The cost of convenience: The impact of weeds on crop yields

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Introduction

Populations of weeds capable of affecting crop yields are present in every field during every year. Perhaps it is the ubiquitous nature of weeds that leads to the complacency in their management across Iowa and the Midwest. A survey of Wisconsin corn and soybean fields found that weeds were managed in a way that resulted in yield losses in more than 10% of surveyed fields, with an average yield loss of slightly less than 10%.

Due to the variability in environmental conditions and herbicide performance, completely risk-free weed management programs are not economically feasible. However, understanding the interactions between crops and weeds can aid the design and implementation of management programs with minimal risk of yield loss.

Crop-weed interference

A complicating factor in managing weeds is our inability to accurately predict their yield impact early in the growing season. Various types of thresholds have been implemented for managing insects and diseases, and these tools simplify decision making. Although there are many reasons why thresholds have been less successful in weed management, the primary reason is the trophic level of the different pest classes. Both insects and plant pathogens are consumers, i.e. they derive their energy from the crop, whereas weeds are producers, i.e. they derive their energy from solar energy. Thus, the interaction between weeds and crops is completely different than that between the other pest classes and crops. This difference results in the interactions between weeds and crops being much less predictable than those with insects and pathogens.

The primary mechanism resulting in yield losses when weeds and crops coexist is competition for limited resources. Light, water and nutrients are the resources most commonly competed for by crops and weeds. The specific resource responsible for yield losses varies with the individual situation. For example, velvetleaf would compete for light much more effectively with soybean than it would with corn. Annual grasses may compete with corn for nitrogen early in the growing season. Effective weed management programs limit competition by minimizing weed numbers and placing the crop in a situation in which has an advantage in capturing resources over weeds.

While competition is the primary interaction between crops and weeds, other types of interactions also influence crop responses to weeds. Plants are able to sense the presence of neighboring plants and may alter their growth pattern in response to these neighbors, even in the absence of limiting resources. This is known as a shade avoidance response, and typically involves increased stem elongation to allow one plant to gain a height advantage over others. This response may be responsible for yield losses that occur when weeds compete for short periods of time early in the growing season when there may be sufficient resources available to satisfy the needs of both the crop and weed.

Recent research efforts have focused on the role of light quality in interactions between crops and weeds. All plants have a photoreceptor (phytochrome) that can detect slight changes in the ratio of red and far red light. Since chlorophyll strongly absorbs red light, light reflected off leaves has a low red:far red ratio (R:FR). Changes in R:FR are what allow plants to know there are potential competing plants nearby. Experiments that eliminate competition for resources but allow changes in R:FR due to the presence of adjacent weeds have shown significant responses in corn shortly after emergence. Corn growing in the presence of weeds changed its growth habit compared to weed-free plants within three days of emergence (Page et al. 2009). Although there were no differences in biomass at this time, corn growing in the presence of weeds had a greater shoot:root ratio than plants growing in weed-free conditions. This indicates the weedy corn sacrificed its root system by reallocating resources to shoot growth. At 15 days after emergence, the weedy corn accumulated 36% less biomass than weed-free seedlings. The sensitivity of corn to neighboring vegetation declined relatively quickly with age, thus weeds present at or shortly after corn emergence had the greatest effect on the light response by corn. The alteration in allocation of resources to the roots and shoots of the plant will influence the corn responses to the presence of weeds and other environmental stresses for the remainder of the season.

The critical period of competition

Weeds that compete with the crop for the entire growing season have the greatest effect on crop yield. Fortunately this scenario rarely happens in modern corn and soybean production. More typically, weed are present either early in the growing season and then eliminated, or they emerge later in the season after management practices have been implemented.

The critical period is an important concept in understanding interactions between crops and weeds. The premise of the critical period is that weeds can coexist with crops for certain periods of time without impacting yield potential. The critical period is the point of time when yield potential is impacted. Once the critical period is breached, crop yield is lost and removal of the weeds will not recover this lost yield. There are two critical periods. The first involves weeds that emerge with the crop and are allowed to compete until postemergence control tactics are implemented. The second involves weeds that emerge after the crop is established, typically after control practices are completed. This paper focuses on early-season competition involving weeds that emerge with the crop.

The importance of early-season competition was dramatically increased with the introduction of glyphosate resistant (GR) crops. Although the competitive relationship between weeds and GR crops is the same as that with conventional crops, the effectiveness of glyphosate allows weeds to be controlled effectively long after the critical period is breached. The longer weed control is delayed, the more bushels lost to competition. The typical yield loss curve to varying periods of early-season competition in corn is shown in Figure 1. In this research (Gower et al. 2003), the critical period was 2" weeds – removing weeds before they reached a 2" height prevented any yield loss associated with weed competition, delaying control until weeds exceeded 2" resulted in significant yield losses.

The difficulty in managing postemergence herbicide applications is that the critical period is extremely variable depending upon the unique situation of individual fields. Factors that influence the critical period include weed density, weed species, weed emergence time in relation to the crop, competiveness of the crop, cultural practices used, soil conditions, environment, and anything else that influences the growth of the crop or weed.

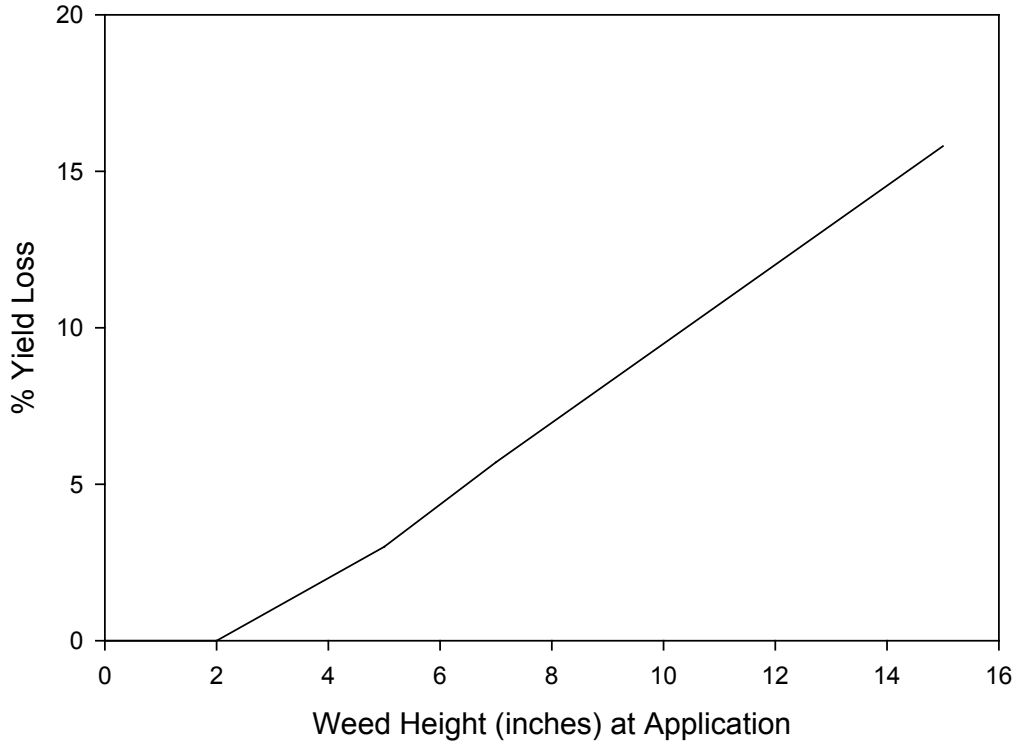

Figure 1. Average response of corn yield to postemergence application timing at 35 locations across the Midwest. Gower et al. 2003.

The data used to generate the curve in Figure 1 represents the average yield response from 35 experiments conducted under a wide range of conditions. With narrow profit margins, farming for the average is a sure way to lose money. One way of evaluating risk is to look at the number of locations that had a specific response (Table 1). In this research the average critical period was 2" weed height. However, at this growth stage 50% of the experiments had a yield loss less than 2%, whereas 50% of the experiments would have experienced a yield loss greater than 2%. Each person has a different level of risk acceptance. Some might see that in 10% of the fields (10^{th} percentile) no yield was lost when weed control was delayed until 6" weed height and be willing to accept those odds. Others might see that ten percent of the fields (90th percentile) experienced greater than 13% yield loss when the weeds were controlled at the 2" height and decide that a total post program presents too great of a risk.

Table 1. Response of corn to early-season competition. Initial glyphosate application made at indicated time, and then followed by a second application to control late-emerging weeds.

	Percentile				
Weed height at glyphosate application	**10^{th}**	**25^{th}**	**50^{th}**	**75^{th}**	**90^{th}**
	% yield loss				
2"	0	0	2	5	13
4"	0	0	4	10	14
6"	0	2	9	14	23

Gower et al. 2003. Weed Technol.

While the authors of this article did not explain factors responsible for the variation in the yield response at the different locations (Table 1), it is likely that differences in weed infestations played a major role. Weed densities ranged from 2 - 325 plants/ft2 among the locations. It is likely that locations in the 10th percentile had low weed populations, whereas those in the 90th percentile had some of the highest weed populations.

The potential for weeds to reduce yields early in the season is understood by most persons involved in crop production. However, the speed at which yield losses can accumulate is often underestimated. The number of bushels lost per day due to competition from a heavy grass infestation increased rapidly as the season progressed (Table 2). From emergence until the V2 stage, an average of 0.5 bushels was lost each day application was delayed. Two weeks later when the corn was at the V5 stage, more than 15 bu/A was lost during each day of competition.

Table 2. Average daily yield loss due to weed competition at different times early in the growing season. Kanawha, IA.

Corn Stage	Bushels/A
VE to V2	0.5
V2 to V4	1.1
V4 to V5	17.2

Hartzler. ISU. 2008.

Managing early-season competition

The critical period simplifies weed management by indicating when weeds need to be controlled to achieve full yield potential. Unfortunately, our inability to accurately predict the critical period results in a certain level of risk whenever weeds are allowed to establish at the same time as the crop. The risk can be minimized either by implementing control tactics very early in the growing season, or by minimizing weed populations that establish with the crop with the use of preemergence herbicides.

Risks of early-season yield losses in a total postemergence program can be reduced by making the initial postemergence application very early in the season. The primary gamble with this approach is that weather conditions, or other factors, often prevent the initial application from being made when intended. Also, changes in light quality due to the presence of weeds can impact corn growth soon after emergence, long before the onset of

competition for resources. How often the shade avoidance response impacts yield potential is unclear.

The second approach to protecting against early-season yield loss is the use of preemergence herbicides. Preemergence herbicide applications reduce the risk compared to relying on early herbicide applications by minimizing weed numbers during crop establishment. Concerns over the cost of the preemergence product have limited this practice, especially in soybean, and the reductions in glyphosate price for 2010 will encourage many growers to forgo this practice.

Summary

A significant percentage of fields in Iowa suffer reduced yields due to weed competition. Unfortunately, much of the yield loss is due to the implementation of flawed management strategies, rather than failed herbicide performance or uncontrollable 'acts of nature'. Our complacent attitude towards weeds may result in this behavior.

This article has focused on early-season competition in corn, and has described how large yield losses can occur relatively early in the growing season. The same principles hold for soybean. Although soybean are somewhat more tolerant of early-season competition than corn, situations occur where their yield potential is dramatically reduced during the first few weeks after establishment. As with corn, the critical period is highly variable depending upon the unique situations of a field, and unable to be predicted accurately. Although planning on an early postemergence application can reduce the risk of yield loss, the application of a preemergence herbicide will provide more stable yields regardless of crop.

References

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