Weed Technology. 2004. Volume 18:183–185

Note

Methods in Weed Ecology: Glue Retains Seeds in Shatter-Prone Seedheads[1]

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Abstract: The difficulty of measuring fecundity of weeds with shatter-prone seeds can be overcome by postanthesis application of nontoxic glues to seedheads. Such glues reduced seed losses of redroot pigweed to <5% of total seed production compared with 12 to 14% for nontreated plants.
Nomenclature: Redroot pigweed, *Amaranthus retroflexus* L. #[3] AMARE.
Additional index words: *Amaranthus retroflexus*, AMARE, fecundity, seed dispersal, seed production, seed shed.
Abbreviation: PVAC, polyvinyl acetate copolymer.

INTRODUCTION

Seed production of most weed species is difficult to study because of asynchronous fruit maturation and seed dispersal. Consequently, fecundity has not been a commonly examined topic for many weed species (Cavers and Benoit 1988). Moreover, as noted by Norris (1996), many uncertainties regarding techniques and accuracies exist in the older literature on weed fecundity.

Fecundity is especially difficult to estimate for species such as redroot pigweed. Its seedhead (infructesence) is a panicle composed of multiple spikelike clusters of very small fruit. The apical seedhead often is subtended by many axillary seedheads, on all of which the fruit matures asynchronously. The small (1 mm) seeds disperse in a continuous manner for several weeks after initial maturation (Forcella et al. 1996). Consequently, harvesting the plant or even individual seedheads at any time after initial seed maturation results in inaccurate estimates of seed production, that is, some seeds will be undeveloped if harvest is early, whereas some seeds already will have dispersed if harvest occurs later. Methods to solve this dilemma will aid research on weed seed fecundity.

We hypothesized that spraying a nontoxic glue onto seedheads of redroot pigweed at the time of initial seed maturation would retain older seeds on the seedhead and still allow undeveloped seeds to mature. Our objective was to test this hypothesis using different types and concentrations of glue.

MATERIALS AND METHODS

Populations of redroot pigweed were selected in border areas of row-crop experiments. In 2001 this was done at the North Farm of the University of Minnesota's West Central Research and Outreach Center, whereas in 2002 the experiment was done at the USDA-ARS Swan Lake Research Farm. Both locations are near Morris, MN. Soils were an Aastad clay loam in 2001 and a Barnes loam in 2002, with both soils classified as Udic Haploborolls, fine-loamy, mixed. The border area each year was about 10 by 20 m. It was not treated with herbicides or fertilizers, but it was disked in early June to eliminate weeds. Thereafter, late-emerging seedlings of redroot pigweed formed nearly monospecific stands. After anthesis in late August, plants were checked regularly for presence of mature seeds.

Once mature seeds were detected, 68 plants were selected for uniformity of size: 50 to 75 cm tall with seedhead lengths (±SD) of 16 (±2) cm in 2001 and 11 (±2) cm in 2002. Groups of four randomly chosen plants were assigned to each of 17 treatments arranged in a completely random design. The first treatment was a "no-glue" check that involved covering each seedhead with a white nylon mesh bag. Mesh size was <1 mm, which retained seeds but allowed movement of air and rainwater. The opening of each bag was secured to ensure retention of dispersed seeds. Identical bags also were placed over the seedheads of the remaining 64 plants but only after these seedheads were treated with glue in mid-September.

The 16 glue treatments involved four types of glue,

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

Table 1. Percent losses of seeds from redroot pigweed seed heads through natural seed shattering after treatment with differing glues applied at four dilutions with water (v/v).[a]

Treatment	Seed loss[b] 2001	Seed loss[b] 2002
	%	%
Check	12.6 a	14.0 a
PVAC 1:8	7.8 bcd	5.1 bcdef
PVAC 1:4	5.2 gh	2.4 def
PVAC 1:2	NA	3.9 cdef
PVAC 1:1	4.9 hi	1.6 ef
Casein 1:8	8.1 bc	9.5 ab
Casein 1:4	5.7 fgh	3.1 def
Casein 1:2	8.5 b	6.1 bcd
Casein 1:1	6.0 efg	2.6 def
Albumin 1:8	7.7 bcd	12.5 a
Albumin 1:4	7.7 bcd	8.8 abc
Albumin 1:2	4.0 i	4.9 bcdef
Albumin 1:1	5.6 fgh	3.4 def
Starch 1:8	5.9 efgh	5.0 bcdef
Starch 1:4	7.0 cde	8.1 abc
Starch 1:2	6.7 def	5.2 bcde
Starch 1:1	8.2 bc	1.6 f

[a] Abbreviations: PVAC, polyvinyl acetate copolymer; NA, not applicable.

[b] Values within columns without common letters differ significantly ($P = 0.05$).

each applied at four rates. The glue types were polyvinyl acetate copolymer (PVAC, Elmer's Washable School Glue) glue, casein (milk) glue, albumin (egg white) glue, and starch glue. The last three glues were synthesized in the laboratory. Briefly, stock casein glue was made from warm (35 C) skimmed milk (125 ml) curdled with vinegar (25 ml). After the curds were removed and mixed with water (10 ml), baking soda (up to 4 g) was added until CO_2 evolution stopped. Stock albumin glue was simply egg whites. Stock starch glue was 10 g of biodegradable starch-based foam packaging material dissolved in 150 ml water. Each stock glue was diluted with water to make the following four concentrations: 1:1, 1:2, 1:4, and 1:8 (v/v).

Approximately 4 to 5 ml of glue solution was applied to each seedhead using a handheld spray bottle. For the highest glue concentrations, this amounted to about 0.58, 0.71, 0.34, and 0.17 g per seedhead of dry glue for PVAC, casein, albumin, and starch glues, respectively. Seedheads intercepted only a fraction, perhaps half, of the intended volume of glue. Seedheads were enclosed in the mesh bags after glue solutions dried.

All seedheads were collected at the time neighboring row-crop experiments were harvested in mid-October. Seeds from the seedheads were separated into two categories. The first category was dispersed seeds, which were the loose seeds that were in the mesh bags at the time the seedheads were harvested. These seeds represented those that would have been lost because of shattering in the absence of the mesh bags. The second seed category was the retained seeds, which were the seeds that remained on the seedheads at the time of harvest. After air-drying for several weeks, loose seeds and seedheads were weighed. The seedheads were then measured for length and threshed, and the seeds were cleaned and weighed.

For analytical purposes, weights of dispersed seeds were divided by total seed weights, and the quotient was multiplied by 100. The result was percent seed lost due to natural seed shedding. These percent data had unequal variances ($P < 0.05$) among treatments according to Bartlett's test for homogeneity of variances (Anonymous 1996). Consequently, data were square-root transformed (Steel and Torrie 1980) to homogenize variances ($P > 0.05$). Because increasing glue concentrations rarely had increasing effects on seed retention, ANOVA was performed in preference to regression. Square-root means were separated by LSD ($P = 0.05$) but back transformed for presentation of results.

RESULTS AND DISCUSSION

The no-glue check treatment lost about 13 to 14% of its seeds by the time seedheads were harvested in mid-October (Table 1). Several glue treatments decreased these losses. Plants treated with dilute glue solutions often lost more seeds than plants treated with concentrated solutions. The higher rates of PVAC glue ($\geq$1:4 concentration) were among the best treatments, reducing seed losses to only 2 to 5% across years.

Appreciable amounts of rain fell between the times of glue application and seedhead harvesting, amounting to 76 mm between September 13 and October 18, 2001, and 80 mm between September 17 and October 24, 2002. Thus, seeds were retained on seedheads by at least some treatments despite the water-soluble nature of each glue.

There was no obvious yellowing of leaves or seedheads of treated plants after glue application. Comparisons of seed production efficiency (i.e., seeds/cm of seedhead length or seeds/g of seedhead weight) between treated and nontreated plants showed no significant trends (data not shown). Consequently, application of glue did not appear to damage plants or affect seed production. Furthermore, glues did not interfere noticeably with seed threshing and cleaning, perhaps because glues adhered only to bracts and tepals that enveloped the seeds. Threshed seeds appeared entirely free of glue.

The results suggest that inexpensive products, such as PVAC glue, can be applied to seedheads of shatter-prone weeds after anthesis to minimize seed dispersal before full seed maturation and sampling by investigators. Retention of seeds on seedheads will facilitate measurement of seed production, which, in turn, should assist weed scientists in documenting fecundity of many more weed species than has been heretofore possible.

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