Summary

- The use of conventional corn herbicides has increased significantly in the past three years due to weed shifts and weed resistance to nonselective herbicides.

- DuPont Pioneer has developed a Corn Hybrid-Herbicide Management Guide to assist producers in selecting and managing their herbicide programs.

- Pioneer research has generally indicated that crop injury is primarily due to the environmental conditions the herbicide and hybrid encountered.

- Pioneer has identified some interactions between certain herbicides and corn hybrids.

- Use of herbicide by hybrid information based on data from limited replicates (e.g., less than 30 replicates) can be misleading and risky to growers.

- Growers are encouraged to contact their Pioneer sales professional for more information. The 2016 Corn Hybrid-Herbicide Management Guide is available at: https://www.pioneer.com/CMRoot/Pioneer/US/products/stewardship/2016-corn-herbicide-ProdList.pdf

- This Crop Insights will describe the rating system for Pioneer® brand corn products, as well as the research studies, field observations and other information used to derive the ratings.

Introduction

With the advent of herbicide-resistant crops, the use of non-selective herbicides increased significantly. However, the widespread use of these herbicides has led to weed shifts, changes in emergence patterns, and weed resistance in some cases. As a result, conventional herbicides have seen resurgence in use to complement non-selective herbicides in herbicide-resistant cropping systems. This increase in use has resulted in an increased need for the evaluation of hybrid tolerance to widely used conventional herbicides.

The risk of crop injury with some herbicides can vary among corn hybrids. DuPont Pioneer scientists conduct research trials to evaluate corn hybrid response to herbicides. The primary objective of this research is to identify hybrids with below-average tolerance to commonly used herbicides. This information is provided to corn producers to help them manage their crop accordingly and reduce the chances of herbicide injury.

Other seed companies have similar goals, but their testing philosophies differ. Some companies test many herbicide products across a few environments rather than major herbicide families at a relatively large number of locations. This article will discuss the scientific basis, methods and results of Pioneer’s herbicide testing program.

Research Studies Indicate Varied Responses

Pioneer, other seed companies, and universities have conducted research studies to evaluate hybrid tolerance to herbicides for a number of years prior to the development of guides to help manage herbicide applications. The published results of university research have been mixed.

Earlier work by Wych and Schoper (1988) evaluated five hybrids and five herbicides, metolachlor (Dual®), dicamba (Banvel®), and bromoxynil (Buctril®) from 1984 to 1987. They found no differences among hybrids in injury ratings for any of the five herbicides, nor were there any significant hybrid by rate interactions. However, there were significant environment by herbicide interactions. This indicates a specific environment was needed for crop injury to occur. However, Lund (1995) reported that hybrids differed in sensitivity to herbicides. His results suggested that in the years that herbicides showed significant early-season crop injury, hybrids with injury were consistently lower yielding when compared to less sensitive hybrids.

University publications also suggest that hybrids differ in their response to herbicides. For example, the 2015 Illinois
Agronomy Handbook states that “hybrids and varieties vary also in their tolerance to herbicides and environmental stress factors”. Many herbicide product labels also hint of interactions, suggesting that growers consult their seed representative for hybrid tolerance information.

**DuPont Pioneer Research Results**

Pioneer has been conducting research on tolerance of its seed products to herbicides for more than 35 years. The results have generally confirmed that environmental conditions at or following application play a much greater role in crop injury than hybrid or variety selection.

Prior to the development of the Corn Hybrid-Herbicide Management Guide, a study was conducted by Pioneer Agronomy Sciences (1993-1995) in which dicamba (Banvel®), metolachlor (Dual®) and nicosulfuron (Accent®) herbicides were applied to leader hybrids at 0, 1, 2 and 4 times the labeled rate. At labeled rates, the results indicated there were no significant hybrid by herbicide interactions for crop injury score or grain yield. The research also indicated that the primary determinant of crop injury was not poor tolerance of the hybrid, but the environmental conditions the herbicide and hybrid encountered.

Additional research by Pioneer Agronomy Sciences evaluated five hybrids and five herbicides across ten locations (2001-2003). The herbicides evaluated were Primextra® (metolachlor + atrazine), Steadfast® (nicosulfuron + rimsulfuron), Converge® (isoxaflutole), and Banvel® (dicamba). The experiment detected an environment by herbicide by hybrid interaction for crop response and grain yield. This three-way interaction indicates that the environment during or after the herbicide application (or crop emergence) affected different hybrids and herbicides at different locations. When comparing the relative variation due to hybrid, herbicide, and environment to the total experimental variability for grain yield, the variation due to environment was overwhelming (Figure 1). These results are similar to findings from a previous study (Gaspar, 1998).

Even though environment was the primary determining factor for hybrid response in this study, additional Pioneer research on newer herbicides has identified some potential hybrid by herbicide interactions. For this reason, Pioneer has continued its herbicide-testing program over multiple years and environments.

**Current Pioneer Hybrid Herbicide Research Efforts**

Since a specific environment is usually needed to produce a crop response, multiple environments must be evaluated to increase the chances of detecting herbicide sensitivity. To determine the number of locations needed, Pioneer Agronomy Sciences applied power analysis to data previously collected from herbicide by hybrid trials (Table 1).

Table 1. Number of locations* required to determine if hybrids show a differential response in grain yield to labeled rates of corn herbicides (2001 to 2003 research data).

<table>
<thead>
<tr>
<th>Prob &gt; F</th>
<th>LSD (bu/acre)</th>
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<tr>
<td></td>
<td>5</td>
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<td>0.01</td>
<td>39</td>
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<td>9</td>
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* Assumes 3 replicates/location.

The results of the power analysis indicated that 10 locations with three replications per location are needed to find significant treatment effects of greater than 10 bu/acre at a Prob > F value of 0.01. A value of 0.01 indicates that if the same study were repeated, results would be different only 1% of the time.

Conducting tests at an adequate number of locations helps ensure that research results are statistically sound. The primary trait measured in Pioneer’s research trials is grain yield. Another important trait used to identify hybrid or variety tolerance is early season injury or “crop response”. DuPont Pioneer researchers evaluate plots at designated intervals following herbicide application to generate these crop response ratings. In addition to the research data, field observations by DuPont Pioneer agronomists and Pioneer sales professionals and herbicide company recommendations are considered in determining hybrid ratings. Since the 1990’s, Pioneer has evaluated hybrid tolerance to four major herbicide families: amides, benzoic acid/phenoxy, 4-HPPD inhibitors, and sulfonylureas (Table 2). Herbicide families not listed in the table showed no evidence of a hybrid by herbicide interaction concern.

With the information generated by evaluating Pioneer® brand hybrids treated with these four herbicide families, a Corn Hybrid-Herbicide Management Guide is developed annually. The management guide assists growers in selecting and managing herbicide programs for specific hybrids.
Table 2. Herbicide families used in DuPont Pioneer testing to detect hybrid sensitivities.

<table>
<thead>
<tr>
<th>Herbicide Family Evaluated</th>
<th>Trade Name Tested</th>
<th>Other Example Products in Herbicide Family</th>
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<tbody>
<tr>
<td>Amide (Chloroacetamide and Others)</td>
<td>Dual® II Magnum®, Frontier®, Focus®</td>
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<tr>
<td>Benzoic Acid, Phenoxy (Synthetic Auxins)</td>
<td>Banvel®, Distinct®, and 2,4-D</td>
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<tr>
<td>Isoxazole (4-HPPD Inhibitors)</td>
<td>Converge®, Laudis®, Callisto®, Impact®</td>
<td></td>
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<tr>
<td>Sulfonlurea (ALS Inhibitors)</td>
<td>Option® or Resolve Q®</td>
<td>Accent®, Elim®, Option®, Permit®, Broadstrike®, Peak®</td>
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</tbody>
</table>

Crop Response Warning

In field observations and research studies, crop injury has occurred with this herbicide/hybrid combination.

Insufficient Data

Additional testing is needed to evaluate the herbicide/hybrid combination.

Herbicide Families

Amides (chloroacetamide and others)

Injury from amide herbicides is more prevalent on sandy soils with low organic matter. Additional conditions that may increase the potential for injury are deep planting, cool, wet conditions and/or soil crusting.

Management options to consider with hybrids with less tolerance to chloroacetamides are listed below:

- Monitor planting depth.
- Avoid sandy soils with low organic matter.
- Use a chloroacetamide herbicide with a safener.
- Aid emergence by rotary hoeing if crusting occurs.
- Avoid ultra-early planting dates.

Benzoic Acid/Phenoxy

The potential for crop injury from benzoic acid or phenoxy herbicides increases when the hybrid is under stress and/or the hybrid is sprayed at a late stage of growth. The additional management suggestions below are helpful in reducing potential for injury:

- Apply herbicide early within label recommendations (up to 5-6 inches or V3 for dicamba).
- Avoid spraying when the daytime temperatures are high and corn plants are growing rapidly.
- Follow recommended rates for different stages of growth.
- Avoid spraying when conditions such as drought, cold soils or wind damage cause abnormal stress.
- Read the labels carefully. Many herbicides have growth regulator herbicides as part of their pre-mix. Many tank mixes require the use of NIS or other additives, which may increase injury potential.
Isoxazole (HPPD Inhibitors)

Crop injury from pre-plant or pre-emergence applications of HPPD inhibitor herbicides is more probable on sandy soils with low organic matter. Cool, wet growing conditions may also increase the potential for damage. Injury from post-emergence applications of HPPD products is more likely if the corn is sprayed when plants are exposed to a stress, such as cool, dry conditions. Suggestions that may reduce the likelihood of injury include:

- Follow recommended rates for specific soil types.
- Avoid sandy soils with low organic matter.
- Plant seed at least 1.5 inches deep with good seed furrow closure.
- Use isoxazole with a safener.
- Aid emergence by rotary hoeing if crusting occurs.
- Avoid ultra-early planting dates to prevent extended slow emergence under cold conditions.
- Avoid post emergence spraying when the corn is under stress extremes, such as hot and humid or cool and dry conditions.

Sulfonylureas

Injury from sulfonylureas is more likely when the corn is sprayed after the plant is 10-12 inches tall and/or the plant is exposed to a stress, such as cool, dry conditions. Additional management suggestions when applying sulfonylureas are:

- Apply the herbicide early in the recommended application window (before the hybrid corn is 10-12 inches tall).
- Avoid spraying when the corn is under stress extremes, such as hot and humid or cool and dry conditions.
- Use of a sulfonylurea herbicide with a safener can reduce the potential for injury.
- Since some sulfonylurea products have restrictions on hybrids less than 88 CRM (2700 heat units), review the label before application to these hybrids.

Conclusion

The purpose of this guide is to assist growers in selecting and managing their herbicide programs. However, under certain environmental conditions, a herbicide may become more active and/or crop tolerance may be reduced. In these cases, crop injury may occur on hybrids that have acceptable tolerance to the applied herbicide. The environmental conditions are the key factor in hybrid or variety by herbicide interactions observed in the field.

Predicting the environmental conditions a producer will encounter in a given year is nearly impossible. Because of this uncertainty, producers must select appropriate strategies to reduce the chances of herbicide injury and maximize yield. First, growers should select the highest yielding set of products for their fields. Secondly, select the least stressful herbicide for the weed pressure present on a given field. Finally, apply the herbicide at the recommended rate and time to minimize possible crop injury and optimize weed control. For more information, please contact your Pioneer sales professional or herbicide representative.

References


1 Research Scientist: Integrated Product Characterization and Development; Soybean Component Characterization; DuPont Pioneer

The foregoing is provided for informational use only. Please contact your Pioneer sales professional for information and suggestions specific to your operation. Product performance is variable and depends on many factors such as moisture and heat stress, soil type, management practices and environmental stress as well as disease and pest pressures. Individual results may vary.