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Dicamba: Past, present, and future

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Dicamba has been an important component of Iowa weed management systems for more than 50 years. The history of its use is somewhat unique in that its popularity has ebbed and flowed over time. The increase in herbicide resistant weeds combined with the introduction of dicamba-resistant soybean (Xtend) promises a large increase in dicamba use in both corn and soybean. This article will review the characteristics of dicamba that differentiate it from other herbicides, provide an overview of problems observed in 2017, and describe how risks can be minimized in 2018.

Introduction

The discovery of 2,4-D and other phenoxy herbicides in the 1940's initiated the ea of chemical weed management. These herbicides mimic the action of auxin, indoleacetic acid), and are frequently referred to as growth regulator herbicides, synthetic auxins, or Group 4 herbicides. They bind to the receptor for auxin, therefore initiating transcription of genes involved in cell growth. Whereas plants can closely regulate concentrations of auxin within cells, they lack this ability with the synthetic auxin herbicides. Presence of Group 4 herbicides in cells results in deregulation of numerous important processes, resulting in abnormal growth and/or plant death. Three distinct chemical families have been discovered that interfere with auxin activity (Table 1).

Table 1. Chemical families that interfere with auxin activity (Group 4 herbicides).

Chemical family	Active ingredient	Tradename
Phenoxy	2,4-D	Weedone, many others
	2,4-DB	Butyrac, many others
	MCPA	Mecoprop, many others
Benzoic acids	dicamba	Banvel, Clarity, Sterling Blue, Engenia, Xtendimax with VaporGrip Technology, many others
	chloramben	Amiben
Carboxylic acids / Pyridines	triclopyr	Garlon, Remedy Ultra, many others
	aminopyralid	Milestone
	clopyralid	Stinger, Transline
	picloram	Tordon
	aminocyclopyrachlor	Streamline

Nearly all Group 4 herbicides selectively control broadleaves in grass crops. The exception is quinclorac which is used to control certain weedy grasses in rice and turf. There is a wide range in selectivity among the products, and they are commonly used in combination to provide a broader spectrum of weed control. A combination of 2,4-D and dicamba was the most popular postemergence program in Iowa corn production in the 1970's and early 1980's. The products vary widely in soil persistence, and hence, length of residual control. Generally, the phenoxy herbicides have the shortest half-lives of the Group 4 herbicides, whereas the pyridines are most persistent. An advantage of dicamba over 2,4-D for use in resistant soybean is its greater residual activity; however, the residual control provided by dicamba is less than half of most other preemergence herbicides. Thus, the value of dicamba as a preemergence herbicide is limited for managing waterhemp and other weeds with prolonged emergence patterns.

Plant sensitivity

Group 4 herbicides induce plant responses at lower fractions of use rates than most other herbicides. For example, it takes 1% of the glyphosate use rate (0.75 lb/A) to injure corn, whereas 0.005% of the dicamba rate (0.5 lb/A) can injure soybean (Figure 1). Due to this high activity, injury to sensitive plants outside of treated areas has been a problem since the introduction of Group 4 herbicides. Improvements in application technology have reduced, but not eliminated, problems with off-target movement of the Group 4 herbicides.

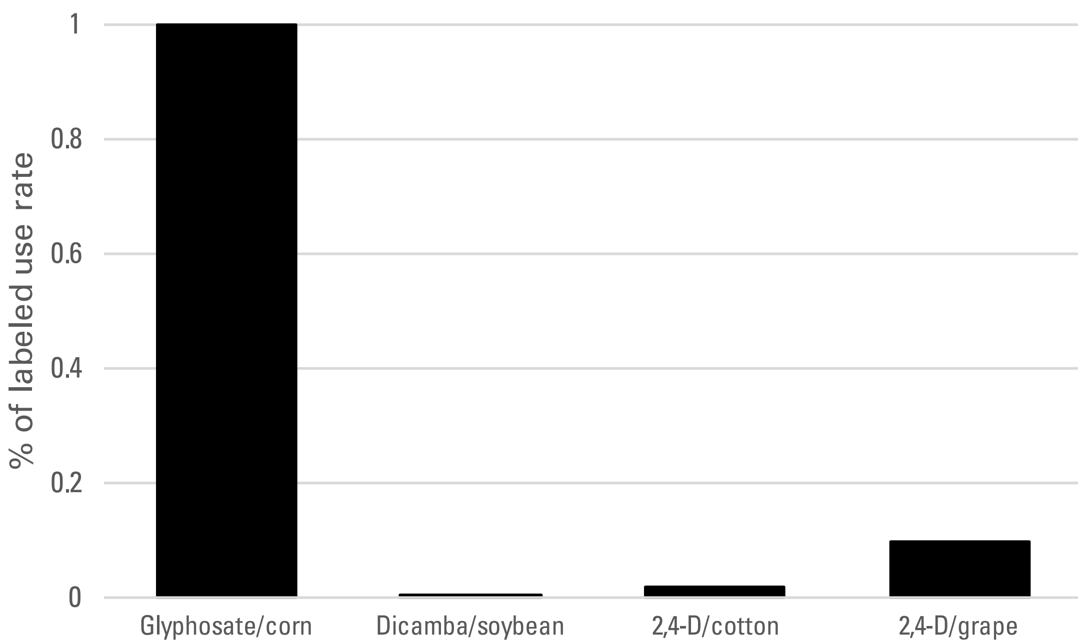

Figure 1. Fraction of labeled rate required to cause visible injury on susceptible species. Adapted from Bhatti et al. (1996), Ellis et al. (2003), Everitt and Keeling (2009), and Solomon and Bradley (2014).

Volatility

Another distinguishing characteristic of dicamba and certain other Group 4 products is their relatively high vapor pressure. Herbicides with high vapor pressures may evaporate following application, resulting in off-target movement even when the applicator uses appropriate application practices. The combination of vapor loss and the high sensitivity of certain plant species to dicamba results in a higher risk of off-target injury than with most other herbicides. The following factors influence the potential for dicamba volatilization following application.

Temperature

The potential for dicamba to volatilize increases as temperature increases (Figure 2). A threshold of 85° F is frequently cited as the temperature where caution should be used when applying dicamba in the vicinity of sensitive vegetation.

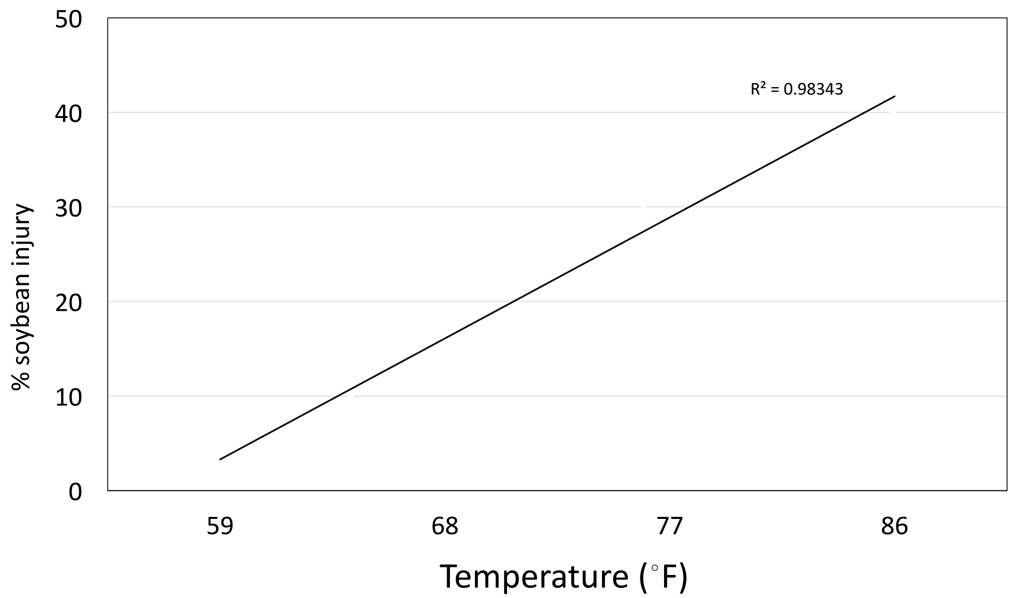

Figure 2. Influence of temperature on soybean injury associated with dicamba volatilizing from corn leaves in growth chamber experiments. Adapted from Behrens and Lueschen, 1979.

Application surface

The amount of dicamba that evaporates varies depending on the characteristic of the surface it lands upon. Behrens and Leuschen (1979) reported that approximately 35% more dicamba volatilized off corn and soybean leaves than from a silt loam soil. Thus, there is greater risk of volatilization with postemergence applications when significant herbicide is intercepted by the crop rather than the soil surface.

Formulation

The vapor pressure of herbicides can be influenced by their formulation. Amine salts of 2,4-D have a sufficiently low vapor pressure that volatility is not an issue under typical application conditions. Thus, volatilization should not be a problem with the choline salt of 2,4-D present in Enlist products. Numerous formulations of dicamba have been introduced with the intention of reducing the risk of volatilization. The parent acid of dicamba has a much higher vapor pressure than the salts used in commercial formulations. Xtendimax with Vapor Grip Technology and Engenia reduce the likelihood of the dicamba salt disassociating to the parent acid compared to older formulations during and after application. Independent research has verified these formulations reduce volatilization compared to older dicamba formulations (e.g. Banvel, Clarity), but they do not eliminate these losses.

The 2017 Iowa experience

The Iowa Department of Agriculture and Land Stewardship (IDALS) received 271 pesticide misuse complaints in 2017, a record number. This increase was largely due to 107 off-target injury complaints associated with dicamba applications. The number of formal complaints to IDALS is a small fraction of total problems associated with pesticide application. At the time this article was written IDALS had not released the breakdown on the percentage of complaints associated with contaminated spray equipment, particle drift, and volatilization. Most people involved in investigating dicamba complaints acknowledge that all three avenues of dicamba exposure were involved with off-target injury. Problems associated with contaminated spray equipment and particle drift can be minimized through better training and improved decision making; however, risks associated with volatilization are not easily managed since vapor movement is determined by the environment following application rather than actions of the applicator.

Moving forward in 2018

There has been considerable debate on how to reduce off-target movement associated with dicamba use in soybean. The United States Environmental Protection Agency (EPA) introduced several important label changes for dicamba products registered for use on dicamba-resistant soybean. These products are now classified as Restricted Use Products (RUPs). This classification will require all users of the products to be certified applicators and maintain detailed records of all applications. In addition, applicators of the products will be required to complete dicamba-specific training prior to use. The maximum wind speed allowed for applications was reduced from 15 MPH to 10 MPH, and applications are limited to hours between sunrise and sunset. Label language regarding sprayer cleanout and susceptible crops has been expanded. These label changes are appropriate to improve recordkeeping and should reduce problems associated with particle drift and sprayer contamination, but they do not address the issue of off-target movement associated with dicamba volatilization.

Independent research and field observations indicate that that the new formulations have not reduced dicamba volatility sufficiently to prevent movement of phytotoxic concentrations of dicamba outside of treated soybean fields. Dicamba has long been used postemergence in corn with what is considered an acceptable level of risk. The following factors differentiate postemergence use in soybean from that in corn: 1) The peak postemergence application timeframe in soybean is mid-June, whereas in corn it is mid-May. This results in higher temperatures at application, increasing the potential for volatilization. 2) Soybean typically are sprayed at stages with more canopy development than corn, resulting in soybean foliage intercepting a greater percentage of the herbicide. Since more dicamba volatilizes from leaves than soil, there is greater risk of volatility with postemergence applications in soybean than in corn. 3) Non-dicamba resistant soybean will be at developmental stages more prone to yield impacts when dicamba is applied postemergence in soybean than when used in corn. It is important to recognize that soybean are not the only sensitive plants in the Iowa landscape. While most plants are not as sensitive to dicamba as soybean, the increase in postemergence applications in soybean will lead to greater risk to non-agricultural plants (e.g. trees, gardens).

The EPA held several teleconferences with academic weed scientists and state regulatory officials during the summer of 2017 to discuss problems with off-target dicamba injury. Most participants agreed limits to how late in the growing season applications could be made were needed to reduce these problems. Persons from the south preferred a date restriction due to a prolonged planting period, whereas persons from northern production regions believed limiting soybean applications to either preplant and preemergence applications would be easier to manage and more effective at limiting off-target injury.

The changes in the dicamba labels introduced by EPA in October, 2017 fail to address risks associated with volatilization. Due to concerns regarding volatilization of dicamba, ISU Weed Science is recommending that dicamba only be used preplant or preemergence when used in dicamba-resistant soybean. While preemergence applications reduce the value of dicamba in managing herbicide-resistant waterhemp, in our opinion the risks associated with postemergence applications exceed the weed management benefits.

Early postemergence applications in soybean have lower risks than applications made later in the season. However, relying on early post-applications puts applicators under pressure due to limited hours suitable for spraying. During a four-year period, half of the days during the last week of May had zero hours suitable for spraying when considering both wind speed and rain (Figure 3). While spraying conditions are more favorable in mid-June, average temperatures are higher, therefore increasing the potential for volatilization. The daily high temperature exceeded 85° F during 22 of the 28 days used in creating the box plots. It is likely that many applications targeted for early in the growing season would be delayed due to weather, resulting in them being made in a time-frame with a much greater likelihood of volatilization losses due to higher temperatures and larger crop canopies. This is our rationale for recommending only preemergence applications in soybean.

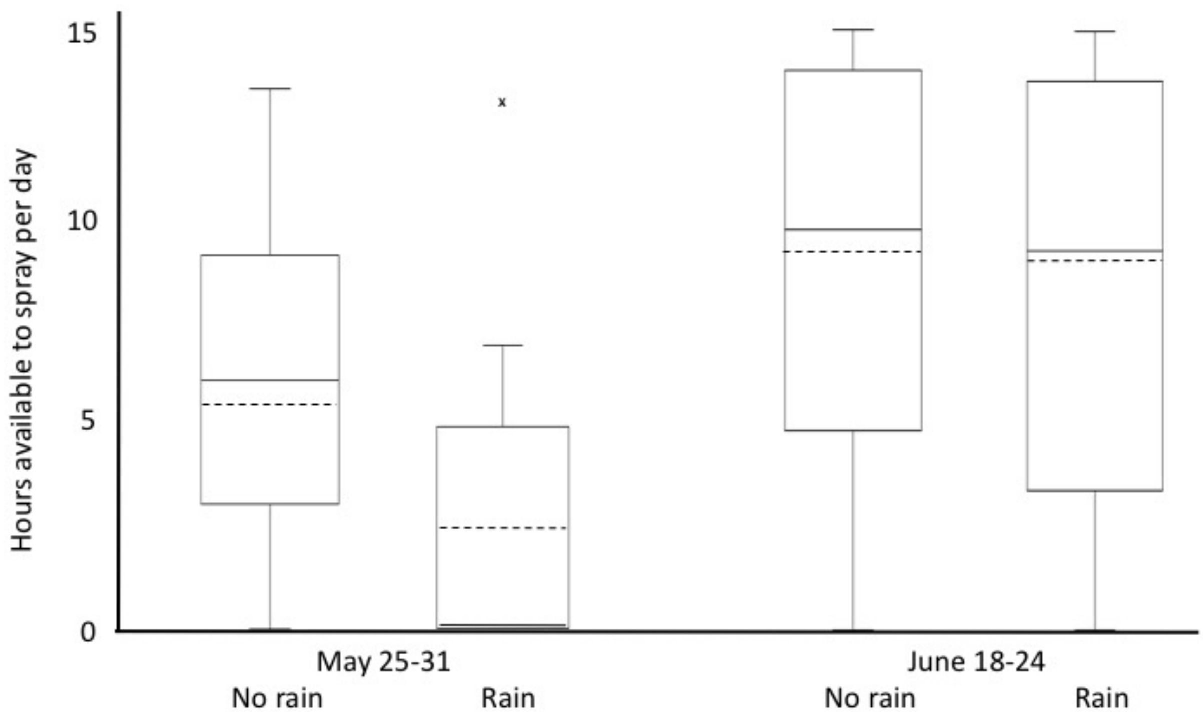

Figure 3. Hours available to spray during daylight when average wind speed is greater than 3 MPH and less than 10 MPH. Data from four years at the ISU Research Farm near Boone Iowa was used, providing 28 data points per plot. The box represents 2nd and 3rd quartiles, the horizontal solid and dashed line within the box represent median and average hours per day, respectively. The whiskers represent the maximum and minimum values. 'x' represents an outlier data point. No rain only considers wind speed, whereas rain considered both wind speed and rainfall in determining available hours.

The rapid increase of multiple herbicide resistant biotypes in waterhemp and other weeds continues to complicate and increase the cost of weed management for Iowa farmers. It is widely recognized that new tools are needed to manage these weed problems. New herbicide options, such as those provided with new herbicide resistant crops (e.g. Xtend, Enlist, Balance GT) will provide some relief from these pressures, however, they require stewardship to be used safely and to sustain their effectiveness. Long-term solutions to herbicide resistance will require diversifying current weed management programs beyond simply modifying herbicide use pattern.

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