Crop Responses to Herbicides

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Selective herbicides have become an integral component of modern crop production systems. These herbicides are selected for their ability to control important weeds without causing significant injury to the crop. Although the margin of crop safety varies widely among products on the market, it has generally been accepted that these products will not impact crop yield potential when used according to label and under ‘favorable’ environmental conditions. However, increasing numbers of persons are beginning to question the validity of this assumption. Several factors are responsible for these concerns, including changes in herbicide use patterns, introduction of herbicide resistant crops that may have the potential to eliminate injury concerns, and the growing popularity of yield monitors which provide an easy means to make yield comparisons. This paper will discuss some of the recent issues concerning herbicide injury.

**Herbicide Injury Concerns**

The application of any chemical to a crop has the potential to invoke an unwanted response. Since herbicides are selected for their ability to kill plants, they typically have a greater potential to cause damage than other materials (fertilizers, insecticides, etc.) that might be applied directly to the crop. In most situations, a crop is able to tolerate a herbicide because of its ability to metabolize the herbicide to non-toxic compounds before the herbicide accumulates at toxic concentrations at the site of action. Any factor which increases the rate at which a herbicide is absorbed or decreases the ability of the crop to metabolize the herbicide will increase the potential for crop injury.

The potential for, and significance of, herbicide injury is dependent upon many factors, including the type of herbicide applied, timing of application, environmental conditions before, during and after application, and other stress factors. Interactions among these factors makes it difficult, if not impossible, to predict the occurrence of injury.

Herbicides vary widely in their margin of crop safety. Contact herbicides generally are considered to have less potential to cause significant damage (yield losses) than systemic herbicides. Although contact herbicides such as Cobra or Buctil may cause significant loss of foliage, growing points generally are unaffected and plants typically recover relatively quickly from defoliation. Research designed to simulate defoliation by insects or hail has shown that removal of 50% or more of the foliage early in the season often does not impact yield. The later in the season the injury occurs, the greater the likelihood of a yield response. For example, a hail adjustment chart reports that 35% loss of leaf area in V5 corn will not impact yields, whereas the same level of foliage removal at the V10 stage will cause a 4% loss. Stress from other factors (diseases, environment, etc.) will reduce the ability of a crop to recover from this type of injury and increase the likelihood of a yield response.

The ability of systemic herbicides to translocate to growing points increases the likelihood of yield reductions compared to contact herbicides. The risk of yield loss increases when herbicides are applied later in the season; applications made when crops approach reproductive stages greatly increase the risk of damage. The ‘pinched ear’ syndrome observed following late applications of Accent to corn is an example of a systemic herbicide translocating to a growing point and disrupting normal development processes.
There is growing evidence that herbicides, particularly postemergence herbicides, may have a greater likelihood to cause small yield losses (<5%) under normal conditions than previously thought. Research has shown that yield losses are not directly related to early season injury ratings. Chris Boerboom at the University of Wisconsin evaluated the effect of Cobra, Galaxy, Pinnacle and Pursuit on soybean growth and yield in 10 separate experiments during the 1996 growing season. Early season injury ratings from labeled rates of these herbicides averaged 16%, ranging from 2 to 45%. Yields from herbicide treated soybeans averaged 4% less than non-treated, weed-free soybeans, yields ranged from 11% less to 6% more. At higher than label rates, early season injury levels up to 80% were observed, but the highest yield loss reported was less than 25%. Similar results have been reported elsewhere.

How big an issue is this potential yield impact. The important thing to note is that similar yield losses were observed with all postemergence herbicides. The losses typically were small, and the benefit of weed control greatly outweighed the yield loss. The risk of injury can be minimized by applying herbicides in a timely fashion.

Herbicide Resistant Crops (HRC)

The introduction of herbicide resistant crops has provided a means of reducing risks associated with herbicide injury. While most HRC’s are not totally immune to the specific herbicide for which they have resistance, they frequently have a larger margin of safety than typically found with traditional selective herbicides used in corn and soybeans.

Should HRC’s be used as a mechanism to increase yield potential by eliminating herbicide stress? One of the first things to consider is whether the highest yielding hybrids or varieties are available with the resistance gene. It is possible that a greater yield penalty will be taken due to limiting your variety selection than would occur from all but the worst cases of herbicide injury. In many situations, additional herbicides will be required to provide broad spectrum weed control. The resistance gene will not protect the crop from stress of the other herbicides required to achieve broad-spectrum control.

HRC’s are not immune to the herbicide for which they have been selected, and a crop response may be observed following herbicide application. In some cases, the response may be due to the herbicide itself, in other cases the response may be triggered by spray additives or the ‘inert ingredients’ found in the commercial formulation. For example, several instances of Roundup-Ready soybeans developing cupped leaves following Roundup Ultra application were observed in 1996. This response may have been due to the active ingredient glyphosate or to the additives found in the commercial formulation. Herbicide resistant crops may provide important advantages over traditional weed management strategies, but they should not be viewed as a means to improve yields.

Specific Concerns

Dicamba injury on corn Dicamba (Banvel, Clarity, Marksman) has been a mainstay of weed management systems in corn for over 20 years, however, there has been an increased incidence in injury concerns in the past few years. Changes in use patterns are largely responsible for many of the observed problems. More dicamba is being used as a preemergence herbicide than in the past. Because of its high water solubility and low adsorption to soil colloids, dicamba is more mobile in the soil than most soil-applied herbicides. The mobility of dicamba increases the likelihood of it reaching the corn seed/seedling during the initial germination and emergence periods, a time when it is more susceptible to injury. Postemergence applications minimize this risk.
In the past two years we have also seen an increase in the occurrence of onion-leafig or buggy-whipping in corn following dicamba applications; the majority of these cases involved tank mixes with an ALS product. There are at least two possible causes for the increased injury with these tank-mixes: 1) an interaction between the two herbicides, or 2) increased absorption of dicamba due to the spray additive required with the ALS product. The second factor, the role of the spray additives, has been well documented but the potential interaction between the two herbicides is not well defined.

The symptoms often develop several weeks to a month after the herbicides were applied. The reason for the delay is that all leaves that emerge later in the season are initiated between the V3 and V5 stage of growth, when many of these applications are made. Dicamba is a systemic herbicide that can accumulate at the growing point and disrupt the development of leaves that are initiated shortly after application. The injury is not noted until these leaves emerge from the whorl later in the season. In many situations the whorl is able to quickly break through the affected leaves, minimizing the impact of the injury. In other cases, the leaves are either tightly wrapped or fused, therefore preventing tasseling and ear development. Damage as extensive as 50% barren stalks were reported in some fields this year.

Non-specific soybean response  Soybeans occasionally respond to postemergence herbicide applications with symptoms characteristic of growth regulator herbicides (2,4-D, dicamba, etc.). These symptoms include cupping and crinkling of leaves, shortening of internodes, and cessation of growth for varying periods of time. The exact cause of these responses is unknown. This response has been observed with all classes of herbicides, thus it does not appear to be directly related to the specific mode of action of the herbicide applied to the field. The response may be due to the herbicide itself or additives found in the commercial formulation or added to the spray tank (COC, 28% N, etc.). In most cases soybeans resume normal growth shortly after the response is observed and it is unlikely that yield potential is affected significantly. These symptoms may also be caused by sprayer contamination or off-target movement of growth regulator herbicides. The first step in investigating these cases is to determine whether a growth regulator herbicide was involved, in many situations this can be a difficult task.