1992

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1992. *Transactions of the Nebraska Academy of Sciences*, XIX: 63–66

POLLINATION CHARACTERISTICS OF BLOWOUT PENSTEMON (*PENSTEMON HAYDENII* S. WATSON)*

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*Journal Series No. 9711, Agricultural Research Division, University of Nebraska–Lincoln

ABSTRACT

The pollination characteristics of blowout penstemon (*Penstemon haydenii* S. Wats.), the only officially endangered plant species in Nebraska, were investigated. Cross-pollination was determined to be the major method of pollination, but self-pollination also occurs. Insects increased cross-pollination. The natural habitat of blowout penstemon has greatly decreased during this century, resulting in only a few isolated populations. The opportunity for cross-pollination with other populations no longer exists. Without cross-pollination, lowered genetic diversity of the species may result in less vigorous plants and declining populations. Introduction of new genetic material into declining populations may help to assure the continued existence of the species.

† † †

Blowout penstemon (*Penstemon haydenii* S. Wats.) is a rare, multistemmed, perennial forb that occurs naturally only in a few Sandhills blowouts, sites of active wind erosion (Stubbendieck et al., 1989). It is endemic to the Nebraska Sandhills and is the only plant species in Nebraska classified as endangered and protected under the federal Endangered Species Act (Fish and Wildlife Service, 1987; Jobman, 1989).

Blowout penstemon was once a common plant in blowouts (Pool, 1914). Populations rapidly declined until it was thought to be extinct by mid-century. Since its rediscovery in 1968 (Sutherland, 1988), extensive searching led to locating about 6,000 plants in only a few isolated blowouts (Fritz et al., 1991). Isolated populations may have a higher vulnerability to extinction because of low genetic variability restricting adaptation to changing environments (Hardy et al., 1989; Soule, 1983). Hardy et al. (1989) stated that decreased vigor, viability, and fecundity associated with inbreeding can be the result of genetic deterioration often occurring in small out-crossing populations. The objective of this study was to determine the pollination characteristics of blowout penstemon.

MATERIALS AND METHODS

The study was conducted in a natural population of blowout penstemon in Cherry County in 1987 and 1988. Four blowout penstemon plants, each having at least six inflorescences, were selected for this study in 1987, and another four plants were selected in 1988. Each plant was considered to be a block. Treatments designed to determine the breeding system of blowout penstemon were randomly applied to inflorescences of each plant.

Before applying a treatment, all immature flower buds, opened flowers, and fruits of the inflorescence were removed with forceps. To standardize the inflorescence, the number of mature (but unopened) flower buds was reduced to 10 per inflorescence. Treatments were two levels of emasculation (not emasculated and emasculated), two levels of bagging (unbagged and bagged), and hand-self- and cross-pollination by hand. Emasculation involved removal of the anthers within the bud with a forceps. Bagging was accomplished by enclosing the inflorescence within a tightly woven cotton bag and securely tying the open end around the base of the inflorescence with a small wire. The mesh was sufficiently fine to exclude all potential insect visitors and pollen.

Hand-pollination included emasculation, the application of pollen with a fine camel's hair brush to the stigma, and enclosing the treated flower stalk with a cloth bag (Hartmann and Kester, 1975). To self-pollinate flowers, pollen collected from flowers of the same plant just prior to hand-pollination was used. To cross-pollinate flowers, pollen collected from a blowout penstemon plant growing in a display garden on the University of Nebraska–Lincoln campus 10 days prior to hand-pollination was used. The display plant was propagated from seed collected in Cherry County. Pollen collection involved removing the anthers from unopened buds, placing them on a sheet of paper, and allowing them to open in a germinator at 30°C. Upon dehiscence, pollen and anthers were removed and stored in a glass vial over $CaCl_2$ at 0°C. Pollen was transported to Cherry County.

Thus, each of the 6 treatments was replicated 4 times in a randomized complete block design. The experimental unit consisted of a standardized inflorescence. In mid-August, 1987, and mid-August, 1988, all treated inflorescences were harvested, placed in separate paper bags, and dried at 25–35°C. After drying, the number of developed fruits, number of seeds, and seed weight were recorded per treated inflorescence. Statistical analysis was performed on data using SAS, PROC GLM for balanced designs (SAS Institute Inc., 1985). Univariate analysis of variance (ANOVA) with preplanned contrasts was used to determine the effect of bagging, emasculation, and hand-pollination on number of fruits, number of seeds, and seed weight (Steel and Torrie, 1980). Mean separation was based upon the 0.05 level of probability. Each year was analyzed separately.

RESULTS AND DISCUSSION

In both 1987 and 1988, inflorescences with emasculated flowers produced nearly the same mean number of fruits, seeds, and seed weight as inflorescences with intact flowers, indicating that cross-pollination was the major method of pollination, but self-pollination also occurred (Table I). Unbagged inflorescences with emasculated flowers produced significantly more seed than unbagged inflorescences with intact flowers in 1988, indicating that cross-pollination was more effective that year (Table I).

In both trials, the bagged inflorescences produced fewer fruits and seeds and lower seed weight on the

Table I. Mean number of fruits and seeds, and mean seed weight (g) produced per treated blowout penstemon inflorescence in 1987 and 1988. Treatment contrasts describe the effects of various treatments on fruit and seed production.

	1987			1988		
Treatment	**# fruits**	**# seeds**	**seed (g)**	**# fruits**	**# seeds**	**seed (g)**
1. Unbagged intact	7	96	0.15	4	12	0.30
2. Unbagged emasculated	8	103	0.19	6	53	0.42
3. Bagged intact	3	0	0.00	0	0	0.00
4. Bagged emasculated	0	0	0.00	0	0	0.00
5. Hand-pollinated, self	<1	<1	<0.01	<1	<1	0.02
6. Hand-pollinated, crossed	2	4	0.01	6	49	0.29
Treatment Contrasts[1]			Pr>F			
Unbagged vs bagged	0.01	<0.01	<0.01	<0.01	0.02	<0.01
Intact vs. emasculated	0.92	0.54	0.80	0.58	0.93	0.99
Natural crossing vs. hand	0.03	0.01	0.02	0.70	0.66	0.51
Natural selfing vs. hand	0.24	0.99	0.97	0.87	0.99	0.87
Self- vs. cross (hand)	0.97	0.61	0.49	<0.01	0.03	0.07

[1]Treatment contrasts were 1, 2 vs 3, 4; 1, 3 vs 2, 4; 2 vs 6; 3 vs 5; and 5 vs 6.

average than unbagged inflorescences, indicating the importance of insects for cross-pollination (Table I). Lower fruit and seed production in 1988 than 1987 is probably a reflection of lower precipitation recorded during the growing season of 1988.

In 1987, the hand-pollinated, bagged inflorescences set fewer seeds than naturally-pollinated inflorescences, indicating inadequate pollination techniques (Table I). In 1988, artificially cross-pollinated inflorescences produced as many fruits, seeds, and seed weights on the average as unbagged inflorescences with emasculated flowers (Table I). The fruit and seed production in artificially self-pollinated inflorescences were limited but not different from naturally self-pollinated inflorescences which did not produce fruit or seed in either year. Pollination techniques presumably improved with practice, and ambient conditions may have influenced success. Fruit and seed production were also greater in artificially cross-pollinated inflorescences than in artificially self-pollinated inflorescences, again indicating that blowout penstemon is largely an outcrosser (Table I).

Many penstemon species exhibit both self- and cross-pollination. For example, Ramstetter and Peterson (1984) reported that *Penstemon lemhiensis* (Keck) Keck & Cronq. was largely an outcrosser, but that many of the plants are self-pollinated as well. Baurer (1983) reported that cross-pollination was important, but not essential, for fruit production of little-flower penstemon (*Penstemon procerus* Dougl.).

Penstemon spp. pollinators include hummingbirds, coleopterans, carpenter bees, honeybees, bumblebees, solitary bees, masarid wasps, bee flies, syrphid flies, moths, hymenopterans, dipterans, and lepidopterans (Schmid, 1976). A wasp *Pseudomasaris vespoides* (Cresson), which provisions its nest exclusively with pollen and nectar, utilizes various *Penstemon* spp. a majority of the time (Tepedino, 1979; Ramstetter and Peterson, 1984). This wasp and many *Penstemon* spp. appear to have coevolved many adaptive features to ensure successful cross-pollination (Straw, 1956; Torchio, 1974).

Several pollen collectors and other insects have been reported to visit blowout penstemon flowers (Flessner, 1988; Lawson et al., 1989). Many different insects were seen removing pollen and nectar from the flowers of blowout penstemon during this study. Thus, it is hypothesized that blowout penstemon pollination is not restricted by inadequate numbers and species of pollinators. Additional research determining the phenology and insect pollinators of blowout penstemon is needed to describe further the pollination characteristics of this species.

Since the natural habitat (the blowout) of blowout penstemon has greatly decreased with improved range management practices and wildfire control, the populations of blowout penstemon have become more isolated (Stubbendieck et al., 1989). Thus, the potential for cross-pollination with other populations has also decreased. Perhaps, a reduction in dispersal and cross-pollination has lowered the genetic diversity of this species, resulting in less vigorous plants followed by declining populations. Introduction of new genetic material into declining populations should be considered as a way to improve vigor of resultant seedlings. Further research on the vigor and reproductive capability of seedlings produced from crosses might aid in the development of vigorous blowout penstemon seedlings for transplant and, ultimately, its recovery.

ACKNOWLEDGMENTS

Research reported here is a part of a project on the status, propagation, and ecology of blowout penstemon funded by the Nebraska Game and Parks Commission.

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