

DEVELOPING WEED MANAGEMENT STRATEGIES THAT ADDRESS WEED SPECIES SHIFTS AND HERBICIDE RESISTANT WEEDS

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Over the last several years, Minnesota producers have experienced noticeable changes in the weed species that are difficult for them to control. In the past, problems controlling velvetleaf, common cocklebur, wild proso millet, shattercane and woolly cupgrass were common. Over the last several years the focus has moved to weed species such as Canada thistle, biennial wormwood, horseweed/marestail, common lambsquarters, common ragweed, and the increasing waterhemp infestations. The purpose of this paper is to help explain some of the causes of weed species shifts and suggest weed management strategies that will reduce the risk of weed control failure.

Why Do Weed Spectrums Change?

Weeds are well equipped to flourish in disturbed agricultural systems. Weeds are genetically diverse and can readily take advantage of the variety of conditions created by any given crop production system. Many common weed species also have the ability to rapidly establish themselves in a field in just a couple of year's time. This is primarily due to some weeds ability to produce a large quantity of viable seeds (if it is an annual) or vegetative tissues such as rhizomes (if it is a perennial) in a single growing season. Most weed species also have the attribute of seed or bud (if it is a perennial) dormancy. This allows a diversity of weed species to exist for long periods of time in the soil. Thus, when changes in the cropping system occur that are favorable for their germination and development, a particular weed species is able to respond fairly quickly and rapidly (often within three to five growing seasons) and establish itself in the cropping system. Therefore, one key to reducing the predominance of any given weed species is to increase the diversity of crops within the cropping system, or at least the diversity of weed management practices within the cropping system.

There are many factors that interact and influence the weed population dynamics in Minnesota's corn and soybean cropping system. Changes in tillage practices, cultural practices such as soybean row spacing and planting date, and weed management practices have all had an impact on the weed spectrum. Further, the ever changing weather patterns only complicate matters. The following is our overview, from our perspective as Extension Weed Scientists, of the factors we perceive to be influencing Minnesota's major corn and soybean weed management problems.

Herbicide Resistant Weeds:

Weeds, by their nature, have a diverse genetic background that gives them the ability to adapt to many different environments. For example, the repeated mowing of a lawn selects for low growing plants that avoid or are not affected by repeated cutting. Therefore, it should not be

surprising that weeds can adapt to certain herbicide programs. Weeds with a diverse genetic background may have a resistant biotype that has a 1 in 1 million chance of occurring within a weed population. Although these odds sound remote, a 1 in 1 million chance of occurrence can translate into a high probability of selecting for a herbicide resistant weed biotype unless proper methods to reduce selection intensity are used.

Despite a 1 in 1 million chance for occurrence, a resistant biotype has the potential to spread and become a dominant part of the population due to its great reproductive potential. Also, the extended viability and dormancy of most weed seeds makes it difficult to eliminate herbicide resistant biotypes from the population, even if extensive remedial weed control measures are used. Weeds such as kochia can tumble for miles spreading seed onto previously un-infested land. As a result of the diverse seed dispersal mechanisms of weeds, it is apparent that a farm manager must always use good herbicide resistance management strategies to prevent resistant biotypes from developing on the land and prohibit the establishment of resistant weed biotypes spreading from adjacent lands or from custom harvesting equipment and other machinery.

Factors Influencing the Weed Spectrum in the Corn and Soybean Cropping System:

Conservation Tillage:

Over the past several years there has been an increase in conservation tillage systems. This change in tillage systems has a dramatic impact on weed management. In conventional tillage systems, moldboard plowing and secondary tillage are effective weed management tools that help crop seedlings get an even start with weed seedlings. In addition, preplant tillage allows the producer the option of using preplant incorporated herbicides and rotary hoeing. In conservation tillage systems, pre emergence and post emergence herbicides must be used to substitute for this tillage. In addition, the reduction of tillage has a dramatic effect on the environment where weeds reside. A reduction in tillage has a dramatic effect on the weed spectrum and weed emergence patterns. In general, a shift to conservation tillage has resulted in increases in perennial (e.g., Canada thistle, and quackgrass) and winter annual weeds (e.g., horseweed/marestail) and summer annual grasses, and a decrease in large-seeded broadleaf weeds such as velvetleaf and common cocklebur.

Crop Row Spacing:

The row spacing of soybeans grown in Minnesota has decreased over the last five years with a shift from 30-inch rows to 10-inch rows or less. The major impact from a weed management perspective is the loss of inter-row cultivation as a weed control option. This loss is compensated somewhat by the gain in weed control associated with narrow-rows shading out late emerging weeds.

Crop Planting Date:

The 1990's have been challenging years from the standpoint of taking advantage of the yield advantages of early corn and soybean planting dates. Early planting dates are the most profitable (from a yield standpoint), but are also subjected to the most intense weed pressure. Due to the impact that weather has on dictating the date of planting, producers in Minnesota are often inclined to favor postemergence weed management options because it frees the producer from having to apply preplant or preemergence herbicides before planting, and thus risk slowing the planting process. However, a postemergence weed control approach allows weeds to compete with the crop from the time of crop emergence until the weeds are controlled. If the weeds are not controlled in a timely manner a significant yield loss due to weed competition can occur.

Decline in Mechanical Weed Control:

The increase in conservation tillage and narrow row soybeans combined with the increase in number of acres managed by an individual has led to a decline in the number of corn and soybean acres that receive field cultivation or rotary hoeing for weed control. As we will point out later in this paper, the elimination of rotary hoeing and inter-row cultivation has a dramatic impact on the consistency of herbicide performance.

Herbicide Use Patterns:

Over the last several years, herbicide use patterns have changed dramatically in Minnesota. Currently, glyphosate and glufosinate are the key herbicide resistant corn (HRC) technologies being used in Minnesota. In soybean, approximately 75% of the 7 million soybean acres in Minnesota are glyphosate resistant. Glyphosate and glufosinate resistant corn each have approximately 8% of the 7 million corn acres in Minnesota. Both herbicides are broad-spectrum in effectiveness with no residual soil herbicide activity. This creates the opportunity for very effective weed control practices with no risk of herbicide-induced crop injury in the HRC or succeeding crop rotations.

From a weed science perspective, a primary concern of adoption of the HRC technology is the increase in the likelihood of weed species shifts or the development of herbicide resistant weeds with the ensuing loss of herbicide function. Such widespread use of this technology (lack of weed management diversity) increases the likelihood of weed species shifts and the development of herbicide-resistant weeds. This is not an unprecedented concern.

Current Postemergence Weed Management Tactics:

As new herbicide technologies come and go the phrase "I have used herbicides for years, yet I still have weed control problems" has been an often-repeated phrase as the newest and latest herbicide begins to lose effectiveness. This loss of effectiveness is often in direct proportion to product use (as indicated by increasing market share) and duration of time in the market place (generally within 5-7 years). The best example from the 1990's was the widespread use of the ALS-inhibiting herbicides such as Accent, Pursuit, and Glean.

At first the weed control in most fields was excellent, however, within several years several tolerant species began to predominate in the field. Often these problems were solved with proper tank mixtures and adjuvants. After a period of time some weed species were found to be resistant to several of the ALS herbicides and soon the effectiveness of the technology was compromised. In the early 1990's the use of Pursuit herbicide resulted in a lot of weed-free soybeans in Minnesota. The early warning signs of loss of herbicide effectiveness included an increase in populations of common lambsquarters and common ragweed. Tank mixtures with another ALS herbicide, Pinnacle, improved common lambsquarters control, however, to improve common ragweed control, addition of herbicides such as Cobra, Flexstar, or Blazer was necessary. Adoption of these tank mixtures often improved weed control but increased the risk of crop injury. Movement from nonionic surfactants to crop oil concentrates had much the same result. As the difficult to control weeds increased in frequency and density in farmers fields the simplicity of using Pursuit as the primary weed management tactic diminished.

Continued use of the ALS chemistry eventually resulted in the development of localized biotypes of weeds resistant to the ALS chemistry. Currently in Minnesota we have localized populations of the following species that are resistant to ALS chemistry: kochia, common cocklebur, waterhemp, wild oat, and green, yellow, and giant foxtail.

Obviously the development of the Roundup Ready corn and soybeans came at a good time to alleviate these weed control problems and reduce herbicide-induced crop injury symptoms and carry over.

What Can Experiences from the 1990's teach us today?

Weed species shifts and herbicide resistant weeds are the direct result of a lack of diversification in weed management systems. Too many ALS herbicides used in multiple crops resulted in a reduction in their performance.

With approximately 75% of the 7 million soybean acres in Minnesota planted to glyphosate resistant soybeans and the potential adoption of Roundup Ready corn the potential for a lack of diversification in weed management systems does, once again, exist.

Weed species shifts are a long-range risk, generally taking 5 to 7 years for significant weed species shifts to occur. The temptation of the short-term gains of using the Roundup Ready technology across all corn and soybean acres is strong and short-term gains are often adopted because "a dollar today is worth more than a dollar tomorrow".

Are All Roundup Ready Crops Created Equal?

From a weed scientist's perspective, much of our research over the last 10 years would indicate that the Roundup Ready trait has more weed control value in soybeans than corn primarily because soybeans can tolerate the presence of early-emerging annual weeds for a longer period of time than can corn.

In general, weeds that emerge with corn must be controlled within 2 to 5 weeks after weed emergence to prevent a yield loss due to weed competition. In general, soybeans can tolerate 4 to 6 weeks of weed/crop competition. This extra 1 to 2 weeks can be very important when you are trying to control weeds over a large number of acres and you are at the mercy of wet fields and windy days limiting your field working days. Also, keep in mind that this period of crop tolerance to weed competition is decreased under high weed densities or environmental stresses such as low moisture or nitrogen levels. Another advantage for soybeans is due to differences in crop growth form and flexibility in row spacing that improves soybean ability to shade-out late-germinating weeds and prevent late-emerging weed escapes. This ability to reduce late-emerging weeds is important when using a herbicide that lacks soil-residual weed control.

Consider Adopting a Risk Management Approach to Weed Control

The current trends in corn and soybean weed management appear to be a movement away from tillage, including inter-row cultivation and a greater reliance on single-pass postemergence weed management programs. It is our belief that this is a fairly risky approach to weed management because it removes some important weed management tools thereby reducing the possibility for developing consistent cost effective integrated weed management systems. Remember, the key to consistently effective weed management is in using a diversity of weed management practices to prevent any particular weed species from taking advantage of any "opportunities" presented by using the same weed management practices year after year.

The primary objective of the risk management approach to weed control is:

1. To anticipate an unfavorable event and act to reduce its occurrence.

2. To take actions which reduce the adverse consequences, should an unfavorable event occur.

An example of objective one would be a situation where you know the critical size for effective postemergence weed control is in the 2 to 4 inch range and that the window of opportunity for total postemergence applications may be as short as 7 to 10 days. Therefore, it is impossible to cover an entire crop area with a total postemergence weed control program because of the large number of acres involved and the limited amount of time that the weeds would be susceptible to herbicidal control. In other words, a lot of stress is placed on the herbicide applicator. One technique to prevent this from occurring would be to treat some or all of the acres with a soil applied herbicide and retreat with a postemergence herbicide only the areas with weed escapes.

An example of objective two would be a situation where a preemergence herbicide failed to perform due to a lack of a timely, activating rainfall. Knowing the consequences of full-season weed pressure on crop yields, the next step would then be to either rotary hoe or cultivate the field depending upon the weed and crop growth stage.

There are probably many reasons why a producer would be opposed to adopting the risk management strategies of integrated weed management but economics and time and labor constraints are often brought up as major barriers. However, although integrated weed management strategies may cost more per acre, well-designed strategies result in a more consistent economic performance when averaged over several growing seasons. The reason for this is that properly designed integrated weed management strategies result in a better sequencing of a crop producers time and labor with the critical stages for weed management and weed/crop competition.

Summary - Preventing weed species shifts and herbicide resistant weeds:

- Use mixtures or sequential treatments of herbicides that each control the weeds in question, but have a different site of action.
- Scout fields after application to detect weed escapes or shifts. If a potentially resistant weed or weed population has been detected, use available control methods to avoid seed deposition in the field.
- Rotate herbicides (sites or modes of action) so you make no more than two consecutive applications with the same site of action against the same weed unless you use other effective control practices.
- Rotate crops, particularly those with different life cycles (for example, winter annuals such as winter wheat, perennials such as alfalfa, summer annuals such as corn or soybeans).

- Clean equipment before leaving fields infested with or suspected to have resistant weeds.

Additional recommendations specific to glyphosate:

- Use of an additional herbicide with another site of action in an intensive 2-crop glyphosate system.
- Emphasis on intensive monitoring for changes.

In Summary - Weed species shifts, whether it is to a resistant weed, or a new biotype, complicate weed management decisions. The best solution is to develop integrated weed management systems that prevent the problem from occurring.