VARIATIONS IN CORN YIELD LOSSES DUE TO WEED COMPETITION

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Introduction

It is important to understand the yield loss associated with different weed species if we use weed thresholds to optimize the economics of weed management. Corn yield loss is often variable among weed species. At a density of 2 weeds per foot of row, corn yield was reduced 10% by giant foxtail, 11 % by common lambsquarters, 18% by velvetleaf, and 22% by common cocklebur (Beckett et al. 1988, Lindquist et al. 1996).

Yield loss is also variable among locations and years even at the same weed density (Cowan 1998, Jasieniuk et al. 1999). For example, a study in Illinois reported maximum corn yield loss from common lambsquarters was 12% in 1985, but no yield loss was observed in 1986 or 1987 (Beckett et al. 1988). Langston and Harvey (1994) reported 9 giant foxtail plants per foot of row did not reduce corn yield in 1993 but reduced yield by 18% in 1994. Lindquist et al. (1996) suggested caution should be taken when estimating crop yield loss solely on weed density in bioeconomic weed management models.

Leaf area based crop yield loss models have been used to minimize location and year variability. These models account for some of the variability associated with different times of weed emergence (Kropff and Spitters 1991). Leaf area based models have also been used to explain differences in weed crop interactions at various locations (Lotz et al. 1996). However, there has been little published information quantifying weed interactions based on early season relative leaf area in Midwest cropping systems.

Most weed-crop interference studies have analyzed only one weed species within a crop. These studies have been criticized because they do not reflect realistic field conditions where two or more weed species are competing with the crop. Also, it is questionable if single weed species interference data can be applied to multispecies scenarios because competition among different weed species may lessen their total competition against the crop. Therefore, the first objective of this research was to quantify interactions between giant foxtail and common lambsquarters at a wide range of densities and proportions in corn. The second objective was to quantify corn yield loss associated with these weed species in mixtures and monocultures based on early season relative leaf area.

Materials and Methods

An addition series experiment was conducted at the University of Wisconsin, Arlington Agricultural Research Station in 1998 and 1999 at total weed densities of 0, 4, 16, 36, and 64 plants m^{-2}. At each density, common lambsquarters and giant foxtail seeds were planted in five proportions (100:0, 75:25, 50:50, 25:75, and 0:100). The experimental design was a randomized complete block with three replications in 3- by 3-m plots.

Dekalb DK493SR (99 day relative maturity) corn seeds were planted at 32,000 plants/acre in 30-in wide rows on May 19, 1998 and May13, 1999. Weed seeds were planted one day after corn planting. Prior to planting, weed seeds were hydrated in an aerated water bath for

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24 h and mixed in laponite gel. Syringes were used to place approximately 5 ml of gel containing 5 seeds of common lambsquarters or giant foxtail at equidistant locations in a predetermined grid for each density and ratio. Weeds were thinned by hand to one plant per location 2 wk after emergence. Early season leaf area was determined nondestructively on a weekly basis for the first 4 weeks after emergence, then biweekly until physiological maturity. Average shoot biomass was determined from 10 randomly selected weeds per plot. Corn grain yield was determined 21 wk after emergence by hand harvesting 20 ears from the middle two rows of each plot and adjusting grain yield to 15.5% moisture.

Results

Leaf area relative growth rates. Leaf area relative growth rates were used to measure the efficiency of plant growth. These values were calculated instantaneously as the rate of leaf area change per cumulative growing degree day per unit leaf area. Cumulative growing degree days were calculated at base 10C for giant foxtail and 6.5C for common lambsquarters. In 1998, leaf area relative growth rates of both species decreased with increasing density (Table 1). Giant foxtail leaf area growth rates were greater than common lambsquarters at each density. As in 1998, leaf area relative growth rates of both species in 1999 decreased with increasing density and giant foxtail leaf area relative growth rates were greater than common lambsquarters at each density. However, leaf area relative growth rates of both species were approximately twice as great in 1999 relative to 1998. The reduced growth rates in 1998 may be attributed to an intense early season rainstorm that stressed the weed seedlings.

Table 1. Giant foxtail (SETFA) and common lambsquarters (CHEAL) leaf area relative growth rates (±s.d.) in 1998 and 1999.

Total weed	1998		1999	
density	SETFA	CHEAL	SETFA	CHEAL
plants m^{-2}	$cm^2\ cm^{-2}\ GDD^{-1}$			
4	0.013 (0.001)	0.009 (0.001)	0.024 (0.001)	0.019 (0.001)
16	0.013 (0.002)	0.009 (0.001)	0.026 (0.001)	0.017 (0.001)
36	0.011 (0.001)	0.007 (0.001)	0.023 (0.001)	0.016 (0.001)
64	0.010 (0.002)	0.006 (0.001)	0.022 (0.001)	0.015 (0.001)

Interactions between giant foxtail and common lambsquarters. Interspecific interactions between giant foxtail and common lambsquarters were quantified with an empirical model used by Law and Watkinson (1987). This model was used to predict per plant biomass of physiologically mature plants as a function of early season relative leaf area. In this model, the maximum biomass is the biomass per plant when grown in the absence of interference from neighbors. The competition coefficient is the per plant equivalence of each species. In 1998, 0.9 giant foxtail plants were equivalent to 1 common lambsquarters based on giant foxtail leaf area and 2.9 common lambsquarters plants were equivalent to 1 giant foxtail plant based on common lambsquarters leaf area (Table 2). Therefore, the species with the lower competition coefficient is considered more competitive.

In 1998, giant foxtail and common lambsquarters emerged at the same time. Giant foxtail produced more biomass per plant than common lambsquarters and the competition coefficient indicated giant foxtail was more competitive than common lambsquarters. In 1999, common lambsquarters emerged 3 days earlier than giant foxtail. Common lambsquarters produced more biomass per plant as a result of earlier emergence, but the competition coefficients indicated that giant foxtail was more competitive. The relative leaf area based competition coefficients were able to account for differences in time of emergence.

Table 2. Estimated maximum biomass production per plant and competition coefficients (±s.d.) of giant foxtail and common lambsquarters in 1998 and 1999.

	1998		1999	
Species	Maximum biomass	Competition coefficient	Maximum biomass	Competition coefficient
	g plant^{-1}		g plant^{-1}	
Giant foxtail	15.5 (1.1)	0.9 (0.5)	56.7 (5.3)	0.8 (0.2)
Common lambsquarters	9.3 (1.5)	2.9 (1.3)	82.7 (13.2)	1.7 (0.6)

<u>Corn yield loss associated with giant foxtail and common lambsquarters.</u> The relative competitive ability of each weed species was also measured based on corn yield loss (Table 3). An empirical model was used to quantify corn yield loss as a function of weed relative leaf area at the V6 corn growth stage in 1998 and 1999. In each year, the competition coefficients associated with each species were not different. The lack of difference between competition coefficients in 1998 was attributed to the high degree of variability associated with the coefficients. The greater variability associated with the competition coefficients in 1998 was mostly due to the decreased influence of each weed species on corn yield loss. The maximum yield loss associated with each weed species was also not different between species in each year. However, the maximum yield loss was greater for both species in 1999 relative to 1998. The reduced impact of the weeds on corn in 1998 may be associated with reduced growth rates of both species that may have resulted from early season weather stress.

Table 3. Coefficients used to predict corn yield loss from early season relative leaf area of giant foxtail and common lambsquarters in 1998 and 1999.

	Competition coefficient (±s.d.)		Maximum yield loss (±s.d.)	
Species	1998	1999	1998	1999
			%	
Giant foxtail	8.1 (7.2)	1.3 (0.5)	13 (1)	40 (6)
Common lambsquarters	0.8 (0.5)	1.2 (0.3)	20 (7)	50 (5)

The corn yield loss associated with weed relative leaf area is described in Figure 1. In each year, the range of early season relative leaf area was similar, but the yield loss associated with the weeds was greater in 1999 than 1998. This difference is perhaps most important at low weed relative leaf areas where decisions on the economic returns to different weed control options are being considered. In 1998, corn yield loss reached 10% when weed relative leaf area accounted for 4% of the total canopy at the V6 corn growth stage. In 1999, 10% yield loss occurred when weed relative leaf area accounted for 10% of the total canopy at the V6 corn growth stage. Even though the weed relative leaf area required to reach 10% yield loss was more than double in 1999 relative to 1998, the difference between 4 and 10% weed relative leaf area may be difficult to visually determine.

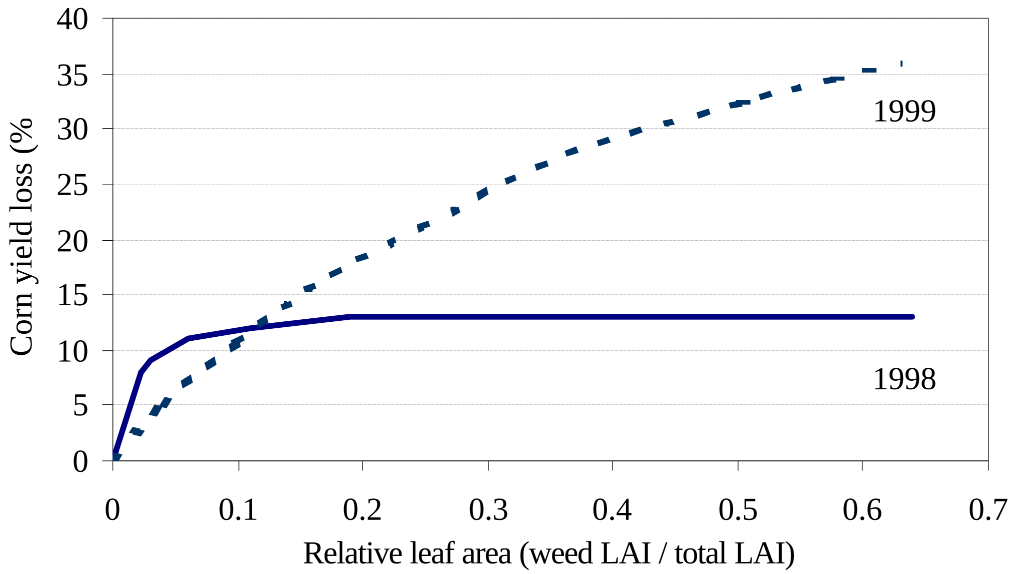

Figure 1. Percent corn yield loss as a function of early season relative leaf area equivalents in each year.

Conclusion

Despite significant changes in environmental conditions between years, the competition coefficients based on relative leaf area remained consistent. In 1998, intense early season rain storms stressed weed seedlings which may have attributed to decreased growth rates of both species over the growing season. In 1999, common lambsquarters emerged 3 days earlier than giant foxtail and resulted in an early size advantage relative to giant foxtail. However, competition coefficients based on weed growth and corn yield loss indicated that giant foxtail relative competitive ability was similar to or greater than common lambsquarters. These results may be attributed to the greater leaf area relative growth rates of giant foxtail in each year. Therefore, giant foxtail should be given equal or greater priority for weed control than common lambsquarters in corn.

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