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M.G.M. Van Creij · D.M.F.J. Kerckhoffs
J.M. Van Tuyl

Interspecific crosses in the genus *Tulipa* L.: identification of pre-fertilization barriers

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Abstract Pollen tube growth in the pistil and pollen tube penetration of ovules have both been studied in crosses between cultivars from *Tulipa gesneriana* L. and 12 tulip species from all eight sections of the genus *Tulipa* to identify pre-fertilization barriers. Depending on the cross, pollen tubes grew as far as the stigma or the style or continued growing down into the ovary. Pollen tubes penetrated none or only a few percent of the ovules of some crosses, despite the presence of many pollen tubes in the ovary. In other crosses, from which no or only a few hybrids have been obtained after seed maturation on the plant, pollen tube penetration was found in up to 79% of the ovules. Apparently, various kinds of barriers preventing fertilization or normal embryogenesis occur in interspecific tulip crosses.

Key words Interspecific hybridization · Pollen tube growth · Ovule penetration · Tulip

Introduction

The genus *Tulipa* comprises about 55 species, of which 49 are described by Van Raamsdonk and De Vries (1992, 1995), who recently revised this genus. The tulip species are classified in two subgenera, *Tulipa* and *Eriostemones*, which are subdivided into five and three sections, respectively (Table 1). The commercial assortment of tulips consists mainly of cultivars from *Tulipa gesneriana* from the section *Tulipa*. Another group of cultivars, the Darwin hybrids, have been obtained mainly from interspecific crosses between members of the cultivar group *T. gesneriana* and genotypes of *T. fosteriana* Hoog ex W. Irving, of the section *Eichleres*.

The present-day tulip assortment could be considerably improved by exploiting traits from other *Tulipa* species. In particular, introduction of resistances against tulip breaking virus (TBV), *Botrytis tulipae* and *Fusarium oxysporum* (bulb-rot), and also characteristics such as a short forcing period, good flower longevity and new flower colours and flower shapes are important targets for tulip breeding programs.

Interspecific crosses are usually made between genotypes of *T. gesneriana* and other *Tulipa* species. *T. gesneriana* proved to be compatible with other species of the same section. Crosses between *T. gesneriana* and representatives of the section *Eichleres* produced hybrids in several cases. Crosses between *T. gesneriana* and species of the other sections of the subgenus *Tulipa* produced no verified hybrids, except for *T. systola* Stapf [former name, *T. stapfii* Turrill (Van Raamsdonk and De Vries 1995)] from the section *Tulipanum*. Crosses between the two subgenera have never been successful (Van Eijk et al. 1991; Van Raamsdonk et al. 1995).

Interspecific crossing barriers (incongruity) may result from lack of genetic information in one partner about the other (Hogenboom 1973). Pre-fertilization barriers originate from the inability of pollen grains to germinate on the stigma or from malfunctioning of the pollen tube and/or sperm cells. Several methods have been developed for bypassing these barriers: the mentor pollen technique (Stettler 1968), a combination of bud pollination and treatment of stigmas with an artificial medium (Gradziel and Robinson 1991); the cut-style and the grafted-style methods (Asano and Myodo 1977; Van Tuyl et al. 1988); and placental pollination (De Verna et al. 1987; Zenkteler et al. 1987).

Post-fertilization barriers can cause premature degeneration of the embryo and/or endosperm. Hybrid breakdown and F_1-sterility of hybrid plants that exclude them from further breeding are also crossing barriers. Post-fertilization barriers are bypassed by using ovary-culture and/or ovule-culture and/or embryo-culture in many crops, such as *Brassica* (Bajaj et al. 1986), *Nicotiana* (Nikova and Zagorska 1990), *Lycopersicon* (Chen and Adachii 1992), *Triticum* (Comeau et al. 1992) and *Lilium* (Asano 1978; Van Tuyl et al. 1991). Custers et al. (1995)

M.G.M. Van Creij · D.M.F.J. Kerckhoffs · J.M. Van Tuyl (✉)
Centre for Plant Breeding and Reproduction Research (CPRO-DLO), P.O. Box 16, NL-6700 AA Wageningen, The Netherlands
Tel. +31-317-477329; Fax +31-317-418094;
e-mail J.M.vanTuyl@cpro.dlo.nl