OFFICE OF CHEMICAL SAFETY AND POLLUTION PREVENTION
WASHINGTON, D.C. 20460

July 21, 2025

**MEMORANDUM**

**SUBJECT:** Assessments of the Benefits for Dicamba Use in Genetically Modified, Dicamba Tolerant Cotton and Soybean Production (PC# 029800, 100094, 128931)

**FROM:** John Orlowski, Ph.D., Agronomist
Biological Analysis Branch

Whitney Opgrand, M.S., Economist
Economic Analysis Branch

Amy Perera, M.S., Biologist
Lindsey Hendrick, M.S., Biologist
Science Information and Analysis Branch
Biological and Economic Analysis Division (7503M)

**THRU:** Monisha Kaul, Chief
Biological Analysis Branch

TJ Wyatt, Chief
Economic Analysis Branch

Hope Johnson, Chief
Science Information and Analysis Branch
Biological and Economic Analysis Division (7503M)

**TO:** Sarah Meadows, Senior Regulatory Specialist
Emily Schmid, Product Manager 25
Lindsay Roe, Branch Chief
Herbicide Branch
Registration Division (7505M)

**BEAD Product Review Panel Date:** April 23, 2025

## SUMMARY

This document describes the benefits of registering dicamba products for Over-the-Top (OTT) use on genetically modified dicamba-tolerant (DT) cotton and soybean and identifies the impacts to cotton and soybean growers of ecological mitigations under consideration. The analyses in these documents take into mitigation measures currently being considered for the proposed applications for registration of OTT dicamba products. OTT dicamba products were last registered in 2020 and the registrations were subsequently vacated in 2024. From 2021 to 2023, growers applied OTT dicamba products on 34% of all cotton acres and 26% of all soybean acres. However, certain regions reported higher usage of OTT dicamba, including cotton grown in the Midsouth and Southeastern US (both regions reported greater than 50% crop treated) and soybean grown in the Midsouth and Southern Plains (both regions reported greater than 40% of crop treated). Across both cotton and soybean OTT dicamba products are used to target pigweed species, primarily Palmer amaranth and waterhemp, as well as other problematic broadleaf weeds present in these cropping systems.

The main OTT herbicide alternatives to the proposed OTT dicamba products are currently OTT 2,4-D and glufosinate products. Both the 2,4-D tolerant system and the dicamba tolerant system seed varieties confer resistance to glufosinate in both soybean and cotton. As OTT dicamba products are not currently registered, soybean and cotton growers are likely either using OTT 2,4-D products and glufosinate in the 2,4-D tolerant system or using only glufosinate in the dicamba tolerant system.

Since OTT dicamba products were last registered in 2020, resistance to 2,4-D, glufosinate and dicamba has been reported in target weed species, particularly Palmer amaranth and waterhemp (pigweeds) has continued to develop and spread, affecting the benefits of OTT dicamba products. On acres where pigweeds have developed resistance to dicamba, the benefits of OTT dicamba products are low, but OTT dicamba may provide marginal benefits for control of other broadleaf weed species. On acres where resistance to dicamba, 2,4-D and glufosinate is not present, there are moderate benefits to the use of OTT dicamba products primarily for resistance management as soybean and cotton growers could utilize either a dicamba-tolerant system or a 2,4-D tolerant system. However, the benefits of the dicamba tolerant system in cotton may be higher than in soybean because the dicamba tolerant system comes with other desirable cotton traits not found in the 2,4-D system.

For acres where 2,4-D resistance is present the benefits to soybean and cotton growers are high, because dicamba would be the only WSSA Group 4 herbicide available for OTT weed control. Using OTT dicamba would represent a small cost savings compared to using OTT 2,4-D products and would provide resistance management benefits if used concurrently or sequentially with glufosinate.

In situations where glufosinate resistance is present, soybean and cotton growers are likely currently utilizing a 2,4-D tolerant system for OTT weed control (as OTT dicamba products are

not currently registered or available). Registration of OTT dicamba products would give these growers access to a wider range of crop varieties and traits, especially in cotton, and represent a small cost savings compared to OTT 2,4-D herbicides. However, as both dicamba and 2,4-D are both WSSA Group 4 herbicides, there would be no resistance management benefits from the registration of OTT dicamba products.

EPA is considering spray drift and runoff/erosion mitigations that take into account, as appropriate, EPA's Herbicide Strategy and Vulnerable Species Action Plan. Spray drift mitigations under consideration, including buffers and the inclusion of a drift reducing agent into the spray solution, may increase production costs for soybean and cotton producers or lead to decreased control of target weeds in the buffer area therefore resulting in loss of yield. The magnitude of the impacts will depend on the size of the spray drift buffer and/or the cost to implement other mitigation practices to reduce the buffer size. Runoff/erosion mitigations under consideration are expected to impose low impacts on both soybean and cotton growers as they should be able to achieve sufficient mitigation points with existing field characteristics and agronomic practices.

The volatility mitigations being considered by EPA are multifaceted and would depend on temperature at time of OTT dicamba application with a prohibition of OTT dicamba applications at or above 95° F. The Agency is considering requiring that for all OTT dicamba applications below 95° F, growers must include a volatility reducing agent (VRA) in the application. The addition of VRA may increase grower costs by $2-$4 per acre which translates to a 22% to 44% increase in per acre costs to make an application of OTT dicamba. This increase in cost makes an application of OTT dicamba comparable to an application of OTT 2,4-D but still less expensive than glufosinate.

In addition to using a VRA, for applications between 85° F and 95° F, EPA is considering two mitigation options for cotton and soybean producers. The first is prohibiting the tank mixing of OTT dicamba products with other pesticides, if treating the entire field. The second option is reducing the area of the field treated by 40% if applying with other pesticides in the same tank. Prohibiting tank mixing would likely cause growers to conduct an additional spray pass through the field costing between $2 and $12 per acre. Most cotton and soybean growers would find reducing treated by 40% to be infeasible because they lack the spray equipment to effectively reduce the area treated while still maintaining acceptable levels of weed control. These mitigation options, while providing flexibility for growers to use OTT dicamba products above 85° F, may make growers unwilling or unable to apply OTT dicamba products above 85° F.

## INTRODUCTION

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Section 3(c) mandates that the Environmental Protection Agency (EPA or Agency) evaluate any proposed use of a pesticide to ensure that it will not pose unreasonable adverse effects to human health or the environment. In determining whether effects of pesticide use are unreasonable, FIFRA requires that the Agency consider the risks and benefits of any use of the pesticide.

The Agency is considering an application to register dicamba for application to dicamba tolerant (DT) cotton and soybean prior to planting, before crop emergence, as well as after crop emergence. Other dicamba products are currently registered for use in cotton and soybean as preplant applications with significant preplant restrictions. The dicamba products being considered for registration allow for preplant, preemergence, and postemergence applications to dicamba tolerant cotton and soybean. Postemergence application refers to the herbicide being applied to the emerged DT soybean or cotton to remove existing weeds in the crop, also referred to as "Over-the-Top" or OTT use.

EPA has completed risk assessments and has identified risks of concern to non-target organisms, including listed species, associated with the use of OTT dicamba products in DT cotton and soybean. Risk mitigation measures being considered to address the identified risks include implementation of spray drift and runoff/erosion mitigations to provide protections to non-target and listed species of concern. EPA has also identified risks from volatility associated with the use of OTT dicamba products and is considering mitigations measures that may vary by temperature including requirement to use a volatility reducing agent (VRA) when applying OTT dicamba products, reductions in the area of a field that may be treated, and prohibition of tank mixing when applying OTT dicamba above certain temperatures. This memorandum assesses the benefits of OTT use of dicamba in DT cotton and soybean and discusses the impacts of these mitigation measures to inform the registration decision.

## METHODOLOGY

This document assesses the benefits of the use of OTT dicamba and the impacts of label restrictions under consideration to growers of cotton and soybeans. The benefits of OTT dicamba are based on various agronomic factors, chemical characteristics of dicamba, and alternative control strategies, which influence how a grower chooses to manage pests and to what extent OTT dicamba is important to the user. The unit of analysis is an acre of cotton or soybeans that might be treated with OTT dicamba. BEAD assesses benefits at this unit of analysis both because growers make pest control decisions at the acre- or field-level, and because risks to non-target organisms generally occur in and around treated fields.

BEAD first reviews production data of cotton and soybeans to identify major production regions. BEAD also evaluates past OTT dicamba usage data to identify use patterns, including variations in regional and seasonal usage such as average application rate, frequency of application, and methods of application to predict how OTT dicamba would be used if approved. BEAD reviews pesticide usage and existing scientific publications to identify the important target pests and the attributes of OTT dicamba that make it useful in the pest control system.

BEAD evaluates the potential benefits of the registration of OTT dicamba products by assessing the biological and economic impacts that cotton and soybean growers likely experienced from employing alternative weed control strategies. BEAD identifies current control strategies by reviewing Extension recommendations and data from grower surveys. Benefits to a grower of using OTT dicamba could include monetary savings (e.g., compared to the use of more expensive chemicals) as well as non-monetary improvements (e.g., improved resistance management, simplicity of use, and flexibility). There may also be gains with respect to reduced crop yield loss and/or quality improvements related to better weed control.

A similar approach is followed to assess the impacts of risk reduction measures on the benefits of the use of dicamba. In this document, BEAD considers how restrictions under consideration that include runoff/erosion reduction mitigations, spray drift mitigation requirements, and volatility mitigations would affect the cost and feasibility for growers to use OTT dicamba.

For these analyses, data are sourced from university extension services, United States Department of Agriculture (USDA) (e.g., publicly available crop production, pesticide usage, and cost data as well as information submitted directly to EPA), public and commercially available grower survey data, public comments submitted to the Agency from various stakeholders, National Oceanic and Atmospheric Administration (NOAA) climate data and BEAD's professional knowledge. The most heavily used source of data from grower surveys of pesticide usage are purchased from Kynetec USA Inc, a private research firm, which provides pesticide usage data on approximately 60 crops collected annually through grower surveys using a statistically valid approach.

## BACKGROUND

### Previous EPA Assessments of the Benefits of Registering Postemergence Dicamba

In 2016, BEAD assessed the benefits of dicamba intended for use in DT crops using registrant claims and found that the main benefit of postemergence OTT dicamba was that it provided DT cotton and soybean growers with another active ingredient to manage difficult to control broadleaf weeds during the crop growing season, especially glyphosate-resistant weeds (Yourman and Chism, 2016).

The Agency again assessed the benefits of dicamba intended for use in DT crops production in 2018 (EPA, 2018). The 2018 assessment found that the registration of postemergence dicamba provided growers with an additional active ingredient to manage problematic broadleaf weeds, especially for situations where herbicide-resistant populations of these weeds are known to occur. The 2018 assessment also found that the registration of postemergence dicamba could provide a long-term benefit as a tool to delay the evolution of resistance in weed species to other herbicides when used as part of a season-long weed management program.

In 2019, EPA also assessed the benefits of another dicamba product, a pre-mix of dicamba and S-metolachlor (Tindall, 2019). EPA found the benefits of the use of the product to be the same as for the active ingredient as discussed in the 2018 assessment.

In 2020, EPA again assessed the benefits of OTT dicamba formulations for use in DT cotton and soybean (Orlowski and Kells, 2020a; Orlowski and Kells, 2020b). Similar to the 2018 assessment, the 2020 assessments found that the registration of OTT dicamba products would give growers an additional tool to manage herbicide resistant weeds and give growers greater flexibility in choosing seed varieties. The 2020 assessments also identified increased flexibility for preemergence applications of OTT dicamba formulations in DT crops as compared to non-OTT formulations and found that the use of an OTT dicamba based weed control program may decrease grower costs compared to some alternative herbicide programs in both cotton and soybeans. However, the 2020 benefits assessments for cotton and soybean noted that dicamba-resistant Palmer amaranth had been identified in two states and concluded that the spread of weed biotypes resistant to dicamba could lower the benefits of OTT dicamba in cotton and soybean.

**Registrant Submission of Information Regarding the Benefits of Registering Dicamba for Postemergence OTT Use on DT Cotton and Soybean**

In 2024, Bayer submitted a document to EPA in support of the registration of postemergence OTT dicamba on DT cotton and soybean (Toscano, 2024). This document states that OTT dicamba, when used on DT cotton and soybean varieties that also contain resistance traits to glyphosate and glufosinate, provides an additional mode of action for postemergence weed control, allowing growers to diversify their herbicide management programs. Bayer also suggests that in the absence of postemergence dicamba, growers who face herbicide-resistant weeds may be forced to use more expensive and less effective alternatives, which may decrease grower revenues and result in yield loss. The document also states that some weed control alternatives, such as tillage, may have a negative impact on the environment because tillage can contribute to soil erosion and runoff. The document suggests that postemergence dicamba, when used as part of a soil residual and postemergence weed management program, can help mitigate the potential for the development of weed resistance to other herbicides. Bayer suggests that the absence of postemergence dicamba may result in overuse of remaining postemergence herbicide modes of action and thus may increase selection pressure in problematic weed species for resistance to these herbicides.

In 2025, Syngenta also submitted a document to the EPA in support of the registration of Syngenta's OTT dicamba product, which is a premix of dicamba and S-metolachlor (Palmer, 2025). The document states that the premix of dicamba and S-metolachlor provides convenience for growers wishing to use a combination of dicamba and S-metolachlor on DT cotton and soybean by providing both herbicides in the same packaging, thus reducing the amount of pesticide containers needing to be stored, transported, mixed, loaded, cleaned, and disposed.

BASF did not provide an updated benefits submission, stating that the 2020 benefits assessment remains accurate and relevant for the current submission (Birk, 2025).

**WEED MANAGEMENT IN COTTON AND SOYBEAN**

Weeds compete with crops like cotton and soybean for limited resources such as space, nutrients, moisture, and may serve as reservoirs or hosts for insect pests and/or pathogens. To effectively manage weeds in fields producing cotton and soybean, growers rely on several management tactics that can include tillage, cultivation, and herbicides (Datta et al., 2017). Hand weeding is usually not economically feasible for soybean and cotton and cultivation is rarely practiced due to crop row spacing, the relatively slow speed of cultivation operations compared to herbicide application, and soil erosion concerns (Gianessi, 2013). Herbicides allow growers to avoid many of these non-chemical management costs and allow for the utilization of conservation tillage. While herbicides are the primary means of weed control in cotton and soybean, growers must consider multiple factors (e.g., timing, weed targets, and resistance management) when making herbicide selections.

The goal of an herbicide program in soybean and cotton is to plant into weed-free conditions and maintain a weed-free period until the crop reaches canopy closure (Everman, 2022). Weeds can be removed prior to planting using conventional tillage practices or with non-selective herbicides as part of a burndown herbicide program. Depending on the weed species present and the weed pressure in the field, preemergence residual herbicides are used to control or suppress weeds during early-season growth. Eventually, the residual activity of preemergence herbicides begins to decline and weeds emerge from the soil, requiring a postemergence application foliar application of a contact or systemic herbicide. One or more foliar-applied herbicide application is likely necessary to remove emerged weeds.

Before the development of herbicide-tolerant soybean, common postemergence weed control herbicides in soybean included bentazon (WSSA Group 6), multiple ALS inhibitor herbicides (WSSA Group 2) including chlorimuron and imazethapyr, and acifluorfen (WSSA Group 14) (Rowe, 2018) while in cotton herbicides included ALS inhibitor herbicides (WSSA Group 2) and postemergence-directed sprays utilizing herbicides such as fluometuron (WSSA Group 7). However, after the introduction of glyphosate-resistant soybean seed in 1995 and cotton seed in 1997, glyphosate rapidly became the most widely used postemergence herbicide used in soybean (Fernandez-Cornejo, 2014; Rowe, 2018).

Glyphosate’s broad-spectrum control and ease of use resulted in glyphosate-tolerant soybean producers using repeated applications to control weeds. Repeated applications of a single herbicide to the same weed species, such as Palmer amaranth, selected for individuals within the population with resistance to glyphosate. These resistant biotypes rapidly became the dominant biotype in a field, rendering glyphosate ineffective as an herbicidal control measure for these species. As control with glyphosate failed, other classes of herbicide were used for postemergence control of glyphosate-resistant weeds. Eventually problematic weeds, such as Palmer amaranth, developed resistance to these herbicides as well, resulting in weed populations with resistance to multiple herbicide modes of action and necessitating the development of novel herbicides. However, until very recently, no new herbicide modes of action have been developed for use in soybean or cotton. In lieu of new modes of action, companies have focused on developing novel herbicide-tolerant cotton and soybean varieties that are tolerant to existing herbicides, like dicamba, that traditionally could not be applied postemergence to soybean or cotton (Heap and Duke, 2017).

## CHEMICAL CHARACTERISTICS

Dicamba is an herbicide in the benzoic acid chemical family. The Weed Science Society of America (WSSA) has classified dicamba as a Group 4 synthetic auxin type herbicide. Dicamba is used as a foliar application to control broadleaf weeds, where it mimics the function of endogenous auxin. Dicamba induces cell wall elongation and increases in RNA, DNA, and protein biosynthesis leading to uncontrolled cell division that eventually results in plant death. Dicamba also induces ethylene production in the plant, which is thought to cause the leaf cupping and epinastic bending symptoms seen in susceptible plants exposed to dicamba. Dicamba is a systemic herbicide, and uptake occurs primarily through foliage. Due to its systemic activity, dicamba is most effective when applied to actively growing weeds and control is best when applied to small weeds. Dicamba was first registered in the U.S. in 1967 and has been used extensively in both crop and non-crop areas ever since (Shaner, 2014).

## CROP PRODUCTION INFORMATION

### Crop Production in Cotton

Average acres harvested, production, and value of cotton are shown in Table 1 by production regions based on those defined by the National Cotton Council (NCC, 2025). Nationally, between 2021-2023, about 8 million acres of cotton were harvested per year, on average, producing 14.7 million 480-pound bales of cotton lint and 4.5 million tons of cottonseed, valued at around a combined $7.4 billion annually (USDA NASS, 2025). USDA’s Economic Research Service (ERS) (2025a) describes cotton as one of the most important textile fibers in the world, accounting for around 25% of total world fiber use. The U.S. is the world’s third-largest cotton producer and the leading cotton exporter, accounting for one-third of global trade in raw cotton (USDA ERS, 2025a). The U.S. cotton industry accounts for more than $21 billion in products and services annually.

Most cotton production occurs in the Plains (or Southwest) region, especially in Texas (USDA NASS, 2025). National cotton yields for 2021-2023 averaged just under two 480-pound bales per acre of cotton lint (Table 1). Average gross returns are around $930 per acre nationally and vary between almost $700 per acre in the Plains to $2,273 per acre in the Far West region (Table 1), primarily due to regional differences in cotton varieties and yield.

**Table 1. Production and Value of United States Cotton, 2021 – 2023 Annual Averages**

| Region | Harvested Cotton Acreage (1,000) | Production (1,000 Bales of Lint) [5] | Cotton lint Yield (bales/acre) | Total Value ($1,000) [6,7] | Gross Revenue ($/acre) |
|---|---|---|---|---|---|
| Plains (or Southwest) [1] | 3,627 | 5,091 | 1.4 | $2,533,000 | $698 |
| Southeast [2] | 2,378 | 4,695 | 2.0 | $2,327,000 | $979 |
| Midsouth [3] | 1,733 | 4,167 | 2.4 | $1,954,000 | $1,128 |
| Far West [4] | 260 | 733 | 2.8 | $591,000 | $2,273 |
| **United States** | **7,997** | **14,686** | **1.8** | **$7,404,000** | **$926** |

Source: USDA NASS, 2025

[1] Plains (or Southwest): Kansas, Oklahoma, and Texas

[2] Southeast: Alabama, Florida, Georgia, North Carolina, South Carolina, and Virginia

[3] Midsouth: Arkansas, Louisiana, Mississippi, Missouri, and Tennessee

[4] Far West: Arizona, California and New Mexico

[5] One bale weighs about 480 pounds.

[6] Total value includes value of cotton lint and cottonseed

[7] The value of Pima production is not available at the state level. Production is generally attributed to the Far West although some Pima production occurs in Texas. As a result, the value of lint production and gross revenue per acre is slightly underestimated for the Plains and overestimated for the Far West.

### Crop Production in Soybean

Regarding U.S. soybean production, 84.9 million acres of soybean are harvested on average annually, valued at around $57.6 billion (Table 2). The United States is the world's leading soybean producer and second leading exporter, and soybeans comprise about 90% of the United States' oilseed production (USDA ERS, 2025b). Between 2019 and 2022, soybean production, processing, and use, including biodiesel and livestock feed, generated about $124 billion in economic activity, supporting the equivalent of 223,000 full-time jobs (LMC International Ltd., 2023).

As shown below in Table 2, around 45% of production comes from the midwestern states of the Corn Belt (USDA NASS, 2025). The Midsouth, Northern Plains and Northern Crescent all rank similarly in terms of overall output, each contributing approximately 15% of the national bushel output annually. National soybean yields for 2021-2023 averaged about 51 bushels per acre. Average gross returns averaged $678 per acre nationally and varied between $404 per acre in the Southern Plains to $812 per acre in the Corn Belt, primarily due to differences in yield (Table 2).

**Table 2. Production and Value of United States Soybean, 2021-2023 Annual Averages**

| Region | Harvested Acreage (1,000) | Production (1,000 bu) | Yield (bu/acre) | Production ($1,000) | Gross Revenue ($/acre) |
|---|---|---|---|---|---|
| Corn Belt [1] | 32,913 | 1,982,000 | 60 | $26,713,000 | $812 |
| Northern Plains [2] | 16,960 | 708,000 | 42 | $9,251,000 | $545 |
| Midsouth [3] | 13,613 | 680,000 | 50 | $9,120,000 | $670 |
| Northern Crescent [4] | 12,658 | 621,000 | 49 | $8,310,000 | $656 |
| Southern Plains [5] | 5,048 | 155,000 | 31 | $2,040,000 | $404 |
| Southern Seaboard [6] | 3,747 | 155,000 | 41 | $2,117,000 | $565 |
| **United States [7]** | **84,941** | **4,300,000** | **51** | **$57,550,000** | **$678** |

Source: USDA NASS, 2025. Regional groupings based on Economic Research Service (ERS) production regions (USDA ERS, 2000).
[1] Corn Belt: Illinois, Indiana, Iowa, Kentucky, Ohio, West Virginia.
[2] Northern Plains: Nebraska, North Dakota, South Dakota.
[3] Midsouth: Arkansas, Louisiana, Mississippi, Missouri, Tennessee.
[4] Northern Crescent: Michigan, Minnesota, New Jersey, New York, Pennsylvania, Wisconsin.
[5] Southern Plains: Kansas, Oklahoma, Texas.
[6] Southern Seaboard: Alabama, Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia.
[7] Numbers may not sum due to rounding.

## DICAMBA USAGE IN COTTON AND SOYBEAN

### Dicamba Usage in Cotton

Table 3 presents usage of OTT dicamba in cotton for the period 2021-2023 at the national level and within the following regions: Midsouth, Plains, Southeast, Far West. This time period represents the most recent usage data since the OTT dicamba products were last registered in 2020 (the first use season for the 2020 registration was 2021) and represents likely future use patterns, subject to differences in risk mitigation measures under consideration.

Nationally, cotton growers reported applying approximately 2.8 million pounds acid equivalent dicamba (lbs AE)[1] in OTT dicamba products to 6 million total acres treated (TAT) annually from 2021 to 2023 (Table 3). Among the surveyed U.S. regions, the Plains had the highest TAT reported with 2.6 million annual TAT out of the US total of 6 million (Table 3). In addition, the Plains also had the highest lbs AI reported of 1.2 million at nearly half of the US total reported

[1] Usage of herbicides is generally reported in pounds of active ingredient (AI). Certain herbicides, like dicamba, are formulated as salts. The herbicidally active part of a dicamba salt is the dicamba acid, so usage is reported in pounds of acid equivalent (AE) instead of active ingredient (AI).

value (Table 3). Throughout the regions, OTT dicamba was reported to have been applied postemergence at least once with the US total of 1.5 average applications (Table 3).

Nationally for cotton, the average annual percent crop treated (PCT) total OTT dicamba products was 34% from 2021-2023; ranging from <5% PCT in the Far West to upwards of 54% PCT in the Midsouth. Among the surveyed regions, the postemergence PCT was higher than the preemergence PCT for every region. Among the postemergence applications of OTT dicamba to cotton, the percent of OTT dicamba treated acres ranged from <5% in the Far West to 53% in the Southeast. Preemergence PCT values remained below 10% for all regions and the US total.

**Table 3. Average Annual OTT Dicamba Usage in Cotton, 2021-2023**

| Region[1] | Total Acres Treated (1,000's)[2] | Pounds AE Dicamba (1,000's) | Percent Crop Treated Total[3] | Percent Crop Treated Preemergence[3] | Percent Crop Treated Postemergence[3] | Number of Applications Postemergence |
|---|---|---|---|---|---|---|
| Plains | 2,600 | 1,200 | 24% | 5% | 21% | 1.5 |
| Southeast | 2,000 | 100 | 53% | <5% | 53% | 1.6 |
| Midsouth | 1,300 | 650 | 54% | 9% | 50% | 1.4 |
| Far West | 12 | 6 | <5% | <5% | <5% | 1.5 |
| **US Total** | **6,000** | **2,800** | **34%** | **6%** | **32%** | **1.5** |

Source: Kynetec, 2024a and 2024b. Calculations subject to rounding.
[1] See Table 1 for states in each region.
[2] Total acres treated accounts for acres treated one or more times.
[3] Preemergence and Postemergence PCTs may not sum to PCT Total estimate due to some acres being treated at both timings.

### Dicamba Usage in Soybean

Table 4 presents usage of OTT dicamba in soybeans for the period 2021-2023 at the national level and within the following regions: Corn Belt, Midsouth, Northern Crescent, Northern Plains, Southern Plains, and the Southern Seaboard. This time period represents the most recent usage data since the OTT dicamba products were last registered in 2020 (the first use season for the 2020 registration was 2021) and represents likely future use patterns, subject to potential differences in risk mitigation measures.

Nationally, soybean growers reported annually applying approximately 13 million pounds of acid equivalent dicamba (lbs AE)[2] in OTT dicamba products to 28 million total acres treated (TAT) from 2021 to 2023 (Table 4). Among the surveyed US regions, the Midsouth and Northern Plains had the highest TAT of 8 million acres each (Table 4). The US total for highest annual average of lbs AE applied was 13 million from 2021-2023. In the regions, the Midsouth has the highest lbs AE of 3.9 million with the Northern Plains following at 3.8 million (Table 4). The

[2] Usage of herbicides is generally reported in pounds of active ingredient (AI). Certain herbicides, like dicamba, are formulated as salts. The herbicidally active part of a dicamba salt is the dicamba acid, so usage is reported in pounds of acid equivalent (AE) instead of active ingredient (AI).

Southern Seaboard had the lowest TAT and lbs AI, at 1.3 million and 630,000 respectively. Throughout the regions, OTT dicamba was reported to have been applied postemergence at least once with the US total of 1.5 average applications (Table 4).

Nationally, the average annual percent crop treated (PCT) total with OTT dicamba products in soybean was 26% from 2021-2023 (Table 4); ranging from 14% PCT in the Northern Crescent to 44% in the Midsouth. Among the surveyed regions, the postemergence PCT per region was higher than the preemergence PCT when cross compared across each region (Table 4). Among the postemergence applications of OTT dicamba to soybeans, the percent of OTT dicamba treated acres ranged from 13% in the Northern Crescent to 42% in the Midsouth. Preemergence PCT values remained at or below 10% for all regions and the US total.

**Table 4. Average Annual OTT Dicamba Usage in Soybeans, 2021-2023**

| Region[1] | Total Acres Treated (1,000's)[2] | Pounds AE Dicamba (1,000's) | Percent Crop Treated Total[3] | Percent Crop Treated Preemergence[3] | Percent Crop Treated Postemergence[3] | Number of Applications Postemergence |
|---|---|---|---|---|---|---|
| Corn Belt | 6,000 | 3,000 | 22% | 6% | 18% | 1.2 |
| Northern Plains | 8,000 | 3,800 | 36% | 10% | 32% | 1.3 |
| Midsouth | 8,000 | 3,900 | 44% | 9% | 42% | 1.3 |
| Northern Crescent | 2,000 | 950 | 14% | <5% | 13% | 1.2 |
| Southern Plains | 2,700 | 1,200 | 41% | 6% | 40% | 1.2 |
| Southern Seaboard | 1,300 | 630 | 28% | <5% | 26% | 1.2 |
| **US Total** | **28,000** | **13,000** | **26%** | **6%** | **24%** | 1.2 |

Source: Kynetec, 2024a and 2024b. Calculations subject to rounding.

[1] See Table 1 for states in each region.

[2] Total acres treated accounts for acres treated one or more times.

[3] Preemergence and Postemergence PCTs may not sum to PCT Total estimate due to some acres being treated at both timings.

## BENEFITS OF PREEMERGENCE DICAMBA IN DICAMBA TOLERANT SOYBEAN AND COTTON

Dicamba is currently registered for use in both soybean and cotton as a preplant, burndown herbicide with a preplant restriction of 14 to 30 days depending on the crop and rate. OTT dicamba products can be used on DT cotton and soybean as a preplant and preemergence treatment without the preplant restriction. EPA previously found this to be beneficial to growers since it increased flexibility in early season weed management (Orlowski and Kells, 2020a; Orlowski and Kells 2020b). This remains the case for the proposed OTT dicamba products.

**BENEFITS OF POSTEMERGENCE DICAMBA IN DICAMBA TOLERANT SOYBEAN AND COTTON**

Using market research data (Kynetec, 2024a), BEAD examined regional OTT dicamba usage for information on target weeds in both cotton and soybean. In cotton, pigweeds including Palmer amaranth and redroot pigweed, were by far the primary targets for OTT dicamba herbicides (Table 5). For soybean, pigweed species (waterhemp, Palmer amaranth, redroot pigweed) were the most commonly targeted weed species across regions (Table 6). Other major targets for OTT dicamba in soybean included kochia in the Northern Plains and marestail in the Southern Seaboard. Pigweed species frequently look very similar, especially when small, and have the ability to hybridize between species (Steckel, 2005). Therefore, BEAD concludes that pigweeds in general are the primary target for OTT dicamba products in both cotton and soybean. These findings are similar to those discussed in the 2020 assessment (Orlowski and Kells, 2020a; Orlowski and Kells, 2020b).

**Table 5. Weeds Targeted with Postemergence OTT Dicamba in Cotton, Percent of Postemergence OTT Dicamba-Treated Acres, 2021-2023[1]**

| Weed | Plains | Southeast | Mid-South | Far West |
|---|---|---|---|---|
| Pigweed species | 85% | 93% | 92% | 49% |
| *Redroot Pigweed* | 65% | 35% | 73% | 9% |
| *Palmer Amaranth* | 11% | 60% | 23% | 40% |

Source: Kynetec, 2024a

[1] Acres can be treated more than once or treated for multiple weeds therefore numbers may not sum to 100%.

**Table 6. Weeds Targeted with Postemergence OTT Dicamba in Soybean, Percent of Postemergence OTT Dicamba-Treated Acres, 2021-2023[1]**

| Weed | Corn Belt | Mid-South | Northern Plains | Northeast | Southern Plains | Southern Seaboard |
|---|---|---|---|---|---|---|
| Pigweed species | 84% | 91% | 64% | 76% | 90% | 71% |
| *Waterhemp*[2] | 78% | 7% | 48% | 69% | 26% | ≤5% |
| *Palmer Amaranth* | 7% | 27% | 19% | ≤5% | 18% | 30% |
| *Redroot Pigweed* | 8% | 62% | 14% | 24% | 54% | 44% |
| Kochia | ≤5% | ≤5% | 54% | 7% | 18% | ≤5% |
| Ragweed[3] | 28% | ≤5% | ≤5% | 44% | 8% | 10% |
| Marestail | 14% | 5% | 14% | 12% | 9% | 20% |

Source: Kynetec, 2024a

[1] Acres can be treated more than once or treated for multiple weeds therefore numbers may not sum to 100%.

[2] Includes common and tall waterhemp.

[3] Includes ragweed and giant ragweed.

**Available Postemergence Over-the-top Weed Control Options in 2025**

BEAD identified three postemergence OTT herbicide programs for soybean and three for cotton (Table 7).

**Table 7. OTT herbicide programs and associated OTT broadleaf herbicides for OTT dicamba products in cotton and soybean.[1]**

| Soybean | | Cotton | |
|---|---|---|---|
| *OTT Program* | *Effective OTT Herbicide* | *OTT Program* | *Effective OTT Herbicide* |
| Glufosinate tolerant | glufosinate | Glufosinate tolerant | glufosinate |
| 2,4-D tolerant | 2,4-D, glufosinate | 2,4-D tolerant | 2,4-D, glufosinate |
| Dicamba tolerant | dicamba[2], glufosinate | Dicamba tolerant | dicamba[2], glufosinate |

[1] Glyphosate tolerance is part of most trait packages offered on the market and glyphosate can also be used to target susceptible weeds after crop emergence. However, due to widespread glyphosate resistance it is largely ineffective for postemergence control of the problematic broadleaf weeds targeted by dicamba identified in this document.

[2] Not currently registered for OTT use.

The three postemergence weed control programs are based on essentially three herbicides, glufosinate, 2,4-D, and, potentially, dicamba, representing only two modes of action. Glufosinate is a glutamine synthetase inhibitor herbicide (WSSA Group 9), while 2,4-D and dicamba are synthetic auxin (WSSA Group 4) herbicides. Cotton and soybean varieties with tolerance to only to glufosinate (e.g., LibertyLink®) or glufosinate and glyphosate are available in the market and are used similarly to the proposed use of the DT system in cotton and soybean. However, both the 2,4-D tolerant system (i.e., Enlist) and the dicamba tolerant system (i.e., Xtend) include traits the confer resistance to glufosinate as well. Thus, although OTT dicamba products are not currently registered for use in DT cotton and soybean, cotton and soybean growers may still plant these varieties while relying on glufosinate for OTT control of problematic weeds like pigweeds.

**Table 8. Annual Average Acres Planted per Crop by Seed Trait, 2021-2023**

| | Cotton | | | Soybeans | | |
|---|---|---|---|---|---|---|
| Variety | Other HT traits included[1,2] | Acres Grown by Trait (1,000's) | Portion of Acres Grown by Trait | Other HT traits included[1,2] | Acres Grown by Trait (1,000's) | Portion of Acres Grown by Trait |
| Dicamba Tolerant[4] | Gly, LL | 7,450 | 64% | Gly, LL, other | 41,810 | 48% |
| 2,4-D Tolerant | Gly, LL | 2,000 | 17% | Gly, LL, other | 35,710 | 41% |
| Glufosinate Tolerant | Gly | 750 | 6% | Gly, other | 2,780 | 3% |
| Glyphosate Tolerant | -- | 400 | 3% | Other | 2,960 | 3% |
| Conventional | -- | 60 | 1% | -- | 1,530 | 3% |
| Other Herbicide Tolerant | -- | -- | -- | Other | 160 | <1% |
| Unknown[3] | -- | 930 | 8% | -- | -- | -- |

Source: Kynetec, 2024a and 2024b
"--" signifies not applicable
[1] "Gly" signifies glyphosate, "LL" signifies Liberty Link (contains glufosinate). "Other" for soybean represents where sulfonylurea tolerance and/or isoxaflutole tolerance may also be offered as part of the overall seed trait.
[2] All varieties of DT cotton are glyphosate and glufosinate tolerant. For all other systems, varieties confer some combination of the traits listed. For example, the DT system for soybean is offered in many combinations – one with glyphosate tolerance, one with glyphosate, glufosinate and sulfonylurea tolerances, as well as other combinations of the three tolerant herbicides listed.
[3] Trait/variety information not reported for about 8% of cotton crop acres grown; most of these acres are located in west Texas.
[4] Dicamba Tolerant Seed is currently available for cotton and soybean regardless of the registration status of OTT dicamba herbicides.

The cotton seed market was largely dominated by the dicamba-tolerant system in the 2020-2023 period with 64% of cotton acres being planted annually with dicamba-tolerant seed compared to 17% for the 2,4-D-tolerant Enlist system (Table 8). EPA expects that this is currently still the case, as significantly more DT cotton varieties incorporate other desirable traits, such as insecticidal traits, compared to available 2,4-D tolerant varieties (discussed in the next section). In contrast the soybean seed market was largely evenly split between the 2,4-D tolerant system with 41% of the market and the dicamba tolerant system with 48% of the market (Table 8). Other sources also suggest that the soybean market is evenly split between the 2,4-D tolerant system and the dicamba-tolerant system (Wiesemeyer, 2023) and EPA expects is still the case today.

**Interaction of Herbicide Resistance Traits and Other Seed Traits**

While EPA traditionally focuses on the benefits and alternatives to a particular herbicide, with respect to OTT dicamba products, the reality for cotton and soybean growers is that the herbicide tolerance traits associated with OTT weed control herbicides (dicamba, 2,4-D, and glufosinate) are incorporated into cotton and soybean varieties alongside other traits, both genetically engineered and conventionally bred, that provide crop production value to producers. In soybean, herbicide-tolerance traits are the only incorporated traits (there are no plant incorporated insect traits available in soybean in the US) and likely explain the relatively even split, in terms of acres planted, between the two primary weed control alternative systems in soybean (2,4-D tolerant vs. dicamba tolerant) (Table 8). In cotton however, there are plant incorporated insecticide traits that are highly important for control of lepidopteran pests, like bollworm, and more recently thrips and plant bugs (University of Tennessee, undated).

Of the major cotton seed brands available to cotton producers, only PhytoGen® offers the 2,4-D and glufosinate tolerance traits associated with the Enlist system (Lege and McKnight, 2024). In contrast, other major brands including FiberMax®, Stoneville®, NexGen®, DynaGro®, and Deltapine® offer the dicamba and glufosinate tolerance associated with the Xtend® weed control system. Across these DT brands, there is a wide offering of plant incorporated insecticide traits, including the recently commercialized Cry51Aa2 (ThryvOn®, Bayer Crop Science) that confers tolerance to thrips and plant bugs. The wider availability of DT cotton varieties with important plant incorporated insecticide traits likely explains why DT varieties are more commonly used across cotton acres grown (64%) when compared to soybean acres grown (48%) (Table 8). In other words, growers may select a cotton variety based on the availability of a trait that protect against economically important insect pests; this insect tolerant trait can therefore dictate the herbicide program that growers chose to utilize rather than anticipated weed control needs.

**Resistance to Dicamba and 2,4-D**

As discussed previously, postemergence control of problematic broadleaf weeds, like pigweeds, currently relies on either dicamba, 2,4-D, and glufosinate. In the 2020 benefits assessment for OTT dicamba in cotton and soybean, EPA noted that there were multiple populations of Palmer amaranth that were confirmed resistant to dicamba and concluded that dicamba resistance in Palmer amaranth would reduce the usefulness and benefits of OTT dicamba in cotton and soybean (Orlowski and Kells, 2020a; Orlowski and Kells 2020b).

Since OTT dicamba products were last registered in 2020, resistance to synthetic auxin (WSSA Group 4) herbicides such as 2,4-D and dicamba has continued to spread in the US. Populations of dicamba-resistant Palmer amaranth have been confirmed in Tennessee, Arkansas, Kansas, North Dakota, and Texas (Ikley, 2023; Petersen et al., 2019; Steckel, 2020a; Barber et al., 2025; Singletary et al., 2025). Another pigweed species, waterhemp, has been confirmed as resistant to dicamba in Tennessee, Illinois, Iowa, North Dakota, and Minnesota (Steckel, 2023; Quinn, 2021; Hamberg et al., 2024; Crossingham, 2023; Singh et al., 2023) and populations of waterhemp resistant to 2,4-D have been identified in multiple states, most recently Iowa (Anderson and Owen, 2024). Since the 2020 benefits assessment for OTT dicamba, resistance in problematic broadleaf weed species, especially pigweeds, has continued to spread with direct implications for the benefits of OTT dicamba products in cotton and soybean.

**Cross Resistance Between 2,4-D and dicamba**

As 2,4-D and dicamba share the same herbicidal mode of action (WSSA Group 4), there is the potential for cross resistance between the two herbicides, meaning that the development of resistance to dicamba in a weed population may also confer resistance to 2,4-D and vice versa. In the first reported cases of decreased Palmer amaranth susceptibility to dicamba in Tennessee, state agricultural Extension agencies indicated that these Palmer amaranth populations were also resistant to 2,4-D, due to cross resistance (Steckel, 2020a). However, the waterhemp population in Tennessee confirmed as resistant to dicamba was found to still be susceptible to 2,4-D (Steckel, 2023). In a limited review of published literature, Hartzler (2021) found that 2,4-D and dicamba exhibited cross resistance about 50% of the time. The differential response in cross resistance is likely due to different mechanisms that individual pigweed populations develop to resist applications of 2,4-D and/or dicamba. These mechanisms include target site resistance, metabolic resistance, and altered translocation. In the 2022 benefits assessment for OTT 2,4-D products, EPA identified cross resistance between 2,4-D and dicamba as a serious threat to the potential benefits of both OTT 2,4-D and dicamba products in cotton and soybean, and with the continued spread of resistance to both dicamba and 2,4-D, this continues to be the case.

**Resistance to Glufosinate**

As described previously, the only currently registered OTT options for postemergence control of problematic broadleaf weeds are 2,4-D and glufosinate. Both the DT system and 2,4-D tolerant cotton and soybean systems also confer tolerance to OTT applications of glufosinate. Glufosinate provides an additional mode of action that can either be used sequentially with OTT dicamba in the Xtend system or in conjunction with 2,4-D in the Enlist system either to improve control of target weeds like Palmer amaranth or for resistance management. However, reliance on glufosinate for OTT control of broadleaf weeds, like pigweeds, has also led to the development of resistance to glufosinate in Palmer amaranth with resistant populations identified in Arkansas, Missouri, and North Carolina (Barber et al., 2021; Geist, 2022; Jones et al., 2024). The 2022 benefits assessment for 2,4-D tolerant cotton and soybean (Enlist One and Enlist Duo) identified emerging resistance to glufosinate as a threat to the benefits of both the 2,4-D tolerant and dicamba tolerant cotton and soybean weed control systems (Orlowski and Kells, 2022). The subsequent confirmation and spread of glufosinate resistant Palmer amaranth influence the benefits of OTT dicamba.

**Herbicide Resistance and Suitability of Alternative Herbicides**

The extent of resistance to various postemergence OTT herbicide modes of action in cotton and soybean differs across the US and is tied to how long and how extensively a mode of action has been relied on for control of a particular weed species. Problematic broadleaf weeds like Palmer amaranth and waterhemp, as well as kochia and marestail, are largely considered to be resistant to ALS inhibitor herbicides (WSSA Group 2) and glyphosate (WSSA Group 9) in major cotton and soybean producing areas of the US, as these modes of action have been relied on for decades for postemergence OTT weed control. In soybean, as glyphosate began to lose effectiveness, PPO inhibitor herbicides (WSSA Group 14) began to be relied on for postemergence OTT weed control of problematic broadleaf weeds, like pigweeds. Eventually, resistance to PPO inhibitor herbicides emerged and has been spreading throughout the US, although in certain areas, PPO inhibitor herbicides remain effective.

The confirmed and suspected resistance to dicamba as well as 2,4-D and glufosinate is even more recent than resistance to PPO inhibitor herbicides, and, while spreading rapidly, is still a relatively recent development. This means that making generalizations about the suitability of dicamba and the alternative herbicide of 2,4-D and glufosinate across US cotton and soybean growing areas challenging. In the near term, the benefit of dicamba to cotton and soybean producers for OTT weed control will vary at the farm level or even at the field level and will depend on the specific resistance characteristics of the weed population at that particular site.

**The Role of OTT Dicamba in Herbicide Resistance Management**

As discussed previously, there are only three main herbicides for OTT control of multiple-herbicide resistant pigweeds in soybean and cotton: dicamba, 2,4-D, and glufosinate. In the 2020 benefits assessment for OTT dicamba in cotton and soybean, EPA concluded that OTT dicamba gives growers an additional tool to delay the further development of herbicide resistance in problematic broadleaf weed species like Palmer amaranth and waterhemp (Orlowski and Kells, 2020a; Orlowski and Kells, 2020b). In cotton and soybean varieties that contain resistance traits to both dicamba and glufosinate, the registration of OTT dicamba products would allow growers to use multiple OTT modes of action on problematic broadleaf weeds, which facilitates herbicide resistance management. However, resistance to both dicamba and glufosinate in certain pigweed populations limits the herbicide resistance management benefits of OTT dicamba products where this resistance occurs. In situations where cross resistance is present, the resistance management benefit of OTT dicamba products would be low. Similar to the weed control benefits provided by OTT dicamba products, the resistance management benefits will largely depend on the location of the field and the associated resistance characteristics of the weed population being controlled in both soybean and cotton.

**Quantitative Benefits of Using Postemergence Dicamba in Cotton and Soybean**

To determine how growers would respond to the registration of dicamba for OTT use, EPA compares grower net operating using currently available OTT programs to the Dicamba-Tolerant Program. BEAD utilizes gross revenue information from NASS, budget information available from USDA ERS and state agricultural Extension agencies, and chemical-specific costs from Kynetec.

Because cotton and soybean operating cost structures can vary based on many factors including location (e.g., climate, soil type, water availability) and production practice (e.g., dryland versus irrigated, row spacing, tillage choice), EPA examined several budgets to capture a range of potential outcomes based on location and production practices. These included national and regional budgets available from USDA ERS (2024a and 2024b) and state agricultural Extension agencies. EPA selected regions and states where significant cotton or soybean production occurs, and where growers report higher reliance on postemergence use of dicamba for weed control (Table 3, Table 4). While gross revenues and costs of production do differ somewhat by region, they are not substantially different across regions while taken together. For example, irrigated cotton commands higher yields and higher gross revenues than dryland cotton but production costs are also higher in irrigated cotton than in dryland cotton.

Table 10 shows the cost of the relevant postemergence alternative herbicides according to market research data (Kynetec, 2024a). Prices are national averages. From 2021-2023, OTT dicamba products were cheaper than alternative OTT active ingredients. Glufosinate cost 60% to 75% more than dicamba on a per acre basis and 2,4-D cost about 25% more than dicamba on a per acre basis. While future costs may vary, EPA expects that relative prices will likely be similar.

**Table 9: Average Per-Acre Per-Application Cost ($/A) of Dicamba and Alternative Postemergence Herbicides, 2021-2023**

| Chemical | Cost ($/A) in Cotton | Cost ($/A) in Soybean |
|---|---|---|
| Dicamba | $9 | $9 |
| 2,4-D | $11 | $12 |
| Glufosinate | $15 | $16 |

Source: Herbicide price data from Kynetec (2024). Prices based on postemergence use and average use rates.

In examining recent commodity price information, EPA found that cotton and soybean prices were higher over the period between 2021 to 2023 when compared to both 2024 prices and when compared to annual averages of several years prior (2016 to 2020). These gross revenues are provided for cotton in Table 11 and soybeans in Table 12. Recent trends in commodity prices indicate that 2024 may be more indicative of what prices a grower would expect to receive in 2025 than the prices received from 2021 to 2023. Therefore, BEAD estimated potential budget outcomes of the OTT dicamba system compared to other OTT systems utilizing an average of 2020 to 2024 gross revenues.

**Table 10. Cotton Gross Revenue (lint + cottonseed) in $/Acre comparing 2021 to 2023 period to other recent years**

| Period | Far West | Southeast | Midsouth | Plains | US |
|---|---|---|---|---|---|
| 2016 - 2020 average | $1,660 | $660 | $890 | $550 | $690 |
| 2021 - 2023 average | $2,275 | $980 | $1,125 | $700 | $925 |
| 2024 | $1,640 | $670 | $1,010 | $450 | $685 |
| 2020 – 2024 average | $ 1,990 | $ 855 | $ 1,060 | $ 610 | $ 830 |

Source: USDA NASS, 2025

**Table 11. Soybean Gross Revenue in $/Acre comparing 2021 to 2023 period to other recent to other recent years**

| | S. Seaboard | S. Plains | N. Plains | N. Crescent | Midsouth | Corn Belt | US |
|---|---|---|---|---|---|---|---|
| 2016 - 2020 average | $370 | $365 | $400 | $450 | $470 | $535 | $470 |
| 2021 - 2023 average | $565 | $405 | $545 | $655 | $670 | $810 | $680 |
| 2024 | $400 | $325 | $445 | $470 | $520 | $600 | $510 |
| 2020 – 2024 average | $515 | $395 | $510 | $600 | $615 | $735 | $620 |

Source: USDA NASS, 2025

EPA presents two detailed budgets below, one for cotton in the Plains Region (Table 12) and one for soybean in the Midsouth (Table 13). In Table 12, the costs of a preplant/preemergence weed control program and any other herbicides that may be applied postemergence but would be consistent regardless of program is captured in the "Other Operating Costs" line item. The "OTT Herbicide Costs" line item includes a first pass with the relevant herbicide for the OTT program and a second pass with glufosinate. For cotton, BEAD models two baseline scenarios – the first where a grower opts to utilize the dicamba tolerant seed even though OTT dicamba is not registered. This could occur because this seed trait would also allow for OTT use of glufosinate and because it would likely also include other desirable traits such as insect traits as discussed in the "Interaction of Herbicide Resistance Traits and Other Seed Traits" above. If a grower selected this program, they would be expected to make two OTT applications of glufosinate.

In the second baseline scenario modeled in Table 12 below, a grower utilizes the 2,4-D tolerant program and would make one pass with 2,4-D and a second with glufosinate. In the alternative scenario, assuming the registration of dicamba for OTT use, a grower is able to utilize the dicamba tolerant system and can make one application of dicamba and a second application of glufosinate.

**Table 12. Cotton in Plains – Comparison of Per-Acre Impacts on Grower Costs and Net Operating Revenues from Switching from Currently Available OTT Systems to an OTT Dicamba System***

| | **Baseline 1:** Dicamba tolerant trait but no OTT dicamba[1] | **Baseline 2:** 2,4-D Tolerant System[2] | **Alternative Scenario:** Dicamba Tolerant Trait with OTT Dicamba[3] |
|---|---|---|---|
| Gross Revenue | $610 | $610 | $610 |
| OTT Herbicide Costs | $29 | $26 | $24 |
| Seed [4] | $78 | $78 | $78 |
| Other Operating Costs [5] | $254 | $254 | $254 |
| Total Operating Costs | $355 | $ 352 | $350 |
| **Net Operating Revenue** | **$255** | **$258** | **$260** |
| Change in Net Operating Revenue | | | $2 to $6 |
| % Change in Net Operating Revenue | | | **0.8% to 2.2%** |

Source: Gross revenue for 2020 to 2024 for Plains from USDA NASS, 2025 (Table 1 of this document). Operating costs for 2024 from ERS (2024a), Prarie Gateway region. OTT Herbicide Costs from Kynetec, 2024a.

*Numbers in the table subject to rounding.

1 OTT herbicides include two applications of glufosinate.

2 OTT herbicides include one application of 2,4-D and one application of glufosinate.

3 OTT herbicides include one application of dicamba and one application of glufosinate.

4 Seed costs are regional average over conventional and GM seeds – budgets do not account for differences in seed costs by herbicide-tolerance traits.

5 Includes other pesticides (such as pre-emergent herbicides, other baseline post emergence herbicides like glyphosate, S-metolachlor, and clethodim as well as insecticides, *etc*), seed, fertilizer, custom services, various equipment costs, irrigation water, hired labor, and interest on operating capital. BEAD includes hired labor in operating costs even though ERS includes labor in overhead. BEAD excludes family labor.

Similarly in Table 13, the costs of a preplant/preemergence weed control program and any other herbicides that may be applied postemergence that are consistent regardless of program are captured in the “Other Operating Costs” line item. The “OTT Herbicide Costs” line includes one pass with the relevant herbicide for the OTT program plus glyphosate. A second pass was not included in this scenario because as reported in Table 4 above, most soybean acres receive only one OTT herbicide treatment.

**Table 13. Midsouth Soybean Comparison of Per-Acre Impacts on Grower Costs and Net Operating Revenues from Switching from Currently Available OTT Systems to an OTT Dicamba System**

| | **Baseline 1:** 2,4-D Tolerant Program[1] | **Baseline 2:** Glufosinate Tolerant Program[2] | **Alternative Scenario:** Dicamba Tolerant Program[3] |
|---|---|---|---|
| Gross Revenue | $519 | $519 | $519 |
| OTT Herbicide Costs | $20 | $24 | $17 |
| Other Operating Costs[4] | $246 | $246 | $246 |
| Seed Cost[5] | $84 | $84 | $84 |
| Total Operating Costs | $350 | $355 | $348 |
| **Net Operating Revenue** | **$169** | **$164** | **$171** |
| Change in Net Operating Revenue | | | $2 to $7 |
| % Change in Net Operating Revenue | | | **1.4% to 4.2%** |

Source: Gross revenue for Midsouth from USDA NASS, 2025 (2020-2024 average as in Table 11 of this document). Operating costs from ERS (2024b), Mississippi Portal Budget. OTT Herbicide Costs from Kynetec, 2024a.
1 OTT herbicides includes one pass with 2,4-D.
2 OTT herbicides includes one pass with glufosinate.
3 OTT herbicides includes one pass with dicamba.
4 Includes other pesticides (such as pre-emergent herbicides, other baseline post emergence herbicides like glyphosate, S-metolachlor, and fomesafen as well as insecticides, *etc*), fertilizer, custom services, fuel, lube, electricity, repairs, hired labor, and interest on operating capital. BEAD includes hired labor in operating costs even though ERS includes labor in overhead. BEAD excludes family labor.
5 Seed costs are regional average over conventional and GM seeds – budgets do not account for differences in seed costs by herbicide-tolerance traits.

The crop budgets presented in this document indicate that regardless of OTT herbicide program chosen, differences in net operating revenues are small, at least based on the herbicide cost alone. EPA also recognizes that grower costs may be influenced by seller incentive programs and rebates that companies may offer to growers who purchase seed and herbicides together.

### Conclusion on the Benefits of Using Postemergence Dicamba in Cotton and Soybean

Previous research has shown that Palmer amaranth left uncontrolled by OTT herbicide applications has resulted in yield losses of 60% in soybean (Klingaman and Oliver, 1994) and 65% in cotton (Morgan et al., 2001).

Currently to control problematic pigweed species, cotton and soybean growers are either utilizing 2,4-D tolerant seed and applying 2,4-D and/or glufosinate for OTT weed control, or utilizing dicamba tolerant seed and applying glufosinate for OTT control of pigweeds, as OTT dicamba products are currently not registered.

Since OTT dicamba products were last registered in 2020, pigweeds like Palmer amaranth and waterhemp have developed resistance to all three primary OTT herbicides, 2,4-D, dicamba, and glufosinate, in soybean and cotton. Therefore, the benefits of OTT dicamba products on an acre will depend on the resistance traits of the pigweeds on that particular acre. In situations where a pigweed species, like Palmer amaranth, has already developed resistance to dicamba, the benefits of OTT dicamba are low as pigweed species will not be controlled. While dicamba would not provide acceptable levels of OTT control, it may still provide a small benefit to growers because it can control other non-dicamba-resistant weeds present in the field.

For soybean and cotton acres where pigweed species have not developed resistance to dicamba, 2,4-D, or glufosinate, use of OTT dicamba has moderate benefits because it provides a rotation partner for glufosinate in a DT system and may result in a small cost savings compared to OTT 2,4-D products in a 2,4-D tolerant system. However, since growers have the option to rotate between a WSSA Group 4 herbicide and glufosinate in both the dicamba tolerant and 2,4-D tolerant system, there would be no benefits for resistance management between the two systems. EPA notes that soybean and cotton growers select which varieties of seed to plant based on a number of factors, of which herbicide tolerance traits are just one. For example, in cotton, a far greater selection of varieties containing regionally important plant-incorporated insect traits are available paired with the dicamba-tolerant trait package than with the 2,4-D tolerant system, resulting in a greater proportion of cotton acres being planted with dicamba-tolerant seed.

For acres where 2,4-D resistance (but no cross resistance with dicamba) is present, the benefits to soybean and cotton growers are high because dicamba would be the only WSSA Group 4 herbicide available for OTT weed control. Using OTT dicamba would likely represent a small cost savings compared to using OTT 2,4-D products (Table 9) and would provide resistance management benefits if used concurrently or sequentially with glufosinate.

In situations where glufosinate resistance is present, soybean and cotton growers are likely currently utilizing a 2,4-D tolerant system for OTT weed control (as OTT dicamba products are not currently registered or available). Registration of OTT dicamba products would allow growers the option to use OTT dicamba products in a DT system, which may result in a small cost savings compared to using OTT 2,4-D products in a 2,4-D tolerant system, as OTT dicamba products are less expensive than OTT dicamba products (Table 9). However, as both dicamba and 2,4-D are both WSSA Group 4 herbicides, there would be no resistance management benefits from the registration of OTT dicamba products. Therefore, registration of OTT dicamba in this situation would have moderate benefits in soybean and cotton, although the benefits will be higher in cotton as cotton growers would greater access to desirable seed traits in the dicamba tolerant system than the 2,4-D tolerant system.

EPA recognizes that the identification of an herbicide resistant weed population would occur only after a control failure, which would occur well after growers have purchased their genetically tolerant seed and thus committed to either the 2,4-D and glufosinate tolerant or the dicamba and glufosinate tolerant system. If, for example, a grower had a soybean or cotton field where the weed population in the field was in the early stages of 2,4-D resistance development and spread, then OTT dicamba would offer no benefit in the current growing year but could be of high benefit in a future growing season. A grower who experiences a resistance related control failure of 2,4-D would only have glufosinate in the current growing season and otherwise will have to wait until they purchase seed for the following year to switch programs and utilize OTT dicamba. Overall, the current year benefits of OTT dicamba products may differ from the benefit that they can provide growers in a future growing season.

**IMPACTS OF POTENTIAL MITIGATION**

The Agency is considering mitigation that would reduce ecological risks, including risks to listed species, associated with the use of OTT dicamba products in cotton and soybean which can occur as a result of spray drift, runoff/erosion, and volatility.

The mitigation measures under consideration to reduce spray drift and runoff/erosion from agricultural pesticide use are consistent with the approaches discussed in the Agency's August 2024 Herbicide Strategy (HS) (EPA, 2024a) and its September 2024 Vulnerable Species Action Plan (VSAP) (EPA, 2024b) in that, 1) off-target movement of pesticides is dealt with in a manner that is consistent, reasonable, and transparent and, 2) mitigation measures on pesticide labels and relevant websites offer growers flexibilities to accommodate their individual circumstances[3]. These measures are described as follows:

- To reduce risks from **spray drift**, EPA is considering wind directional spray buffers and the inclusion of a drift reduction adjuvant. The buffers could be reduced if applicators take measures to reduce exposure, such as using a hooded sprayer or by establishing physical barriers such as a windbreak.

- To reduce risks from **runoff and erosion**, EPA is considering implementation of certain practices including, for example, land modifications (e.g., terracing, retention ponds, vegetative filter strips), production practices (e.g., cover cropping, mulching), and/or application practices (e.g., reduced rates, banded applications) to achieve a three to six runoff/erosion mitigation points before making an application of OTT dicamba products on a particular field.

The volatility measures under consideration are described as follows:

- To reduce risks from **volatility**, EPA is considering, depending on the temperature, requiring use of a VRA, prohibiting tank mixing with other herbicides,

[3] Mitigation measures can be found at https://www.epa.gov/pesticides/mitigation-menu

and/or limiting the area of a field that can be treated. Additionally, the Agency is considering no applications above a certain temperature threshold.

**Spray Drift**

Buffers

The Agency is considering wind directional buffer requirement for OTT dicamba use in cotton and soybean to reduce the risks of spray drift. The purpose of a buffer requirement is to reduce the risk of OTT dicamba moving beyond the intended target area and affecting sensitive non-target species. Based on the applications for registration under consideration, only ground applications would be allowed with OTT dicamba products in cotton and soybean.

Spray drift buffers can affect a substantial portion of a field. Larger buffers impact a larger proportion of the field than smaller buffers. To characterize the effect that buffers may have on growers, BEAD shows how different sizes of no-spray buffers can impact growers who want to use OTT dicamba products on different sized fields (Table 14). To illustrate the potential extent of a buffer, BEAD considered a rectangular field with length equal to twice its width, with the long side of the field immediately adjacent to a sensitive area. A 15-foot buffer would extend across about 3% of a 10-acre field and around 2% of a 40-acre field (Table 14). If the buffer were to fall on the short side, the affected area would be less. Irregularly shaped fields could be affected substantially more. In situations where the field to be treated is not immediately adjacent to a protected area, the part of the field affected by the spray buffers is less than if the field edge is immediately next to the habitat.

**Table 14. Percent of fields of various sizes lost to in-field buffers of various sizes[1]**

| **Field Size (Acres)** | **1** | **10** | **40** | **160** |
|---|---|---|---|---|
| Buffer Size | | | | |
| 15 Feet | 10% | 3% | 2% | 1% |
| 25 Feet | 17% | 5% | 3% | 1% |
| 50 Feet | 34% | 11% | 5% | 3% |
| 100 Feet | 68% | 21% | 11% | 5% |
| 300 Feet | 100% | 64% | 32% | 16% |

[1] Calculations based on a rectangular field with length equal to twice its width, with the in-field buffer on the long side of the field.

Consistent with the Herbicide Strategy EPA is considering wind-directional spray drift buffers—that is buffers to be used when winds are blowing in the direction of a non-target site—for OTT dicamba products in cotton and soybean. Growers will likely try to apply OTT dicamba products when winds are not blowing or wait for the wind direction to change. However, waiting for no wind or the wind direction to change in order to apply OTT dicamba may significantly reduce the number of hours that growers have to spray OTT dicamba, which may result in poor application timing and reduced weed control. Growers could leave the buffer untreated, if the wind is blowing toward the sensitive area, but that could lead to weed problems in the area, ultimately reducing yields and potentially leading to an increase in herbicide resistance in the untreated part of the field. Finally, a grower could treat the buffer area separately, either with a different herbicide or return to apply OTT dicamba when conditions are favorable, but this would increase the fixed costs of an application and the complexity of the production system.

Consistent with the Herbicide Strategy, the mitigations under consideration would allow for OTT dicamba users to reduce buffer size by implementing other drift control mitigations such as using larger droplet sizes, using hooded sprayers, and/or establishing and maintaining windbreaks. Growers may incur costs associated with implementing these spray drift mitigations including the purchase of new nozzles, the cost of a new hooded sprayer, and the costs associated with establishment and maintenance of windbreaks. The burden of purchasing a hooded sprayer or installing windbreaks may be greater for smaller operations, which may face higher per-acre costs for equipment and potentially higher financing costs.

Drift Reduction Agent

The Agency is considering the requirement to include a drift reduction agent (DRA) in the spray tank with OTT dicamba products in order to reduce the potential for OTT dicamba products to drift off-field. In 2020, the Agency found that the inclusion of a DRA would increase the cost of using OTT dicamba products by $1 to $4 per acre, based on estimated from registrants (Chism et al., 2020). EPA reviewed several DRAs currently on the market. Suggested use rates for DRA products, typically expressed as rates per volume of spray solution, vary widely which influences costs. EPA estimates that costs would likely still fall in the $1 to $4 per acre range estimated in 2020, but could be up to $6 per acre, depending on the DRA product. This requirement would make the cost per acre of dicamba to be roughly the same as the cost for 2,4-D, but dicamba would still be lower in cost than glufosinate. However, when the cost of the DRA is combined with the cost of the VRA (discussed later in the document), the cost of OTT dicamba is largely the same as glufosinate, decreasing the benefits for OTT dicamba over alternative herbicides.

**Runoff/Erosion**

EPA is considering requiring 3 runoff/erosion mitigation points for OTT dicamba products on both cotton and soybean across the US, and 6 points in certain Pesticide Use Limitation Areas (PULAs). To illustrate the potential feasibility of runoff/erosion mitigation requirements, this memo considers measures cotton and soybean growers may need to implement to achieve up to the 6 points.

BEAD first considers whether soybean or cotton growers could be eligible for points based on location and whether typical characteristics of cotton and soybean field in a particular region would be eligible for points. If a field's location and typical permanent characteristics do not achieve six points, BEAD identifies additional mitigation measures that a grower would likely adopt by considering those that would be appropriate to the crop and region. BEAD then describes the impacts that a grower would face for these potential additional mitigation measures.

Midwest Soybeans

The scenarios are evaluated for application of OTT dicamba products to soybean in the Midwestern US since the region has both flat and sloped fields (Table 15). Soybean grown on flat fields (<3% slope) would receive a flat field credit of two points while sloped fields would not receive this credit. Most parts of Midwestern states receive two points of geographic relief given relatively low pesticide runoff vulnerability.[4] Most of the soybean in the Midwestern US are not irrigated, and these growers achieve three points for non-irrigated production (USDA NASS, 2023). Thus, many fields in the Midwestern US would obtain five (sloped fields) to seven points (flat fields) based on geographic factors and field characteristics alone (Table 15).

Soybean grown on sloped fields in counties in this region that do not receive two geographic relief points would need to add additional mitigations to compensate for the lack of geographic relief. However, soybean growers in the Midwest have several mitigation options available to them to obtain the additional point necessary to reach six mitigation points. Conservation tillage practices (reduced tillage) is a runoff mitigation measure that is already widespread in both the Midwestern US with 75% of total acreage in the Northern Plains and 73% of acreage in the Corn Belt currently practicing reduced tillage (EPA, 2024c). Similarly, a survey conducted by the American Soybean Association found that 56% of soybean grower respondents currently practice no-till or reduced tillage on 75%+ of their acres (Holland, 2025). These data indicate that reduced tillage is a highly feasible practice for a large percentage of growers in this region. Reduced tillage can be implemented on both sloped and flat fields and allows growers to earn two mitigation points.

Data from a survey conducted by the American Soybean Association suggest that grassed waterways (18%), terracing (11%), contour farming (10%), soil incorporation, (9%) and cover cropping (8%) are also runoff/erosion mitigation measures that are currently being implemented on sloped fields (Holland, 2025). Soybean producers in a PULA that do not receive geographic relief and who do not currently have these mitigation measures will incur costs associated with their adoption, which will vary by the practice being adopted. For example, measures that require land modification (grassed waterways, terracing) impose high up-front costs and are probably not practical for land that is rented.

[4] The mitigation menu, including geographic relief points, can be found at https://www.epa.gov/pesticides/mitigation-menu

**Table 15. Runoff Mitigation Points Example Scenario for Soybean Midwestern US on Non-Sandy Soils**

| | Number of Points | |
|---|---|---|
| **Field Location and Permanent Characteristics** | **Flat Fields** | **Sloped Fields (>3%)** |
| Pesticide Runoff Vulnerability | 2 | 2 |
| Flat Field (≤3% slope) | 2 | 0 |
| Irrigation Water Management | | |
| *Non-irrigated* | 3 | 3 |
| **Total points for field location and permanent characteristics** | **7** | **5** |
| **Mitigation Measures** | | |
| Reduced Tillage Management | | |
| *Reduced Tillage* | | 2 |
| **Total points for mitigation measures** | | |
| **TOTAL POINTS ACHIEVED:** | **7** | **7** |

Color scheme: Grey rows indicate field location and semi- or permanent characteristics which EPA expects growers and/or applicators can claim year after year. Orange colored rows are for on-field mitigations implemented prior to herbicide use.

Overall, BEAD concludes that soybean growers in the Midwestern US on both flat fields and sloped fields would be able to achieve at least 6 mitigation points of runoff/erosion mitigations in order to use OTT dicamba products with little or no impact. This conclusion is supported by national survey data published by the American Soybean Association which concluded that 95.8% of soybean growers surveyed would currently earn the six points that may be required for runoff/erosion compliance. (Holland, 2025).

Midsouth Cotton and Soybeans

This scenario is for application of OTT dicamba products to cotton and soybean in the Midsouth (Table 16). Specifically, this scenario represents furrow-irrigated cotton and soybean production on flat fields in the Mississippi Delta region of the Midsouth, which encompasses large soybean growing areas in Mississippi, Louisiana, Arkansas, and Missouri[5]. This region generally receives no geographic mitigation relief. As most fields in this area are flat, they would receive the flat field (<3% slope) credit of 2 points. Thus, some growers in the Midsouth may only be eligible for two points in total for field location and permanent characteristics.

[5] Soybean and cotton growers outside of the Delta region in these states, generally in more hilly topography, would likely use mitigation measures more similar to those presented for the Midwest US runoff/erosion scenario presented above.

Most cotton and soybean in the area are furrow irrigated and may receive two points for using furrow irrigation if used with a precision technology, such as computerized hole selection software, soil moisture sensors, and/or surge valves. Adoption of a technology like computerized hole selection (i.e., Pipe Planner) appears to vary by state in the Mississippi Delta. Data from 2018 presented by the Mississippi Soybean Promotion Board (MSPB) suggests that computerized hole selection has been adopted on 52% of furrow-irrigated acres in Mississippi, but only 17% of furrow-irrigated acres in Louisiana (MSPB, 2018). However, BEAD anticipates that adoption has increased since the 2018 report by MSPB. This is in part because online computer hole selection tools are generally free to use and such a technology reduces grower operating costs by conserving water and energy.

As cotton and soybean in the Mississippi Delta are grown on raised beds that need to be rebuilt every year, reduced tillage practices are generally not practiced in this region. Furthermore, adoption of practices like cover crops have been limited in this region, and the use of furrow irrigation precludes the use of mitigations such as vegetative filter strips and grassed waterways. Overall, the only practice available to soybean and cotton producers in the Mississippi Delta would be the use of vegetated ditches, which are already widespread in the Mississippi Delta (EPA, 2024c). Soybean and cotton growers would be able to achieve one point for vegetated ditches (an off-field or in this case, adjacent-to-field measure) and another point for using precision irrigation management (see furrow irrigation discussion previous paragraph which is an on-field measure). Additionally, soybean and cotton growers in the Delta would achieve another point for utilizing both an on-field and an off-field mitigation measure. After accounting for geographic factors, field characteristics, and typical production practices, soybean and cotton growers in the Midsouth would be able to achieve 3 runoff/erosion mitigation points with little to no impacts. However, in order to achieve six runoff/erosion points growers may need to make small investments in precision irrigation technology if they have not already done so (Table 16).

**Table 16. Runoff Mitigation Points Example Scenario for Furrow-Irrigated Soybean and Cotton in the Delta region of Mississippi**

| | **Number of Points** |
|---|---|
| **Field Location and Permanent Characteristics** | |
| Geographic mitigation relief | 0 |
| Flat Field (<3% slope) | 2 |
| **Total points for Field Location and Permanent Characteristics** | **2** |
| **Mitigation Measures** | |
| Irrigation Water Management – computerized hole selection software, soil moisture sensors, and/or surge valves | 2 |
| Vegetated Ditch | 1 |
| Point for both on and off-field measures | 1 |
| **Total Points for Mitigation Measures** | 4 |
| **TOTAL POINTS ACHIEVED:** | **6** |

Color scheme: Grey rows indicate field location or permanent characteristics which EPA expects growers and/or applicators can claim year after year. Orange rows represent mitigation measures that are typical production practices.

Texas Cotton

This scenario is for application of OTT dicamba products to cotton in West Texas (Table 17). This region generally receives three points of geographic mitigation relief, as it is a very dry production region for cotton. Dryland cotton in West Texas would be eligible for 3 mitigation points for being non-irrigated, resulting in a total of 6 mitigation points for field location and permanent characteristics and allowing growers to achieve the potential 6 points of runoff/erosion irrigation with little to no impacts.

**Table 17. Runoff Mitigation Points Example Scenario for Dryland Cotton in West Texas**

| | **Number of Points** |
|---|---|
| **Field Location and Permanent Characteristics** | |
| Geographic mitigation relief | 3 |
| Irrigation Water Management | |
| *Non-irrigated* | 3 |
| **Total points for Field Location and Permanent Characteristics** | **6** |
| **TOTAL POINTS ACHIEVED:** | **6** |

**Volatility**

The Agency is considering multiple mitigation options to address off-target movement of dicamba via volatilization. Dicamba volatilization is affected by a number of factors including air temperature and pH of the spray tank. EPA is considering a layered mitigation approach based on the predicted air temperature and the use of a volatility reducing agent (VRA). EPA is also considering limits on the area treated or, alternatively, a prohibition on tank mixing, at high air temperatures (Table 18). Growers who want to make OTT applications of dicamba may need to determine the predicted maximum temperature on the day of application as well as the following day to identify the necessary application mitigations.

At temperatures below 75°F, growers may be required to add 20 oz/ac of VRA[6] in order to apply dicamba. Between 75°F and 85°F growers may be required to double the rate of VRA to 40 oz/ac in order to apply OTT dicamba. To apply at temperatures greater than 85°F, growers may need to use 40 oz/ac of VRA as well as reduce the area treated by 40% or apply dicamba without tank mixing with other pesticides. OTT dicamba applications may not be allowed above 95°F (Table 18). Growers may need to check the predicted maximum temperature for both for the day of application and the following day to determine which temperature category that they fall into.

**Table 18. Proposed volatility mitigation structure for OTT dicamba products**

| 48 Hour Max Temperature | Amount of VRA needed | Additional Mitigation |
|---|---|---|
| <75˚ F | 20 oz/acre | No |
| ≥75˚ F - <85˚ F | 40 oz/acre | No |
| ≥85˚ F - <95˚ F | 40 oz/acre | 40% reduction in area treated or prohibition of tank mixing |
| ≥95˚ F | No applications | |

Volatility Reducing Agent

In general, as the pH of a spray solution decreases (i.e., becomes more acidic), more of the dicamba within that spray solution exists in the dicamba acid form, which is volatile. Adding a spray adjuvant, known as a volatility reducing agent (VRA), to the spray tank raises the solution's pH, reducing the amount of dicamba acid and thereby decreasing volatility. Multiple VRAs are available on the market, but the two primary VRAs available are potassium acetate or potassium hydroxide/ethanoic acid (VaporGripXtra®, Bayer) and potassium carbonate (Sentris®,

[6] The amount of VRA added will depend on the formulation of VRA that is being used and how effective the VRA is at buffering the pH of the spray tank. The 20 oz/acre and 40 oz/acre rate are for the potassium hydroxide/ethanoic acid (VaporGripXtra®, Bayer) VRA.

BASF). Price information across the many different VRAs offered is not readily available, but some VRA price information was found online through Farmers Business Network (FBN), an online agricultural chemical retailer. FBN provided a cash price for a 275-gallon container of Field Grip VRA (the same formulation as VaporGrip® Xtra) of $3,528, resulting in a VRA price of $12.83/gallon or $0.10/oz of VRA. Therefore, a grower applying OTT dicamba at < 75° F may incur an additional cost of $2/acre, while a grower applying at temperatures at or above 75° F may incur an additional $4/acre cost, if the addition of a VRA is required. In addition to the cost of the VRA product itself, users of OTT dicamba products would incur additional costs from storing, transporting, and mixing large quantities of VRA. Mixing large quantities of VRA adds time and complexity to what may be a time sensitive application. The additional cost associated with the addition of VRA would also essentially eliminate the small herbicide cost savings for the dicamba-tolerant system over the 2,4-D tolerant system ($9/acre vs $12/acre), however, OTT dicamba products would still be less expensive than glufosinate.

If combined with a drift reduction agent, these mitigation measure would further decrease the magnitude of the benefits of OTT dicamba as costs would be about the same as glufosinate. Use of dicamba would still provide benefits in areas with resistance to other OTT herbicides and in rotation with glufosinate as part of a resistance management program.

Reduction in Area Treated

The Agency is considering a requirement that growers reduce the area treated if applying OTT dicamba products between 85˚ F and 95˚ F. Growers wishing to make a reduced area application of OTT dicamba products have multiple options to achieve a 40% reduction. Cotton and soybean growers could treat 60% of their field with OTT dicamba and the remainder of the field with an alternative OTT herbicide, like glufosinate. Treating the same field with two separate herbicide applications would require mixing and loading of multiple tanks of herbicides and multiple sprayer trips to the same field and would likely be logistically and cost prohibitive for most cotton and soybean growers. Another option to reduce the field area treated by 40% would be to apply OTT dicamba as a banded application. In banded applications, the herbicide is concentrated in a certain area, primarily in the crop row, while an alternative weed control method, like cultivation is performed between rows. While banded applications would theoretically be feasible for both cotton and soybean, currently banded applications in both crops are likely limited. This is because most cotton and soybean growers do not currently own the specialized equipment necessary to conduct a banded application. Additionally, conducting banded applications is much slower than over-the-top broadcast applications, which may make banded applications logistically prohibitive.

Growers seeking to make a reduced area treated application of OTT dicamba users could do so by utilizing a targeted spray system. Targeted spray systems use cameras and machine learning to apply OTT herbicides, like dicamba, only to emerged weeds in the field, instead of the whole field. While the amount of area treated compared to a broadcast application will vary by the number and size of emerged weeds at the timing of application, studies suggest that precision spraying technology can reduce area treated by up to 62% percent compared to a broadcast application (Avent et al., 2024). Targeted spraying technology is still a relatively recent introduction so adoption across all US cotton and soybean acres is still likely limited. Cotton and soybean growers wishing to adopt targeted spray systems technology could purchase an upgrade kit for their existing sprayer for approximately $25,000 (Seymour, 2024). However, the upgrade kit is only available for certain sprayers and only for certain model years. Growers could also choose to purchase a new sprayer with targeted spray technology included for approximately $959,000 (Seymour, 2024). Growers using targeted spray systems may also be required to pay a $4/acre subscription fee to use the technology (Seymour, 2024). While targeted spray systems may be the most feasible strategy to decrease area treated by 40%, the financial costs of adopting the technology may be cost prohibitive for most cotton and soybean producers. Overall, the ability of growers to reduce treated area by 40% at the field level would be limited, meaning that most growers would need to consider not tank mixing OTT dicamba products with other pesticides in order to apply the proposed OTT dicamba products between 85˚ F and 95˚ F.

<u>Prohibition of Tank Mixing</u>

EPA is also considering a requirement that to prohibit tank mixing any other pesticides with OTT dicamba products to apply between 85˚ F and 95˚ F. Pesticide usage information from 2021-2023 suggests that OTT dicamba products were frequently applied with other pesticides, primarily with other herbicides, commonly glyphosate, (Kynetec, 2024a) to achieve broader spectrum weed control. In these tank mixes, glyphosate is used to control grass weeds that would not be controlled by OTT dicamba as well as provide an additional mode of action to control the array of broadleaf weeds present in cotton and soybean fields that are not resistant to glyphosate. In order to comply with a tank mixing restriction, soybean and cotton growers would likely need to forgo applying glyphosate which would leave grass weeds uncontrolled and likely result in yield loss. Alternatively, growers could apply OTT dicamba products alone and then return to make an additional pass to apply glyphosate and/or other pesticides. This would result in increased management costs.

Aside from the cost of the pesticide, there are significant costs associated with making a pesticide application to a soybean or cotton field. BEAD determined the range of per acre costs from multiple state agricultural Extension agencies where they surveyed custom application rates for both tractor and pull-behind sprayers and self-propelled sprayers (Table 19, U of AR Farm Equipment, 2025; U of GA cotton budget, 2025; Langemeier, 2023). The per acre costs include fuel, equipment repairs, and depreciation. Operator labor is sometimes, but not always, incorporated into the budget estimates provided.

**Table 19. Cost estimates for a single spray application**

| Application type | Per acre costs | 160-acre field | 500-acre operation | 1,000-acre operation |
|---|---|---|---|---|
| Tractor + sprayer | $2 to $10 | $320 to $1,530 | $1,000 to $4,775 | $2,010 to $9,550 |
| Self-propelled sprayer | $5 to $12 | $800 to $2,880 | $2,500 to $9,000 | $5,000 to $18,000 |

Sources: U of AR Farm Equipment, 2025; U of GA cotton budget, 2025; Langemeier, 2023

Making an additional spray pass through the field would cost growers from $2 to $10 per acre for a tractor and pull behind sprayer and from $5 to $12 per acre a self-propelled sprayer (Table 19). Additional labor and machinery costs would likely exceed the cost savings from the use of dicamba instead of glufosinate. Overall, EPA concludes that allowing growers to apply between 85˚ F and 95˚ F by prohibiting tank mixes would allow increased flexibility to make timely OTT dicamba applications; however, the costs associated with this would have a high financial impact for soybean and cotton growers using OTT dicamba products.

<u>Temperature Thresholds</u>

While the addition of VRA alone may allow OTT dicamba products to be used up to 85°F, environment and climatic conditions in cotton and soybean growing areas will determine the extent to which OTT dicamba products can be used in the field. To assess how likely a grower applying OTT dicamba may be to experience temperatures at or below the potential temperature thresholds under consideration (Table 18), EPA conducted an analysis of 48-hour maximum temperatures for three soybean and cotton producing counties in the US. Due to differences in weather patterns and stages of crop development from north to south in the US, EPA selected three cotton and/or soybean producing counties at different latitudes; from north to south: Webster County, Iowa (soybean), Mississippi County, Arkansas (soybean and cotton), and Lubbock County, Texas (cotton).

EPA sourced daily maximum temperature data from the National Oceanic and Atmospheric Administration National Centers for Environmental Information US Daily Climate Normals database for 1995 to 2024 (Menne et al., 2012). EPA assigned each consecutive 2-day period to the higher of the temperature bins for the paired days. The recommended planting dates for the crops in these states is generally April to May, with a second application, if needed, occurring in June or July (discussed below). Therefore, EPA determined the distribution of maximum 48-hour temperatures of the consecutive day pairs in each week of these months.[7]

Recommended planting dates for soybean in Iowa are from early April and extend to late May (Licht and Clemens, 2021), while recommended soybean planting dates for Arkansas are also generally from early April but typically are completed in early May (University of Arkansas, undated). Recommended cotton planting dates for Arkansas are from late April to late May (Barber, et al., undated), while recommended cotton planting dates for West Texas are from early May to late May (Bell et al., 2022). The recommended planting dates largely align with crop progress reports published by USDA (USDA NASS, 2025b). The first OTT dicamba application will generally occur 2-4 weeks after planting, but the timing of the first OTT application will vary based on environmental conditions, weed size, and whether a preemergence herbicide was used. Therefore, in the regions represented in these case studies, the first OTT dicamba application could occur in late April but would likely occur in May and June with the second application (if necessary) occurring in June or July.

EPA calculated the percent of consecutive days in each week of the cotton and soybean growing seasons when OTT dicamba may be applied (April through July) that were at or below each of the temperature ranges for the last 30 years (Figures 1-3). The detailed results presented in the Appendix of this document and are an indication of the percentage of consecutive days per week users of OTT dicamba products would need to consider temperature-specific application requirements.

In Webster County, Iowa, the 48-hour maximum daily temperature was below 85°F for nearly all consecutive days in April and about 90% of days in May (Fig. 1). In June around 70% of consecutive days were below 85°F while in July the percentage was about 60%. Therefore, EPA expects that soybean growers in Iowa and similar environments would be able to make one OTT dicamba application and possibly two OTT dicamba applications (if necessary), indicating low impacts from temperature thresholds in Iowa and similar environments.

[7] For this analysis, each week began on Sunday. Each week was assigned to a corresponding month based on the 2025 ISO week-numbering year (the ISO year). While this is a crude assignment of month, as there is variation year to year depending on which day of the week the year begins, it is sufficient for the purposes of this analysis.

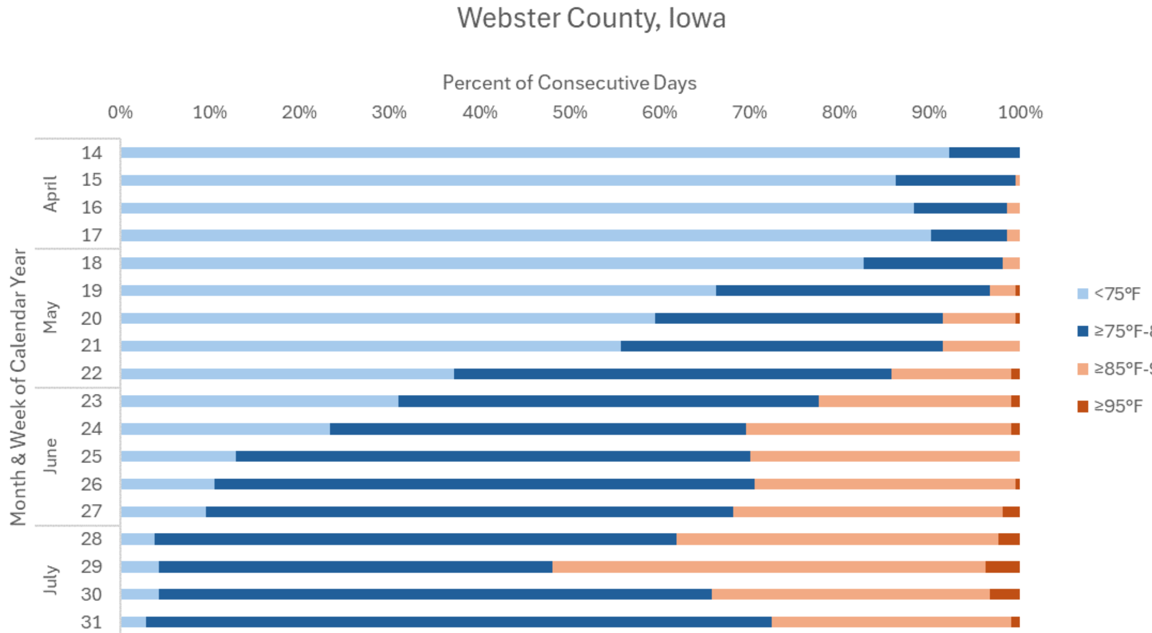


**Fig. 1. Distribution of 48-hour maximum daily temperature ranges for Webster County, Iowa, 1995-2024.**

In Mississippi County, Arkansas, the 48-hour maximum daily temperature was below 85°F for over 90% of days in April and nearly 60% of consecutive days in May (Fig. 2). However, in both June and July, approximately 75% and 85%, respectively, of 48-hour maximum temperatures were 85°F or higher. Most days in April would be available for OTT dicamba applications with the addition of VRA. The higher temperatures beginning in May enable the use of OTT dicamba only with the addition of the higher rate of VRA. EPA expects that soybean and cotton planted in April would be able to receive one application of OTT dicamba, but for cotton and soybean acres that are planted later, timely application of OTT dicamba products in June and July may not be possible based on the 85°F temperature threshold unless using the tank mix prohibition or reduced area treated options discussed previously. As OTT dicamba products are not currently registered for use in cotton or soybean, growers are likely currently relying on one or two applications of glufosinate in DT cotton and soybean in Arkansas. The registration of OTT dicamba products would allow growers to apply dicamba for the first OTT herbicide application slightly reducing costs versus glufosinate for this application. Growers could then use glufosinate for the second OTT application, when higher temperatures are more likely to occur, if a second OTT application is needed. While this second application of glufosinate costs more on a per acre basis than dicamba, the inclusion of a herbicidal mode of action different from OTT dicamba would benefit herbicide resistance management.

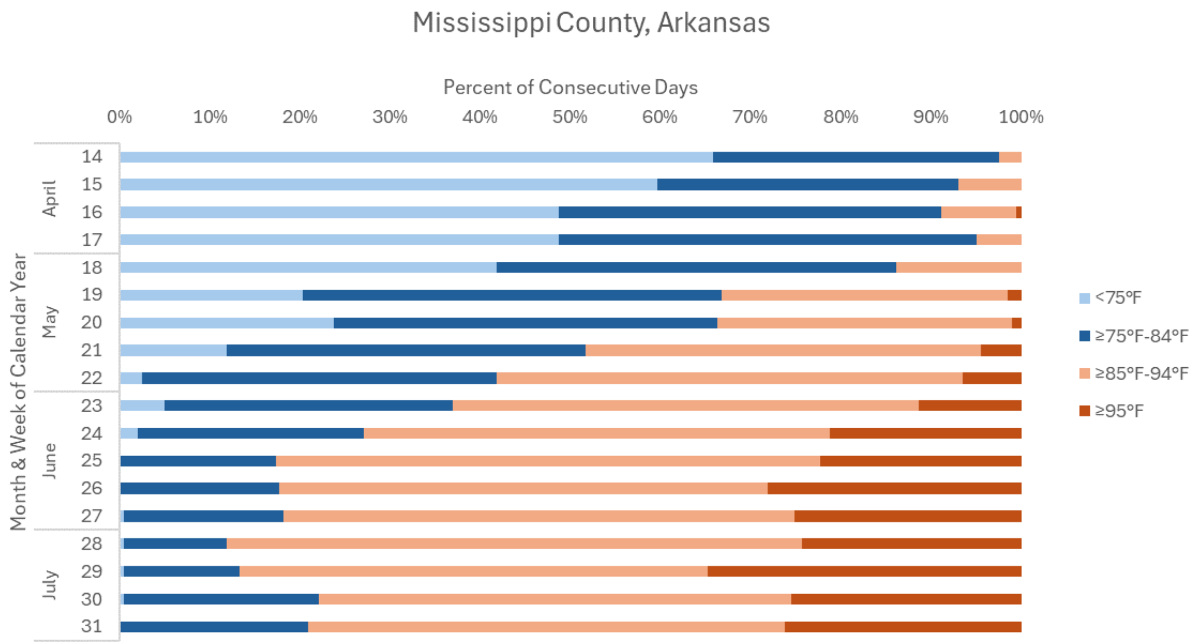


**Fig. 2. Distribution of 48-hour maximum daily temperature ranges for Mississippi County, Arkansas, 1995-2024.**

In Lubbock County, Texas, around 80% of 48-hour maximum daily temperatures in April were below 85°F (Fig. 3). In May, this percentage dropped to around 50%. By June and July, approximately 10%-15% of 48-hour temperatures were below 85°F. Recommended planting dates for cotton are generally the month of May (Bell et al., 2022). EPA expects that cotton planted in April or May would be able to receive one application of OTT dicamba, but for cotton and soybean acres that are planted later, timely application of OTT dicamba products in June and July may not be possible based on the 85°F temperature threshold unless using the tank mix prohibition or reduced area treated options discussed previously. As OTT dicamba products are not currently registered for use in cotton, growers are likely currently relying on one or two applications of glufosinate in DT cotton in Texas. The registration of OTT dicamba products would allow growers to apply dicamba for the first OTT herbicide application slightly reducing costs versus glufosinate for this application. Growers could then use glufosinate for the second OTT application, when higher temperatures are more likely to occur, if a second OTT application is needed. While this second application of glufosinate costs more on a per acre basis than dicamba, the inclusion of an herbicidal mode of action different from OTT dicamba would benefit herbicide resistance management.

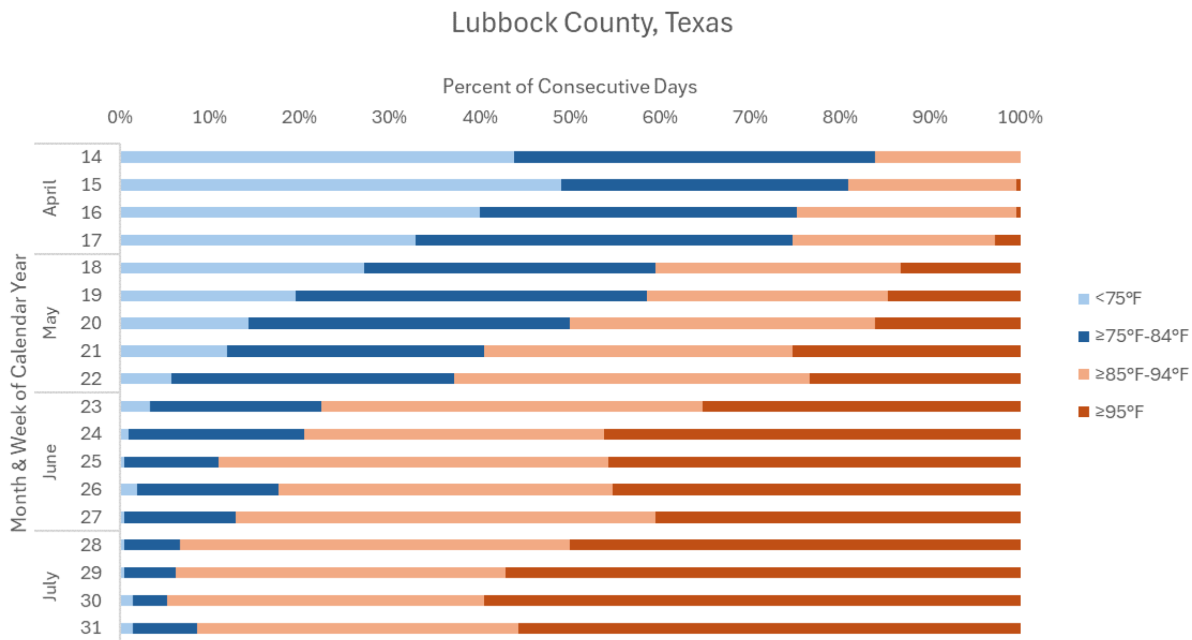


**Fig. 3. Distribution of 48-hour maximum daily temperature ranges for Lubbock County, Texas, 1995-2024.**

## CONCLUSION

This document describes the benefits of registering dicamba products for Over-the-Top (OTT) use on genetically modified dicamba-tolerant (DT) cotton and soybean and identifies the impacts to cotton and soybean growers of ecological mitigations under consideration. The analyses in these documents take into mitigation measures currently being considered for the proposed applications for registration of OTT dicamba products. OTT dicamba products were last registered in 2020 and the registrations were subsequently vacated in 2024. From 2021 to 2023, growers applied OTT dicamba products on 34% of all cotton acres and 26% of all soybean acres. However, certain regions reported higher usage of OTT dicamba, including cotton grown in the Midsouth and Southeastern US (both regions reported greater than 50% crop treated) and soybean grown in the Midsouth and Southern Plains (both regions reported greater than 40% of crop treated). Across both cotton and soybean OTT dicamba products are used to target pigweed species, primarily Palmer amaranth and waterhemp, as well as other problematic broadleaf weeds present in these cropping systems.

The main OTT herbicide alternatives to the proposed OTT dicamba products are currently OTT 2,4-D and glufosinate products. Both the 2,4-D tolerant system and the dicamba tolerant system seed varieties confer resistance to glufosinate in both soybean and cotton. As OTT dicamba products are not currently registered, soybean and cotton growers are likely either using OTT 2,4-D products and glufosinate in the 2,4-D tolerant system or using only glufosinate in the dicamba tolerant system.

Since OTT dicamba products were last registered in 2020, resistance to 2,4-D, glufosinate and dicamba has been reported in target weed species, particularly Palmer amaranth and waterhemp (pigweeds) has continued to develop and spread, affecting the benefits of OTT dicamba products. On acres where pigweeds have developed resistance to dicamba, the benefits of OTT dicamba products are low, but OTT dicamba may provide marginal benefits for control of other broadleaf weed species. On acres where resistance to dicamba, 2,4-D and glufosinate is not present, there are moderate benefits to the use of OTT dicamba products primarily for resistance management as soybean and cotton growers could utilize either a dicamba-tolerant system or a 2,4-D tolerant system. However, the benefits of the dicamba tolerant system in cotton may be higher than in soybean because the dicamba tolerant system comes with other desirable cotton traits not found in the 2,4-D system.

For acres where 2,4-D resistance is present the benefits to soybean and cotton growers are high, because dicamba would be the only WSSA Group 4 herbicide available for OTT weed control. Using OTT dicamba would represent a small cost savings compared to using OTT 2,4-D products and would provide resistance management benefits if used concurrently or sequentially with glufosinate.

In situations where glufosinate resistance is present, soybean and cotton growers are likely currently utilizing a 2,4-D tolerant system for OTT weed control (as OTT dicamba products are not currently registered or available). Registration of OTT dicamba products would give these growers access to a wider range of crop varieties and traits, especially in cotton, and represent a small cost savings compared to OTT 2,4-D herbicides. However, as both dicamba and 2,4-D are both WSSA Group 4 herbicides, there would be no resistance management benefits from the registration of OTT dicamba products.

EPA is considering spray drift and runoff/erosion mitigations that take into account, as appropriate, EPA's Herbicide Strategy and Vulnerable Species Action Plan. Spray drift mitigations under consideration, including buffers and the inclusion of a drift reducing agent into the spray solution, may increase production costs for soybean and cotton producers or lead to decreased control of target weeds in the buffer area therefore resulting in loss of yield. The magnitude of the impacts will depend on the size of the spray drift buffer and/or the cost to implement other mitigation practices to reduce the buffer size. Runoff/erosion mitigations under consideration are expected to impose low impacts on both soybean and cotton growers as they should be able to achieve sufficient mitigation points with existing field characteristics and agronomic practices.

The volatility mitigations being considered by EPA are multifaceted and would depend on temperature at time of OTT dicamba application with a prohibition of OTT dicamba applications at or above 95° F. The Agency is considering requiring that for all OTT dicamba applications below 95° F, growers must include a volatility reducing agent (VRA) in the application. The addition of VRA may increase grower costs by $2-$4 per acre which translates to a 22% to 44% increase in per acre costs to make an application of OTT dicamba. This increase in cost makes an application of OTT dicamba comparable to an application of OTT 2,4-D but still less expensive than glufosinate.

In addition to using a VRA, for applications between 85° F and 95° F, EPA is considering two mitigation options for cotton and soybean producers. The first is prohibiting the tank mixing of OTT dicamba products with other pesticides, if treating the entire field. The second option is reducing the area of the field treated by 40% if applying with other pesticides in the same tank. Prohibiting tank mixing would likely cause growers to conduct an additional spray pass through the field costing between $2 and $12 per acre. Most cotton and soybean growers would find reducing treated by 40% to be infeasible because they lack the spray equipment to effectively reduce the area treated while still maintaining acceptable levels of weed control. These mitigation options, while providing flexibility for growers to use OTT dicamba products above 85° F, may make growers unwilling or unable to apply OTT dicamba products above 85° F.

## REFERENCES


Anderson, M. and M. Owen, 2024. Suspected 2,4-D Resistant Waterhemp Population Discovered. Iowa State University. https://crops.extension.iastate.edu/cropnews/2024/02/suspected-24-d-resistant-waterhemp-population-discovered

Avent, T.H, J.K. Norsworthy, W.L. Patzoldt, L. M. Schwartz-Lazaro, M.M. Houston, T.R. Butts, and A.R. Vazquez. 2024. Comparing herbicide application methods with See and Spray™ technology in soybean. Weed Tech 38: 1-10. doi: 10.1017/wet.2024.70

Barber, T., G. Lorenz, and K. Smith. Undated. Recommendations for Late Planted Cotton. University of Arkansas Division of Agriculture. https://www.uaex.uada.edu/farm-ranch/crops-commercial-horticulture/cotton/Managment%20of%20late%20planted%20cotton.pdf

Barber, T., Scott, B., Wright-Smith, H., Jones, S., Norsworthy, J.K., Burgos, N., M. Bertucci. 2025. MP44: Recommended Chemicals for Weed and Brush Control. A University of Arkansas publication. Accessed https://www.uaex.uada.edu/publications/pdf/mp44/mp44.pdf [Accessed April 2025]

Barber, T. J. Norsworthy, and T. Butts. 2021. Arkansas Palmer Amaranth Found Resistant to Field Rates of Glufosinate. University of Arkansas Division of Agriculture. https://www.uaex.uada.edu/farm-ranch/pest-management/weed/weed-science-highlights-blog/glufosinate-resistant-pigweed.aspx

Bell, J.M., M. Maeda, M. Bragg, and D. Coker. 2022. Last Effective Cotton Flowering Date in the Texas Panhandle. Texas A&M AgriLife Extension. https://lubbock.tamu.edu/files/2022/09/Last-Effective-Cotton-Flowering-Date-in-the-Texas-Panhandle-SCSC-2022-07.pdf

Birk, J. 2025. Email communication regarding BASF benefits submission to USEPA. March 14, 2025.

Chism, B., Becker, J., Tindall, K., Orlowski, J., Kells, B., Wyatt, T.J. 2020. Dicamba Use on Genetically Modified Dicamba-Tolerant (DT) Cotton and Soybean: Incidents and Impacts to Users and Non-Users from Proposed Registrations. U.S. Environmental Protection Agency.

Crossingham, R. 2023. First confirmed case of dicamba-resistant waterhemp found in ND. Farm and Ranch Guide. https://agupdate.com/farmandranchguide/news/crop/first-confirmed-case-of-dicamba-resistant-waterhemp-found-in-nd/article_341d536c-fa5a-11ed-be33-7f345dbdf76a.html

Datta, A., H. Ullah, N. Tursun, T. Pornprom, S. Knezevic, and B.S. Chauhan. 2017. Managing Weeds Using Crop Competition in Soybean [Glycine Max (L.) Merr]. Crop Protection 95: 60-68. https://www.sciencedirect.com/science/article/pii/S0261219416302496#bib32

Everman, W. 2022. Weed Management in. North Carolina Soybean Production Guide. NC State Extension. https://content.ces.ncsu.edu/north-carolina-soybean-production-guide/soybean-weed-management

Farmers Business Network (FBN), 2025. Available at: https://www.fbn.com/direct/product/fieldgrip-vra-f1. Accessed April 2025.

Fernandez-Cornejo, J., S. Wechsler, M. Livingston, and L. Mitchell. 2014. Genetically Engineered Crops in the United States. United States Department of Agriculture Economic Research Service. Report number 162. https://www.ers.usda.gov/webdocs/publications/45179/43668_err162.pdf?v=719.3

Geist, L. 2022. Glufosinate-resistant Palmer amaranth found in Missouri Bootheel. University of Missouri Extension. https://extension.missouri.edu/news/glufosinate-resistant-palmer-amaranth-found-in-missouri-bootheel

Gianessi, L.P. 2013. The Increasing Importance of Herbicide in Worldwide Crop Production. Pest Management Science 69: 1099-1105. https://scijournals.onlinelibrary.wiley.com/doi/10.1002/ps.3598

Hamberg, R.C., Y. Ramawatar, R. Hartzler, and D.K. Owen. 2024. Confirmation of a four-way herbicide-resistant Palmer amaranth (Amaranthus palmeri) population in Iowa. Weed Science 72: 330-338. doi: 10.1017/wsc.2024.19

Hartzler, B. 2021. Will a dicamba-resistant waterhemp be resistant to 2,4-D (and vice versa)? Iowa State University. https://crops.extension.iastate.edu/post/will-dicamba-resistant-waterhemp-be-resistant-24-d-and-vice-versa

Heap, I. and S.O. Duke. 2017. Overview of glyphosate-resistant weeds worldwide. Pest Management Science: https://doi.org/10.1002/ps.4760

Holland, J. 2025. Down to the wire: How Close are Farmers to Endangered Species Act Compliance? American Soybean Association. https://soygrowers.com/news-releases/falling-short-how-close-are-farmers-to-endangered-species-act-compliance/

Ikley, J. 2023. Pigweed Awareness Coalition: Increasing the Awareness About the Risk of Palmer Amaranth and Waterhemp in North Dakota. North Dakota Soybean Council 2023 Research Report. https://ndsoybean.org/wp-content/uploads/2024/06/Ikley-Pigweed-Awareness-Coalition.pdf

Jones, E.A., J.C. Dunne, C.W. Cahoon, K.M. Jennings, R.G. Leon, W.J. Everman. 2024. Confirmation and inheritance of glufosinate resistance in an Amaranthus palmeri population in North Carolina. Plant Environ Interact. doi: 10.1002/pei3.10154

Klingman, T.E. and L.R. Oliver. 1994. Amaranth (Amaranthus palmeri) Interference in Soybeans (Glycine max) Weed Science 42: 523-527. https://www.jstor.org/stable/4045448?seq=1

Kynetec USA, Inc. 2024a. "The FarmTrak® Study from Kynetec USA, Inc." iMap Software. Database Subset: 2021-2023. Accessed March 2025.

Kynetec USA, Inc. 2024b. "The FarmTrak® Study from Kynetec USA, Inc." Microsoft Access Database. Database Subset: 2021-2023. Accessed March 2025.

Langemeier, 2023. 2023 Indiana Farm Custom Rates. https://ag.purdue.edu/commercialag/home/wp-content/uploads/2021/04/202303_Langemeier_2023IndianaFarmCustomRates.pdf

Lege, K.E. and B.M. McKnight. 2024. Commercially available cotton transgenic traits and associated seed brands. Texas A&M AgriLife Extension. https://lubbock.tamu.edu/files/2024/03/Cotton-Trait-Summary-SCSC202404.pdf

Licht, M and Z. Clemens. 2021. Corn and Soybean Planting Date Considerations. Iowa State University Extension and Outreach. https://crops.extension.iastate.edu/post/corn-and-soybean-planting-date-considerations

LMC International Ltd. 2023. The Economic Impact of U.S. Soybeans and End Products on the U.S. Economy – 2023 Update, Report for the United Soybean Board and National Oilseed Processors Association. August 2023. Available at https://www.nopa.org/wp-content/uploads/2023/08/0LMC_SoyEconStudy_Aug2023.pdf. Accessed April 2025.

Menne, M.J., I. Durre, B. Korzeniewski, S. McNeill, K. Thomas, X. Yin, S. Anthony, R. Ray, R.S. Vose, B.E.Gleason, and T.G. Houston. 2012: Global Historical Climatology Network - Daily (GHCN-Daily), Version 3. [Accessed April 2025].

Morgan, G.D., P.A. Baumann, and J.M. Chandler. Competitive Impact of Palmer Amaranth (Amaranthus Palmeri) on Cotton (Gossypium hirsutum) Development and Yield. Weed Tech. 15: 408-412. https://www.jstor.org/stable/3988958

National Cotton Council. 2025. Properties of the Growing Regions, Cotton Production regions – Properties of the Growing Regions. Available at: https://www.cottoninc.com/cotton-production/quality/us-cotton-fiber-chart/properties-of-the-growing-regions/.

National Cotton Council. 2023. 2023 United States Cotton Production. Available at: https://www.cotton.org/econ/cropinfo/production/upload/2023-cotton-production-map.pdf

Orlowski, J. B. Kells. 2020a. Assessment of the Benefits of Dicamba Use in Genetically Modified, Dicamba-Tolerant Cotton Production. Biological and Economic Analysis Division. Available at: https://www.regulations.gov/document/EPA-HQ-OPP-2020-0492-0005

Orlowski, J. B. Kells. 2020b. Assessment of the Benefits of Dicamba Use in Genetically Modified, Dicamba-Tolerant Soybean Production. Biological and Economic Analysis Division. Available at: https://www.regulations.gov/document/EPA-HQ-OPP-2020-0492-0004

Orlowski, J. and B. Kells. 2022. Use, Usage, and Current and Future Benefits of Enlist One and Enlist Duo Herbicides in Corn, Soybean, Cotton. Biological and Economic Analysis Division. Available at: https://www.regulations.gov/document/EPA-HQ-OPP-2021-0957-0010

Palmer, E. 2025. Tavium Plus VaporGrip Technology Herbicide Benefits Overview. Syngenta Crop Protection. Benefits Submission to USEPA.

Peterson, D., M. Jugulam, C. Shyam, and E. Borgato. 2019. Palmer amaranth resistance to 2,4-D and dicamba confirmed in Kansas. Kansas State Agronomy eUpdates March 1, 30 2019. https://webapp.agron.ksu.edu/agr_social/eu_article.throck?article_id=2110

Quinn, L. 2021. First dicamba-resistant waterhemp reported in Illinois. University of Illinois College of Agricultural, Consumer, and Environmental Sciences. https://aces.illinois.edu/news/first-dicamba-resistant-waterhemp-reported-illinois

Rowe, A. 2018. Evolution of soybean weed management in the United States. Iowa State University.https://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=1060&context=creativecomponents

Seymour, C. 2024. Sprayer Upgrade Kits: Technology, Options, and Pricing. Successful Farming. https://www.agriculture.com/sprayer-upgrade-kits-technology-options-and-pricing-8599615

Shaner, D.(ed). 2014. Herbicide Handbook. Weed Science Society of America

Singh, N., D. Sarangi, R. Miller, T. Peters, and S. Naeve. 2023. Multiple herbicide-resistant waterhemp is spreading rapidly across Minnesota. Minnesota Crop News. https://blog-crop-news.extension.umn.edu/2023/06/multiple-herbicide-resistant-waterhemp.html

Singletary, M.M., P.A. Dotray, L. Steckel, G. Morgan, M.C. Woolard, and B. Rodriguez. 2025. Strategies for Controlling Dicamba-Resistant Palmer amaranth in Texas. Texas A&M Agrilife Extension. https://lubbock.tamu.edu/files/2025/02/Feb-12-1005-1025-M-Mill-Singletary-2025_SW-Cotton-Physiology-Conference_MMS.pdf

Steckel, L. 2005. Mature Pigweed Identification. University of Tennessee Extension W072. https://utia.tennessee.edu/publications/wp-content/uploads/sites/269/2023/10/W072.pdf

Steckel, L. 2020a. Dicamba-resistant Palmer amaranth in Tennessee: Stewardship even more important. University of Tennessee Extension. July 7, 2020. https://news.utcrops.com/2020/07/dicamba-resistant-palmer-amaranth-in-tennessee-stewardship-even-more-important/

Steckel, L. 2020b. Strategies to address Palmer amaranth, junglerice and goosegrass Escapes from Follow-up Applications in Xtend and Enlist Crops. July 7, 2020. https://news.utcrops.com/2020/07/strategies-to-address-palmer-amaranth-junglerice-and-goosegrass-escapes-from-follow-up-applications-in-xtend-and-enlist-crops/#more-19506

Steckel, L. and C. Perkins. 2020. Concerns About Poor Palmer Amaranth Control with Dicamba. June 30th, 2020. Accessed online on June 30th, 2020. https://news.utcrops.com/2020/06/concerns-about-poor-palmer-amaranth-control-with-dicamba/

Steckel, L. 2023. Multiple-herbicide Resistant Palmer amaranth in Tennessee. University of Tennessee Extension. https://news.utcrops.com/2023/10/multiple-herbicide-resistant-waterhemp-in-tennessee/

Tindall, K. 2019. Review of Benefits and a Resistant Management Plant for a New Premix Herbicide Product, Dicamba (diglycolamine salt) + s-Metolachlor, for Use on Dicamba-Tolerant Cotton and Soybean (PC# 0128931 and 108800, DP# 450536 & 450508).

Toscano, A. 2024. Benefits of Dicamba Formulations For Use on Dicamba Tolerant Crops. Bayer Crop Science. Benefits Submission to USEPA.

University of Arkansas. Undated. Arkansas Soybean Handbook. Chapter 16-Early Soybean Production System. https://www.uaex.uada.edu/publications/pdf/mp197/mp197fullpub.pdf

University of Arkansas. 2025. Estimated Farm Machinery Costs per Acre. Available at: https://www.uaex.uada.edu/farm-ranch/economics-marketing/farm-planning/budgets/crop-budgets.aspx. Accessed June 2025.

University of Georgia, 2025. Dryland Cotton budget, see PreHarvest tab for cost of implements and tractors. https://agecon.uga.edu/extension/budgets.html. Accessed June 2025.

University of Tennessee. Undated. Bt. Cotton. University of Tennessee Crops. https://utcrops.com/cotton/insects-and-mites/biological-control/bt-cotton/

US Environmental Protection Agency (EPA). 2018. Over-The-Top Dicamba Products For Genetically Modified Cotton and Soybeans: Benefits and Impacts. https://www.regulations.gov/document?D=EPA-HQ-OPP-2016-0187-0966

US Environmental Protection Agency (EPA). 2024a. Herbicide Strategy to Reduce Exposure of Federally Listed Endangered and Threatened Species and Designated Critical Habitats from the Use of Conventional Agricultural Herbicides. Available at: https://www.regulations.gov/document/EPA-HQ-OPP-2023-0365-1137.

US Environmental Protection Agency (EPA). 2024b. Action Plan to Reduce Exposure of Vulnerable Federally Listed Endangered and Threatened Species from the Use of Conventional Pesticides. Available at: https://www.regulations.gov/document/EPA-HQ-OPP-2023-0327-0208

US Environmental Protection Agency (EPA). 2024c. Application of EPA's Runoff and Erosion and Spray Drift Mitigations Through Scenarios that Represent Crop Production Systems in Support of Endangered Species Strategies. Published August 20, 2024. Available at: https://www.regulations.gov/document/EPA-HQ-OPP-2023-0365-1139. Accessed January 2025.

USDA ERS. 2025a. Cotton and wool. Updated 3/7/25, Contacts listed are Leslie Meyer and Taylor Dew. Available at: https://www.ers.usda.gov/topics/crops/cotton-and-wool. Accessed April 2025.

USDA ERS. 2025b. Soybean and oil crops. Available at: https://www.ers.usda.gov/topics/crops/soybeans-and-oil-crops. Accessed April 2025.

USDA ERS. 2024a. Commodity Costs and Returns, 2023 Recent Costs and Returns for Cotton (Base Survey 2018). Economic Research Service, U.S. Department of Agriculture. Last Updated 10/1/2024. Available at: https://www.ers.usda.gov/data-products/commodity-costs-and-returns . Accessed April 2025.

USDA ERS. 2024b. Commodity Costs and Returns, 2023 Recent Costs and Returns for Soybeans (Base Survey 2018). Economic Research Service, U.S. Department of Agriculture. Last Updated 10/1/2024. Available at: https://www.ers.usda.gov/data-products/commodity-costs-and-returns. Accessed April 2025.

USDA ERS. 2000. Farm resource production regions. Available at: https://www.ers.usda.gov/publications/pub-details?pubid=42299. Accessed April 2025.

USDA National Agricultural Statistics Service (NASS) 2025a. Cotton production annual survey data – acreage, production (lbs and bales) value in $ and Soybean production data – acreage, production (lbs and bushels) value in $. Averaged years 2021-2023. Available at: https://quickstats.nass.usda.gov/. Accessed March 2025.

USDA National Agricultural Statistics Service (NASS). 2025b. Crop Progress and Condition reports. Washington, DC: USDA NASS.

Wiesemeyer, J. 2023. Is Corteva Now Beating Out Bayer? Company's Market Share Surges On Soybeans. Ag Web. Farm Journal. https://www.agweb.com/news/business/taxes-and-finance/corteva-now-beating-out-bayer-companys-market-share-surges-soybeans

Yourman, L. and B. Chism. 2016. Review of Benefits as Described by the Registrant of Dicamba Herbicide for Postemergence Applications to Soybean and Cotton *and* Addendum Review of the Resistance Management Plan as Described by the Registrant of Dicamba Herbicide for Use on Genetically Modified Soybean and Cotton. U.S. Environmental Protection Agency.

## APPENDIX

**Appendix 1. Percentage of consecutive 48-hour temperatures per week by temperature and location, 1995-2024.**

| Location | Month[a] | Week of Year[b] | <75°F | ≥75-84°F | ≥85-94°F | ≥95°F |
|---|---|---|---|---|---|---|
| Webster Co., IA | April | 14 | 92% | 8% | 0% | 0% |
| | | 15 | 86% | 13% | 0% | 0% |
| | | 16 | 88% | 10% | 1% | 0% |
| | | 17 | 90% | 8% | 1% | 0% |
| | May | 18 | 83% | 15% | 2% | 0% |
| | | 19 | 66% | 30% | 3% | 0% |
| | | 20 | 60% | 32% | 8% | 0% |
| | | 21 | 56% | 36% | 9% | 0% |
| | | 22 | 37% | 49% | 13% | 1% |
| | June | 23 | 31% | 47% | 21% | 1% |
| | | 24 | 23% | 46% | 30% | 1% |
| | | 25 | 13% | 57% | 30% | 0% |
| | | 26 | 10% | 60% | 29% | 0% |
| | | 27 | 10% | 59% | 30% | 2% |
| | July | 28 | 4% | 58% | 36% | 2% |
| | | 29 | 4% | 44% | 48% | 4% |
| | | 30 | 4% | 61% | 31% | 3% |
| | | 31 | 3% | 70% | 27% | 1% |
| Mississippi Co., AR | April | 14 | 63% | 30% | 2% | 0% |
| | | 15 | 58% | 32% | 7% | 0% |
| | | 16 | 47% | 41% | 8% | 0% |
| | | 17 | 47% | 45% | 5% | 0% |
| | May | 18 | 40% | 43% | 13% | 0% |

| Location | Month[a] | Week of Year[b] | <75°F | ≥75-84°F | ≥85-94°F | ≥95°F |
|---|---|---|---|---|---|---|
| | | 19 | 20% | 45% | 30% | 1% |
| | | 20 | 23% | 41% | 32% | 1% |
| | | 21 | 11% | 39% | 42% | 4% |
| | | 22 | 2% | 38% | 50% | 6% |
| | June | 23 | 5% | 31% | 50% | 11% |
| | | 24 | 2% | 24% | 50% | 20% |
| | | 25 | 0% | 17% | 58% | 21% |
| | | 26 | 0% | 17% | 52% | 27% |
| | | 27 | 0% | 17% | 55% | 24% |
| | July | 28 | 0% | 11% | 64% | 24% |
| | | 29 | 0% | 13% | 52% | 35% |
| | | 30 | 0% | 21% | 52% | 25% |
| | | 31 | 0% | 21% | 53% | 26% |
| Lubbock Co., TX | April | 14 | 44% | 40% | 16% | 0% |
| | | 15 | 49% | 32% | 19% | 0% |
| | | 16 | 40% | 35% | 24% | 0% |
| | | 17 | 33% | 42% | 22% | 3% |
| | May | 18 | 27% | 32% | 27% | 13% |
| | | 19 | 20% | 39% | 27% | 15% |
| | | 20 | 14% | 36% | 34% | 16% |
| | | 21 | 12% | 29% | 34% | 25% |
| | | 22 | 6% | 31% | 40% | 23% |
| | June | 23 | 3% | 19% | 42% | 35% |
| | | 24 | 1% | 20% | 33% | 46% |
| | | 25 | 0% | 10% | 43% | 46% |
| | | 26 | 2% | 16% | 37% | 45% |
| | | 27 | 0% | 12% | 47% | 40% |
| | July | 28 | 0% | 6% | 43% | 50% |
| | | 29 | 0% | 6% | 37% | 57% |
| | | 30 | 1% | 4% | 35% | 60% |
| | | 31 | 1% | 7% | 36% | 56% |

[a] The month associated with each week of the year varies based on which day of the week the month starts.
[b] Each week of the year begins on Sunday and ends on Saturday.