Effect of Harvest Method on Seed Yield of *Coreopsis lanceolata* L. and *Gaillardia pulchella* Foug.[1]

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Abstract

Seed of north Florida ecotypes of lanceleaf coreopsis (*Coreopsis lanceolata* L.) and blanketflower (*Gaillardia pulchella* Foug.) were sown in February 1998 and harvested manually or mechanically (portable seed stripper) at two different times during the growing season. Mechanical harvesting of both species was more efficient based on the length of harvesting time relative to the yield of clean seed but hand harvesting yielded substantially more clean seed. Date of harvest (mid-July or early October) had several significant effects on blanketflower yield and quality. The July harvest resulted in 67% higher clean seed yield, 45% higher clean seed yield rate (a measure of harvesting efficiency), 9% greater seed mass, and 95% greater germination rate than the October harvest. Date of harvesting for lanceleaf coreopsis (late June and late August) had minimal effects on clean seed yield or quality.

Index words: lanceleaf coreopsis, Indian blanket, blanketflower, firewheel, native wildflower, seed stripper.

Species used in this study: lanceleaf coreopsis (*Coreopsis lanceolata* L.), blanketflower (*Gaillardia pulchella* Foug.).

Significance to the Nursery Industry

There is an increasing demand for seed from regionally adapted native wildflowers for use in roadside stabilization and beautification projects, and restoration, reclamation, and enhancement of natural areas. Most production of regionally adapted native wildflower and grass seed is in the West and Midwest. Large-scale production in the Southeast is extremely limited by the lack of technical information for potential growers in this section of the country and the very limited availability of regionally adapted seed. Because of the limited seed sources, growers must begin with small plots and increase their seed. In such cases, growers should consider the use of hand harvesting. While hand harvesting is more labor intensive than using a seed stripper, clean seed yields are much greater. Also, the results of our study indicate that seed of lanceleaf coreopsis and blanketflower can be harvested twice during the same season that the seed is sown, although there was a reduction in yield and quality of blanketflower seed harvested late in the growing season (early October).

Introduction

There is a growing demand for native wildflower seed for use in roadside stabilization and beautification projects. Other large land management agencies and private companies that must reclaim large areas of land have also expressed a strong desire in purchasing native wildflower seed. In many cases, the demand for regionally adapted seed sources results from evidence that seed source can affect germination, survival, growth, and/or flowering of native wildflower species (3, 4, 5, 11, 12, 17). The importance of seed origin in ecosystem management has not only been recognized by the research community but by many states and their respective departments of transportation, especially those in the West and Midwest. Use of regionally adapted native wildflowers and grasses avoids genetic contamination and facilitates adaptability along roadsides and in natural areas.

Because seed origin is becoming such an important issue, field production of native wildflower and grass seed has become a commercially viable enterprise, especially in the West and Midwest. However, production in the Southeast is ex-

[1]Received for publication September 4, 2001; in revised form December 10, 2001. Florida Agricultural Expt. Station Journal Series No. R-08342. The authors would like to thank Ms. Lucy Rogers for technical assistance with this project.

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tremely limited, with one of the major impediments being lack of technical information for potential growers in this region of the country. Most of the work on native wildflower seed production has been conducted at USDA Plant Materials Centers, but the number of published plant guides is limited (16). Seed production information for a limited number of species can also be obtained on-line through the Native Plants Network (10). Information generated by universities is even scarcer. Norcini et al. (13) published an extension circular on seed production of black-eyed susan (*Rudbeckia hirta* L.), and Johnson and Whitwell (6) recommended several native wildflower species for commercial production based on uniformity of seed maturation and germination of the harvested crops.

Native wildflower seed is harvested by hand or mechanically. With hand harvesting, mature seed can be selected for harvest. While very labor intensive, this method is desirable for species whose seed do not ripen uniformly, such as many ecotypes of native wildflowers. A grower in Minnesota noted that enough seed heads of false sunflower [*Heliopsis helianthoides* (L.) Sweet] could be hand harvested in 1 hour to yield (after cleaning) about 226 g (0.5 lb) of seed, with a 1996 wholesale value of about $37 (7). Johnson and Whitwell (6) noted that seed of lanceleaf coreopsis (*Coreopsis lanceolata*) and blanketflower (*Gaillardia pulchella*) do not mature uniformly; hence, hand harvesting might be justified for these species if the market price could justify labor costs. Mechanical harvesting can be accomplished with either a seed stripper or a combine. A seed stripper is more selective than a combine but less selective than hand harvesting, as small sections of a crop with mature seed can be targeted for harvest. While there are several types of seed strippers, all of them are designed to strip off primarily mature seed and either deposit the seed in a receptacle or move it by air into a hopper. Unripe seed and the remainder of the plant are supposed to be left intact. Use of a seed stripper, like hand harvesting, allows harvesting of a crop over a period of time. Combining, while very efficient, is best used on a uniformly maturing seed crop because the whole crop is harvested at the same time.

Data on direct comparisons of harvesting methods for native wildflower seeds is sparse. Johnson and Whitwell (6) noted that yields resulting from mechanical harvesting (no methods stated) of three wildflower species with relatively uniform seed maturation were substantially less than those resulting from hand harvesting. Norcini et al. (13) suggested that hand harvesting of black-eyed susan may be economical for crops of 0.4 ha (1 A) or less.

In preliminary work, we noted that our portable seed stripper (Prairie Habitats, Inc., Manitoba, Canada) removed nearly all mature and immature seed heads of lanceleaf coreopsis and blanketflower after just a few passes. Hence, the objective of our study was to compare labor inputs and yield when all lanceleaf coreopsis and blanketflower seed heads were harvested manually or by portable seed stripper.

Materials and Methods

Seed. Seed of lanceleaf coreopsis and blanketflower were collected from several native upland populations located in the Florida panhandle (AHS Heat Zone 9; USDA Hardiness Zone 8b) in 1996 and 1997. After the seed was cleaned, it was stored in the dark at 5.6C (42F) at 40% relative humidity (RH) until it was planted.

Plant establishment and maintenance. Adjacent plots [about 3 m (10 ft) apart] of lanceleaf coreopsis [2.4 × 35 m (8 × 115 ft)] and blanketflower [2.4 × 61 m (8 × 200 ft)] were established in a fallow field located at the North Florida Research and Education Center in Monticello, Florida (30.5°N, 83.9°W; AHS Heat Zone 9; USDA Hardiness Zone 8b). The soil was a Fuquay fine sand (0.5–2% OM, 0–5% slope), with average initial pH in the lanceleaf coreopsis and blanketflower plots of 5.6 and 5.7, respectively. Total initial nitrogen levels (ammoniacal + nitrate) in the coreopsis and blanketflower plots were l.5 mg/liter (ppm) or less.

On January 30, 1998, glyphosate (Roundup Ultra; Monsanto, St. Louis, MO) at 2.2 kg ai/ha (2 lb ai/A) was applied to kill existing vegetation in the two plots. Ten days later, the plots were lightly harrowed and seed were sown into slightly moist soil. Seed of blanketflower (0.52 g Pure Live Seed/m^2 [4.6 lb PLS/A]) and lanceleaf coreopsis (0.28 g PLS/m^2 [2.5 lb PLS/A]) were each thoroughly mixed with 4 liters (1.1 gal) of slightly moistened, packed builder's sand in 18.9-liter (5-gal) buckets yielding 6 liters (1.6 gal) of mixtures. For each species, the 6-liter (1.6-gal) sand-seed mixtures were divided in half, and two people applied seed over the plot so that there was 100% overlap. After the seed were sown, the plots were overhead irrigated with 0.25 cm (0.1 in) of water. Precipitation from seed sowing to initial lanceleaf coreopsis harvest was 45.2 cm (17.8 in), with an additional 37.3 cm (14.7 in) between the first and second harvests. Rainfall on blanketflower plots was 52.8 cm (20.8 in) until initial harvest and 79 cm (31.1 in) between the first and second harvests.

No supplemental fertilizer was applied, but plots were irrigated as necessary during extended dry periods. Grassy weeds were controlled with fenoxaprop (Acclaim Extra; Aventis Environmental Science, Montvale, NJ) applied at 0.10 kg ai/ha (0.09 lb ai/A) on April 28, 1998, and sethoxydim (Vantage; TopPro, Memphis, TN) applied at 0.31 kg ai/ha (0.28 lb ai/A) on July 8, 1998 (lanceleaf coreopsis only), 0.34 kg ai/ha (0.30 lb ai/A) on July 21, 1998, and 0.31 kg ai/ha (0.28 lb ai/A) on Aug. 3, 1998 (blanketflower only). All other weeds were removed by hand as necessary. No other pesticides were used.

Seed harvest. Achenes of lanceleaf coreopsis sit loose at the end of the flower stem and are easily dispersed by wind, rain, or slight vibration of the plant. In contrast, blanketflower achenes are more tightly held to the receptacle and persist longer. Achenes of each species were harvested manually and mechanically during the 1998 growing season — lanceleaf coreopsis on June 30 and August 24, and blanketflower on July 17 and October 5. Seed were harvested when it visually appeared that most achenes were mature. The lanceleaf coreopsis and blanketflower plots were divided into 12 and 20 1.5 m × 1.5 m (5 ft × 5 ft) subplots, respectively, with buffers of at least 0.6 m (2 ft) between adjacent plots and at least 0.3 m (1 ft) in from the edge of the plots. Half the plots were harvested by hand (two to three people), and the other half harvested mechanically with a portable seed stripper (Prairie Habitats Inc., Manitoba, Canada). Harvesting method for each subplot was assigned using a completely random design. Total time to harvest each subplot was recorded. Harvested seed were dried in a greenhouse and stored in the dark at 6.7C (44F) and 60% RH until manually cleaned or tested. The mass of three randomly selected 100-seed

Table 1. Effect of date and harvesting method on seed yield of a north Florida ecotype of lanceleaf coreopsis.

	June 30, 1998		August 24, 1998		Significance		
	Hand	**Mechanical**	**Hand**	**Mechanical**	**Date**	**Method**	**D × M**
Bulk harvest dry mass (g)/plot	127.9	26.4	74.7	15.5	0.0639	<0.0001	0.2110
Total dry seed mass (g)/plot	25.3	5.5	17.2	2.8	0.1073	<0.0001	0.4119
Percent seed mass (per plot)	20.1a[z]	20.7a	24.5a	18.0b	0.3851	0.0041	0.0080
100-seed mass (mg)	124.0a	128.0a	123.0a	113.0b	0.0141	0.3197	0.0311
Seed yield (kg/A)	44.0	9.6	29.9	4.8	0.1073	<0.0001	0.4119
Harvesting time (min)/plot	—[y]	—[y]	11.6	0.6	—	—	—
Seed yield rate (g/min/plot)	—[y]	—[y]	1.36	4.23	—	—	—
Percent germination	13.7b	29.5a	18.7a	18.9a	0.1426	0.0060	0.0075

[z]Means, within rows, followed by different letters are significantly different as determined by LSD (α = 0.05).
[y]Time to harvest data were not recorded for lanceleaf coreopsis on June 30.

samples for each species and date by harvest method was recorded. Germination tests were conducted by Agri Seed Technologies (Tallahassee, FL) according to AOSA guidelines (1).

Data were analyzed using general linear model (GLM) procedures of SAS and an appropriate model statement (14). Significant main effects means were separated using Duncan's Multiple Range Test (α = 0.05), and significant interactive effects means separated using LSMEANS/PDIFF. Percentage data were transformed (arcsine) as necessary prior to analysis but retransformed means are presented.

Results and Discussion

The bulk seed harvests (total dry mass harvested) of both species using either harvesting method contained a high percentage of stems, leaves, and/or flowers. The percentage of seed in the harvest was usually about 20 to 25% (Tables 1 and 2) but was as low as 10% for blanketflower harvested with the seed stripper in October (Table 2). The relatively low percentage of seeds in the bulk harvest was a result of unevenly maturing seed heads (6) and the harvesting of seed heads embedded in the canopy. Under our conditions the seed stripper harvests most seed heads (both mature and immature) after just one pass. For these reasons, our bulk seed harvest rates were higher than reported for other wildflower species harvested with the seed stripper (7).

The greater bulk harvest of hand harvested seed compared to mechanical (Tables 1 and 2) is an important consideration with respect to drying and conditioning of the seed. First, there must be sufficient drying space available to ensure that seed and other plant parts dry within a few days. In our experiments, extraneous plant material in the bulk harvest did not affect seed quality as determined by percent germination. Second, the higher percentage of extraneous plant material in the bulk hand harvest will result in increased seed conditioning costs because of the greater amount of conditioning needed. This seed conditioning cost factor is another reason that the actual or inherent value of the seed must be considered when selecting a harvesting method.

Mechanical harvesting of both species was more efficient than hand harvesting based on time spent harvesting seed and the ultimate yield of clean seed (see *Seed yield rate* in Tables 1 and 2), but hand harvesting yielded at least four times more clean seed. The relatively low mechanical harvest yields occurred because we observed that seed stripped off by the rotating 'brush' (tube with many short pieces of string trimmer line distributed evenly around and along the length of the tube) was not always discharged into the hopper. The lower mechanical harvest yields of lanceleaf coreopsis may have also been related to the easily dislodged nature of its achenes. Hence, hand harvesting might be justified for seed increase plots, small plots of specialty species, or for high value seed, but not for general seed production of 0.4 ha (1 A) or less as had previously been suggested for black-eyed susan (13). Hand harvesting of all ripe seed in just 0.2 ha (0.5 A) of lanceleaf coreopsis or blanketflower could easily take more than a week. For general seed production, combining would seem to be the most efficient. An acre of seed could be harvested with a combine in about 30 min for $35 to $45 (Steve Melton, pers. comm.).

Our seed yields of lanceleaf coreopsis and blanketflower were substantially lower than those reported by Johnson and Whitwell (6), who hand harvested lanceleaf coreopsis and

Table 2. Effect of date and harvesting method on seed yield of a north Florida ecotype of blanketflower.

	July 17, 1998		October 5, 1998		Significance		
	Hand	**Mechanical**	**Hand**	**Mechanical**	**Date**	**Method**	**D × M**
Bulk harvest dry mass (g)/plot	188.0	35.4	138.6	31.6	0.0242	<0.0001	0.0512
Total dry seed mass (g)/plot	37.3	8.8	24.5	3.2	0.0003	<0.0001	0.1226
Percent seed mass (per plot)	20.5b[z]	25.2a	17.7b	10.2c	<0.0001	0.1188	<0.0001
100-seed mass (mg)	125.0	123.0	118.0	109.0	0.0004	0.0308	0.2302
Seed yield (kg/A)	65.1	15.4	42.6	5.6	0.0003	<0.0001	0.1226
Harvesting time (min)/plot	17.7a	2.0b	20.0a	1.0b	0.3814	<0.0001	0.0331
Seed yield rate (g/min/plot)	2.10	4.40	1.22	3.19	<0.0001	<0.0001	0.4738
Percent germination	40.9a	36.7a	16.7b	23.3b	<0.0001	0.6976	0.0413

[z]Means, within rows, followed by different letters are significantly different as determined by LSD (α = 0.05).

blanketflower seed in early and late June, respectively. Their germination rates were greater for lanceleaf coreopsis (~43% vs 14%) but less for blanketflower (~20% vs 41%) compared to our initial hand harvested seed. Differences in germination rates and especially in seed yields were not surprising given differences in seed sources, growth conditions (their plots were fertilized and irrigated), harvest dates, and germination testing protocols. Baskin and Baskin (2) point out numerous biotic and abiotic factors that can affect seed germination rates.

Date of harvest had several significant effects ($P < 0.05$) on blanketflower yield and quality, with the early harvest date the best. Comparing July and October harvest dates, there was a greater percentage of seed in the harvest (23% vs 14%), seed mass was about 9% greater (100-seed mass of 124 vs 114 mg), per acre seed yield was 67% greater (40.2 vs 24.1 kg), seed yield rate was 45% greater (3.2 vs 2.2 g/min), and germination rate was 95% greater (39% vs 20%). We did not investigate any of the numerous biotic and abiotic factors (e.g., see 8, 9, 15) that could have caused differences in seed yield and quality of blanketflower. However, a seasonal effect on seed production was reported for rue anemone (*Thalictrum thalictroides* (L.) Eames and Boivin) (8). Future research is planned to begin studying the effects of nutrition and irrigation on seed production.

Date of harvesting had minimal effects on lanceleaf coreopsis yield or quality. While there were date by harvest method interactions for seed mass and germination rate for lanceleaf coreopsis, there weren't enough interactive effects to alter conclusions about harvesting methods or dates. These results clearly indicate that seed of lanceleaf coreopsis and blanketflower can be harvested twice during the growing season, although there is a reduction in quality and quantity of blanketflower seed harvested in early October.

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