

# APOMIXIS AND THE REPRODUCTIVE DYNAMICS OF EASTERN GAMAGRASS *TRIPSACUM DACTYLOIDES* (L.) L.

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## ABSTRACT

Studies were conducted to determine the reproductive characteristics of *Tripsacum*, a perennial, native pasture species and to identify methods for breeding agronomically superior cultivars. Reproductive methods and types of individuals generated were evaluated with triploid and hexaploids possessing a novel method for transferring sexual germplasm into apomictic tetraploids and tetraploid germplasm into sexual diploids. Triploids and hexaploids are demonstrated to be useful materials for introgressing and transferring desirable alleles across ploidy levels and reproductive barriers.

## KEYWORDS

*Tripsacum*, apomixis, reproduction, breeding

## INTRODUCTION

Eastern gamagrass (*Tripsacum dactyloides*) is a perennial bunchgrass native only to the Western hemisphere. The genus consists of diploid ( $2n=2x=36$ ), and triploid ( $2n=3x=54$ ), tetraploid ( $2n=4x=72$ ), pentaploid ( $2n=5x=90$ ) and hexaploid ( $2n=6x=108$ ) cytotypes and comprises fifteen species in two sections (deWet et al., 1981, 1982, 1983).

To further develop *Tripsacum* as a commercially viable pasture species, our primary task is the development and release of superior genotypes. This paper focuses on the reproductive attributes of diploid ( $2n=2x=36$ ), triploid ( $2n=3x=54$ ), tetraploid ( $2n=4x=72$ ) and hexaploid ( $2n=6x=108$ ) germplasm which can be used to develop eastern gamagrass as a superior native grass species.

## METHODS

Crosses were made or attempted in all combinations utilizing diploid, triploid, tetraploid, and hexaploid germplasm and evaluated in the greenhouse or summer nurseries. Methods for mitotic root-tip chromosome counts and seed germination are described elsewhere (Ahring and Frank, 1968; Kindiger, 1994). PCR-RAPD analyses were performed following standard protocols (Williams et al., 1990; Kindiger and Dewald, 1996).

## RESULTS AND DISCUSSION

Diploids ( $2n=2x=36$ ) exclusively exhibit a sexual reproductive process (i.e. haploid reduced egg and sperm nuclei,  $1n=1x=18$ ). However, this does not exclude them from contributing and exchanging germplasm with their apomictic, polyploid counterparts (Farquharson, 1954). Crosses between diploids and tetraploids, the most common ploidies, occur in nature and can be easily replicated in the nursery.

Triploids ( $2n=3x=54$ ) are generated from a  $2x \times 4x$  crossing scheme. Most triploid hybrids are either completely or partially male and female sterile. However, some triploids can exhibit a high degree of maternal fertility (Dewald and Kindiger, 1994). Chromosome counts and PCR-RAPD evaluations indicate that fertile triploids are almost exclusively apomictic and vary in their level of maternal fertility (0-60%). Pollen fertility in triploids range from 0% to 50% (Sherman et al., 1991; Kindiger, unpublished).

Sterile or highly sterile triploids have received only cursory study. Fertile triploids, have been evaluated and found to provide a robust

method for exchanging germplasm between sexual and apomictic cytotypes (Dewald and Kindiger, 1994). Progeny tests have indicated their ability to generate  $B_{III}$  derived hybrids via  $2n + n$  matings (Kindiger and Dewald, 1994). Backcrossing fertile triploids with sexual diploids can result in a  $2n + n$  mating, resulting in the generation of a new and unique tetraploid  $B_{III}$  hybrid.

Tetraploids ( $2n=4x=72$ ) are naturally occurring or can be created in a breeding program. Seed generated from tetraploid germplasm are almost exclusively apomictically derived. The predominant form of apomictic reproduction in *Tripsacum* is characterized as being diplosporous pseudogamy of the *Antennaria* type which results in a complete omission of meiosis (Burson et al., 1990; Leblanc et al., 1995). Subsequently, the opportunity for genetic change is prohibitive or restricted. However, an infrequent occurrence of a *Taraxacum* form of diplosporous apomixis has been identified to provide an outlet for genetic change. This form of apomixis, is characterized by the occurrence of a first division restitution (FDR) nucleus which does not preclude the omission of chromosome pairing and recombination. When the unreduced egg is a product of a FDR, genetic change is possible due to recombination and segregation without chromosome reduction (Peloquin, 1983; Hermsen, 1984).

Crosses using apomictic tetraploids as the maternal parent generate apomictic offspring,  $B_{III}$  derived hybrids ( $5x$  and  $6x$ )(5-8% occurrence), and an occasional apomictic tetraploid offtype arising from an infrequent FDR event (2-4%) (Kindiger et al., 1996; Kindiger and Dewald, 1994, 1996). Progeny arising from a reduced egg fertilized by a sperm nuclei have not been observed and are likely extremely rare.

Hexaploids ( $2n=6x=108$ ) are  $B_{III}$  derived hybrids generated from  $2n + n$  mating following a  $4x \times 4x$  cross. Hexaploids often exhibit diminutive phenotypes but can also produce individuals with a robust and vigorous phenotype. Hexaploids are often but not exclusively female sterile. Female fertile hexaploids are completely apomictic in their mode of reproduction. All classes of hexaploids are highly pollen fertile. Sexual diploid  $\times$  hexaploid crosses predominately generate diploid hybrids (99%) and the infrequent (1%) triploid, tetraploid and aneuploid hybrid. By utilizing a  $2x \times 6x$  crossing scheme, hexaploids provide a bridge for moving apomictic tetraploid germplasm to the sexual diploid level.

This study has identified that triploids provide a method to transfer sexual diploid germplasm into a tetraploid cytotype while hexaploids can provide for the transfer of tetraploid germplasm to sexual diploid cytotypes. The ability to move germplasm across ploidy lines, regardless of reproductive method (i.e. sexual vs apomictic), provides one means to develop a vast array of superior genotypes and stabilizing them via apomixis.

## REFERENCES

- Ahring, R. M. and H. Frank. 1968. Establishment of eastern gamagrass from seed and vegetative propagation. *J. Range Manag.* **21**:27-30.
- Burson, B. L., P.W. Voigt, R.A. Sherman and C.L. Dewald. 1990. Apomixis and sexuality in eastern gamagrass. *Crop Sci.* **30**:86-89.

- Dewald, C. L. and B. Kindiger.** 1994. Genetic transfer of gynomonoeocy from diploid to triploid eastern gamagrass. *Crop Sci.* **34**:1259-1262.
- deWet, J. M. J., D.H. Timothy, K.W. Hilu and G.B. Fletcher.** 1981. Systematics of South American *Tripsacum* (Gramineae). *Am. J. Bot.* **68**:269-276.
- deWet, J. M. J., J.R. Harlan and D.E. Brink.** 1982. Systematics of *Tripsacum dactyloides* (Gramineae). *Am. J. Bot.* **69**:1251-1257.
- deWet, J. M. J., D.E. Brink and C.E. Cohen.** 1983. Systematics of *Tripsacum* section Fasciculata (Gramineae). *Am. J. Bot.* **70**:1139-1146.
- Farquharson, L. I.** 1954. Natural selection of tetraploids in a mixed colony of *Tripsacum dactyloides*. *Proc. Ind. Acad. Sci.* **63**:80-82.
- Hermesen, J. G. Th.** 1984. Mechanisms and genetic implications of 2n gamete formation. *Iowa State J. Res.* **58**:421-434.
- Kindiger, B.** 1994. A method to enhance germination of eastern gamagrass. *Maydica* **39**:53-56.
- Kindiger, B., and C. Dewald.** 1994. Genome accumulation in eastern gamagrass, *Tripsacum dactyloides* (L.) L. (Poaceae). *Genetica* **92**:197-201.
- Kindiger, B., V. Sokolov and C. Dewald.** 1996a. A comparison of apomictic reproduction in eastern gamagrass (*Tripsacum dactyloides* (L.) L.) and maize-*Tripsacum* hybrids. *Genetica* **97**:103-110.
- Kindiger, B. and C.L. Dewald.** 1996. A system for genetic change in apomictic eastern gamagrass. *Crop Sci.* **36**:250-255.
- Leblanc, O., M.D. Peel, J.G. Carman and Y. Savidan.** 1995. Megasporogenesis and megagametogenesis in several *Tripsacum* species (Poaceae). *Am. J. Bot.* **82**:57-63.
- Peloquin, S. J.** 1983. Genetic engineering with meiotic mutants. *In: Mulcahy, D. L., Ottaviano E. (Eds.) Pollen biology and implications for plant breeding.* Elsevier, New York, pp311-316.
- Sherman, R. A., P.W. Voigt, B.L. Burson and C.L. Dewald.** 1991. Apomixis in diploid x triploid *Tripsacum dactyloides* hybrids. *Genome* **34**:528-532.
- Williams, J. G. K., A.R. Kubelik, K.J. Livbak, J.A. Rafalski and S.V. Tingey.** 1990. DNA polymorphisms amplified by arbitrary primers are useful as genetic markers. *Nucleic Acids Res.* **18**:6531-6535.