Are Weeds in Corn Risky Business?

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Introduction

We are in an advanced age of weed management with a diverse array of herbicides, herbicide-resistant trait technologies in our corn, and sophisticated application equipment. Yet weeds remain an annual foe in our corn because the ecology of weeds has not changed. They have evolved to survive. Their survival is based on seed dormancy, which allows weed seed to persist and germinate across many years. Weed seedlings escaping control at some future time will set seed and replenish the seedbank. As a consequence, weeds will not be eradicated from agricultural fields. Therefore, we are obligated to manage weeds each year as compared to insect pests or diseases, which may be transient. Given this persistence, we must understand the net effect of these unwanted plants, which is competition against our corn. By understanding weed competition, we should be able to design more appropriate weed management programs.

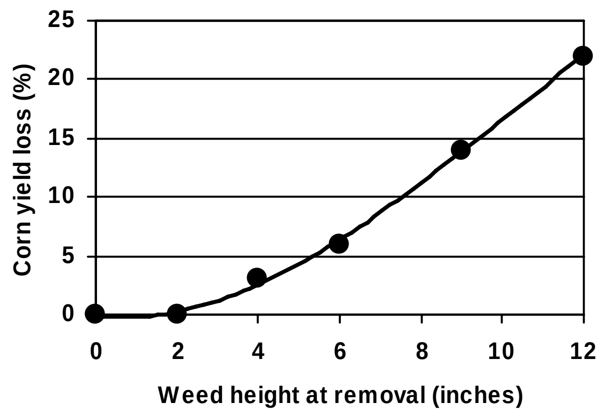


Figure 1. Early-season weed competition reduces corn yield. As weeds become taller before they are controlled, yield loss increases. Adapted from Gower et al. 2003.

The three resources that weeds and corn compete for are light, water, and nutrients. While it is interesting that we do not fully understand how weeds and corn compete for these resources, we know early-season weed competition can dramatically reduce corn yield (Figure 1). Thus, a standard recommendation is that weeds should be removed before they exceed a 4-inch height in corn. While we know that weed competition occurs early, is it competition for light, water, or nutrients that is primarily responsible for corn's yield loss?

Competition for Light

Early in the season, it seems unlikely that corn is truly in competition for light because the corn is typically taller than most weeds (Figure 2). Of course, giant ragweed can be an exception, but giant ragweed can be an exception to most situations. Later in the season, tall weeds are more likely to be important in light competition.

Figure 2. Do weeds compete significantly for sunlight early in the season?

However, another mechanism might be affecting corn growth and competition with weeds. Plants can detect if other plants are growing nearby because the spectrum of light changes. Light reflecting off plants has more far-red light and less red light, so the ratio of red to far-red (R:FR) light decreases. One hypothesis is that corn detects the presence of weeds when the light spectrum changes and then corn growth shifts to more shoot growth at the expense of root growth. Over time, this would limit corn's yield potential, if true.

University of Wisconsin weed scientists (D. Stoltenberg and M. Markham) field tested this idea during two summers by measuring corn growth and yield when grown with "normal" light conditions (weed-free corn) and low R:FR light (simulated weed competition). Weed-free corn was grown at 22,000 plants/A for the normal light treatment. For the low R:FR light treatment, corn was grown at 44,000 plants/A which simulated the light spectrum associated with weed competition. The plots were irrigated and fertilized so that these factors would not limit corn growth. When corn plants started to shade each other at V6-7 in the low R:FR (high density) treatment, one-half of the corn stand was removed such that both treatments had the same plant density and spacing for the remainder of the season. This simulated the action of controlling weeds postemergence (i.e., removing the weeds for the rest of the season).

The amount of sunlight, soil moisture, and soil nitrogen were similar between the normal and low R:FR light treatments through the V6-7 growth stage. However, the higher density of corn shifted the light spectrum such that the R:FR ratio was about 50% lower than the normal light treatment by V6-7. In other words, the extra corn plants changed the light spectrum to simulate weed competition.

Did the corn's growth differ because of the shifted light spectrum? For 18 characteristics that included early-season leaf, shoot, and root growth, corn did not differ between the normal or low R:FR light conditions in 2005 (only a few of these results are shown in Table 1). In 2006, corn plants in the low R:FR conditions (the simulated weed competition treatment) were taller, had longer leaves, and had fewer tillers than corn plants in normal light conditions. The root-to-shoot ratio did not differ between the light quality treatments in either year, which means the corn did not shift its growth to the shoot at the expense of root growth. Hand-harvested corn grain yield was also similar between these treatments in each year.

Some of the previous research to determine the effects of light spectrum (R:FR) on corn growth has been conducted under controlled conditions such as in growth chambers. However, the results from these Wisconsin field experiments suggest that the effect of early-season light quality had little effect on early corn growth and no effect on corn grain yield. Is light quality a critical factor affecting corn growth and a significant component of early-season weed's interaction with corn? Perhaps not, but further research would help to understand light competition better.

Table 1. Effect of normal (control) and low R:FR light spectrums on early- and late-season corn growth.

	2005		2006	
	Control	Low R:FR	Control	Low R:FR
Early-Season				
Extended plant height (cm)	77.0	76.4	86.5	95.1*
Stalk length (cm)	19.5	19.1	22.9	26.7*
Longest leaf (cm)	59.6	57.2	57.5	60.6*
Tiller weight (g)	--	--	0.12	0.014*
Shoot weight (g)	11.0	9.3	2.9	3.2
Root:shoot ratio (g/g)[a]	0.20	0.19	0.51	0.47
Late-Season				
Grain yield (bu/a)	255	255	243	250

*An asterisk indicates a significant difference ($p < 0.05$) between control and low R:FR treatments within year.

[a]For root:shoot ratio measurements, root systems were removed from the soil profile by hand in 2005; plants contained in pots placed in the soil profile were measured in 2006.

Competition for Water

Early-season competition for water between weeds and corn as a primary factor affecting yield loss certainly seems plausible, but how much water might small weeds use? To get an estimate, weeds were harvested from plots that were treated postemergence with glyphosate in a recent study in Wisconsin (Table 2). The two application timings were to 4- and 12-inch tall weeds, which were a mixture of giant foxtail, common lambsquarters, and common ragweed and the applications were made 8 days apart. To estimate water use, a water use efficiency of 400 lb water/lb weed biomass was used in this example, which is a reasonable average for the species present in the field. Water use efficiency varies by species and efficiencies of 300-900 lb/lb biomass have been reported for different weed species.

In the 2 years of this study, weeds removed (i.e., killed by glyphosate) at the 4-inch height may have used approximately 22,200 to 28,500 gallons/A or the equivalent of 0.8 to 1.0 inches of rain. In the subsequent 8 days, the weeds had nearly doubled or tripled in height and weight, which would suggest a similar increase in water use to approximately 1.5 to 2.9 inches/A. This level of water use could certainly affect corn growth and yield, especially under droughty conditions. Overall, the effect of competition for water would depend on several factors such as initial soil moisture levels, rainfall amounts and timing, and soil texture.

Table 2. Weed biomass at two removal timings and estimated water use by early-season weed competition in corn at Arlington, WI.

	2006			2007		
Weed height at removal	Weed biomass	Estimated water use		Weed biomass	Estimated water use	
	(lb/a)	(gal/a)	(inches/a)	(lb/a)	(gal/a)	(inches/a)

4 inch	462	22,200	0.8	593	28,500	1.0
12 inch	852	40,900	1.5	1635	78,500	2.9

The corn yields associated with these two treatments are presented in Table 3.

Competition for Nitrogen

If weeds are competing for nutrients with corn, they would most likely be competing for nitrogen. Some weeds are even classified as luxury nitrogen consumers, but are early-season weeds a significant competitor for nitrogen? A potential answer to this question can be found in a corn study being conducted by C. Laboski and myself that has weed management and nitrogen rates as variables. Weeds were harvested and analyzed for nitrogen when glyphosate was applied postemergence at two weed growth stages. The nitrogen accumulation by corn at tasseling was also determined. In this study, the mixture of giant foxtail, common lambsquarters, and common ragweed accumulated 12 lb/A nitrogen by the time they grew to a 4-inch height and accumulated 25 lb/A nitrogen by the 12-inch height (Table 3). The nitrogen uptake by the larger weeds was apparently sufficient to limit the nitrogen availability for the corn as the corn accumulated less nitrogen by tasseling. The net effect of the weed competition created by allowing weeds to grow and reach a 12-inch height was a 12 to 15 bu/A corn yield loss compared to when weeds were controlled preemergence or controlled at the 4-inch height. This data suggests that the yield loss is associated with competition for nitrogen. In fact, applying nitrogen at a high rate appeared to compensate for the nitrogen removal by the weeds and eliminated the yield loss associated with the 12-inch weed removal timing (data not shown).

Table 3. Average accumulation of nitrogen by weeds at the time of removal and corn at tasseling and corn yields in a study where nitrogen was applied at rates from 0 to 200 lb/A at Arlington, WI in 2006.

Weed height at removal	N accumulation		Corn yield
	Weeds [a]	Corn at tassel	
	(lb/A)	(lb/A)	(bu/A)
No weeds	--	85 a	209 a
4 inch	12 a	82 a	206 a
12 inch	25 b	70 b	194 b
Weedy	74 c	41 c	133 c

[a] Weedy treatment was harvested at corn tasseling.

What's the Risky Business of Weeds in Corn?

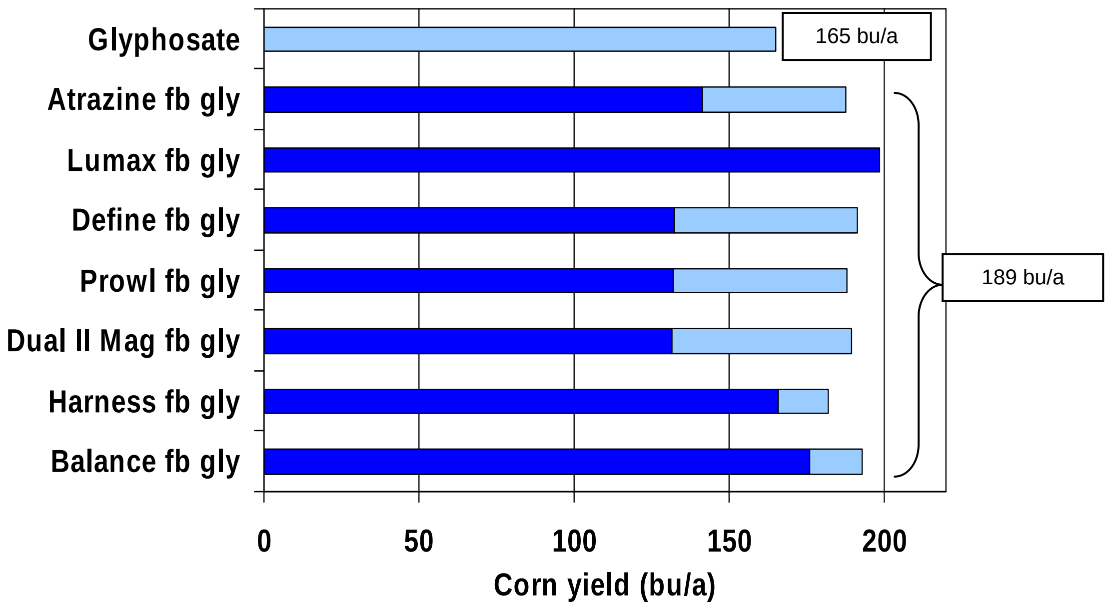
It is clear that weeds can and do reduce corn yields if they compete for resources for too long early in the season. It is also clear that more growers are trying to manage corn with total postemergence programs. Part of this management approach may be driven by glyphosate, a highly effective and cost effective herbicide, and the availability of glyphosate-resistant corn. In a glyphosate-based system, excellent weed control can be achieved even when larger weeds are treated. In fact, fewer weeds may be present at harvest with a later application because more weeds may emerge after early applications (Figure 3). In the case of our nitrogen study, the 4-inch treatment timing had 7-fold more weed biomass at harvest than the 12-inch treatment timing. Even though a herbicide program may have killed all of the weeds and the field may look clean at harvest, an “invisible” yield loss may have occurred, which was 12 bu/A in our study. Certainly, 194 bu/A was a good yield in our study, but over $30/A of profit was missed because of the late herbicide application.

Figure 3. Corn treated with glyphosate when weeds were 4-inches tall (left) had weeds emerge after treatment whereas the corn treated when weeds were 12-inches tall (right) had few weeds. Photo taken mid-July, 2006.

Good weed management is more than good weed control. Good weed control simply means that weeds were killed. It does not describe when the weeds were controlled. On the other hand, good weed management is focused on protecting the corn’s yield potential, which includes limiting weed competition and reducing the risk of weed competition. Timeliness is a critical feature of good weed management and this is where risk is occurs and also needs to be managed. With increasing farm sizes, increasing demand for postemergence applications, and application delays because of wind, rain, or equipment breakdowns, the risk of application delays is real. In 2 years, we experienced 8 inches of weed growth in 8 days. This critical time of weed control is quite short. Fortunately, management programs exist that can reduce the risk of delayed applications.

Managing the Risk of Yield Loss

I have also measured the value of using preemergence herbicides to reduce the risk of yield loss from late applications of postemergence herbicides (Figure 4). In a 2-year study, half rates of common preemergence herbicides were applied alone or were followed with a standard glyphosate application. The half rate of these preemergence herbicides provided partial weed suppression and limited early season weed competition. This also increased the amount of time available for the postemergence glyphosate application. This two-pass approach substantially increased corn yields as compared with a single postemergence glyphosate application. The single application of glyphosate yielded 165 bu/A, whereas corn yielded 189 bu/A when averaged across the seven two-pass herbicide programs.



[[IN THE FIGURE ABOVE, the bottom is cut off. I tried to fix this, but could not]]Figure 4. Corn yields with a half rate of a preemergence herbicide (dark blue bar) and the additional yield achieved when the preemergence herbicide was followed by glyphosate (dark blue plus light blue bars).

Conclusion

It is true that we are in a fantastic age with great new technologies to manage weeds. However, we must not lose sight that these technologies are just tools for getting the job done. In our case, our job is to protect the yield potential of these crops by managing weed competition. We need to design or select weed management programs to achieve that goal. After all, the last few extra bushels of yield are almost pure profit. Is it worth the risk to lose that potential profit?