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CALIBRATION -- CONSIDERATIONS FOR THE CUSTOM APPLICATOR

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Commercial applicators faced with applications on large acreages during short periods of time often use some type of monitor or controller to give them increased confidence in their calibration. Although they are useful, such methods do not fully substitute for individual applicator knowledge of the variables affecting calibration.

Nebraska study

During 1986, Grisso et. al. (1988) assessed the accuracy of 140 pesticide applicators in 12 counties of central and eastern Nebraska. Twenty-four commercial (17%) and 116 private (83%) applicators were checked.

An earlier Nebraska study done in 1979 had found that only 40% of private and two-thirds of commercial applicators were within (plus or minus) 10% tolerance of intended application rates.

During the 1986 study, 42% of commercial applicators and 27% of private applicators were within a 5% tolerance of intended rates.

Private applicators had more calibration-only type of errors (53% private vs. 33% commercial). Both groups scored about equally in terms of mixing errors (13% commercial and 9% private). Also, significant numbers had both calibration and mixing errors (13% commercial and 11% private).

When tolerance levels were widened to 10%, two-thirds of a "broadcast only" group were within limits. This group contained all 24 commercial units measured and approximately an equal number of private units. Twelve of 14 commercial applicator units treating 5,000 acres or more were within the 10% tolerance. Put another way, one in 7 large acreage commercial units were operating outside the 10% tolerance range.

Speed was identified as a major source of error. One of every two applicators in the study were traveling at speeds which varied more than 5% from their estimate. One of four applicators had a speed variation of greater than 10% from their estimate. Such information indicates the inaccuracies possible with mechanical speedometers, wheel slip and sinkage.

Use of some type of calibration method several times during the season was correlated with an increased tendency to be within calibration limits. Monitors and controllers seemed the best method to stay within calibration.
Applicators seemed to be relying on a false sense of security though as none of the monitors/controllers had been recalibrated since installation. Approximately one in ten were operating outside the 10% tolerance range.

**Controller effects on droplet size and pattern**

Seven factors combine to determine the amount of chemical applied on a given land area. Three of the factors (nozzle, pressure, and concentration) determine the amount of chemical product leaving the nozzle per minute.

Nozzle type and orifice size affect the pattern and amount of flow mixture leaving the nozzle. Flow rate through any specific nozzle is directly proportional to the square root of the pressure at the nozzle orifice. The amount of chemical flowing from the nozzle is also a function of the strength of the concentration of chemical in the tank mixture.

Two factors, nozzle spacing and applicator speed, affect the amount of area covered per minute by each nozzle. Both are inversely proportional to the amount of mixture being applied. Halving nozzle spacing (or doubling the number of nozzles) doubles the application rate. Reducing applicator speed by one half also doubles application rate.

Wind, a sixth factor, also affects the amount and uniformity of chemical applied on a given area. The above six factors are important in determining the amount of chemical being applied over a total area. A seventh factor, boom or nozzle height, affects the uniformity of application in individual nozzle spray patterns by affecting overlap or ensuring an evenly uniform band.

Relatively small changes in speed require much larger pressure changes to compensate for a given application rate. For example, assume that TK5 or D5 flooding nozzles are being used at 15 psi and 6 mph to apply 15.2 gal/ac.

If speed is reduced to 4.5 mph, a pressure of 8.4 psi is required to compensate for this reduced speed. Pattern is narrowed due to the lack of pressure. Volume median diameter of the droplets is increased by 20%.

If speed is increased to 8.0 mph, a pressure of 26.7 psi is required to compensate. Pattern is slightly widened with an increased tendency for mixture application directly under the nozzle and at the edges. Volume median diameter of the droplets is reduced by 20%. Recommended pressure range of about 10 to 25 psi is exceeded in this example and limits the application uniformity that may be achieved.

Droplet size is important as it affects both environmental drift and the ability of the product to control pests. Large droplets are desirable for drift control and useful for chemicals with systemic action, such as dicamba (Banvel).

Smaller droplet sizes are important for chemicals with contact action, such as bentazon (Basagran). Generally larger droplet sizes of flooding nozzles tend to restrict their use on post emergence applications where good overall coverage with many small droplets may be important depending on product.
Injection systems

Injection systems offer several potential advantages for chemical application. Some inherent features of injection also impact calibration accuracy.

Using products in a bulk concentrated form limits the amount of leftover material for disposal. Handling risks may be reduced with less mixing. A constant pressure may be used at each nozzle so that sprayed width and pattern are more easily kept within an optimum range.

Injection control systems rely on varying the concentration of chemical in the flow along the boom to adjust for changes in applicator speed.

As mentioned above for control systems, several factors affect application rate. Conventional controller systems control the amount of spray being released from a nozzle for a given tank mix. As desired gallons per acre, nozzle spacing or applicator speed increase, pressure and flow rate are increased to release more spray and thus keep the amount of product being sprayed per acre a constant amount.

Because chemical product is being mixed "on the go" in an injection system, the total amount of sprayed material, product, and carrier being released from a nozzle can be held constant. To vary the amount of product applied per acre the concentration of product in the flow being supplied to the boom is varied.

An important point to note is that a finite amount of time, often several seconds, is required for a change in chemical concentration at the injection point to reach individual nozzles. A typical injection system contains some length of feeder line from the injection pump into a center section of the spray boom.

As speed changes are sensed at the injection pump, the volume of product entering the feeder line is adjusted accordingly. During the time it takes this new concentration to reach individual nozzles, spray output is still based on prior information sensed by the injection pump. This time delay is affected by flow time through the boom supply hose. Factors affecting this flow time include hose diameter, length, and nozzle flow rate.

A Kansas State study (Koo et. al, 1987) modeled the time delay effects of an injection system on application uniformity. A computer model created the simulation and was checked with dye tests in the laboratory. The injection system used 5 feet of feeder line into one end of a 3/4 inch diameter boom. Twelve nozzles spaced 20 inches apart delivered 0.2 gallons per minute each.

When the applicator was accelerated from 0 to 6 mph in 5 seconds, it took 40 seconds for the boom output to stabilize. During this time, 40% of the area covered was misapplied using a tolerance of plus or minus 10% of the intended rate.
In another case the applicator simulated slowing for a field hazard and then returning to established speed. The applicator decelerated from 6 to 3 mph in 5 seconds. It continued at 3 mph for 2.5 seconds and then accelerated back to 6 mph in another 5 seconds. The system took 47 seconds to stabilize during which 34% of the area was misapplied.

The preceding case of slowing for a field hazard was tested as it might apply during application in a 40-acre field. Each time through the field the applicator slowed for three terraces and for turning at the field border. In this case, 41% of the field was misapplied.

Possible improvements in such a system may not be obvious unless one considers the fundamental physical principles which affect this application. Using a smaller hose (1/2 inch diameter) resulted in a faster travel time to the end nozzles and reduced the area misapplied to 32%. In this case, with so much speed variation, a simple fixed metering system with no adjustment for speed changes reduced the misapplied area to 30%.

**Summary**

These examples illustrate the importance of being able to identify the major factors affecting calibration and to further sort out which ones may be of most importance in an individual situation. Engineering advances such as monitors, controllers and injection systems are useful aids.

Accurate application is still, however, dependent on the reliability and competence of the applicator. A sound knowledge of the interactive effects of nozzle selection, pressure, mixing concentration, nozzle spacing, and applicator speed is required to use any calibration method efficiently.

**References**


