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Soybean Canopy Gap Influence on Velvetleaf Seed Production

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Gaps in the soybean row provide locations for velvetleaf (*Abutilon theophrasti*) plant growth. Gap width, and velvetleaf plant location within the gap, were investigated for effect on seed production. There was no significant difference in velvetleaf capsule production between plants that grew either centered in a gap or at the western end of a gap in east-west oriented soybean rows. Also, there was no difference in plant survival, emergence through the soybean canopy, flowering, locule number per capsule, or average seed weight of velvetleaf based on gap width. However, there was a difference in capsule production based on gap width. In 1999, seed capsule production increased from approximately 35 capsules $plant^{-1}$ at 0 cm gap width to 140 capsules $plant^{-1}$ in the 90 cm gap. In 2000, seed capsule production increased from approximately 9 capsules $plant^{-1}$ at 0 cm gap width to 98 capsules $plant^{-1}$ in the 90 cm gap. Seed production ranged from an estimate of 300 to 5900 seeds $plant^{-1}$. As gap width in the soybean row increases, it becomes more important to monitor and control velvetleaf growth. It is even possible, however, to have significant velvetleaf seed production from plants that emerge in a 30 cm gap in the row.

INDEX DESCRIPTORS: seedbank, soybean, *Glycine max,* velvetleaf, *Abutilon theophrasti.*

Velvetleaf (*Abutilon theophrasti*) is a serious weed problem in soybeans (*Glycine max*) and other row crops in the north-central and southern United States (Spencer 1984, Kremer and Spencer 1989). Velvetleaf is not as effectively controlled in glyphosate-tolerant soybeans as some common weeds, and velvetleaf that emerges in the gaps in the crop row will not be removed by mechanical cultivation. Gaps can occur in the soybean row due to planter malfunction, nongermination of the seed, or death of the crop seedling soon after either germination or emergence. These gaps provide sites for weed establishment. It is possible that even small gaps in the row may provide velvetleaf space to survive and to produce significant numbers of seeds that can potentially be added to the seed reserve in the soil weed seedbank.

An understanding of gap influence on velvetleaf seed production will allow for better management decisions including timing of weed scouting, spot treating emergent weeds, and replanting decisions because the presence of seeds in the seedbank infers that velvetleaf may be an agronomic problem for many years. The long-term impacts of the seedbank are a result of the high level of dormancy in the seed and a long seed life in the soil (Toole and Brown 1946, Khedir and Roeth 1981, Lueschen and Andersen 1980, Lueschen et al. 1993). It is recognized, however, that weed seedbank dynamics are also affected by seed loss through predation, degradation, germination, and dispersal (Wright et al. 2000). The objective of this research was to determine the effect of gap size in soybean rows on velvetleaf seed production and estimate the potential impact on velvetleaf seed reserve.

METHODS

Velvetleaf seed production, in relation to soybean canopy gap width, was investigated near Ames, Iowa, at the Iowa State University Johnson Farm in 1999 and at the Iowa State University Curtiss Farm in 2000. Soils at both sites belong to the Clarion series (fine-loamy, mixed, superactive, mesic Typic Hapludolls) with less than 3% slope. Soybean variety planted in 1999 was Prairie Brand PB2120, and the variety planted in 2000 was Prairie Brand PB237. Mention of a specific variety does not imply endorsement to the exclusion of other suitable varieties. Planting was in 0.76 m wide east-west rows at approximately 350,000 seeds ha^{-1} on 6 June 1999 and on 12 May 2000. The warmer and drier Spring of 2000 relative to Spring 1999 necessitated the earlier planting that year. At soybean emergence, plots and planting locations of velvetleaf within the soybean row were established. Velvetleaf planting location was either within the soybean row or within gaps in the soybean row that were created by removing all soybeans for a specified distance. In 1999, planting location was either within the row (0-cm) or in gaps of 15, 30, 60 or 90 cm. In each gap, velvetleaf-planting location was either centered in the gap or at the west end of the gap. The planting at the west end of the gap was to determine a possible zone of influence on weed growth where the influence of position would be subordinate to the influence of the gap width. The west end of the gap was chosen, rather than the east end, because access to the fields in 1999 and 2000 was from roads on the eastern side of the field. This enabled rapid visual inspection from the access road during the growing season. In 2000, the planting location was either within the row (0-cm) or in gaps of 30, 60 or 90 cm. The planting at the western end of the gap was included only for the 90-cm gap. The day following plot establishment, six velvetleaf seeds were planted at the desired location (gap size by location) in the plot. Three weeks following initial plot establishment, the same treatments were established within the replication in another row. In 1999, plantings were also established six weeks from the initial planting.

Experimental design was split-plot (by velvetleaf planting date) with three replications per block and four blocks. Date was the whole plot and gap width by location was the subplot. Velvetleaf planting date was randomly assigned within replication. Gap size, and plant-

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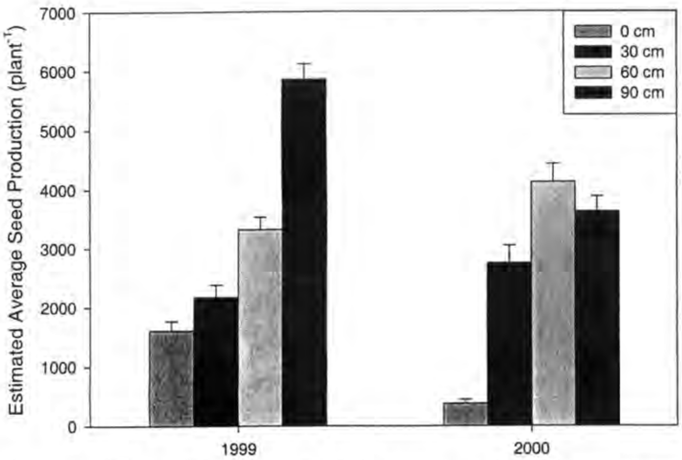

Fig. 1. Effect of gap width on estimated average seed production per velvetleaf plant near Ames, Iowa, in 1999 and 2000. Error bars represent standard error of the mean.

ing location within gap size, were randomly assigned within velvetleaf planting date. The first block was established 5 m from the eastern edge of the field. Three border rows separated the first replication of each block from the south side of the field. There were three rows between planting dates within a replication, six rows between replications, and 10 m between the back of one block and the front of the next block.

Hand cultivation of plots was done throughout the growing season as needed to maintain weed free blocks. A single herbicide treatment was applied when the third trifoliate soybean leaf emerged. In 1999, acifluorfen at 35 g ai (active ingredient) ha^{-1}, bentazon at 750 ae (acid equivalent) ha^{-1}, and sethoxydim 350 g ai ha^{-1} were applied with crop oil at 2.34 l ha^{-1}. In 2000, imazamox at 45 g ai ha^{-1} and acifluorfen at 35 g ai ha^{-1} were applied. Velvetleaf plants of interest were covered by waxed cups prior to spraying, and the cups were removed the following morning.

Velvetleaf capsules were monitored for maturity and were harvested as close to the onset of dehiscence as possible. At harvest, the location of each capsule on the plant was recorded. Harvested capsules were stored at 4°C until processing. Capsule processing consisted of counting the number of locules per capsule, opening each locule and removing seeds and counting total seeds per capsule. Percentage seed recovery was calculated based on an average of three seeds per locule. Seeds were then weighed and an average weight of seed per capsule was calculated.

Data were analyzed in t-test using SAS (alpha = 0.05). Means were compared using Tukey's Studentized Range (HSD). Because there were significant effects due to year, results are presented separately for each year.

RESULTS AND DISCUSSION

Velvetleaf seed production patterns for the two years were different (Fig. 1); therefore, results are presented separately. This difference could be explained by the earlier planting date in 2000, and/or by environmental factors (2000 was warmer and drier in early June than in 1999) leading to more rapid soybean canopy closure. Soybean canopy closure in 2000 was approximately 3.5 to 4 weeks sooner than in 1999. Data are only shown for the first velvetleaf planting date for both years. In 1999, only 6 of 108 plants from the second planting date produced any capsules, and maximum seed production from any of these six plants was 29 seeds. In 2000, none of the second velvetleaf planting produced seed. Eaton et al. (1976), Oliver (1979), and Hagood et al. (1980) also demonstrated that velvetleaf emerging more than 3 weeks after soybean emergence was significantly less competitive than earlier emerging plants.

In 1999, comparing the gap-centered and western plantings, the difference in average capsule production was less than 9 capsules, except for the 90 cm planting where the difference was approximately 45 capsules. Higher values were for the centered planting. This difference was not statistically significant (data not shown), but the 90 cm gap seemed as though it might be significant under better growing conditions. Therefore, the western plantings were eliminated in 2000 for all gap widths except for the 90 cm gap width. In 2000, as in 1999, there was no difference in the average capsule production between the 90 cm gap centered and 90 cm western planting. Therefore, data from the western planting position will not be discussed.

If soybean rows were oriented in a direction other than east-west, it is doubtful if a greater influence on velvetleaf seed production would have been observed by planting location within gaps. Between latitudes of approximately 25° and 55°, light absorption by the canopy is greatest in north-south oriented rows during the summer months (May to August), but the magnitude of the difference between north-south and east-west orientation decreases with increasing latitude up to 65° (Mutsaers 1980). The fields were located at approximately 42° N latitude.

In 1999 and 2000, there was no difference in velvetleaf plant survival, emergence through soybean canopy, flowering, or average seed weight based on gap width (data not shown). There was a difference in capsule production based on gap width (Table 1).

Table 1. Effect of gap width on phenological characteristics.

	1999 Johnson Farm	2000 Curtis Farm
Survival	0.488^{NS}	0.165^{NS}
Emergence through soybean canopy	0.102^{NS}	0.102^{NS}
Flowering	0.342^{NS}	0.188^{NS}
Average seed weight	0.561^{NS}	0.332^{NS}
Capsule production	0.002**	0.004*

* P = 0.05
** P = 0.01

Gap size, and weed position in the gap, had no significant effect on the number of locules produced per capsule (data not shown). Maximum locule number was 17, minimum number was 7, and average was 14. Seeds per locule ranged from 2 to 4, but more than 99% of the locules had three seeds. Seeds recovered per capsule ranged from 74 to 80% (Fig. 2).

Our estimates of up to 6000 seed per plant at the 90 cm gap width (Fig. 1) are within the range of seed production reported by Winter (1960), Hartgerink and Bazzaz (1984), Bello et al. (1995), and Hartzler (1996). Velvetleaf that germinated and grew within the soybean row (0-cm gap) were still able to produce an average of 300 to 1600 seeds $plant^{-1}$.

Buhler and Hartzler (2001) exposed seeds to conditions approximating field conditions, while maximizing seed recovery, and reported a cumulative emergence of 31% of the original velvetleaf seed bank after four years. Hartzler (1996) and Webster et al. (1998) reported that up to 25% of the velvetleaf seed introduced into the soil emerged over the next four years. Assuming a 90% loss of seed due to predation, disease, and dormancy, there would still be sufficient velvetleaf seed to pose a significant problem in following years

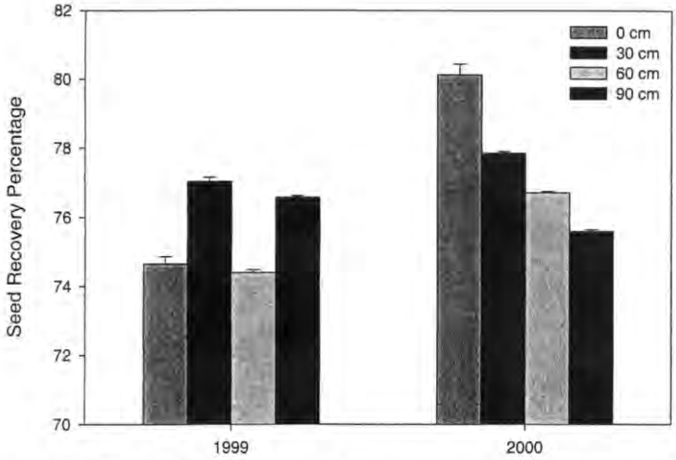

Fig. 2. Effect of gap width on seed recovery percentage per velvetleaf capsule near Ames, Iowa, in 1999 and 2000. Error bars represent standard error of the mean.

and replenish the weed seed bank. Excellent control of velvetleaf is necessary because establishment of a strong soybean stand is not enough to limit velvetleaf seed production. Even in small gaps (<30 cm) significant number of velvetleaf seeds can be produced that have the potential to be a problem in subsequent years.

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