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Diagnosing Dicamba Injuries on Sensitive Soybean

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Summary

- Dicamba is an effective herbicide for managing glyphosate-resistant broadleaf weeds in dicamba-tolerant crops; however, it is prone to both particle drift during, and vapor drift after application, which can cause unintended exposure of nearby sensitive vegetation.
- Dicamba drift can cause injury on sensitive soybean and other sensitive broadleaf crops at extremely low doses, but symptoms do not always result in yield loss.
- Soybean growth stage at exposure determines severity: plants are most sensitive around flowering, showing the highest injury and yield loss.
- Visual thresholds (which will be explained in this publication) for 5% yield loss are approximately 55% (V2), 37% (V7/R1), and 30% (R2) injury.

Introduction

After the original registration in 2016, soybean growers have rapidly adopted dicamba-tolerant (DT) varieties and dicamba products for the post-emergence control of multiple-herbicide resistant broadleaf weeds. This increase in dicamba usage has resulted in many reports of dicamba off-target movement, causing damage to sensitive broadleaf plants (Environmental Protection Agency, 2021). In 2021, EPA received nearly 3,500 reports alleging effects from off-target movement of dicamba onto various nontarget vegetation, including sensitive cotton and soybean varieties, ornamentals, and other crops (e.g., grapes, cucurbits, peaches, vegetables, etc.). Incidents were also reported for non-crop areas such as state parks and wildlife refuges (Environmental Protection Agency, 2021).

Regulatory status of dicamba products has changed substantially in recent years. Following widespread reports of off-target movement and legal challenges, registrations for over-the-top dicamba applications in dicamba-tolerant (DT) soybean and cotton have been subject to cancellations, expirations, and re-registrations under revised label requirements. Most recently, new dicamba products (e.g., Strax®) have received registration with updated application restrictions and stewardship guidelines. Dicamba also remains labeled for use in other crops (e.g., corn and non-crop areas), and off-target exposure to sensitive vegetation continues to occur. Therefore, understanding and diagnosing dicamba injury remains relevant for growers, consultants, and regulators.

Dicamba

Dicamba (3,6-dichloro-2-methoxybenzoic acid) is a selective systemic herbicide from the class of synthetic auxins (WSSA Group 4). It is widely used to control broadleaf weeds in field crops, pastures, turf, and non-crop areas. Dicamba was first introduced in the 1960s and is now a major component of dicamba-tolerant soybean and cotton systems that were developed to manage glyphosate-resistant weeds. These systems were available from 2017 to 2024, and were recently approved again for 2026 to 2028.

Dicamba is a weak acid herbicide whose behavior in the environment is strongly influenced by its formulation and prevailing weather conditions. Earlier dicamba formulations, including the acid form and dimethylamine salts, were highly volatile and prone to vapor drift (volatilization), allowing dicamba to move off-target hours or even days after application. To address this concern, newer low-volatility formulations were developed; however, volatilization and secondary movement can still occur, particularly under high temperatures, low relative humidity, and temperature inversion conditions. Because dicamba can move both as physical spray droplets and as vapor, sensitive crops located several hundred yards, or even farther from treated fields, may receive biologically active doses sufficient to cause visible injury.

Mode of Action

Dicamba mimics the natural plant hormone indole-3-acetic acid (IAA), which regulates normal cell elongation, division, and differentiation. As a systemic herbicide, dicamba is absorbed through foliage, stems, or roots and moves via both the xylem and phloem, accumulating in actively growing tissues such as shoot tips and young leaves. In sensitive plants, dicamba causes auxin overdose, overstimulating hormone signaling and triggering a cascade of biochemical reactions resulting in abnormal cell division and elongation, disruption of vascular tissue integrity, and transport processes.

Understanding Dicamba Drift

Dicamba can move off target through two main pathways: particle drift and vapor drift (volatilization). Particle drift occurs when fine spray droplets are carried away by wind during or shortly after application. Particle drift is mainly influenced by droplet size, spray pressure, nozzle type, boom height, and wind speed at application. Vapor drift happens when dicamba volatilizes and moves with the air off the target site, which can occur up to 72 hours after application. The highest dicamba concentrations in air are typically observed within the first eight hours of application. Risk of vapor drift increases under stable atmospheric or temperature inversion conditions, when air movement is limited (Bish et al., 2019).

Volatility of dicamba is influenced by temperature, humidity, and spray solution pH. Higher temperatures and lower humidity increase volatilization, while higher pH reduces volatility (Velini et al., 2022; Mueller & Lawrence; 2019). Tank-mixing dicamba with glyphosate lowers the spray solution pH, which enhances volatility and can increase dicamba concentrations in the air by several orders of magnitude. Furthermore, the dicamba formulation also affects volatility: older dicamba formulations such as the dimethylamine (DMA) salt (e.g., Banvel®) are more volatile than newer diglycolamine (DGA) (e.g., Clarity® and XtendiMax®) or N,N-bis(aminopropyl)methylamine BAPMA salts (e.g., Engenia®). However, field research has shown that even the newer "lower-volatility" formulations can volatilize similarly over time (Bish et al., 2019). In addition to drift, improper or incomplete cleaning of spray equipment can result in unintended dicamba exposure of sensitive crops. Even trace amounts of dicamba remaining in spray tanks, hoses, or nozzles can be sufficient to cause visible injury and may produce symptoms similar to those observed following particle or vapor drift.

Dicamba Injury Symptoms

Phytotoxic effects of dicamba on sensitive broadleaf species, including sensitive soybean, are very distinctive and include upward leaf cupping (Figure 1, Figure 2), epinasty (curly stems) (Figure 3), cracked and swollen stems (Figure 4), chlorosis, and necrosis (Figure 5) (Solomon & Bradley, 2014), with symptoms first occurring on new growth. It has been reported that soybean injuries and yield losses are influenced by both dicamba dose and soybean growth stage at the time of exposure (Milosevic & Knezevic 2024; Osipitan et al., 2019; Robinson et al., 2013;). Early-season soybean exposure to dicamba stimulates lateral growth (branching) especially when the apical meristem is suppressed or killed while exposure during flowering or early-pod stage, can result in abnormal pods, fewer pods, fewer seeds per pod and lower seed weight. However, injury symptoms, even if visible and distinctive, do not always cause yield reduction.

Figure 1. Leaf cupping in soybean, a characteristic symptom of dicamba exposure. Young trifoliates show upward cupping and puckering following drift exposure. Dicamba was applied at V2 growth stage, photo taken 14 DADE.

Figure 2. Dicamba-induced upward leaf cupping and puckering on new soybean trifoliates. Dicamba was applied at V2 growth stage, photo taken 14 DADE.

Figure 3. Epinasty—curling and twisting of soybean stems following dicamba exposure. Stem distortion and nodal bending typically occur at higher drift doses than simple leaf cupping. Dicamba was applied at V2 growth stage, photo taken 14 DADE.

Figure 4. Cracked and swollen soybean stem with localized necrosis. Stem damage of this type is associated with very high drift doses (e.g. 1/10 of the label rate) and more severe injury (>80%). Dicamba was applied at V2 growth stage, photo taken 21 DADE.

Figure 5. Chlorosis, necrosis, and pronounced epinasty in dicamba-injured soybean. Canopy layover is commonly observed at higher drift doses (1/5 to 1/10 of the label rate) during reproductive stages. Dicamba was applied at R1 growth stage, photo taken 21 DADE.

Figure 6. Healthy soybean flowers (left) and aborted flowers (right) following dicamba exposure at the beginning of flowering (V7/R1), photo taken 14 DADE. Flower abortion at this stage can significantly reduce pod set and yield.

Given the high sensitivity of soybean to dicamba and the widespread occurrence of off-target dicamba movement, this publication aims to provide clear diagnostic guidance supported by photo-based visual references to assist producers, crop consultants, Extension educators, and regulators in accurately identifying dicamba injury. These resources are intended to support informed decision-making and help address drift-related concerns and disputes among neighboring landowners. In addition, the information presented may assist Nebraska policymakers and regulatory agencies as they consider science-based guidelines for spatial separation and stewardship practices between dicamba-tolerant crops and adjacent sensitive vegetation. Although the future of over-the-top dicamba applications in dicamba-tolerant soybean remains uncertain past 2028, dicamba-related injury will likely continue to be a concern because dicamba products are widely used in other crops, including corn and sorghum.

Photos and results presented here are derived from a project that (1) evaluated the influence of six micro-rates of dicamba products (Clarity®, Engenia®, and XtendiMax®) on growth, development, and yield of sensitive soybeans at three different growth stages of application [second trifoliate (V2), beginning of flowering (V7/R1), and full flowering (R2)], and (2) established baseline data on the potential injury and yield reduction of sensitive soybeans relative to micro-rates of dicamba products.

Results published in a number of studies (Osipitan et al., 2019, Milosevic et al., 2024), clearly demonstrated that all non-DT soybeans tested (Conventional, Liberty-Link®, Roundup-Ready®, Enlist®) were equally sensitive to micro-rates of Engenia® or XtendiMax®. Visual injuries ranged from 20–80% with flowering stage being the most sensitive with the greatest soybean injury and greatest yield losses. Types of soybean injuries ranged from: leaf cupping at V2 and V7/R1 spraying (Figure 2), epinasty (curly stems) at V2, V7/R1 and R2 timings (Figure 3); abortion of flowers at V7/R1 (Figure 6); curly pods and swollen stems at R2 timing (Figure 7 and Figure 8).

Soybean height was reduced by 10–85% across dicamba micro-rates and the growth stages of dicamba application. Reduction in soybean height delayed canopy closure when sprayed at V2 stage, while there was no complete canopy closure when sprayed at V7/R1 soybean growth stage. From a practical standpoint, the reduced soybean height and delayed (or no) canopy closure could potentially reduce soybean competitive ability against weeds. Delayed flowering and maturity (Figure 9) caused by the micro-rates of dicamba, resulted in later harvest timing, thereby potentially subjecting the soybeans to early frost damage.

Yield losses varied with the doses and application time. The 5% yield loss is utilized to illustrate potential for yield losses, which is equivalent to about 3 bushel/acre assuming a 60 bu/ac yield. It is reasonable to determine such level of yield differences consistently across years and locations despite the natural variability in field experiment. The range of doses that reduced yields by 5% varied from 0.01 to 0.07 oz/A (0.3 to 1.9 g ae/ha) across all herbicides, application times, and soybean types. The lowest rate of 1/1800 of the label rate (or 0.07 tsp/ac equivalent) was estimated for V7/R1 stage and to highest rate of 1/300 of the label rates (or 0.46 tsp/ac) for V2 and R2 stages.

Figure 7. Normal pods (left) versus pod curling and pedicel twisting (right) after dicamba exposure at R2, photo was taken 28 DADE

Figure 8. Swollen soybean node and petal twisting following dicamba exposure at R2, photo taken 21 DADE.

Figure 9. Delayed maturity in dicamba-injured soybean (center) compared to surrounding untreated plants undergoing normal senescence. Dicamba exposure during reproductive stages can delay pod fill and extend maturity.

How to Assess Dicamba Injury in Soybean

Accurate assessment of dicamba injury is essential for documenting drift events, estimating potential yield impact, and resolving disputes among growers. The following photo series and accompanying descriptions (Table 1) are intended to serve as a practical visual guide for assessing the severity of dicamba injury symptoms in non–dicamba-tolerant soybean. These images illustrate a range of injury responses under field conditions and are designed to help users compare symptom expression across growth stages and injury levels. This reference can assist producers, crop consultants, Extension personnel, and regulatory officials in making informed evaluations of dicamba injury and in distinguishing mild, moderate, and severe symptomology during field inspections.

Note: The photos were taken 28 days after drift event (DADE). Because dicamba injury expression on sensitive soybean changes over time, these reference images should be used for comparison only at a similar interval (approximately 3–4 weeks after dicamba drift or exposure). Injury assessed too early (e.g., 5–6 DADE) or too late (e.g., more than 6–8 weeks after drift event) may not accurately represent final symptom intensity or potential yield effects.

Table 1. Visual injury reference guide for assessing dicamba injury in sensitive soybean exposed to dicamba at V2 growth stage. Listed symptoms and approximate yields are based on harvested plot data and illustrate how visual injury relates to yield loss.

Injury level (%)	Typical field symptoms	Approx. yield (bu/ac)	Outcome
0%—No injury	Normal trifoliate expansion, flat leaflets, uniform green canopy.	73	Untreated check (reference) (Figure 10).
5%	Slight cupping on youngest trifoliate only.	73	Cosmetic only; no measurable yield loss (Figure 11).
10%	Mild cupping and puckering.	73	Typical of very low drift exposure (Figure 12).
30%	Noticeable cupping on upper canopy; moderate wrinkling; no height reduction.	71	Usually below yield-loss threshold (Figure 13).
50%	Severe cupping, slightly swollen petioles, early epinasty, reduced internode length.	70	Borderline injury for minor yield effects (Figure 14).
60%	Severe cupping and stunting, thinner canopy, height reduction.	68	≈5% yield loss at V2; practical visual yield-loss threshold (Figure 15).
70%	Epinasty, very thin canopy, high stunting, and height reduction.	53	Moderate reproductive loss (Figure 16).
80%	Necrosis, epinasty, cracked stems, meristem death possible, extremely thin canopy and very high stunting and height reduction.	46	Severe yield loss (Figure 17).
> 90%	Extreme necrosis and stem cracking; apical meristem and upper canopy completely dead; plants near death or non-recoverable.	15	Possible crop death (Figure 18).

Figure 10. Untreated soybean (0% injury reference). Plants show normal trifoliate expansion, uniform height, and full canopy development. Yield = 73 bu/ac.

Figure 11. Approximately 5% dicamba injury. Slight cupping limited to the youngest trifoliates (circled red). Yield = 73 bu/ac.

Figure 12. Approximately 10% dicamba injury. Mild cupping on several of the youngest trifoliates. Yield = 73 bu/ac.

Figure 13. Approximately 30% dicamba injury. Noticeable cupping across the upper canopy with moderate puckering; no height reduction. Yield ≈ 71 bu/ac.

Figure 14. Approximately 50% dicamba injury showing severe cupping and early canopy thinning with slight height reduction. Cosmetic only; no measurable yield loss (≈70 bu/ac).

Figure 15. Approximately 60% dicamba injury with severe cupping, canopy thinning, and noticeable height reduction. This level represents the practical visual threshold for significant yield loss (5% loss or ≈68 bu/ac).

Figure 16. Approximately 70% dicamba injury—severe height reduction, thin canopy, and death of the growing point. Associated with moderate yield loss (20% loss or yielded ≈ 53 bu/ac compared to 73 in non-treated).

Figure 17. Approximately 80% dicamba injury characterized by terminal node death, extreme stunting, and severe canopy loss. Associated with severe yield reduction 40% loss (yielding ≈46 bu/ac compared to 73 in non-treated).

Figure 18. Reference gradient of dicamba injury in soybean (left to right): 70%, 80%, 90%, 95%, and 99% severity. Increasing severity is associated with progressive loss of apical dominance, internode shortening, canopy collapse, increasing necrosis, and ultimately plant death at ≥95–99% injury.

Range of Dicamba Injury and Injury Thresholds

Dicamba drift often results in obvious visual injury on sensitive soybeans, but the presence of symptoms does not always cause yield loss. Although we can experimentally determine dicamba doses that reduce yield, in real-world drift events, the actual dose that reaches a neighboring field is difficult to quantify. It depends on wind speed, direction, temperature, nozzle type, distance, and canopy interception. For this reason, a more practical approach is to use visual injury as a field indicator of potential yield loss. Therefore, our recent research introduced the concept of visual injury thresholds: the level of visible injury corresponding to a specific percentage of yield reduction. For practical purposes, we use a 5% yield loss as significant for field decision-making. The level of visual injury associated with this 5% yield loss was approximately 55% at V2 (Figures 19, 20 and 21), 37% at V7/R1 (Figures 22, 23 and 24), and 30% at R2 (Figures 25, 26 and 27) soybean growth stages.

In most cases, injury levels below these thresholds do not cause measurable sensitive soybean yield reduction, even though visual symptoms may appear severe. This distinction helps differentiate between a cosmetic and an economically significant injury, providing a more objective way to interpret off-target dicamba exposure in the field.

Although not every dicamba exposure results in measurable yield loss, efforts should always be made to prevent off-target injury. This is important because off-target movement of any pesticide should be a concern. Dicamba exposures that do not result in measurable yield loss can cause visible crop injury, generate complaints, and strain relationships among neighboring landowners. Preventing dicamba drift is therefore essential to protecting sensitive crops, ornamentals, and natural vegetation, while also promoting trust and cooperation within the agricultural community. Responsible dicamba management requires strict adherence to label requirements, careful consideration of weather conditions, appropriate nozzle and application parameter selection, and proactive communication with nearby growers before application.

No-Observed-Adverse-Effect Level (NOAEL)

The NOAEL represents the highest dicamba dose that produces no observable adverse effects on non-dicamba-tolerant soybean. This dose is extremely low, as even trace amounts can cause some level of visual injury. However, injury does not always translate into yield loss. Therefore, it is practical to distinguish between two types of NOAELs:

- Visual NOAEL is derived from the most sensitive response, which is the appearance of injury symptoms such as leaf cupping. This threshold is reached at very low dicamba doses, in the range of 0.000012–0.00134 oz ae/ac, or roughly 0.00007–0.008 of a teaspoon of product (XtendiMax®) per acre, depending on the growth stage.
- Yield NOAEL is based on the absence of measurable yield loss, which is a more agronomically important indicator. Yield-based NOAELs are much higher than visual ones, ranging from about 0.004–0.07 oz ae/ac, corresponding to 0.2–1.2 teaspoons of product per acre, suggesting a strong ability for soybean to recover from medium-level injury without yield impact.

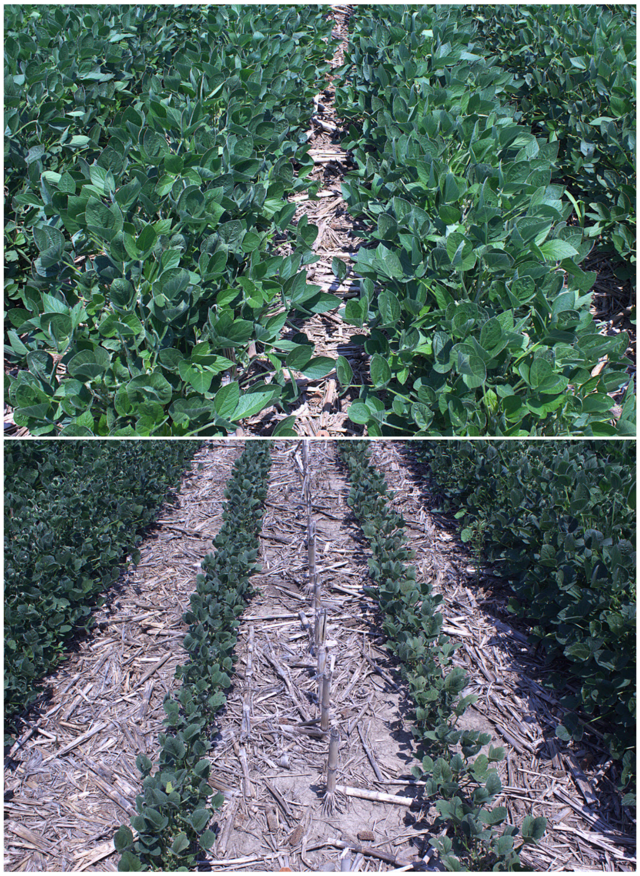

Figure 19. Visual injury threshold at V2 (plot-level view). Untreated soybean (top; 73 bu/ac) contrasted with threshold plants (bottom; 68 bu/ac) corresponding to a ~5% yield loss. Threshold plants show severe stunting, height reduction, and canopy thinning. Photo taken 28 DADE.

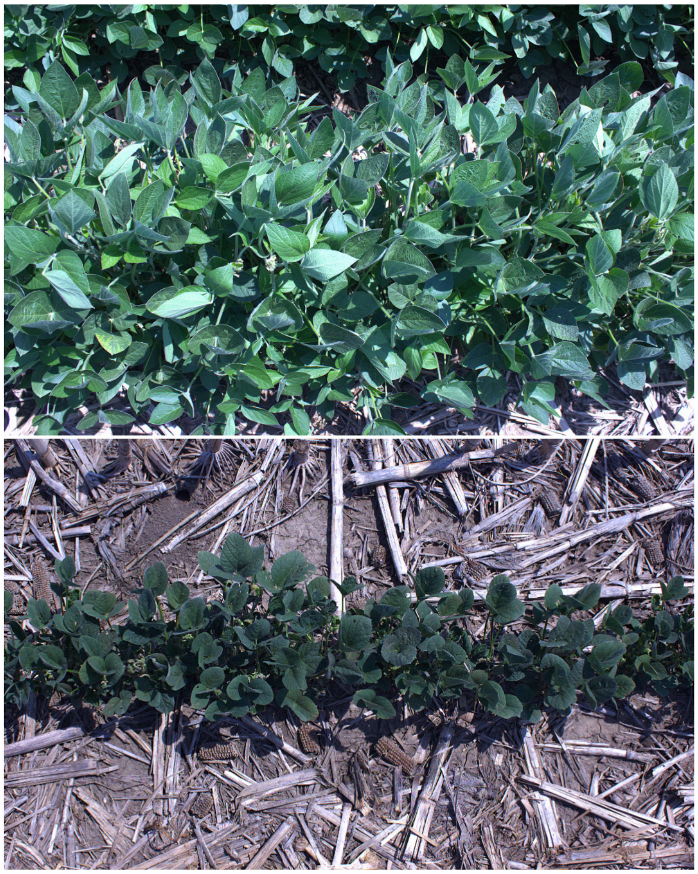

Figure 20. Visual injury threshold at V2 (overhead canopy view). Untreated soybean (top; 73 bu/ac) compared with plants at the ~5% yield-loss threshold (bottom; 68 bu/ac). Photo taken 28 DADE.

Figure 21. Height reduction as a practical threshold indicator (V2). Untreated soybean (left; 26 in, 73 bu/ac) compared with threshold plants (right; 12 in, 68 bu/ac). Photo taken 28 DADE.

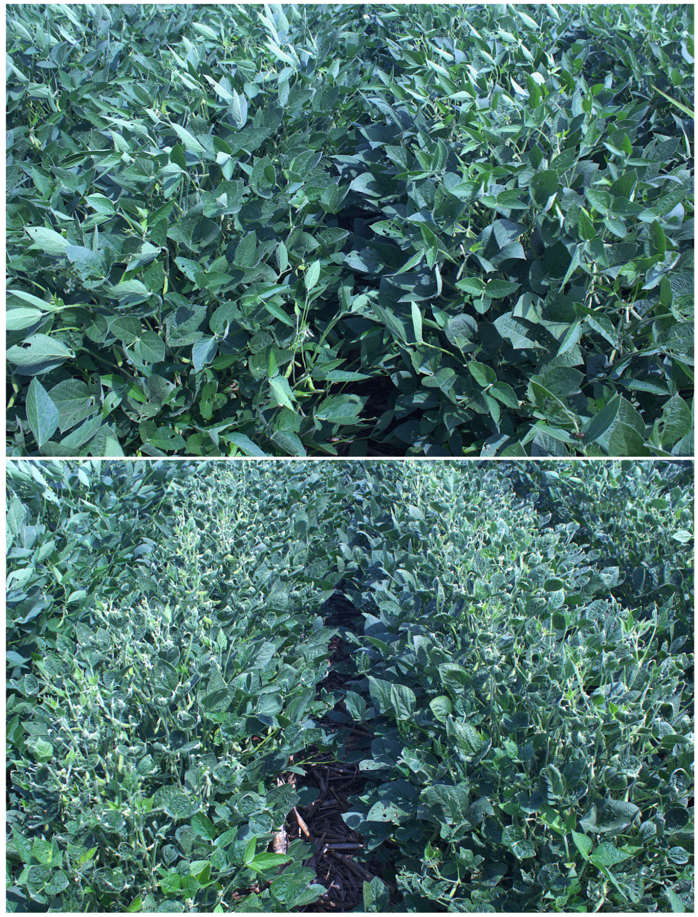

Figure 22. Visual injury threshold at R1 (plot-level view). Untreated soybean (top; 73 bu/ac) contrasted with threshold plants (bottom; 68 bu/ac) corresponding to a ~5% yield loss. Threshold plants show severe cupping of the youngest trifoliates and slight canopy thinning. Photo taken 28 DADE.

Figure 23. Visual injury threshold at R1 (overhead canopy view). Untreated canopy (left; 73 bu/ac) as reference, compared with threshold injury of approximately 35% (right; 68 bu/ac). Photo taken 28 DADE.

Figure 24. Height reduction as a practical threshold indicator (R1). Untreated soybean (left; 40 in, 73 bu/ac) compared with threshold plants (right; 34 in, 68 bu/ac). Photo taken 28 DADE.

Figure 25. Visual injury threshold for dicamba at R2 (plot-level view). Untreated soybeans (top; ~73 bu/ac) compared with plants at the approximate 5% yield-loss threshold (bottom; approx. 69 bu/ac; 30% visual injury). Photo taken 28 DADE.

Figure 26. Visual injury threshold at R2 (overhead canopy view). Untreated canopy (left; 73 bu/ac) as reference, compared with threshold injury of approximately 30% (right; 69 bu/ac). Photo taken 28 DADE.

Figure 27. Height reduction as a practical threshold indicator (R2). Untreated soybean (left; 40 in, 73 bu/ac) compared with threshold plants (right; 37 in, 69 bu/ac). Photo taken 28 DADE.

Dicamba Tissue Residues After Drift Exposure

In a complementary study, soybean plants at the V2 growth stage were exposed to simulated drift rates equivalent to 1/10, 1/100, and 1/200 of the labeled dicamba application rate under glasshouse conditions. Plant tissue was collected at 14- and 28- DADE and analyzed for dicamba residues to determine whether dicamba remains detectable in soybean tissue following low-dose exposure.

Dicamba rate	14 DADE	28 DADE
	ppm	
1/10 of label	0.222	0.123
1/100 of label	0.129	< LOQ*
1/200 of label	0.083	< LOQ*

* LOQ = limit of quantification (0.040 ppm)

Dicamba residues were detectable in soybean tissue 14 DADE at all three doses, with concentrations decreasing as the dose decreased. By 28 DADE, dicamba persisted at quantifiable levels only at the 1/10 rate, while residues at the 1/100 and 1/200 rates were below the analytical limit of quantification (LOQ, 0.040 ppm).

The results indicate that the persistence of dicamba in soybean tissue is strongly influenced by the level of exposure. At lower exposure doses, dicamba residues generally dissipate within approximately four weeks; however, at higher doses, residues may persist for a longer period. Importantly, the presence of quantifiable dicamba residues demonstrates that dicamba can remain in plant tissues even after visible injury symptoms begin to diminish. This finding highlights that symptom expression and chemical dissipation do not occur simultaneously and that the absence of visible symptoms of dicamba does not necessarily indicate the complete absence of dicamba within the plant.

Key references:

Anderson, S.M., Clay, S.A., Wrage, L.J., Matthees, D. (2004). "Soybean Foliage Residues of Dicamba and 2,4-D and Correlation to Application Rates and Yield". *Agron. J.*, 96:750–760

Egan, J.F., Barlow, K.M., Mortensen, D.A. (2014). "A Meta-Analysis on the Effects of 2,4-D and Dicamba Drift on Soybean and Cotton". *Weed Science*, 62:193–206

Foster, M.R. and Griffin, J.L. (2018). "Injury Criteria Associated with Soybean Exposure to Dicamba" *Weed Technology*, 32:608–617

Griffin, J.L., Bauerle, M.J., Stephenson, D.O., Miller, D.K., and Boudreaux, J.M., (2013) "Soybean Response to Dicamba Applied at Vegetative and Reproductive Growth Stages". *Weed Technology*, 27:696–703

Kniss, A.R. (2018). "Soybean Response to Dicamba: A Meta-Analysis". *Weed Technology*, 32:507–512

Osipitan, O.A., Scott, J.E., Knezevic, S.Z. (2019). "Glyphosate-Tolerant Soybean Response to Microrates of Dicamba Based Herbicides". *Agrosystems Geoscience and Environment*, 2:1–8.

Milosevic, L., Osipitan, O.A., Scott, J.E., & Knezevic, S.Z. (2023). "Soybean tolerance to ultra-low doses of dicamba: Hormesis or not?". Crop Protection, 173, 106356.

Robinson, A.P., Simpson, D.M., Johnson, W.G. (2013). "Response of Glyphosate-Tolerant Soybean Yield Components to Dicamba Exposure". *Weed Science*, 61:526–536

Soltani, N., Nurse, R.E., Sikkema, P.H. (2016). "Response of Glyphosate-Resistant Soybean to Dicamba Spray Tank Contamination during Vegetative and Reproductive Growth Stages" *Can. J. Plant Sci.*, 96:160–164

Dicamba FAQs:

https://cropwatch.unl.edu/2018/dicamba-faqs-updated

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