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1 Do You Always Know What You Are Spraying?

2 Illinois Aerial Applicators Prepare for Busy Season

2 Don't Drift Away in 2007

3 Increased Aerial Applications Expected

4 Update on the Occurrence of Glyphosate-Resistant Weeds

5 Household Products Database

6 Formulations of 2,4-D: Acids, Esters, and Amines

Do You Always Know What You Are Spraying?

This spring there have been numerous reports of applicators spraying without having a copy of a work order or pesticide label with them. As a result, many don't know what they are applying. Is it a herbicide, insecticide, fungicide, or pancake syrup? They haven't a clue, but they should know exactly what chemical is in their possession.

The argument could be made that the intense label work has been completed already. The label was consulted in choosing and mixing the product. The applicator is dressed appropriately in the personal protective equipment (PPE) carefully outlined on the label. What more could the label offer at this point? In short, it could offer vital health and safety information.

Life happens and things can go wrong. Accidents and spills can occur. Winds can shift, and the pesticide application can blow back onto the applicator's skin. Equipment can break down, and hoses can rupture. Eyes can be splashed into. If the label is readily available, first-aid information can be obtained in a matter of minutes if not seconds. But if the applicator has to first determine what the chemical even is, precious time is lost.

Perhaps the spill is not on your skin but on the roadway instead and to the tune of several gallons. What is the proper cleanup procedure? Is the pesticide a threat to ground-water? Is it highly flammable? If you don't know what the pesticide even is, these questions are very difficult to answer. Much of this information can be found on the label or MSDS. Typically, on the label are phone numbers that can be called for medical assistance or in the event of an emergency.

Although it is highly recommended to have a copy of the label on hand, the applicator is not required to have it with them during all phases of the application. At the very least, an invoice or work order detailing the product and rate being used should be in the user's possession. Labels can be kept back at the plant but in an accessible location. When many different products are used, it may be impractical to keep a current copy of all labels on the spray vehicle.



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On a related topic, applicators and operators are required to keep in their possession their Illinois Department of Agriculture-issued pesticide license while using pesticides. This means that your license should be kept with you in your billfold and not in a file cabinet back at the office. An IDA inspector can stop you at any time while you are using pesticides and ask to see your license. It's best to be prepared and have it available. (*Michelle Wiesbrook*)

Illinois Aerial Applicators Prepare for Busy 2007 Season

It looks as if 2007 is going to be a big year for aerial applications in Illinois. Fungicide applications to corn, along with the potential threat of soybean rust and soybean aphids, will mean many applications will be done by agricultural aircraft this season. In preparation for the upcoming year, the Illinois Agricultural Aviation Association (IAAA) held an Operation S.A.F.E. (Self-regulating Application and Flight Efficiency) fly-in on April 26 and 27, 2007. The fly-in was held at the Coles County Memorial Airport in Mattoon. The fly-in was sponsored by Syngenta, who ran the flight line and collected all the spray data. Spray-pattern and droplet-size data were analyzed by members of the Department of Agricultural and Biological Engineering at the University of Illinois Urbana-Champaign, who are certified as S.A.F.E. analysts with the National Agricultural Aviation Association. A total of 12 aircraft were pattern-tested over the 2 days of the fly-in, with a total of 132 passes made over the flight line.

The purpose of an Operation S.A.F.E. fly-in is to make sure aerial applications are made accurately and safely. At a fly-in clinic, an aerial applicator can view the spray pattern, determine effective swath

width, and examine the spray-droplet size created by the aircraft. If corrections need to be made, the applicator can make adjustments to the aircraft setup and then immediately rerun the aircraft over the flight line to verify the changes have improved the spray pattern or droplet size. In many cases, an aerial applicator may run multiple series over the flight line, checking the different setups used for the various spray-application rates used throughout the course of a spraying season. For instance, nozzle-orifice size, nozzle-deflection angle, and the number of nozzles used on the boom can vary, depending on the GPA the applicator is setting the aircraft up to apply. For more information about Operation S.A.F.E. fly-ins and aerial applications, see *Illinois Pesticide Review*, vol. 17, no. 3, May 2004; vol. 18, no. 3, May 2005; and vol. 19, no. 3, May 2006. (*Scott Bretthauer*)

Don't Drift Away in 2007

It seems to be a good time to discuss drift, so here are a few reminders about application equipment and techniques that can help you reduce your risk of particle drift when making an application.

Read the label: The label is always the place to start when planning an application. The following recommendations are general guidelines to help reduce your risk of drift, but the label may contain more specific language related to drift, which must be followed during the application.

Control spray-droplet size: Of all the factors that influence drift, droplet size is one of the most important to consider when setting up your spray equipment for an application. The size of droplets created during an application is something an applicator can control, as opposed to weather conditions. Small spray droplets are the ones most likely to drift off target, and reducing their formation during an

application lowers the risk of drift. For a review of spray-droplet size measurement and classification, see *Illinois Pesticide Review*, vol. 17, no. 1, January 2004. Here are a few things you can do to create larger spray droplets:

- Use a larger nozzle size and reduce pressure: Larger nozzle orifices and lower pressures both create larger spray droplets. You can maintain your required flow rate while increasing droplet size by selecting a nozzle with a larger orifice and using a lower pressure.
- Use drift-reduction nozzles: Certain nozzle types, such as pre-orifice, air-induction, and turbo nozzles, are designed to reduce the formation of small, drift-prone droplets.
- Use a drift-reduction additive: Drift-reduction additives reduce the formation of small spray droplets during an application.
- Increase your spray application rate: Increasing your spray application rate typically involves selecting a nozzle with a larger orifice, which, as mentioned above, creates larger spray droplets.
- Watch rate controllers: Automatic rate controllers work by using pressure to adjust nozzle flow rate in response to changes in speed so the spray application rate (GPA) is held constant during the application. Unfortunately this change in pressure also changes the spray-droplet size. Higher speeds means higher pressures, which reduce spray-droplet size and increase the risk of drift. Here are a few things you can do to contend with this problem.
 - Limit speed changes: Keep speed changes within a certain range so that the pressure, and thus droplet size, does not vary too much during the application.
 - Use pulse-width modulation: Pulse-width modulation technology allows you to have independent control of

nozzle flow rate and pressure. For more information, see *IPR*, vol. 17, no. 2, March 2004

– Use variable-orifice nozzles: Some new nozzle designs change orifice size in response to pressure changes. This allows for a wider range of flow rates from a single tip, while maintaining a more consistent droplet size through the pressure changes. For more information, see *IPR*, vol. 18, no. 6, November 2005.

Set correct boom height: The height of the boom determines the distance spray droplets must travel to reach the target. The greater the distance, the more exposed the spray droplets are to the wind. Keeping the boom as low as possible reduces the exposure of the droplets to the wind. Remember, however, to keep the boom high enough to get the correct amount of overlap for the type of nozzle you are using. Nozzle catalogs have boom-height tables to assist you with determining the correct boom height, depending on which nozzle you are using.

Monitor the weather: Wind speed, wind direction, temperature, and humidity all influence drift; and while you certainly can't control the weather, you can monitor it. Knowing what the exact weather conditions are can help not only to decide whether or not you should spray but also to determine if you need to make any adjustments to your equipment or techniques to deal with the weather conditions. For instance, you might want to switch from extended-range nozzles to air-induction nozzles in wind speeds that are closer to the upper speed limit for making an application. For more information about how weather affects drift and how to measure weather, see *IPR*, vol. 17, no. 5, September 2004. When you measure wind speed, remember to measure it at the height of the mounted nozzles, not the height of your eyes. Also, remember to record all of your weather observations as proof of both the weather conditions during the

application and your professionalism. As a general rule, weather conditions to avoid making applications in or those that require adjustments to either application equipment or technique include:

- Wind speeds over 10 mph: Higher wind speeds increase the risk of drift and carry spray particles farther downwind.
- No wind: Very calm conditions allow small spray droplets to remain suspended in the air in a concentrated mass near the application site.
- Shifting wind speed and direction: It is difficult to assess your risk of drift and take steps to reduce it if you do not know how fast the wind will be blowing or in what direction.
- High temperatures: Spray droplets begin to evaporate once they leave the nozzle, and higher temperatures increase the evaporation rate. As droplets evaporate, they become smaller, and thus more prone to being blown off target by the wind.
- Low humidity: Low humidity also increases the evaporation rate, resulting in rapidly shrinking droplets that become more prone to drift as they get smaller.
- Inversions: Under normal conditions, the air is warmest at the surface of the earth and the temperature decreases as elevation increases. Because warm air rises, there is a continuous vertical mixing of the air that prevents small spray droplets from remaining suspended in a concentrated mass near the application site. During an inversion, which typically occurs early in the morning or late in the evening, cool air is trapped at the surface of the earth below a layer of warm air, and vertical air mixing does not occur. The end result is calm air, which can allow small droplets to remain suspended in the air in a concentrated mass and drift off target.

Utilize buffer zones: Buffer zones can be utilized along the downwind side of the application site. These buffer zones can be no-spray buffers, in which case the buffer zone can be treated at a later time when the winds have changed direction, or an area where the application equipment and techniques are adjusted to lower the risk of drift even further than that from the rest of the application site. For instance, an applicator might switch from an extended-range nozzle to an air-induction nozzle, switch to a larger nozzle orifice and reduce pressure, or slow down in a downwind buffer zone. (*Scott Bretthauer*)

Increased Aerial Applications Expected

Higher corn prices due at least, in part, to increased ethanol production has caused an anticipated increase in acreage planted to corn in the Midwest. With these higher prices, options to achieve even relatively small yield increases have sparked interest in producers.

One of these options is the reported yield increases to be achieved through the application of pyraclostrobin, sold by BASF as Headline. One application during an approximate 2-week time window is reported to increase yield 6 to 12%. However, research at universities indicates a 0 to 6% yield increase.

As a result, Indiana, Illinois, and other states are expecting a several hundred percent increase in aerial application of Headline to field corn this year. Several aerial applicators have apparently already pre-sold all of the acres to which they can apply. Illinois Department of Agriculture and similar state lead agencies in nearby states are getting many applications for licensure from out-of-state applicators.

Several years ago during a twospotted spider mite outbreak in soybeans, large

increases in aerial applications with an increased number of out-of-state applicators resulted in a much higher than normal level of misapplication. Most of these misapplications were apparently caused by out-of-state applicators. Large numbers of rural and small-town vegetable gardens, home fruit orchards, and residential landscapes were oversprayed, resulting in many complaints.

Whether or not you are associated with aerial application, you should be ready for numerous queries from affected residents concerning the edibility of over-sprayed fruits and vegetables, as well as perceived damage to landscape plants. It has been the policy of University of Illinois Extension that fruits and vegetables are not to be eaten if sprayed in any amount by a pesticide for which there is no tolerance or label. These home crops become complete losses for the year. In addition to the concern of potential toxicity to humans, there will likely be many questions about the toxicity of this spray to pets. (*Phil Nixon*)

Update on the Occurrence of Glyphosate-Resistant Weeds

Since the commercialization of glyphosate-resistant crops, the question of whether glyphosate-resistant weeds will or will not be selected has been extensively bantered around by individuals involved in virtually every phase of production agriculture. The first contemporary report of glyphosate resistance in a weed species occurred in Australia, where scientists discovered a biotype of rigid ryegrass (*Lolium rigidum*) that was not controlled by glyphosate. Shortly after this watershed report of glyphosate resistance, another grass species, a biotype of goosegrass (*Eleusine indica*) in Malaysia, was reported to be glyphosate-resistant. While these initial instances occurred in grass species

outside of the United States, it didn't take long for glyphosate resistance to be discovered in broadleaf species within sovereign borders of this country.

A list of confirmed glyphosate-resistant weeds (as well as cases of resistance to myriad other herbicide families) is maintained by *The International Survey of Herbicide Resistant Weeds*. According to the organization's Web site (www.weedscience.org), "The International Survey of Herbicide Resistant Weeds is a collaborative effort between weed scientists in over 80 countries. Our main aim is to maintain scientific accuracy in the reporting of herbicide resistant weeds globally. This collaborative effort is supported and funded by the Herbicide Resistance Action Committee, the North American Herbicide Resistance Action

Committee, and the Weed Science Society of America."

Table 1 provides an updated list of confirmed glyphosate-resistant weeds. The table includes grass and broadleaf species, weeds with an annual or perennial life cycle, and species that occur in the United States and around the globe. Significant progress has been made toward understanding the mechanisms some of these biotypes use to survive glyphosate. A recent article in the journal *Weed Technology* provided a very good summary of what is currently known about these mechanisms. Table 2 is produced from that article.

As Illinois farmers enter the 2007 growing season, weed scientists continue to stress several significant points related to glyphosate-resistant weeds:

Table 1. Glyphosate-resistant weeds in the United States and around the world.

Common name	Scientific name	Year identified and location
Rigid ryegrass	<i>Lolium rigidum</i>	1996: Australia (Victoria)
		1998: California
		2001: South Africa
		2005: France
		1997: Malaysia
Goosegrass	<i>Eleusine indica</i>	2000: Delaware
		2001: Kentucky, Tennessee
Horseweed	<i>Conyza canadensis</i>	2002: Indiana, Maryland, Missouri, New Jersey, Ohio
		2003: Arkansas, Mississippi, North Carolina, Pennsylvania
		2005: California, Brazil
		2006: Nebraska, China
		2001: Chile
		2003: Brazil
		2004: Oregon
		2003: South Africa
		2003: South Africa
		2004: Spain
2005: Brazil		
Italian ryegrass	<i>Lolium multiflorum</i>	2006: Colombia
		2004: Missouri, Arkansas
Buckhorn plantain	<i>Plantago lanceolata</i>	2005: Georgia
		2005: Argentina
Hairy fleabane	<i>Conyza bonariensis</i>	2005: Missouri
		2005: Brazil
Common ragweed	<i>Ambrosia artemisiifolia</i>	2004: Ohio
		2005: Indiana
Palmer amaranth	<i>Amaranthus palmeri</i>	2004: Missouri, Arkansas
		2005: Georgia
Johnsongrass	<i>Sorghum halepense</i>	2005: Argentina
		2005: Missouri
Waterhemp	<i>Amaranthus rudis</i>	2005: Missouri
		2005: Brazil
Wild poinsettia	<i>Euphorbia heterophylla</i>	2005: Brazil
		2004: Ohio
Giant ragweed	<i>Ambrosia trifida</i>	2004: Ohio
		2005: Indiana

Source: Heap, I. *The International Survey of Herbicide Resistant Weeds*. Online. Internet. April 25, 2007. Available at www.weedscience.com.

1. A selection pressure for herbicide-resistant weeds occurs each time the same herbicide is applied to a particular field.
2. Increased adoption of glyphosate-resistant corn hybrids, with a concomitant use of glyphosate to the exclusion of other weed-management tools, will speed the selection of glyphosate-resistant weeds.
3. Rotating herbicides (sites of action) or tank-mixing herbicides may help slow the selection of glyphosate-resistant weeds, but it is unlikely to completely prevent their selection. Keep in mind that it's nearly impossible to make blanket statements about how effective a particular alternative herbicide or tank-mix partner will be in slowing the selection of glyphosate-resistant weeds.
4. Stewardship of glyphosate herbicide is an easy concept to discuss, but it is often more difficult to implement. (Aaron Hager; The Bulletin, no. 5, April 27, 2007; <http://www.ipm.uiuc.edu/bulletin/article.php?id=699>)

Household Products Database

On the heels of my recent article, "Disposing of Household Hazardous Waste," I'll share with you a related database I recently discovered. The *Household Products Database*, located at <http://householdproducts.nlm.nih.gov/index.htm>, contains a wealth of health and safety information about the chemicals under your sink and in your garage. This free database was created by the National Institutes of Health and the National Library of Medicine Special Information Services. One of the nine categories featured among auto products and home maintenance is pesticides.

Of course, the best source of information about a pesticide is the product label. However, further health and safety information can be found on the product's MSDS, the Material Safety Data Sheets, which are available by request from the manufacturer. This database combines

information from both of these resources and puts it into a searchable format. Manufacturers are always changing formulations, and as a result labels do change. This database is updated at least twice a year. With so many products available, not everything is included in the database. However, there are more than 7,000 brands included, which is impressive. According to the site's FAQ page, "Products included in the database are selected by market share and shelf presence in retail stores." The bulk of the pesticides included are products for homeowners, but some are professional use.

Ever wonder what the chronic health effects are from applying a certain garden weed preventer or what pre-existing medical conditions may be aggravated by handling or applying the product? You can learn this information and much more using the database. It is worth mentioning that the LD50s that are given on the MSDS and the signal words that are stated on the label are not listed in the database. Instead, they use what they call an HMIS Health Rating which is "based on the toxicity of chemicals contained in a specific brand and its ability to cause skin and eye irritation." The scale focuses on acute exposures: 0 = Minimal, 1 = Slight, 2 = Moderate, 3 = Serious, 4 = Severe, N = No information provided by manufacturer.

The addition of an asterisk (*) after the number indicates that exposure to chemicals in the specific brand could also pose a chronic hazard (such as emphysema or kidney damage).

Another interesting feature of the database is that one can search by health effects. For example, suppose that you were exposed to a pesticide application your neighbor just made and now your head hurts. You could search the database for "headache." Unfortunately, the numerous results may not help your headache, as 62 records were found when I did the search. Learning about a mystery rash may be a little easier. There were only 12 products that popped up when I typed in the term

Table 2. Glyphosate-resistant weed populations and mechanisms of resistance identified in resistant populations.

Weed species	Scientific name	Country	Mechanism of resistance identified ^a
Common ragweed	<i>Ambrosia artemisiifolia</i>	United States	—
Flaxleaf fleabane	<i>Conyza bonariensis</i>	South Africa Spain	—
Canada horseweed	<i>Conyza canadensis</i>	United States	Reduced translocation ^b
Goosegrass	<i>Eleusine indica</i>	Malaysia	Target site ^c
Italian ryegrass	<i>Lolium multiflorum</i>	Brazil Chile United States	— Target site —
Rigid ryegrass	<i>Lolium rigidum</i>	Australia United States South Africa	Reduced translocation Target site Target site —
Buckhorn plantain	<i>Plantago lanceolata</i>	South Africa	—

^aCells with a "—" have not yet had a mechanism of resistance identified.

^bReduced translocation: reduced translocation of glyphosate to meristematic regions.

^cTarget site mechanism: mutation in the EPSPS gene, changing PRO106 to Ser or Thr. Both mechanisms (reduced translocation and target site) are inherited as single gene, nuclear traits.

Source: Powels, S.B., and C. Preston. 2006. "Evolved glyphosate resistance in plants: biochemical and genetic basis of resistance." *Weed Technology* 20:282–289.

“rash.” But you get the idea. It would be best to simply ask your neighbor what pesticide he applied and then you can research the product. (*Michelle Wiesbrook*)

Formulations of 2,4-D: Acids, Esters, and Amines

The herbicide active ingredient 2,4-D, discovered in the 1940s, continues to find utility across a diversity of landscapes. The herbicide is a popular tool among homeowners for the selective control of certain broadleaf weed species in turf, and it is frequently a component of burndown herbicide applications in agronomic crops. A large selection of commercially available 2,4-D formulations, trade names, and so on exist from which weed-management practitioners can select. However, not all formulations and products are identical.

One characteristic of 2,4-D-containing products that is of particular importance is the “type” of formulation. There are several ways to define formulation, but let’s say the formulation consists of the active ingredient and all associated inert components that aid in handling, mixing, application, and absorption. Most often, 2,4-D products are available as one of three formulations: acid, amine, or ester. Each type of formulation has unique characteristics that can influence where and how a particular product is used. This article compares characteristics of these formulations to help explain how and why different formulations are used for different applications.

Figure 1 illustrates the chemical structure of the herbicide 2,4-D. The molecule is considered a weak acid because the carboxyl hydrogen atom (the one to the far right) can dissociate, imparting a net negative charge to the molecule. In the dissociated (negatively charged) form, the

acid molecule is very soluble in water but is not readily absorbed through a plant leaf. The waxy cuticle that covers the leaf surface is composed of many noncharged substances, which reduce the ability of a charged molecule to penetrate and enter the plant. Somehow altering the parent acid form can influence how quickly and thoroughly it enters a plant through the leaf. These alterations produce derivatives

that have physical and chemical properties different than the parent acid, such as increased ability to penetrate through a waxy leaf or increased water solubility for enhanced root uptake. The two most common derivatives of 2,4-D acid are amines and esters.

Esters are formed by reacting the parent acid with an alcohol, while amine salts are formed when the parent acid is

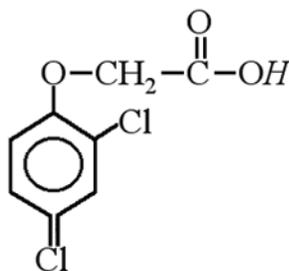


Figure 1. 2,4-D acid.

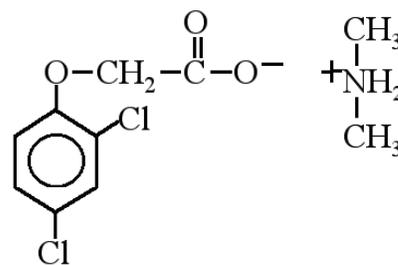


Figure 2. Dimethylamine salt of 2,4-D.

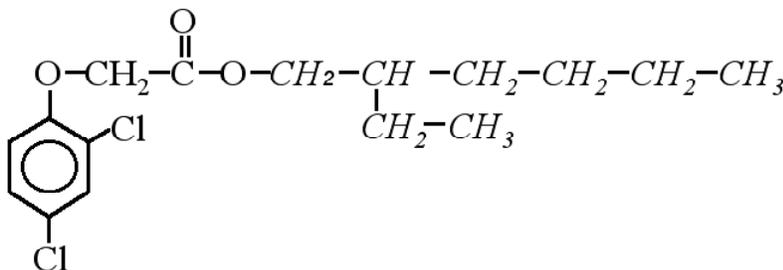


Figure 3. Isooctyl ester of 2,4-D.

Table 1. Comparisons between amine and ester formulations of 2,4-D.

Amine salt	Ester
High water solubility	Generally insoluble in water
Low solubility in oils and waxes	Higher solubility in oils and waxes
Slow absorption into plant leaves	Faster absorption into plant leaves
No or very low volatility potential	Low to high volatility potential
Clear or slightly amber-colored in water	Milky when mixed in water
Does not mix well with liquid fertilizers	More compatible with liquid fertilizers
Less-preferred formulation for no-till burndown applications	Preferred formulation for no-till burndown applications
Reduced probability of crop injury following POST application	Greater probability of crop injury following POST application
Preferred formulation for in-crop (i.e., corn) applications when air temperatures exceed 85 degrees	Less-preferred formulation for in-crop (i.e., corn) applications when air temperatures exceed 85 degrees

reacted with an amine. Figures 2 and 3 illustrate the chemical structures of 2,4-D amine (dimethylamine) salt and isooctyl ester, respectively. The isooctyl ester is a very common ester formulation of 2,4-D, while the ammonium salt is perhaps the most common amine formulation. Other esters and amine salt formulations, however, are available.

As mentioned, these different types of derivatives impart different characteristics to the formulation. For example, the isooctyl ester formulation is more soluble in hydrophobic (“water-avoiding”) substances, like waxes, while amines are more soluble in hydrophilic (“water-loving”) substances. In practical terms, esters are better able to penetrate the waxy leaf surface of weeds (and crop plants) than amines, while amines are more easily moved into the soil by rainfall for root uptake (an important characteristic in certain brush-control applications).

Table 1 provides some general comparisons between the amine and ester formulations of 2,4-D. These comparisons are somewhat relative, as the specific type of amine salt or ester chain length can influence some of these characteristics. For example, ester formulations are considered more volatile (the change from a liquid state to a vapor state) than amine formulations, but the actual volatility potential of the ester formulation is influenced by the length of the ester chain (that is, the number of carbon atoms in it). Also remember that different derivatives can impact the amount of “active ingredient” contained in a quantity of formulated product.

To accurately compare among various products, calculations of “equivalency” should be based on the amount of acid equivalent contained in the formulation rather than the active ingredient. For instance, the acid equivalents of the isooctyl and ethyl acetate ester formulations of 2,4-D are 66% and 88%, respectively. Several years ago, we discussed the concept of acid equivalence as it applies to herbicides such as glyphosate (“Herbicide

Formulations and Calculations: Active Ingredient or Acid Equivalent?” *The Bulletin*, issue no. 2, April 7, 2000). The same concepts and applications can be used to make comparisons among various 2,4-D formulations.

2,4-D is frequently used as a burndown tank mix prior to corn or soybean planting. Both the amine and ester formulations are labeled for burndown applications prior to soybean planting, but the ester formulation is usually preferred over the amine formulation. The low water solubility of an ester reduces the potential for it to be moved into the soil by precipitation, where it could cause severe injury to germinating soybean seed. Also, the ability of esters to better penetrate the waxy leaf surfaces of weeds often results in better control of large weeds and better control during periods of cool air temperatures. The labels of many 2,4-D ester formulations (3.8 lb acid equivalent per gallon) allow applications of up to 1 pint per acre 7 days prior to soybean planting; increasing the rate to more than 1 pint increases the waiting interval to 30 days. In addition to waiting intervals, labels sometimes also indicate that tillage operations should not be performed for at least 7 days after application and that the seed furrow must be completely closed during the planting operation or severe crop injury may result. Factors that increase the likelihood of the 2,4-D coming in direct contact with the crop seed increase the probability of severe crop injury. (*Aaron Hager; The Bulletin, no. 7, May 11, 2007, <http://www.ipm.uiuc.edu/bulletin/article.php?id=713>*)

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