeated dieback or death of trees until herbicide has leached out (Usually requires one year; longer on heavy clay soils)	5
Forestry/Pasture Herbicides[b]	Symptoms vary Can include dieback and delayed tree death depending on chemistry used and degree/nature of exposure	9

[a] Long-term injury risk is rated on a 0-10 scale, where 0 = no risk of damage and 10 = potential tree death or long-term production loss.

[b] Forestry or pasture herbicides may include triclopyr, imazapyr, hexazinone, picloram, sulfometuron methyl, and metsulfuron methyl among others.

Drift from cotton defoliants

Drift onto pecan trees often occurs when cotton is defoliated in the fall. Many of these applications use a combination of herbicides and plant growth hormones, most notably ethephon or materials that stimulate ethylene production. Ethylene is a natural plant hormone that is released by ripening fruit.

Ethylene will cause a wide range of effects in plants, depending on the age of the plant and how sensitive it is to ethylene. Ethylene effects include fruit ripening, loss of chlorophyll, abortion of plant parts, stem shortening, leaf abscission (shedding), and the bending of stems. Ethylene can have both positive and negative effects.

When pecans are sprayed with ethylene, leaf abscission occurs within a few days and often ripening of the pecan fruit occurs, advancing shuck split. Therefore, timing is of critical importance in determining the full effects of ethylene drift.

When otherwise healthy pecan trees lose their leaves prior to August for any reason, they will usually refoliate. Carbohydrate levels are returned to normal in the aboveground portions of the tree and the large roots. Carbohydrates are depleted in the feeder roots, where the largest concentration of carbohydrates occur, and the depletion lasts all winter. Yield may be hurt to some extent the following year.

Commercial pecan growers make every attempt to protect the foliage of trees until the first frost occurs in the fall. This normally occurs around November 15. *Complete defoliation of pecan in September virtually guarantees no return crop. Depending upon the crop load, pecan trees can likely tolerate up to 10% loss of foliage prior to October.* If much of this is from the lower interior canopy, trees should not be significantly affected because of the low efficiency of these leaves late in the season. Those trees with a very light to no pecan crop can probably tolerate a little more leaf loss in October and still maintain a return crop. Trees with a heavy nut crop need to maintain as much foliage as possible at least into October but preferably to November 1. *Defoliation of trees from early November on will not significantly affect return crop the following year.*

Often when premature defoliation from drift occurs, we see that the defoliated side of the tree does not produce a return crop but the side of the tree which retained its leaves does produce a crop the following year. Any herbicides included with the defoliant may complicate the situation depending upon the herbicide used.

Herbicide uptake by tree roots

In addition to damage from herbicide drift, pecans are susceptible to herbicide injury from root uptake. This may occur from preemergence herbicides applied to herbicide strips in the orchard, or more commonly, from preemergence herbicides applied to adjacent row crop fields.

Diuron is an herbicide labeled for use on pecan trees for control of annual broadleaf weeds and some annual grasses, but only under trees that have been established in the orchard for at least three years. Injury can occur with this herbicide, particularly on sandy soils, most often when there is a heavy rainfall event within a few days following application. Symptoms appear as development of necrosis (yellowing, browning, or scorching) between the veins of pecan leaflets. Trees normally recover from this with minimal damage. At heavy rates, some limb dieback may occur, especially with repeated applications.

When peanuts treated with imazapic are grown adjacent to pecan orchards, injury from pecan roots' uptake of imazapic can occur. Imazapic is a common postemergence herbicide used in peanut fields early in the growing season to control various broadleaf weeds, grasses, and sedges. Similar materials are sometimes used by highway crews, so trees adjacent to right-of-ways are also at risk for uptake.

Imazapic is rapidly absorbed by plant roots and shoots and transferred to other parts of the plant, accumulating in actively growing tissues. Due to its soil residual activity, imazapic has long rotation restrictions before subsequent crops can be planted in the field. This long residual may sometimes cause the damage on pecan to appear again the year after application. The heavier the soil, the longer it will take for rainfall to wash the herbicide out of the soil profile.

The roots of mature pecan trees can extend to a length twice the width of the tree canopy, often reaching into adjacent fields even when tree trunks and row crop fields are separated by 60 feet or more. When mature pecan tree roots uptake imazapic, there are usually no visible external symptoms of damage. However, as harvest approaches, the pecan shucks do not split and kernel development is inhibited, resulting in hollow nuts or "pops" (Figure 9). As pecan fruit matures, ethylene is produced by the kernel to stimulate shuck split. Since the herbicide inhibits kernel development, there is no ethylene produced to open the shucks and they may remain closed on the tree through the harvest season.

Figure 9. Imazapic injury to pecan nuts (bottom). Trees often absorb herbicide by root uptake from soil of adjacent fields. Mature trees appear normal but kernels inside shuck fail to develop.

When young pecan trees are transplanted into a field where imazapic was used the previous year (and sometimes two years prior on heavy soil), they can be injured to the point of death, or at the very least, to stunted or delayed growth. Young trees planted in imazapic-treated areas often grow initially, then die back, with this process repeating itself until the herbicide is flushed out of the field.

Herbicide injury from forestry and pasture applications

Forestry and pasture herbicides are sometimes used to eliminate broadleaf tree competition from pine plantation stands and cow pastures or hay fields. Commonly applied materials include triclopyr, imazapyr, hexazinone, picloram, sulfometuron methyl, and metsulfuron methyl. Those materials with soil residual activity such as imazapyr may be of greatest concern depending on the amount of soil coverage. Since many of these materials are designed to kill broadleaf trees, shrubs, brush, and vines, they can be particularly damaging to pecan. As with any herbicide, the extent of damage to pecan will depend on the coverage and concentration of the herbicide application. Damage from forestry and pasture herbicide overspray or drift is less common than that from row crop fields, but there is often a greater risk of long-term damage from these materials than from row crop herbicides when drift does occur. In addition, planting pecan trees into pasture land or land where pine trees are cleared when there has been a recent herbicide application (within one to two years) can lead to damage of newly planted pecan trees due to the long soil residual activity of many of these herbicides.

Summary

Herbicide injury to pecan can occur from a number of sources both within and outside of the orchard. It is important to identify the source of the injury when damage occurs. Injury from off-target drift is likely to occur from April through June as row crop fields are burned down for planting and as herbicide applications are made to row crop fields in the early stages of weed emergence after planting. In addition, injury can occur from defoliation of nearby cotton fields in the fall. While no long-term injury may develop, each herbicide drift case is different and the level of injury is dependent upon the herbicide used, rate applied, wind speed and direction, timing, and the level of coverage obtained. Herbicide injury via root uptake can occur when there are other activities occurring adjacent to the pecan orchard. Damage from overspray or drift from some forestry herbicides may be especially injurious to pecan.

Any symptoms of injury should be documented as soon as possible after they are detected. Documentation and sampling of tissue through the Georgia Department of Agriculture and UGA Extension can help in the event of a serious incident.

extension.uga.edu

Circular 1146 **Reviewed February 2022**

Published by the University of Georgia in cooperation with Fort Valley State University, the U.S. Department of Agriculture, and counties of the state. For more information, contact your local UGA Cooperative Extension office.