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Breeding Systems of Plants Used for Prairie Restorations: A Review

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ABSTRACT

Compatibility systems (i.e., self-compatible vs. self-incompatible) and types of individuals (e.g., heteromorphic, dioecious, etc.) in prairie plant species are usually ignored in prairie flower publications. Lack of knowledge regarding this information can hinder the success of prairie restoration. In this paper, I provide an explanation for why those involved in restoration should be concerned about the compatibility system and types of individuals of prairie plants. In addition, a list of the compatibility systems and types of individuals for some of the most common species used in prairie restorations is provided.

Prairie restoration is becoming a big business for landscapers and a major effort undertaken by many state (e.g., Departments of Natural Resources) and federal agencies (e.g., United States Department of Agriculture Forest Service, United States Fish and Wildlife Service). However, in most cases it is local environmental groups, local park districts, and some individuals doing prairie restorations. Most people doing prairie restorations are very knowledgeable about the biology of prairie plant species, such as their habitat and seed germination requirements and the best propagation techniques. However, many are unaware of additional factors affecting the reintroduction, establishment, and persistence of a species in a restoration, such as patch dynamics, pollinator guilds, and reproductive biology including plant compatibility systems (i.e., self-compatible vs. self-incompatible), and that some prairie species have different individual types (e.g., heteromorphic, dioecious, etc.). This oversight is understandable because many guides and other books on prairie plants fail to provide this basic information and explain how these factors influence the success and persistence of a species in a restoration. Making this information accessible will ensure a higher level of public awareness.

One aspect of plant biology that is rarely reported is the species' compatibility system. The compatibility system of a plant species is concerned with which pollen is accepted or rejected. In general, plants fall into two categories: self-compatible and self-incompatible. Self-compatible means that both self and outcross pollen will be accepted by a flower (stigma). In the case of self-incompatiblility, only cross pollen will be accepted by the flower (stigma). For example, most members of the Carrot Family (Apiaceae) and plants

with both chasmogamous and cleistogamous flowers (see Appendix for definition) are self-compatible. Published data indicates that 49 percent of prairie species are known to be self-compatible (Table 1). Members of the Sunflower (Asteraceae) and Milkweed (Asclepiadaceae) families generally are considered to be self-incompatible (Wyatt and Broyles 1994; Richards 1997; Schlessman and Graceffa 2002). Published data indicates that 39 percent of prairie species are known to be self-incompatible (Table 1). For the remaining 12 percent of prairie species, either data was not available or the species has a mixed compatibility system (i.e., self-compatible/self-incompatible; Table 1).

For species that are propagated by cuttings or are clonal (i.e., vegetative reproduction), self-incompatibility may limit reproduction if only one or a few genotypes are used in the restoration. One example of such a situation is the self-incompatible *Filipendula rubra* (Queen-of-the-prairie). If all the plants in a restoration are cloned from a single plant, fruit set will be hindered (i.e., no fruit set) because only self pollen will be transferred (Aspinwall and Christian 1992). To avoid such reproductive problems, particular emphasis should be placed on seed or cutting origin. Collection of seeds or cuttings from multiple nearby populations (sites) may decrease this reproductive problem, because more genotypes will be available.

Regardless of compatibility system, collecting seeds from a single population or from widely separated populations might result in either inbreeding or outbreeding depression, which can reduce reproductive success and fitness. Inbreeding depression is when genetically similar (i.e., closely related) individuals cross with each other resulting in the reduction in fitness of the offspring. Outbreeding depression is when very genetically different (i.e., distantly related) individuals cross with each other resulting in the reduction of the fitness of the offspring. Both inbreeding and outbreeding depression can hinder species persistence in a restoration.

Another usually overlooked aspect of reproductive biology is that some prairie species have different types of individuals (e.g., heteromorphic (pin/thrum), monoecious, dioecious, gynodioecious; see Appendix for definitions). Published data indicates that 24 percent of prairie species have different types of individuals (Table 1). Most prairie plants produce only one type of plant, hermaphroditic. However, some prairie species produce plants of different sexes. An example of a prairie species with different types of individuals is *Lobelia siphilitica* (Blue lobelia). This species has two breeding types in natural populations: hermaphroditic and female (i.e., gynodioecious). If a restoration project with this species includes hermaphroditic individuals, reproduction may succeed, however, if a high proportion of females are re-planted, reproduction will be negatively affected.

A more subtle situation is heterostyly, in which different plants bear their stigmas and anthers at different levels in different plants. An excellent example is *Lithospermum canescens* (Hoary puccoon). This species has two types of individuals, pin and thrum. Individuals that are thrum have flowers with the style half way down the corolla tube and the anthers visible at the top of the corolla tube. Pin individuals are the opposite. Both types of individuals have to be present for successful reproduction. Populations that depart from equal numbers of pin and thrum individuals suffer reduced reproduction. In addition, plant species with pin and thrum flowers are usually self-incompatible (Richards 1997, Proctor et al. 1996).

Table 1 lists the compatibility system and types of individuals, when applicable, for some of the more common species used in restorations. A total of 67 species were chosen either because they are commercially available or easy to establish. Also, the species were chosen because information about compatibility systems and types of individuals was found in peer-reviewed publications. An appendix has been included defining terminology presented in this paper or that the readers may encounter in the literature cited. Hopefully this data will provide an additional tool to improve prairie restorations.

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Table 1. List of the compatibility systems and individual types for some of the most common species used in prairie restorations (SC = self-compatible; SI = self-incompatible; SI/SC = both compatibility systems found; SI/sc = mostly self-incompatible but self-compatibility found occasionally; SC/si = mostly self-compatible but self-incompatibility found occasionally; CH = chasmogamous; CL = cleistogamous; H = Heterostylous; GD = Gynodioecious; GM = Gyno-monoecious; ? = suspected but unconfirmed; * = in Canada).

Genus/species	Common Name	Family	Compatibility system
Allium stellatum	Cliff onion	Liliaceae	SC (Molano-Flores et al., 1999)
Amorpha canescens	Leadplant	Fabaceae	SC (Parrish and Bazzaz, 1979)
Andropogon gerardii	Big bluestem	Poaceae	SI (McKone et al., 1998)
Anemone canadensis	Canada anemone	Ranunculaceae	SI (Douglas and Cruden, 1994)
Anemone cylindrical	Thimbleweed	Ranunculaceae	SC (Molano-Flores and Hendrix, 1998)
Anemone patens	Pasque flower	Ranunculaceae	SC (Cruden, 1977)
Apocynum cannabinum	Hemp dogbane	Apocynaceae	SI (Lipow and Wyatt, 1999)
Asclepias incarnata	Swamp milkweed	Asclepiadaceae	SC/si (Lipow and Wyatt, 2000)
Asclepias sryriaca	Common milkweed	Asclepiadaceae	SI/sc (Kephart, 1981)
Asclepias tuberosa	Butterfly milkweed	Asclepiadaceae	SI/sc (Wyatt, 1976)
Asclepias verticillata	Whorled milkweed	Asclepiadaceae	SI (Kephart, 1981)
Astragalus canadensis	Canada milk-vetch	Fabaceae	SC (Boe and Fluharty, 1993)
Baptisia leucantha	White false indigo	Fabaceae	SC (Haddock and Chaplin 1982)
Baptisia leucophaea	Cream false indigo	Fabaceae	SC (Haddock and Chaplin 1982)
Bromus kalmii	Prairie brome	Poaceae	SC (McKone, 1985)
Buchloe dactyloides	Buffalo grass	Poaceae	Dioecious [SC-monoecious, hermaphrodite] (Huff and Wu, 1992)
Chamaecrista fasciculata	Partridge-pea	Fabaceae	SC (Fenster, 1995)
Cephalanthus occidentalis	Buttonbush	Rubiaceae	SI (Imbert and Richards, 1993)
Coreopsis lanceolata	Sand coreopsis	Asteraceae	SI (Banovetz and Scheiner, 1994)
Dalea purpureum	Purple prairie clover	Fabaceae	SC (Parrish and Bazzaz, 1979)
Echinacea angustifolia	Pale-purple coneflower	Asteraceae	SI/sc (Leuszler, 1996)
Elymus canadensis	Canadian wild rye	Poaceae	SC (Sanders and Hamrick, 1980)
Eryngium yuccifolium	Rattlesnake master	Apiaceae	SC (Molano-Flores, 2001)
Eupatorium perfoliatum	Common boneset	Asteraceae	SI (Byers, 1995)
Fragaria virginiana	Wild strawberry	Rosaceae	SC [GD] (Ashman, 2000)
Filipendula rubra	Queen-of-the-prairie	Rosaceae	SI (Aspinwall and Christian, 1992)
Gaillardia pulchella	Blanket-flower	Asteraceae	SI (Heywood, 1993)
Gentiana andrewsii	Closed gentian	Gentianaceae	SC (Costelloe, 1988)
Gentiana puberula	Downy gentian	Gentianaceae	SC (Parrish and Bazzaz, 1979)
Helianthus occidentalis	Western sunflower	Asteraceae	SI (Fore and Guttman, 1999)
Houstonia caerulea	Bluets	Rubiaceae	SI [H (distyly)] (Wyatt and Hellwing, 1979)
Lespedeza capitata	Round-headed bush clover	Fabaceae	SC [CH/CL] (Cole and Biesboer, 1992)
Liatris aspera	Rough blazing star	Asteraceae	SI (Levin, 1968b)
Liatris cylindrical	Prairie blazing star	Asteraceae	SI (Schaal and Levin, 1978)
Liatris spicata	Dense blazing star	Asteraceae	SI (Levin, 1968b)
Lilium philadelphicum	Wood lily	Liliaceae	SI (Edwards and Jordan, 1992)
Lithospermum canescens	Hoary puccoon	Boraginaceae	SI? H (distyly) (Johnston, 1952)
Lithospermum caroliniense	Hairy puccoon	Boraginaceae	SI/sc [CH/CL, H (distyly), homostylous] (Levin 1968a)
Lithospermum incisum	Yellow puccoon	Boraginaceae	SC [CH/CL] (Johnston, 1952)
Lobelia cardinalis	Cardinal flower	Campanulaceae	SC (Johnston, 1991)
Lobelia siphilitica	Blue lobelia	Campanulaceae	SC [GD] (Johnston, 1991)

Table 1. continued.

Genus/species	Common Name	Family	Compatibility system
Lobelia spicata	Spiked lobelia	Campanulaceae	SC [GD] (Molano-Flores, 2002)
Lythrum alatum	Winged loosestrife	Lythraceae	SI? [H (distyly)] (Brown and Mitchell, 2001)
Mirabilis nyctaginea	Four-o'-clock	Nyctaginaceae	SC [CH (early summer) and CL (late summer)] (Cruden, 1973)
Monarda fistulosa	Wild bergamont	Lamiaceae	SC (Cruden at al., 1984)
Oenothera bienns	Common evening primrose	Onagraceae	SC/si (Steiner and Levin, 1977)
Oenothera missouriensis	Missouri evening primrose	Onagraceae	SI (Delbart et al., 1983)
Oenothera pilosella	Prairie sundrops	Onagraceae	SI (Straley, 1977)
Parthenium integrifolium	Wild quinine	Asteraceae	SI (Hashemi et al., 1989)
Penstemon digitalis	Foxglove beard tongue	Scrophulariaceae	SC (Clinebell and Bernhardt, 1998)
Penstemon pallidus	Pale beard tongue	Scrophulariaceae	SC (Clinebell and Bernhardt, 1998)
Phlox pilosa	Prairie phlox	Polemoniaceae	SI (Levin and Kerster, 1970)
Pycnanthemum virginianum	Mountain mint	Lamiaceae	Apomixis* (Chambers, 1961)
Ruellia humilus	Hairy wild petunia	Acanthaceae	SC [CH/CL] (Long, 1966)
Silene regia	Royal catchfly	Caryophyllaceae	SC (Menges, 1995)
Solidago nemoralis	Field goldenrod	Asteraceae	SI? [GM] (Bertin and Gwisc, 2002)
Solidago speciosa	Showy goldenrod	Asteraceae	SI? [GM] (Bertin and Gwisc, 2002)
Sorghastrum nutans	Indian grass	Poaceae	SI (McKone et al., 1998)
Stipa spartea	Porcupine grass	Poaceae	SC [CH/CL] (Cruden and Lyon, 1989)
Thalictrum dasycarpum	Meadowrue	Ranunculaceae	Dioecious (Gleason and Cronquist, 1991)
Tradescantia ohiensis	Spiderwort	Commeliaceae	SI (Ownes and McGrath, 1984)
Verbena hastata	Blue vervain	Verbenaceae	SC (Cruden et al., 1990)
Verbena stricta	Hoary vervain	Verbenaceae	SC (Cruden et al., 1990)
Viola pedatifida	Prairie violet	Violacea	SC [CH/CL] (Kirt, 1995)
Viola pedata	Birdfoot violet	Violacea	SI (Becker and Ewart, 1990)
Zizia aptera	Heart-leaf meadow parsnip	Apiaceae	SC (Lindsay 1982)
Zizia aurea	Golden alexanders	Apiaceae	SC (Parrish and Bazzaz, 1979)

APPENDIX

Dellaporta and Calderon-Urrea (1993) have listed (with some modifications) and defined a variety of terms used to describe types of individuals at different levels in plants (female = pistil(s); male = stamen(s):

Individual Flowers

- Hermaphrodite - bisexual flower with both female and male
  - ♦ Cleistogamy - Closed flowers that self pollinate
  - ♦ Chasmogamy - Open flowers capable of open pollination
  - ♦ Heterostyly - Modification of flower parts
- Unisexual - flower is either female or male

Individual Plants

- Hermaphrodite - the plant has only hermaphrodite flowers
- Monoecious - unisexual male and female flowers are on the same plant
- Dioecious - unisexual male and female flowers are on different plants
- Gynoecious - only female flowers
- Androecious - only male flowers
- Gynomonoecious - both hermaphrodite and female flowers
- Andromonoecious - both hermaphrodite and male flowers
- Trimonoecious (polygamous) - hermaphrodite, male, and female flowers are all on the same plant

Plant Populations

- Hermaphrodite - only hermaphrodite plants
- Monoecious - only monoecious plants
- Dioecious - only dioecious plants
- Gynodioecious - both female and hermaphrodite plants
- Androdioecious - both male and hermaphrodite plants
- Trioecious (or subdioecious) - hermaphrodite, male, and female plants are all in the same population