FIELD CASE STUDIES OF DICAMBA MOVEMENT TO SOYBEANS

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Every summer, a small percentage of Wisconsin's soybean fields have injury, which is generically described as "leaf puckering". Although the severity of the injury may not be great, the injury generates a lot of concern for the soybean grower. The grower may be concerned that the injury will result in yield loss and/or be concerned over who was responsible for causing the injury. Leaf puckering may be caused by growth regulator herbicides such as dicamba, which is an ingredient in Banvel, Clarity, and several other corn herbicides. These herbicides mimic the plant's natural hormones and distort new leaf growth. Dicamba is applied to nearly 1 million acres of corn in Wisconsin each year (232,000 lb applied to 0.95 million acres in 2002) (NASS 2003). As a consequence, the potential for dicamba drift or tank contamination is real. However, there have been several other suggested theories for these puckered soybeans. These suggested reasons include the following:

1. A physiological response to adverse growing conditions such as high temperatures are suggested to cause a hormone-type response.
2. The new high yielding soybean varieties are responding to environmental stresses.
3. Nitrogen additives such as the biuret concentration in 28% UAN are causing leaf distortion.
4. Under certain environmental conditions, glyphosate (Roundup) is causing a hormonal response in Roundup Ready soybeans.
5. Other translocating herbicides are moving to the growing point and disrupting the hormonal balance in the soybeans, which causes puckering.

Scientific evidence to support these other reasons of leaf puckering are lacking, but they persist because there is a belief that dicamba could not be responsible.

There are other factors that may cause soybean leaves to crinkle (aphids, herbicide injury from PPO inhibitors, etc.), to drawstring (herbicide injury from acetamides), or to become distorted (rugosity from viruses). However, these symptoms are distinctly different from the leaf puckering caused by dicamba or other growth regulator herbicides, where four nodes of leaves typically show the puckering. It is important to be able to distinguish among these different types of injury to provide an accurate diagnosis and to solve the soybean problem.

Sources of Dicamba

Soybeans can be exposed to dicamba through vapors, particle drift, or contaminated spray. A review of each of these sources will help to understand the potential for these exposures. The most information is available about dicamba volatility. In a series of field and glass chamber experiments, Behrens and Lueschen (1979) documented several variables. In the field, volatility was measured from 100 by 100 ft blocks of corn that were sprayed with 0.5 pt/a Banvel. One hour after the application, potted soybean plants were placed downwind of the corn for 1 day and then moved to a greenhouse. The soybeans were rated on a scale of 10 = slight crinkle of terminal leaf; 20 = cupping of terminal leaf; 30 = two leaves cupped; 40 = terminal leaves malformed; 50 = terminal leaf not expanding; 60 = malformed axillary shoots developing; and

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70 = terminal bud dead. From these experiments, dicamba symptoms were rated at 60 to 72 at 10 ft from the corn and 18 at 200 ft from the corn. Clearly, dicamba can volatilize under field conditions. Additional glass chamber studies showed that other formulations would volatilize less than Banvel, which is a dimethylamine salt. While Banvel volatility caused a 67 soybean injury rating, the sodium salt of dicamba caused less injury (a 37 rating). Distinct and Northstar have a sodium salt of dicamba. Clarity uses a diglycolamine salt, but this salt was not tested. As expected, volatilization increased with increasing temperature where the injury rating was 2 at 59F, but increased to a rating of 38 at 86F. Volatilization was also greater from corn leaves (injury rating of 39) versus soil (rating of 26). The volatilization from leaves could be drastically reduced with as little as 0.05 inch of rainfall. Soybeans exposed to dicamba-treated corn had substantial injury after 4 hours.

A second potential source of dicamba is spray particle drift. The Spray Drift Task Force (1997) reported that drift from a 8004 flat fan nozzles at a 20 inch height, 40 psi, and 8 mph wind was about 0.5% at 25 ft, 0.2% at 100 ft, and 0.125% at 200 ft. Increasing boom height or reducing droplet size greatly increased drift in their studies. Dicamba drift to soybeans was not tested in these studies, but the levels of drift are useful for later discussions in this paper.

The third source of dicamba may be contaminated spray, which may occur from a contaminated spray tank, make-up water or nurse truck, transfer hoses, measuring containers, or jugs. It has been reported that as little as 0.01% of a dicamba use rate can cause soybean symptoms. If a 500 gallon spray tank sprayed 1 pt/a Clarity, 6.4 oz of this spray solution remaining in the tank, sump, or lines would be sufficient to contaminate the next 500 gallon load at the 0.01% level. Two quarts of this solution would contaminate 500 gallons at the 0.1% level, which is likely to cause symptoms. If lower rates of dicamba are being applied (e.g. 4 oz /a Distinct or 5 oz/a NorthStar), four times more solution would be required for the same levels of contamination. Similarly, small amounts of dicamba from an old jug used to shuttle glyphosate or adjuvants can contaminate spray solutions. Only 0.05 oz or 1.5 ml of Banvel or Clarity would contaminate a 500-gallon load (calibrated to spray 15 gpa) at the 0.01% level. A non-rinsed jug could certainly retain this small amount of dicamba.

Field Case Studies of Dicamba Movement

The source of dicamba that injures soybeans may be from drift or volatility from nearby corn fields or a contaminated sprayer. However, these sources have not been documented under field conditions. Therefore, three sets of case studies were planned in 2003 to gather information and documentation on dicamba movement to soybeans. The specific case studies were:

1. Drift/volatility: document the potential of dicamba to drift or volatilize and move to soybeans that are adjacent to dicamba-treated corn fields.
2. Tank contamination: document the potential of dicamba residues to contaminate a field sprayer after rinsing.
3. Grower samples: analyze soybean plants from Wisconsin fields that have puckered leaves for dicamba residues to determine if dicamba was the cause of the injury.

<u>Drift/volatility</u>. Three moderate-sized corn fields were selected that were adjacent to four soybean fields and were scheduled to be sprayed postemergence with a dicamba-containing product. Production fields were used instead of test plots to increase the total amount of dicamba applied, which may be a factor in the amount of vapors generated. The dicamba was sprayed at 20 gpa using 8008XR nozzles and 35 psi. Two or 3 days following these application,

the soybeans were sampled at 25, 100, and 200 ft distances from the corn at three locations in each soybean field. This time period was selected to allowed potential volatilization (Behrens and Lueschen observed volatility for 3 days). The samples were frozen and submitted to the DATCP's Bureau of Laboratory Services for residue analysis at a 50 ppb level of detection. At 2 to 3 weeks after the dicamba applications, the soybean fields were evaluated for visual symptoms.

Field A was treated in an afternoon with a light wind that started from the northeast and changed directions a complete 360 degrees during the application (Table 1). The final wind direction increased to 4-6 mph from the east at the end of the application. Despite the light wind and final direction blowing away from the soybean field, soybeans exhibited very slight (but noticeable) to slight deformity of the upper leaf tips at 25 ft from the corn field. However, dicamba residues were not detected in any of the soybean samples collected 3 days after the application.

Field B had soybeans to the north and west (Table 1). Unfortunately, the application to this field was also made during extremely low wind conditions. Slight injury symptoms were still noticed on the soybeans at 25 ft, but no symptoms were seen at 100 ft in the soybeans to the west or at 200 ft in the soybeans to the north. Dicamba residues were not detected in any of the soybean samples collected 3 days after application.

The application to Field C was intentionally made on a windy afternoon with the wind direction towards the soybeans (Table 1). Moderate injury was noted on some of the soybeans at 25 ft, but the soybeans were not injured at 100 or 200 ft. Dicamba residues were not detected in any of the soybean samples collected 2 days after application. It is not possible to distinguish between particle drift or volatility in these field situations.

Table 1. Application information and soybean injury symptoms for case studies of dicamba drift or volatility from corn fields to soybeans.

	Application information							Soybean injury[a]		
Field	Date	Time	Wind (mph)	Direction	Herbicide	Rate (oz/a)	Location of soybean field	25 ft	100 ft	200 ft
A	6/16	1410-1450	1.5-6	variable	NorthStar	5	to east	VS-S	N-S	N-S
B	6/17	0730-0825	0-3	E-SE	Distinct	5	to north	S	VS	N
							to west	S	N	N
C	6/27	1330-1355	13-15	WSW	Distinct	5	to east	S-M	N	N

[a] N = no symptoms; VS = very slight deformity of leaf tips; S = slight deformity of leaf tips; M = moderate, cupping of leaves evident

Tank contamination. A trailer-mounted sprayer with a 500 gallon poly tank was tested for dicamba residues after spraying dicamba. The tank was cleaned using the standard procedures of the operation, which including draining and washing and flushing the system with an ammonia-water solution. The tank was re-filled with water to simulate a new load being mixed for an application to soybeans. The water from the spray tank was sampled and water sprayed out of the boom was sampled. After collecting these two samples, the water was allowed to remain in the tank overnight to determine if additional dicamba residues might dissolve and increase the dicamba concentration. Water from the tank and boom were sampled the following day. The water samples were analyzed by DATCP's Bureau of Laboratory Services.

Dicamba was detected in all of the water samples from the sprayer even when an ammonia-water solution was used (Table 2). The dicamba concentration in the spray tank's water was low, but the concentration may have been sufficient to cause slight injury symptoms. Allowing the water to stand overnight did not increase the dicamba concentration. This may indicate that dicamba residues had not absorbed into the poly tank or that previous washings were effective at removing most dicamba residues. The water from the spray boom contained a high concentration of dicamba, which might cause moderate soybean injury. This concentration may indicate the boom was not flushed adequately. Discharging water to collect the first sample from the boom apparently flushed most of this contaminated water from the boom and the dicamba concentration was lower the following day.

Table 2. Dicamba residues detected in the mix water in a sprayer following clean-out procedures after making a dicamba application.

Sample description	Dicamba (ppb)	Percent of use rate[a]
Water from spray tank	945	0.024%
Water from spray tank after overnight	822	0.021%
Water from spray boom	24,800	0.63%
Water from spray tank after overnight	1320	0.034%

[a]Based on 1 pt/a Banvel applied in 15 gpa water.

<u>Grower samples</u>. Ten field samples with puckered leaves were submitted for analysis for dicamba residues to determine if dicamba could be confirmed as the cause of the leaf puckering. One additional sample was submitted with suspected 2,4-D injury and one non-injured soybean sample was used as a control. All 10 of the field samples had moderate injury symptoms that would be considered classic dicamba symptoms. Despite the significant injury symptoms, dicamba residues were not detected in any of the samples at a 50 ppb detection level. Six of the 10 field samples were positive for soybean mosaic virus and the 2,4-D and control samples were also positive for soybean mosaic virus. With this high frequency of virus detection, it is important to be familiar with the leaf deformities caused by both virus and dicamba.

Summary

The observation of soybean injury symptoms and lack of detection of dicamba residues likely indicate that these soybean plants were either 1) not exposed to high doses of dicamba, 2) the dicamba was metabolized, 3) the dicamba concentration was diluted in the plant as the plant grew after the exposure, or 4) a combination of the previous factors. Hypothetical scenarios were used to calculate the dicamba concentration in soybean plants with different types of exposure. In all cases, a soybean plant with a 25 in^2 surface area and 10 gram weight were assumed. In the first hypothetical situation with 1% drift or tank contamination of a full use rate, the 50 ppb detection level used by the laboratory should be able to detect dicamba residues for 3 weeks after exposure (Table 3). In the second scenario, dicamba residues should be detected after 6 days with 1% drift at a low rate, which might have been expected in Field C. Grower samples may have been exposed to dicamba doses similar to the second scenario and metabolism of the dicamba may have reduced the residues below the 50 ppb level of detection. In the third scenario, low levels of exposure would likely cause symptoms on soybeans, but may not be detected at this level.

Table 3. Hypothetical dicamba concentrations in soybean plants after exposure to different sources of dicamba using potential rates of metabolism.

Day	Dicamba metabolism	Source of dicamba exposure		
		1% drift or 1% tank contamination at use rate[a]	0.25% drift of use rate[a] or 1% tank contamination at low rate[b]	0.25% drift of low rate[b]
		Dicamba concentration in soybean plant (ppb)		
0	0	1,000	250	63
3	33%	670	170	40
6	67%	330	80	20
12	83%	170	40	10
24	95%	50	10	3

[a]Application of 1 pt/a Banvel applied in 15 gpa.

[b]Application of 4 oz/a Distinct or 5 oz/a NorthStar applied in 15 gpa.

The effect of dicamba injury on soybean yie ld has been measured in several studies. In 1997 in Wisconsin, I applied 0.5 and 1% rates of dicamba (0.03 and 0.16 oz/a Banvel) to soybeans to simulate tank contamination. The 0.5% rate reduced soybean height 20%, but yield was only 4% less than soybeans that were not treated with dicamba. The 1% rate reduced height 34% and reduced yield 16%. A similar study conducted by South Dakota State University measured a 40% height reduction and 14% yield loss after applying a 1% dicamba rate (Anderson et al., 2001). Soybeans have tolerated higher dicamba rates in other studies before a yield loss was measured. Most studies have shown that soybeans in the vegetative stage tolerate injury from low doses of dicamba and do not suffer a yield loss. Soybeans suffering significant damage in the reproductive stages are more likely to suffer a yield loss. Overall, if dicamba has only caused minor leaf puckering, it is unlikely that soybean yield will be affected.

References

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