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Synthetic Auxin Herbicide Injury in Cotton

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Introduction

Synthetic Auxin herbicides, often referred to as Phenoxy class herbicides, have been in use since the 1940's for post-emergent control of broadleaf weed species. The use of 2,4-D has increased in recent decades as a result of new uses being developed, an increase in herbicide resistant weeds and the loss of 2,4,5-T in the early 80's. Today they play an important role in controlling weed growth in various horticultural and rangeland systems and are a useful tool in many forage and food cropping systems including corn, small grain and rice production systems. They are considered relatively safe, inexpensive and effective weed control agents and when properly applied can provide the desired control level required to help manage a fairly large spectrum of difficult to manage broadleaf weed populations.

Plant terminal effected approximately 9 days after application at 11 node stage. "Strapping" of new growth, with older leaves showing few or no symptoms.

Auxin-type herbicides have also been scrutinized for their ability to damage non-target crops at low concentrations. To help protect important sensitive crops, many states and counties limit the use of these herbicides, particularly when sensitive crops are actively growing. Depending on the local crop mix and environmental conditions, synthetic auxin herbicide use has been banned or highly restricted due primarily to crop injury concerns. Additional restrictions including the use of less volatile formulations, limiting aerial and ground applications when inversion layers are present, the use of hooded or shielded sprayers, the use of drift reducing nozzles or spray drift agents and requiring applications be made under favorable environmental conditions are also safeguards used to limit unintentional offsite movement (or spray drift). There are 11 auxin-type inhibitors and two auxin transport inhibitors that make up the active ingredients in the US market, but only a few of them are registered in California, Table 1.

Sensitivity in Crops

In recent years additional restrictions have been placed on the use of synthetic auxin and other herbicides as a consequence of drift damage not previously experienced. With the increased acreage of permanent crops in western Fresno and Kings Counties for example, there has been an increase in late winter crop damage caused by synthetic auxin's and other herbicide classes. Recent attempts have been made to further limit potential damage to economic crops resulting in further applications restrictions by some counties.

Typical range of 2, 4 –D leaf symptoms observed with highly impacted leaves on the far left and low impact of far right.

Cotton and grapevines are considered to be among the most sensitive crops to the synthetic auxin class of materials, however other crops such as tomatoes, many tree crops, nursery crops and other winter planted vegetable crops can be injured. Because of its hormone-like characteristics, this class of compounds can cause injury at very low concentrations in sensitive crops. Oftentimes synthetic auxin injury is not enough to kill sensitive crops such as cotton, but can cause varying degrees of injury including delayed maturity and reduced productivity.

Table 1. Synthetic auxin herbicide families used in California agriculture include the phenoxy acetic acids.

Synthetic auxin herbicides by common and trade name	
Herbicide family - Benzoic Acids	
dicamba	Banvel, Clarity, others
Herbicide family - Phenoxy acetic acids	
2,4-D	2,4-D Amine, Weedar, Weedone, others
2,4-DB	Butyrac, Butoxonem, others
MCPA	MCPA Amine
MCPP (mecoprop)	Mecoprop-P, Target, others
Herbicide family - Pyridine carboxylic acids	
aminopyralid	Milestone
clopyralid	Transline, Stinger
picloram	Tordon
triclopyr	Garlon, Grandstand, Remedy, others

"Oftentimes synthetic auxin injury is not enough to kill sensitive crops such as cotton, but can cause varying degrees of injury including delayed maturity and reduced productivity."

Cotton's Sensitivity and Symptoms

Upland cotton *Gossypium hirsutum L.* and Pima cotton *Gossypium barbadense* varieties have shown dramatic impacts to relatively low concentrations of 2,4-D, dicamba and other auxin-type herbicides. Visual symptoms are first observed near plant meristems where the active growth of vegetative and fruiting structures is occurring. The damage typically noted can be seen in newly formed leaves and fruiting bodies with little or no damage occurring to mature plant structures such as older leaves or developed bolls. New plant growth often shows signs of "leaf strapping" or "leaf frogging" which results from a limitation of interveinal leaf tissue growth. At higher exposure levels, a general malformation of newly formed squares and bolls appears when exposure occurs near or after squaring begins.

Low concentration exposures tend to impact developing leaves but have little impact on square growth and development.

Reddening of plant stems, petioles and bracts is also common to injured cotton and leaf or square yellowing may also be present. Plant terminal damage or death can result at very high exposure concentrations giving rise to a candelabra effect from later vegetative branch growth producing most of the fruit. Root initiation can be reduced and stem swelling can be noticeable in younger plants exposed to higher concentrations.

Most of the literature on auxinic injury in cotton points to an increased potential for injury with 2,4-D exposure compared to other chemistry's within the class and it has been shown that some cultivars are more sensitive than others. It should also be noted that while there is local experience with 2,4-D herbicide injury in Pima cotton, much of the research conducted on exposure is limited to Upland cotton types.

Environmental Conditions

High Winds-
Generally considered as having the greatest potential for off-site movement, windy conditions have the ability to move herbicides many miles downwind potentially causing exposure to sensitive crops. California and county Department of Agriculture regulations restrict the application of restricted herbicides to speeds below 10 MPH and in some cases, less than 7 MPH. Frequent monitoring of wind speeds is also required by the applicator. High temperature, conditions also increase the potential for offsite herbicidel movement.

Inversion layers-
Occasionally low wind climatic conditions exist resulting in low level exposure due to unstable air masses known as inversion layers. Off-site movement of herbicides can occur over great distances when these unstable masses are present. San Joaquin Valley winter inversions are particularly problematic since the inversion can occur at as little as 500 feet above the ground surface blocking the air masses ability to transport, mix and dilute contaminants. Inversions are less likely to form when wind speeds are above 2 to 3 MPH.

Cotton Growth and Production Impacts

Cotton yield impacts from auxin herbicide injury vary depending on the level of exposure, timing of application, cultivar planted and the crop management practices that have occurred prior to and following exposure. Previous weed management research has evaluated a number of Upland cotton varieties over a wide range of environmental conditions and exposure levels. These studies have worked to observe a range of crop growth, yield and quality impacts following experimental treatments intended to simulate spray drift or tank contamination effects on plant development, yield and quality.

Studies have shown yield impacts range from no measurable yield loss, to severe yield loss that can be linked to the timing and degree of the exposure. Exposure occurring during early to peak bloom periods has generally shown the greatest impact on yield whereas exposure at early square and late bloom will give rise to more uncertain impacts on yield. How the crop is treated following exposure at early stages is critical to ultimate yield impact.

Exposure at early square- Because of the effect 2,4-D has on cell division and elongation, the most dramatic visual impacts come from young plants that are rapidly expanding their canopies and increasing the number of squares. Visual symptoms appear quickly following exposure impacting leaf and square appearance at relatively low concentrations. Expect some square loss that may persist depending on severity of exposure. At low 2,4-D exposure levels, plants may begin to recover from injury symptoms two to four weeks after exposure. At moderate exposure levels, plants may recover after four weeks before more normal vegetative and fruit growth resumes. At high exposure levels expect delays of more than four weeks and in some cases may not show more normal vegetative and fruit growth before the season ends.

Drift mitigation practices:

- Use drift reducing agents and safe formulations to reduce the number of small droplets and material volatility that leads to off-site movement.
- Use drift reducing spray nozzles at pressures that produce larger spray droplets and are less likely to drift.
- Use spray shields when practical.
- Eliminating applications during windy conditions is crucial and wind speed should be monitored regularly during applications.
- Avoiding applications when atmospheric inversions exist. These conditions are most likely to form later in the day or during the evening and coincide with very low wind speeds that inhibit air mixing conditions.
- Where sensitive winter crops have emerged or permanent crops are no longer dormant, limit the dates of application to pre-emergent and pre-bud swell stages of growth.
- Restrict aerial applications dates, conditions and equipment specifications that could lead to low efficacy applications.

Cotton Growth — cont.

Exposure during effective flower- This is considered one of the most sensitive stages for exposure due to the rapid growth and development of plant canopy and young undifferentiated flowers and bolls. Because of the intense activity of cell division and expansion, exposure to the synthetics auxins will keep newly formed floral buds from fully developing, flowering structures from properly pollinating and seed ovules from developing normally. Significant exposure during this period can also be long-lived and remain in the plant for several weeks before more normal growth habit resumes. One major consequence of exposure at this stage is the loss in earliness and therefore the time required for cotton bolls to set, grow and mature. Post boil set exposures have been shown to have the least impact on cotton.

Low dose exposure showing initial signs of terminal growth normalization approximately 20 days after exposure.

Delayed crop maturity is a common outcome with early and mid-season exposure to 2,4-D. Because of the deformation of leaves and fruit, canopy development is delayed as well as the plants ability to capture sunlight through photosynthesis. This delayed canopy growth when coupled with the loss of existing and future squares translates to a significant delay in the development of bolls. Whether there will be a yield impact or not will depend in part on the amount of season remaining and if there is time for the plant to compensate by retaining an additional boll set later in the season. Much of the compensation will take place primarily on vegetative (Monopodial) branches and secondarily on second and third position fruit being set on the main stem fruiting branches produced after herbicide exposure.

Crop Management Following Herbicide Injury

The movement and translocation of 2,4-D in cotton has been found to be enhanced by increased water availability. Studies have also demonstrated a connection between temperature and humidity in the translocation of herbicides in the plant. Though there are no clear recommendations for how to specifically manage cotton following injury the available evidence suggests that increasing water availability to the crop can prolong the occurrence of injury symptoms. On the other hand, increasing water stress to the point that yield will be affected is also not desired. Another consideration at early square exposures is the fact that with reduced rates of plant growth, crop ET will remain fairly constant and not increase significantly until more normalized growth habits resume. With this in mind, there appears to be no good reason for long irrigation delays following early season exposures.

Perhaps the most difficult period for the grower following exposure is the time it takes to resume normal growth of leaves and fruit. The greater the exposure, the longer it will take to begin seeing normalized growth and the greater the delays in crop maturity and yield loss. When season length is compromised as a consequence of exposure, delay making dramatic

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Herbicide Injury — Continued

management changes until injury symptoms subside and normal growth rates resume. Responding prematurely can further delay crop maturity or have other undesired effects.

Prevention and Safe Application Practices

Primary mechanisms for impacts on non-target areas include accidental direct application, spray drift, spray tank contamination or other misapplication. For more information on protecting your cotton from the most common type of contamination (the spray rig), see UCCE's cotton website publication "Avoiding problems with 2,4-D injury to cotton". Several tools are available that when used properly, will help minimize risk of spray drift or other offsite herbicide movement and help protect sensitive crops. Key to any prevention plan is the knowledge and proper adoption of application practices outlined by the Department of Agriculture's permit conditions at both the state and county levels. Consult your local Agricultural Commissioner's office code restrictions and conditions prior to applying for a Notice of Intent.

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