Figure 1 (left). *Diuron foliar contact phytotoxicity*

Herbicide application stewardship

By Stephen H. Futch, Masoud Salyani and Roy Sweeb

Over the years, citrus herbicide applicators have conducted various calibration activities to ensure proper amounts of herbicides are being applied on a treated acre basis in citrus groves. These activities included 1) determination of ground speed of the application equipment, 2) proper nozzle selection, 3) pressure adjustment and 4) flow rate measurement.

Historically, little attention has been given to the pattern of spray distribution – particularly the angle of the off-center (OC) nozzle at the end of the boom. The nozzle angle can greatly impact the distance the spray will travel or may cause the spray to reach low-hanging limbs in the tree canopy. The spray distance and the OC nozzle angle can greatly impact the potential for phytotoxicity from a herbicide application on low-hanging fruit or foliage contacted by the herbicide mixture.

Figure 3. *Glyphosate foliar contact phytotoxicity*

Figure 2. *Paraquat fruit phytotoxicity (above) and foliar contact phytotoxicity (below)*

Phytotoxicity symptoms can be seen in citrus groves where the herbicide spray material has inadvertently contacted low-hanging branches. Phytotoxicity symptoms have been documented for frequently used herbicides including diuron, paraquat, glyphosate, 2,4-D and indaziflam (Alion).

When diuron contacts the foliage, the foliage will turn yellow, and in many cases, may fall from the tree (Figure 1). Symptoms will vary with the degree of herbicide contact to the foliage.

When paraquat contacts the foliage or fruit, it will cause chlorosis and necrotic spotting with no distinctive pattern (Figure 2). Any green tissue contacted — including leaves, stems, fruit and/or twigs — may exhibit the necrotic damage.

For glyphosate, the injury results from the material being absorbed and translocated by the green tissue. Leaf damage in the form of spots and/or defoliation may result up to several weeks after application. New growth that occurs after glyphosate contact to the affected foliage on the canopy may appear as small, narrow and strap-shaped leaves (Figure 3). Fruit which comes in contact with the glyphosate spray may exhibit burn-like rind damage and fall. Sensitivity of the fruit to glyphosate increases as the fruit approaches maturity.

Symptoms for 2,4-D injury on new shoot growth are curling or rolling of the leaves, producing a boat-shaped distortion (Figure 4, page 21). Twigs may also be distorted.

Indaziflam (Alion) has recently been registered for use in Florida citrus. When applied in a manner that allows it to come into contact with foliage, foliage will exhibit varying degrees of phytotoxicity depending on the extent of contact with the foliage and/or fruit. The degree of bleaching of the

Figure 4. *2,4-D foliar contact phytotoxicity*

Figure 5. *Indaziflam foliar contact phytotoxicity*

foliage may range from a small dot or dots to the entire leaf being bleached to a white-to-yellow color (Figure 5). If a large area is contacted, those leaves may fall from the tree; whereas, if just a small area is contacted, that area may re-green with time. Symptoms may be visible for four to five months after application. The material is not translocated within the plant; thus subsequent growth flushes will emerge unaffected.

Data reprinted here from the TeeJet™ catalog indicates that the width (Figure 6) of the spray pattern will vary depending on the selected nozzle and increase with increasing pressure. The catalog indicates that the covered distance increases with increasing nozzle size and pressure (Table 1, page 22). For an OC 02 at 30 PSI and 18 inches above the soil surface, the distance covered with spray material is 68 inches and increases to 91 inches when the nozzle size is increased to an OC 04. Pressure will also increase the distance covered as noted in Table 1. Herbicide applicators need to

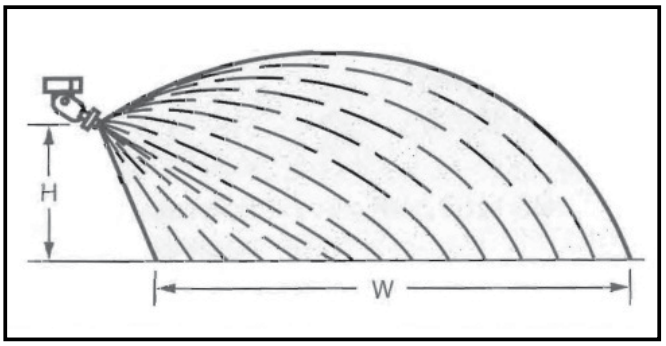

Figure 6. *Width in inches covered by an off-center TeeJet nozzle*

remember that as they increase the pressure, smaller spray droplets are produced and are more prone to drift.

In an effort to quantify the impact of the OC nozzle angle

Table 1. Distance covered in inches (and feet) for various TeeJet OC nozzles used at 30 or 40 PSI with a boom height of 18 inches. Source: TeeJet Catalog

Nozzle	PSI	Distance covered
OC 02	30	68 (5.7 feet)
OC 02	40	70 (5.8 feet)
OC 04	30	91 (7.6 feet)
OC 04	40	93 (7.8 feet)
OC 06	30	99 (8.3 feet)
OC 06	40	101 (8.4 feet)

on the distance the spray droplets travel, a study was conducted at the Citrus Research and Education Center in Lake Alfred using water-sensitive paper. This study utilized an OC 04 spray tip, spraying at 22 PSI, a tractor travel speed of 3.1 mph, the spray boom level with the sprayed surface, and the nozzle tip being approximately 12.5 inches above the spray target. The nozzle angle was set to 0°, 10°, 20°, 30° and 40° as measured from the nozzle housing. Figure 7 shows the angle of the nozzle body at 0 and 40 degrees.

The nozzle angle had a major impact on the distance that the spray droplets traveled and ranged up to 22 inches, 30 inches, 47 inches, 67 inches and greater than 78 inches for 0°, 10°, 20°, 30° and 40°, respectively (Figure 8). Additionally, as the angle of the nozzle body increased from 0° to 40°, the distance from the nozzle where the spray pattern began likewise increased to almost 13 inches from the nozzle body for the 40° angle.

When the nozzle angle was positioned at 10°, the spray reached a height of approximately 5 inches at 1.5 feet beyond the target, and none was noticed at 3 feet beyond the target (Figure 9). However, when the nozzle was increased to 40°, spray droplets were measured to a height of 16 inches at 1.5 feet beyond the target, and at approximately 11 inches at 3 feet beyond the target. With spray droplets reaching 16 inches at 1.5 feet beyond the end of the boom, the chance for phytotoxicities to occur in the tree canopy greatly increases.

Herbicide applicators should think about the angle of the OC nozzle on the end of the herbicide boom. The nozzle angle will have a major impact on where the spray is directed upward as well as the distance from the end of the boom. The higher and farther beyond the end of the boom that the spray is directed greatly increases the chances for phytotoxicity to occur in the tree canopy. The height of the boom and its angle will also impact the distance and height that the spray is directed into the canopy of the citrus tree.

Figure 7. *Nozzle body angle at 0° and 40° as measured from the nozzle housing.*

In conclusion, the potential for phytotoxicity is impacted by the product selected, application speed, ground conditions, application pressure, angle of the OC nozzle and boom height. All of these factors are within the operator's control and can be adjusted. The herbicide applicator needs to carefully evaluate the standard calibration of the herbicide system, but also be aware of how the OC nozzle on the end of the herbicide boom may be directing herbicide material into the tree canopy, resulting in phytotoxicity symptoms being expressed in the tree canopy and fruit drop.

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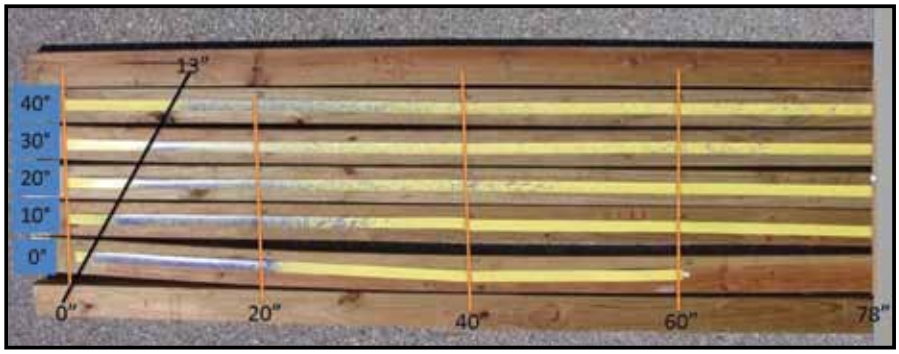

Figure 8. *The distance of the deposited spray for the OC nozzle angles of 0°, 10°, 20°, 30° and 40° as shown on the bottom to top target strips, respectively. The black line, beginning at the bottom lefthand side of the photo, shows the increasing distance from the nozzle where the spray begins to reach the target with increasing nozzle angle. At 0°, the target is contacted near the nozzle tip, and at 40°, it approaches 13 inches from the nozzle.*

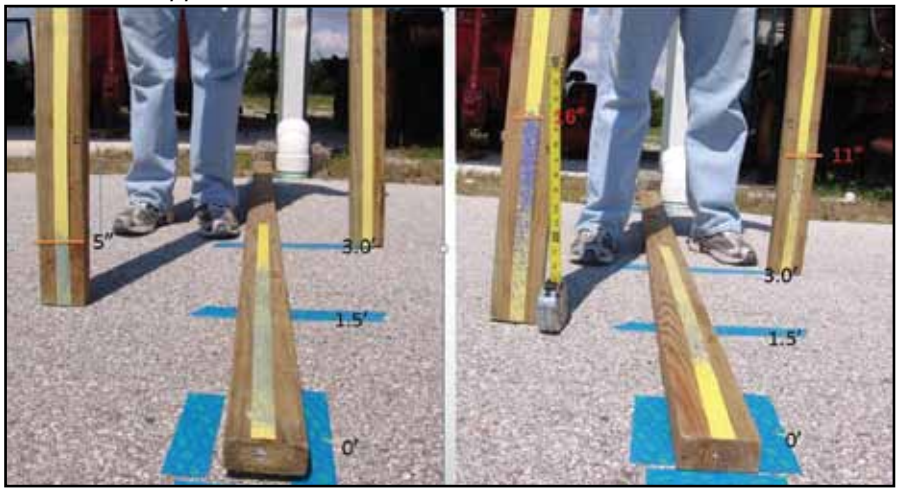

Figure 9. *The left photo indicates that with the nozzle adjusted to 10°, the spray was directed approximately 20 inches beyond the end of the boom and reached a height of approximately 5 inches at 1.5 feet from the end of the boom. No spray was detected on the target at 3 feet beyond the OC nozzle. Whereas, when the angle is increased to 40° (right photo) panel spray was measured to a height of 16 inches at 1.5 feet beyond the boom and to a height of 11 inches at 3 feet.*