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Dicrotophos Use In Arizona

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Summary
Dicrotophos is an important compound with a very specific role in Arizona. It is used on just one crop, cotton, and almost exclusively for the control of the brown stink bug, Euschistus servus*, even though it can provide collateral, partial control of Lygus (*Lygus hesperus*) and as a synergist to pyrethroids in the control of whiteflies (*Bemisia tabaci*). At least in part because of the specific requirements for its use, our growers use dicrotophos only sparingly but very strategically. No more than 12% of our cotton acreage was sprayed with dicrotophos in 2013 (<20,000 acres). The Arizona cotton system has invested repeatedly in a progressive IPM plan that has largely replaced broadly toxic pyrethroids, organophosphates, carbamates and endosulfan, with safer, more environmentally friendly, reduced risk, and more selective controls. However, there are no equivalent products for stink bug control in cotton. In fact there are very few viable options for stink bug control in Arizona, throughout the U.S. and worldwide. As such, dicrotophos is a tool critical to the economic success of our growers. Furthermore, we are concerned that without efficient stink bug controls in cotton, our industry may become vulnerable to the environmental natural toxin, alfatoxin, due to elevated boll infection by Aspergillus flavus, which exploits stink bug feeding behavior to gain entry to cotton bolls. Dicrotophos was used safely in Arizona cotton for decades before the state label was not renewed in the 1980s by the registrant. In 2013, AMVAC pursued and was granted the state label for Bidrin® starting in 2013, after an outbreak of brown stink bugs in 2012. Arizona's concerns revolve around the continued availability for the safe usage of dicrotophos in the cotton system. We wish to see the excessive re-entry interval reduced from 6 days to no longer than 72 hrs, which is more appropriate for the residual dynamics of this chemistry. The 6 d REI is just one of the limitations on its use by pest managers in our system, who need to visit fields twice per week. The current label for dicrotophos is otherwise sufficient to meet the needs of our growers without any adverse impacts on the environment. We do not wish to see further constraints on the label and can show clear evidence that the current rate structure and use pattern is important to our cotton growers. The Arizona Pest Management Center, host to the University of Arizona's expert IPM scientists and a unique 23-year historical pesticide use database, supports the continued safe and effective use of dicrotophos in Arizona cotton as part of comprehensive IPM programs designed to protect economic, environmental and human health interests of our growers and citizens.*

EPA is currently seeking information regarding certain active ingredients including dicrotophos. The Arizona Pest Management Center provides the information below on usage patterns in Arizona cotton in support of this very important and strategic active ingredient and as part of its role in "comments coordination" for the Western IPM Center, a core function of this organization.

Through cooperative agreements with Arizona Department of Agriculture, the Arizona Pest Management Center obtains use of, improves upon, and conducts studies with ADA's Form L-1080 database. This database, among other prescriptions, contains data on 100% of custom-applied pesticides in the state of Arizona. In addition, the Arizona Pest Management Center is host to scientists in the discipline of IPM including experts in the usage of this compound in our agricultural systems. The comments within are based both on the extensive data contained in the Arizona Pest Management Center Pesticide Use Database and the expertise of its member faculty.

Our cotton industry is populated by licensed, professional pest managers known as Pest Control Advisors (PCAs). Nearly 100% of our cotton acres are professionally scouted by these PCAs, who assist growers in pest management decision-making and who write prescriptions for pesticide use. These prescriptions conform to the state's requirements for the Form L-1080, which are generally reported to ADA as required by state laws and regulations, and by voluntary action. These PCAs must maintain their licensing status through continuing education, participating in at least 15 hours of training each year. Through the APMC, we provide over 50 hrs of continuing education each year on pest management and pesticide-related issues, including the safe use of pesticides as part of an IPM program.

Our analyses consider the following issues.

1) Tools and approaches growers have to address the elevated pest status of brown stink bug in cotton and the associated risks of pest injury.

> The brown stink bug has had elevated pest status in Arizona cotton since 2012 when populations broke out over the entire low desert production regions. Populations were detected in wheat, corn, alfalfa, and cotton, where injury to bolls was clearly evident. About 110,000 acres were infested with stink bugs in 2012 & 2013 or 54–67% of cotton acres. Stink bugs have been the 2nd leading cause of arthropod-related yield loss since 2012 (0.78% and 1.57% yield loss in 2012 and 2013, respectively; Ellsworth, unpubl. data). Growers sprayed on average 0.86 times in 2013 at a cost of $17.57 / A, usually with broad-spectrum insecticides such as the pyrethroid bifenthrin, the organophosphate acephate, and dicrotophos. The impact on pest resurgence of whiteflies or Lygus and secondary pest outbreaks of mites and mealybugs are difficult to calculate but readily recognized by practitioners. Many avoided the use of acephate for fear of subsequent mite infestations. Others elected to use bifenthrin hoping it to be less hazardous to use and with fewer complications with beneficial reductions. However, whiteflies often resurged after bifenthrin use. Others combined bifenthrin with one or more organophosphates to control both whiteflies and stink bugs together. However, this approach was broadly damaging to natural enemy populations. Stink bugs (mostly brown stink bugs) were directly responsible for over 23% of the total costs and losses associated with arthropods in cotton in 2013 with an economic impact of $5,906,842. This does not include the increased costs of controlling other pests in our system because of the highly disruptive nature of brown stink bug control programs. It also does not consider the risk to aflatoxin levels in cottonseed, which were at decade-high levels in the 2013 cotton crop. Stink bugs injure cotton bolls in their attempts to reach the developing seeds. The brown stink bug is capable of harboring and transmitting the causal organism, *Aspergillus flavus*, in its mouthparts. This wounding of the boll also serves as a route of entry for an entire complex of boll rot organisms. Hard lock or the condition that

freezes boll locules in place, preventing them fluffing out and being harvested, is also associated with stink bug feeding and associated pathogens.

UA-APMC testing of dicrotophos and other candidate materials for brown stink bug control have resulted in mixed results. Once stink bugs are in the field, it is likely impossible to completely eliminate the infestation. This is in part because of their behavior, staying lower in the canopy often outside the zone where insecticides can readily reach them. Nevertheless, dicrotophos has been a mainstay of growers in the southeastern U.S. wishing to control the brown stink bug specifically. Our tests confirm the efficacy of dicrotophos on brown stink bugs. In a replicated, field efficacy trial, we tested 7 commercial products as well as experimental materials in 2014. Each material was sprayed at its highest labeled cotton rate with two exceptions. Flonicamid (Carbine) was tested at 150% of maximum cotton labeled rate. Dinotefuran (Venom) was tested at the highest rate for vegetables, which is higher than for cotton. Bolls taken from this trial immediately after spraying were transferred to the lab where they were used in a bioassay of brown stink bugs. Dicrotophos killed the largest fraction of brown stink bugs in this assay. Acephate (Orthene 97) also killed brown stink bugs but with somewhat less protection of the boll from feeding. Bifenthrin (either in Hero or Athena) only nominally lowered survival of brown stink bugs. Oxamyl (Vydate C-LV), flonicamid, and the experimental compounds were completely ineffective; however, repellency and therefore some boll protection was noted for dinotefuran (see Fig. 1–2 below).

The distribution of insecticide usage in Arizona can be tracked by our database based on the pest target(s) listed for each recorded spray. An analysis was made of the 2013 data to determine what compounds were most frequently used when addressing the brown stink bug problem (see table below). 444 prescriptions (i.e., form L-1080, the state-mandated form for agricultural pesticide recommendations) were written for brown stink bug control on over 115,000 acres in 2013. Growers are desperate for options in brown stink bug control. Thus, there were many attempts to use sulfoxaflor and flonicamid to control brown stink bugs, even though testing has shown that these materials do not work against this target.

Active Ingredient	Acres Sprayed	%1080s	Efficacy**
Bifenthrin	40324	62.6	Yes
Sulfoxaflor	20682	24.6	No
Flonicamid	17202	23.9	No
Dicrotophos	15338	19.6	Yes
Acephate	10257	16.9	Yes
Lambda-cyhalothrin	3449	5.9	not tested
Chlorpyrifos	2892	2.5	not tested
Imidacloprid	1896	3.2	No
Dimethoate	1528	2.5	not tested
Zeta-cypermethrin	797	3.2	Yes
Fenpropathrin	317	1.6	not tested
Thiamethoxam	226	1.4	not tested
Esfenvalerate	78	0.5	not tested
Permethrin	65	0.9	not tested
Novaluron	40	0.2	not tested
Total*	**115091**	**169.1**	

*% add to > 100, because of spray mixtures.

**Based on recent research in Arizona trials.

Fig. 1. Survival over time of brown stink bugs exposed to freshly deposited field residues in a laboratory bioassay. Candidate materials were sprayed in the field with a ground sprayer at 20 GPA. One inch bolls were immediately harvested, placed on floral picks with water in Styrofoam cups. One brown stink bug was added to each cup, 20 cups per treatment. Brown stink bugs were sourced from a laboratory colony that was established from field populations one year earlier. Dicrotophos (Bidrin) killed the most stink bugs and did so quicker than any other treatment. Acephate (Orthene 97) also killed stink bugs. The bifenthrin containing pyrethroid Hero also killed significantly more stink bugs than the UTC. However, the bifenthrin containing pyrethroid Athena did not. Dinotefuran (Venom), flonicamid (Carbine) and oxamyl (Vydate C-LV) failed to reduce survival below the UTC. A combination of experimental compounds also failed to reduce survival of brown stink bugs (Brown & Ellsworth, unpubl. data).

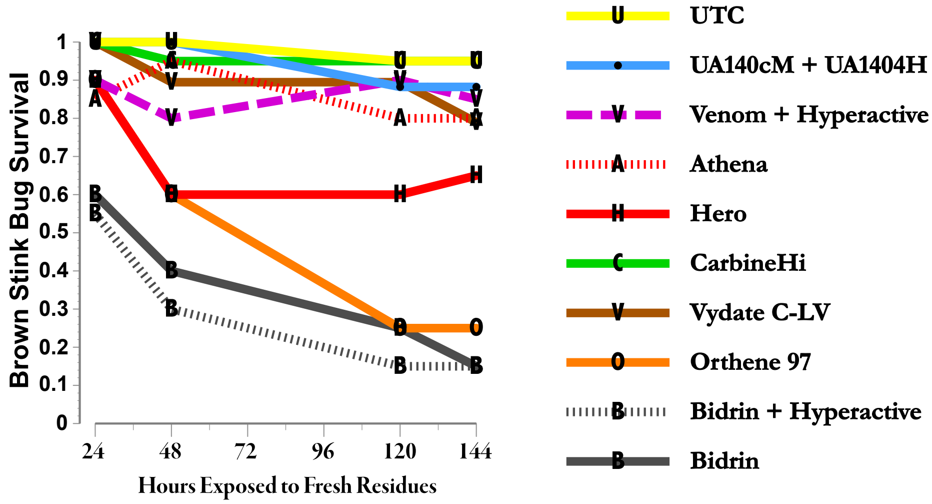
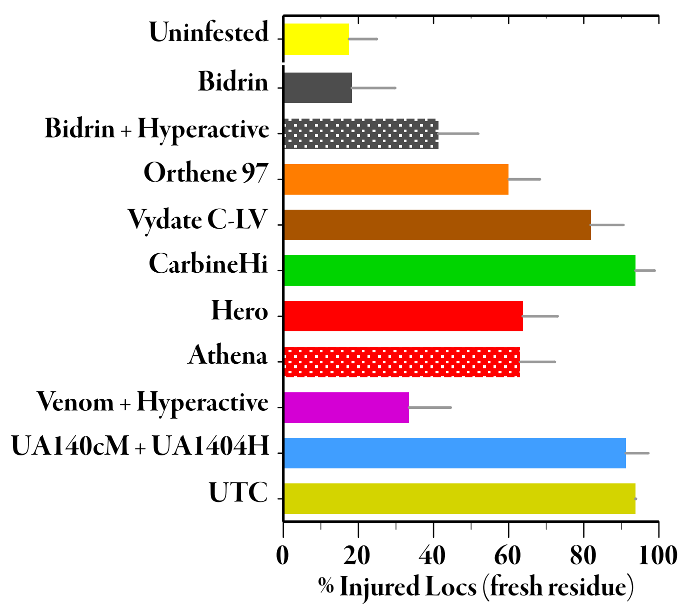


Fig. 2. Boll injury expressed as the percentage of locules showing evidence of carpel wall or lint / seed damage due to the brown stink bug from bioassays described in Figure 1. As each brown stink bug died or at the conclusion of the bioassay at 144 hrs, each boll was cracked open and examined for the presence of callous tissue (wound response) or punctures to the carpel wall, or direct staining and injury to seed and fiber for each locule. In addition to infested UTC bolls, there were UTC bolls that were uninfested in the bioassay in order to measure background levels of boll injury that occurred in the field prior to boll collection. Dicrotophos (Bidrin) significantly reduced injury to the boll to levels similar to the uninfested controls. Dinotefuran (Venom) also had significantly less boll injury; however, the source of this protection appeared to be related to repellency and not stink bug mortality (Brown & Ellsworth, unpubl. data).



2) The pesticide can perform its intended function without unreasonable adverse effects on human health or the environment.

We are unaware of any adverse effects of dicrotophos use in Arizona cotton. Special attention was given to educational outreach programs early in 2013 and 2014 to alert growers, pest managers, and applicators of the new availability of this compound in Arizona. Many were not old enough to remember dicrotophos use in the 1980s. Ground rigs were retrofitted with quick connect fittings to provide the engineering controls needed in the safe use of dicrotophos. Aerial applicators were made aware of potential honeybee and avian hazards. We see no support or need for buffer zones of any kind. UA-APMC personnel directly participated and observed commercial applications both by ground and air. At no time was off-site movement of the compound observed or reported. Our desert climate and distribution of usage in cotton are not likely to place water supplies at any risk.

3) Confirmation of the following label information: sites of application; formulations; application methods and equipment; maximum application rates; frequency of application, application intervals, and maximum number of applications per season; geographic limitations on use.

Our analyses of usage patterns in Arizona cotton and discussions with professional pest managers (Pest Control Advisors, PCAs) suggest that the 6-day re-entry interval is needlessly restrictive and severely limits the use of this compound. PCAs typically scout their fields twice per week (2013 Cotton Pest Losses, Ellsworth, unpubl. data). A 6 d REI prevents the timely scouting and associated decision-making needed following dicrotophos use. This places the crop at undue risk of undetected infestation by economic levels of whiteflies, aphids, mites, mealybugs and other pests of cotton. These are all arthropods that reproduce quickly and damage the quality of the crop, interfering with efficient chemical defoliation, harvest, and market processing of the cotton fiber. Dicrotophos was applied by fixed winged aircraft, helicopter, and by ground rig. No human flaggers were used.

4) Use distribution (e.g., acreage and geographical distribution of relevant use sites).

Arizona's irrigated agricultural production that depends on dicrotophos is largely confined to 6 desert Counties: Pinal, Maricopa, Pima, Mohave, La Paz, and Yuma. In 2 use seasons (2013–2014), dicrotophos was used on less than 12% of Arizona's cotton acreage in 5 of the 6 counties noted. Over 19,000 acres were sprayed with dicrotophos in 2013. Over 8,500 lbs ai were applied to cotton in 2013. Charts at the conclusion of this report further describe use patterns.

County	No. of 1080s	Total Acres	Total lbs ai
La Paz	16	2315.86	1153.86
Maricopa	14	1367.70	647.56
Pima	5	752.00	358.00
Pinal	68	14762.69	6306.49
Yuma	3	134.90	67.45
Statewide	106	19333.15	8533.36

Total Cotton Acreage in Arizona: 166,789 (Upland & Pima cottons in 2013)

5) Median and 90th percentile reported use rates from usage data – national, state, and county.

Use rates are very consistent with most applications at the maximum use rate of 8 oz of Bidrin or 0.5 lbs ai / A, a reflection of just how difficult it is to control brown stink bugs. The median and 90th percentile use rates and dates of application for cotton are shown below.

	Lbs ai / A	Use Date
Mean	0.452	6-Aug
Median	0.485	3-Aug
90th Percentile	0.500	5-Sep
Minimum	0.200	15-Jun
Maximum	0.500	15-Sep

6) Application timing (date of first application and application intervals).

Our database does not permit easy interpretation of multiple sprays of this or other products. However, based on interactions with the industry, the vast majority of users used dicrotophos just one time in 2013. At least one grower used dicrotophos twice. Thus application intervals are not well understood, except to say that brown stink bug control where it has been needed has not been easy to achieve, necessitating the use of multiple insecticides multiple times.

Dates of application are shown in the table above. In general, growers in 2013 deferred usage of Bidrin until later in the cotton season for three reasons: a) to limit damage to non-target beneficials on which they depend for whitefly and other pest control, b) to follow-up previous applications with alternative products like bifenthrin and/or acephate, and c) in an attempt to avoid using Bidrin because of the stringent requirements of its use such as posting, 6 d REI, and engineering controls.

Fig. 3. Total acres (left) and total lbs ai (right) of dicrotophos sprayed per day by air for applications made in 2013 in Arizona cotton. Median = 131 acres / d; 56.0 lbs ai / d (N = 101 prescriptions for aerial application of Bidrin).

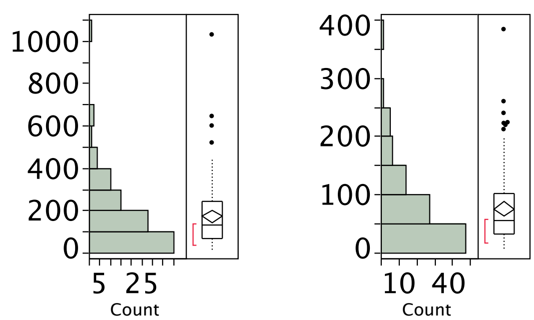


Figure 4. Seasonal total acres (left), total lbs ai (middle), and total no. of days of application (right) of Bidrin use per aerial applicator in Arizona cotton in 2013. Median = 752 acres; 358 lbs ai; 9 days of application (N = 13 aerial applicators).

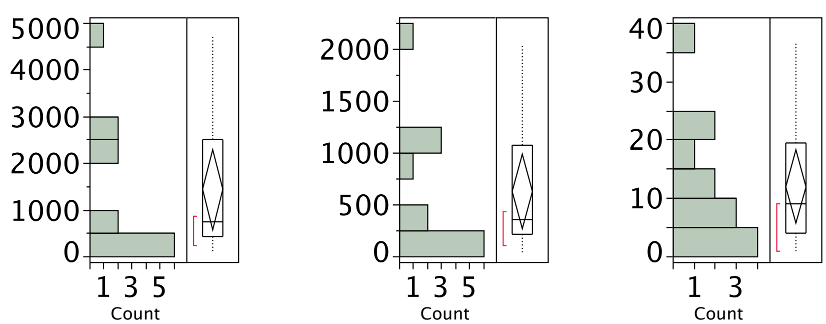
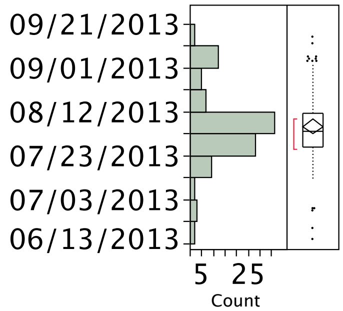


Figure 5. Dates of application for Bidrin in Arizona cotton in 2013. Median = 8/3/13; Min: 6/15/13; Max: 9/15/13 (N = 106 prescriptive uses)



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Disclosures

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