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Longspine Sandbur (*Cenchrus longispinus*) Ecology and Interference in Irrigated Corn (*Zea mays*)[1]

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Abstract: Longspine sandbur is a troublesome weed infesting corn in the Great Plains. However, herbicides are now available to control this species. This study characterized longspine sandbur ecology in irrigated corn to aid producers in integrating herbicides into their production systems. Longspine sandbur began emerging May 25, and by June 15, 84% of the seasonal emergence had occurred. Plant development was related to cumulative growing degree days. Seeds were viable early in longspine sandbur's development, with 20% of seeds viable by heading. Producers can minimize seed production of longspine sandbur in field borders by mowing plants at the boot stage. Bur production per plant was related to time of emergence, with seedlings emerging in late May producing 1,120 burs per plant. Seedlings emerging 4 wk later produced 84% fewer burs. Controlling longspine sandbur before 4 wk of interference prevented loss of corn grain yield.

Nomenclature: Longspine sandbur, *Cenchrus longispinus* (Hack.) Fern. #[3] CCHPA; corn, *Zea mays* L. 'Pioneer Brand 3732.'

Additional index words: Bur production, growing degree day accumulation, herbicides, plant development, CCHPA.

Abbreviations: GDD, growing degree day; N, nitrogen; POST, postemergence.

INTRODUCTION

Longspine sandbur is a difficult-to-control annual weed infesting corn in the Great Plains[4] (Peterson et al. 1993; Wicks 1985). Preemergence herbicides currently available perform poorly on longspine sandbur, unless they are mechanically incorporated into soil (Phillips 1969; Todd et al. 1984; Wiese and Chenault 1986). Producers are concerned with protecting their soil resource; thus, they are seeking production systems that minimize tillage (Peterson et al. 1993; Wyse 1994).

Nicosulfuron {2-[[[[(4,6-dimethoxy-2-pyrimidinyl)amino]carbonyl]amino]sulfonyl]-*N*,*N*-dimethyl-3-pyridinecarboxamide} controls longspine sandbur when applied postemergence (POST) (Anderson 1989; Wilson 1993). In addition, other POST herbicides have been developed for grass control in corn (Swanton et al. 1996; Tweedy and Kapusta 1995).

With these new herbicides, producers can use production systems that minimize tillage yet still control longspine sandbur. Knowledge of a weed's emergence and plant development can help producers plan effective management strategies (Staniforth and Wiese 1985). For example, herbicide activity is affected by grass development (Harrison et al. 1985; Neal et al. 1990). Control decreased 20 to 30% when giant foxtail (*Setaria faberi* Herrm.) was tillering compared with pretillering at time of graminicide application (Derr et al. 1985).

To aid producers in selecting control strategies, scientists are developing decision aid models (Lybecker et al. 1991; Swinton and King 1994). These models incorporate ecological data of selected weeds, such as seedling emergence patterns, to predict long-term consequences of various management options (Wiles et al. 1996). Longspine sandbur's emergence pattern has been described in Washington (Boydston 1990). However, the emergence pattern of a species may differ between regions (Aldrich 1984). For example, redroot pigweed (*Amaranthus retroflexus* L.) emerges 1 mo earlier in Washington than in Colorado, a difference that could not be attributed to air temperature (Anderson and Nielsen 1996). In addition, models use knowledge of seed production of individual plants to predict seedbank dynamics and guide future crop choices (Swinton and King 1994).

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[3] Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

[4] Wicks, G. A. and R. G. Wilson, Jr., 1994, Sandbur control in corn, University of Nebraska NebGuide, G74-121-A.

The effectiveness of POST herbicides is related to the critical period of interference (Carey and Kells 1995; Hall et al. 1992), the period of time that longspine sandbur can interfere with corn without causing yield loss. A second consideration related to use of POST herbicides is that longspine sandbur may emerge after the herbicide is applied and contribute seeds to the soil seedbank for future infestations. Therefore, integrating ecological characteristics of longspine sandbur with planning of herbicide use will improve control, and hence, long-term management of this species in Great Plains cropping systems.

The objectives of this study were to characterize seedling emergence, plant development, and productivity of longspine sandbur infesting irrigated corn, and to define its critical period of interference.

MATERIALS AND METHODS

Site Description. The study was conducted from 1988 to 1990 near Akron, CO. The yearly precipitation is 419 mm (89-yr average), while average precipitation during the corn-growing season (May through September) is 290 mm. Average air temperature during the growing season is 18.9 C, and ranges from 13.5 C in May to 22.9 C in July. The soil was a Platner loam (Aridic Paleustoll) with 1.4% organic matter and pH 6.4 (0- to 15-cm depth). Cropping history of the site was continuous irrigated corn. For all years, study sites were established at different locations in the same field. Predominant weeds were longspine sandbur and redroot pigweed.

Corn Production Practices. Corn, Pioneer Brand 3732 (hybrid with semiupright leaves with medium height), was planted at 61,800 seeds/ha in the first week of May of each year, with plants emerging within 14 d of planting. Row spacing was 75 cm. The seedbed was prepared by tandem disk harrowing twice before planting, with no tillage occurring after planting. Ammonium nitrate was applied broadcast in a dry formulation, before tillage at 90 kg nitrogen (N)/ha. During the growing season, urea ammonium nitrate was applied with the irrigation water at 65 kg N/ha, in mid-July and early August, for a total of 220 kg N/ha. The crop was irrigated as needed with a center pivot sprinkler, beginning in June and continuing until mid-September. Dicamba (3,6-dichloro-2-methoxybenzoic acid) was applied in early June of each year to control redroot pigweed.

Seedling Emergence Study. In 1988, 1989, and 1990, eight 1-m^2 quadrats were established in corn. Seedling emergence was recorded weekly, starting May 1 and continuing until corn harvest in October. After each counting, seedlings were removed. Total seedlings per year ranged from 230 to 1,220/m^2, averaging 780 seedlings/m^2. The source of weed seeds was the indigenous soil seedbank. Other weeds emerging in the quadrats were hand removed weekly during the data collection period.

Emergence pattern for each year was developed by converting seedling emergence per week into a percentage of total emergence over the growing season for all replications. Data across the 3 yr were averaged by weekly intervals, with one standard deviation derived from yearly averages for each week.

Plant Development and Productivity Study. To assess plant development, longspine sandbur seedlings were evaluated weekly during the growing season. Seedlings were established every 2 wk, starting May 25 and continuing for 10 wk, in 1989 and 1990. The sites were located where longspine sandbur was not present the previous year.

To establish seedlings, burs, collected the previous year, were planted in peat pellets[5] and incubated in a greenhouse until seedling emergence. Pellets containing seedlings 8 to 10 mm tall were transplanted between corn rows, 38 cm from the row. There were eight replications, with seedlings from each transplanting date being 30 cm apart and randomly mixed in each replication. The areas surrounding the seedlings were maintained weed free by hoeing.

Seedling development was characterized with the Zadoks-Chang-Konzak scale (Bauer et al. 1983). This scale assigns a number for each development stage, with the entire life cycle defined between 0 and 100. Development was measured until anthesis. Rate of development was related to growing degree day (GDD) accumulation. Growing degree days were calculated from daily air temperatures using a base temperature of 10 C and a maximum of 30 C, the same temperature range for corn (Aldrich et al. 1978).

Plants were harvested 2 wk before maturity to measure aboveground biomass and number of tillers and burs.[6] The early harvest prevented bur loss due to shattering.

In 1989 and 1990, five sites were designated within a 30- by 30-m area in corn infested with longspine sandbur. From each site, 10 inflorescences were collected at the following development stages: boot, heading, anthesis, milk, dough, and maturity. Inflorescences from each

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[5] American Clayworks and Supply Co., Denver, CO 80204.

[6] Burs usually contain two seeds.

site were placed in paper bags and stored in a greenhouse until viability assessment was conducted 4 mo later. Seeds were separated from burs (50 seeds for each development stage per site), placed between layers of moist standard germination paper in petri dishes, and germinated at 18 C/10 C (day/night) temperatures for 14 d. Seeds that did not germinate were tested for viability with tetrazolium (Moore 1976). Seeds were cut in half and placed in a solution of 2,3,5-triphenyltetrazolium solution (1% aqueous solution of tetrazolium chloride) for 3.5 h. Seeds were assessed for viability by red staining of the embryo. Viability values are the sum of germination and tetrazolium data.

Critical Period of Interference Study. Longspine sandbur was removed by hoeing 2, 3, 4, and 5 wk after initiation of emergence (May 25) in 1989 and 1990. When the 2-wk removal treatment was initiated, corn had four leaves fully emerged, with seven leaves fully emerged at the 5-wk treatment. Treatments were maintained weed free for 7 d. Weed-infested and weed-free controls also were established. Weeds were removed from the weed-free control treatment weekly. Plot size was 4 by 8 m, with four replications. Longspine sandbur density at corn tasseling was approximately 150 plants/m². Corn yield was determined using a plot combine, harvesting a 15-m² area from each plot. Grain yield was standardized to 15.5% moisture content, with treatment means expressed as percent yield loss compared with the weed-free control.

Data Analyses. Experimental design was a randomized complete block for the plant development and critical period of interference studies. The seed viability study was a completely randomized design. Treatment means were analyzed by ANOVA, and if the *F*-test was significant, means were compared with LSD at the 0.05 level of probability. Treatment by year interactions did not occur; therefore, data were averaged across years.

RESULTS AND DISCUSSION

Seedling Emergence. Longspine sandbur began emerging May 25, with 84% of seasonal emergence occurring by June 15, a 4-wk period (Figure 1). Emergence continued until early August.

Producers can plan more effective control strategies if they are able to predict when longspine sandbur emergence occurs. Roberts and Feast (1973) suggested that initial seedling emergence of weeds is governed by a temperature threshold, such that when air temperatures reach a specific level, seedling emergence begins if moisture is available. Stoller and Wax (1973) also suggested a temperature threshold; however, they found that GDD accumulation did not correlate with seedling emergence. Egley (1986) reported that amplitude of daily temperature fluctuation most accurately described temperature effect on seedling emergence.

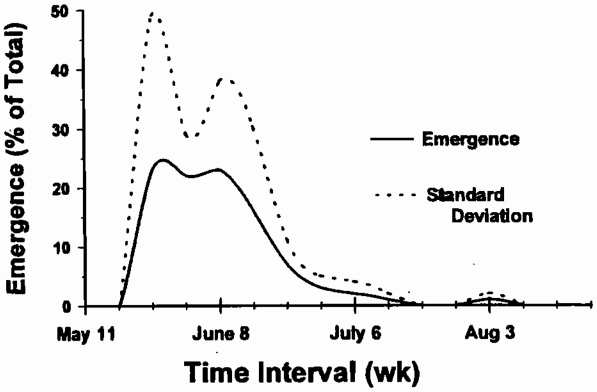

Figure 1. Longspine sandbur seedling emergence, averaged over 3 yr. Dotted line represents one standard deviation.

Following Egley's guidelines, daily air temperature fluctuation during the 7-d period before initial seedling emergence was calculated and averaged across 3 yr. Longspine sandbur began emerging when the maximum and minimum daily temperatures were 25.4 C ± 4.8 and 8.8 C ± 2.5, respectively. The average daily temperature was 17.0 C ± 3.2. Longspine sandbur begins emergence in Colorado in late May, which contrasts with emergence in Washington, where seedlings began emerging in mid-April (Boydston 1990). However, this difference in time can be attributed to temperature, as emergence in Washington began when soil temperature at 2.5-cm depth averaged 15 to 20 C, a temperature range similar to this study. However, longspine sandbur duration of emergence differed between the two regions, as seedlings continued to emerge through October in Washington, contrasting with the Colorado site, where seedlings did not emerge after early August (Figure 1).

Plant Development. Longspine sandbur development was affected by its time of emergence. Seedlings emerging on May 25 began heading 75 d later, while seedlings emerging July 5 headed 49 d later (data not shown). This time difference was not related to temperature, as GDD accumulation by heading was 35% less for seedlings emerging on July 5. However, seedlings emerging in May and June developed similarly (data not shown). Thus, to aid producers in assessing development, rate of plant development for this time period was related to GDD accumulation (Figure 2). Seedlings began tillering

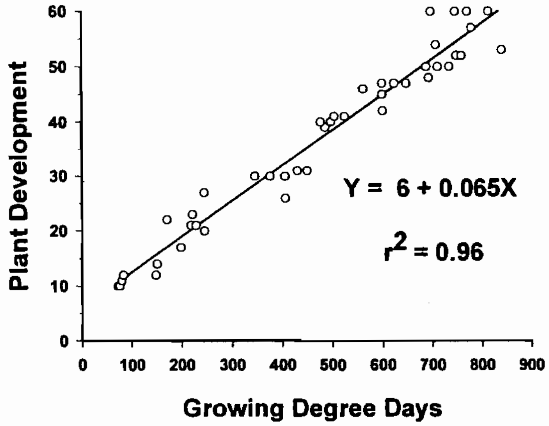

Figure 2. Longspine sandbur development as affected by temperature. Development characterized by the Zadoks-Chang-Konzak scale (Bauer et al. 1983), where 20 = tillering, 30 = stem elongation, 40 = boot, 50 = heading, and 60 = anthesis.

after approximately 215 GDD and reached anthesis after 830 GDD. This relationship enables producers to estimate longspine sandbur development, thus improving their management planning.

Seed Viability Development. Longspine sandbur is common along roadsides and field borders, which serve as a seed source. Producers can reduce seed production in these areas by mowing, but timing of the mowing operation is critical, as viable seeds can develop early in the life cycle of grasses. For example, some seeds are viable by late anthesis with downy brome (*Bromus tectorum* L.) (Upadhyaya et al. 1986) and by early milk with wild oat (*Avena fatua* L.) (Aldrich 1984).

Longspine sandbur develops viable seeds earlier than either downy brome or wild oat, as 20% of seeds were viable when burs were collected at heading (Figure 3). As with other species, seed viability increased with development, shown by the relationship: $Y = -98 + 2.4X$; [$r^2 = 0.91$, Y = viable seeds (%); X = development stage based on Zadoks-Chang-Konzak scale]. Producers can minimize seed production from field borders by mowing longspine sandbur before plants begin to head. However, producers may need further control actions to prevent seed production from plant regrowth.

Plant Productivity. Simulation models can predict economic optimal thresholds over a long-term basis by using information on seed production per plant (Jordan 1992). Models are now available for two annual weeds, corn cockle (*Agrostemma githago* L.), (Firbank and Watkinson 1986) and sterile oat (*Avena sterilis* L.) (Gonzalez-Andujar and Fernandez-Quintanilla 1991) in small grains, that predict long-term population projections as affected by control strategies.

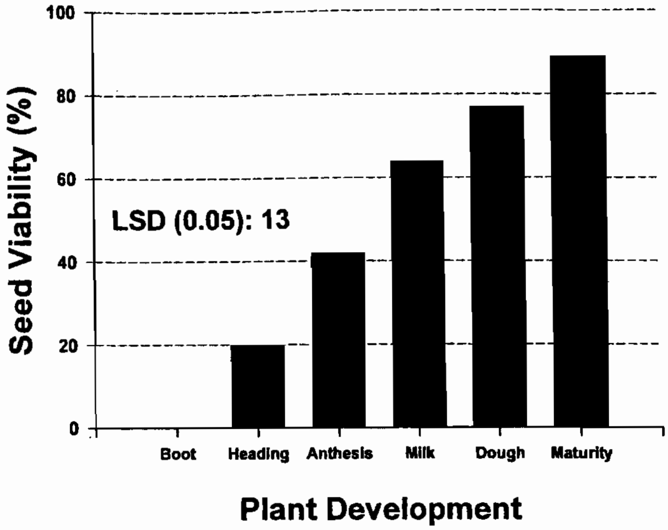

Figure 3. Seed viability of longspine sandbur as affected by plant development. Treatment means are the sum of germination and tetrazolium data.

For longspine sandbur growing in corn, dry weight, number of tillers, and burs per plant responded similarly to time of emergence (Table 1). If emerging on May 25, seedlings produced 71 g of biomass and 1,120 burs/plant. In contrast, seedlings emerging June 22 produced 80% less biomass, while burs per plant decreased 86%, from 1,120 to 150. Bur production as related to time of seedling emergence was described by: $Y = 1052 - 48X + 0.54X^2$, ($r^2 = 0.86$, X = days after May 25).

Critical Period of Interference. Corn grain yield was not affected by longspine sandbur interference of 3 wk or less (Figure 4). Four weeks of interference (May 25 to June 22) reduced grain yield 11%, while full season interference reduced yield 35%.

Producers planning herbicide application for control of longspine sandbur will need to consider other factors in addition to duration of interference, such as growth stage of seedlings. Herbicide activity is reduced if grasses are tillering (Derr et al. 1985; Neal et al. 1990). Because longspine sandbur tillers after approximately 215

Table 1. Longspine sandbur productivity as affected by time of emergence. Data are averaged across 2 yr.

Date of emergence	Dry weight	Tillers	Burs
	g/plant	——— No. per plant	———
May 25	71	45	1,120
June 8	26	20	370
June 22	12	8	150
July 6	4	4	72
July 20	1	2	2
LSD (0.05)	12	7	162

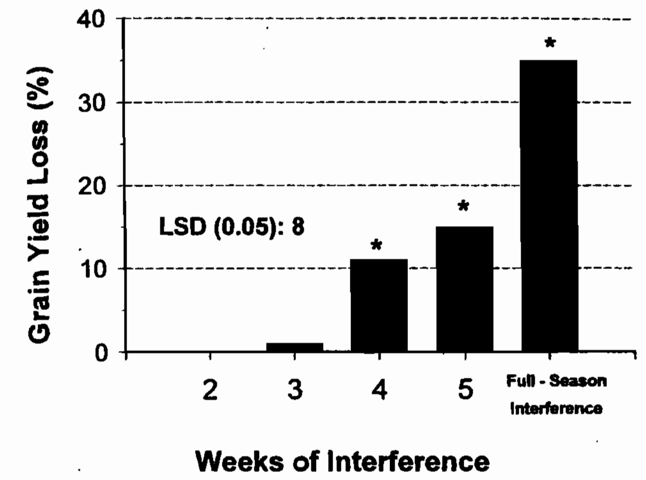

Figure 4. Effect of duration of longspine sandbur interference on grain yield of irrigated corn. Treatment means were expressed as percent yield loss compared to the weed-free control. Treatment means differing from the weed-free control are designated with an asterisk.

GDD, seedlings emerging in late May will tiller by June 22 with average temperatures in Colorado.

Another consideration, however, is that controlling seedlings too early allows seedlings that emerge after the herbicide application to produce considerable seeds (Figure 1; Table 1). For example, seedlings emerging June 8 produced more than twice the number of burs as seedlings emerging June 22 (Table 1). In addition, the grass herbicides may have application restrictions based on corn growth stage. Nicosulfuron can be applied only with drop nozzles if corn has more than six leaves.[7] In this study, corn developed seven leaves by July 1 (data not shown).

The data from this study suggest that a POST grass herbicide should be applied near June 15 to produce the most favorable results related to all factors. Decision aid models that integrate longspine sandbur ecological characteristics with assessing management strategies for herbicides could help producers in predicting long-term consequences of their decisions.

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[7] Accent herbicide product label, E. I. du Pont de Nemours and Company, Wilmington, DE 19898.