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Successful Crosses Between *Festuca arundinacea* Schreb. and *Dactylis glomerata* L.

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Summary. Five F_1 plants have been obtained after extensive crossing between different ecotypes or varieties of *Festuca arundinacea* Schreb. and *Dactylis glomerata* L. The success did not appear to depend on specific treatments (spraying with ϵ-aminocaproic acid or gibberellic acid or pre-pollination with killed pollen from the seed parent), but the crossability is limited to exceptional plants.

F_1 hybrids showed characteristics of both the parents. In four hybrids various developmental disturbances were observed (low viability, aneusomaty, absence of development of inflorescences). Only one hybrid consistently showed 2n = 35 chromosomes, good viability and growth, however, it was sterile. After clonal propagation, attempts for polyploidization were started.

Key words: Intergeneric hybrids – *Festuca arundinacea* – *Dactylis glomerata* – Crossability – Characteristics

Introduction

Interspecific and intergeneric hybrids have frequently developed into new alloploid species in nature. Interspecific hybridization is also important for plant breeders, who try to combine useful features of different species or want to increase the genetic variability within a species. Formerly, in most of the cases only closely related species or genera were crossed. However, in the last few years crosses between phylogenetically distinct species have also often been made, using improved methods. Thus, already some papers have prepared describing attempts to cross different genera of cereals (e.g. Bates et al. 1974; Kruse 1976; Islam et al. 1976; Thomas et al. 1977; Cooper et al. 1978; Fedak 1978a, b; Dehne et al. 1980). In this paper, results will be reported concerning successful crosses between the remotely related species *F. arundinacea* Schreb. and *D. glomerata* L.

Materials and Methods

Several ecotypes and cultivars from both parental species were used. The emasculated and pollinated plants of *F. arundinacea* were descended from Sveriges Utsädesförening Svalöf, 2n = 42 (Pop. 1); Botanischer Garten und Museum Berlin-Dahlem, 2n = 42 (Pop. 2); Kulturpflanzenweltsortiment Gatersleben, 2n = 42 (Pop. 3); 'Sapadnaja', variety from USSR, 2n = 42 (Pop. 4); 'Kentucky', variety from USA, 2n = 42 (Pop. 5); Station Nationale d'Essais de Semences Versailles, ssp. *orientalis*, 2n = 42 (Pop. 6); Station Nationale d'Essais de Semences Versailles, ssp. *fenas*, 2n = 28 (Pop. 7); Station Nationale d'Essais de Semences Versailles, ssp. *pseudo-mairei*, 2n = 56 (Pop. 8); Station Nationale d'Essais de Semences Versailles, ssp. *X*, 2n = 70 (Pop. 9). From *D. glomerata*, the varieties 'Lischower Spätes' (Pop. 1), 'Kutzlebener' (Pop. 2), 'Motycka' (Pop. 3), and a population growing in the environments of the village of Gatersleben (Pop. 4) were used as pollinators.

About five hours after pollination the ovaries, along with stigmata from some of the mother plants, were fixed for cytological studies of pollen germination and tube growth (according to Dionne 1958; Naether 1971). About 15 – 19 days after pollination the embryos were isolated and cultured on a modified Norstog (1973)-medium (0.2 mol/l sucrose, 2 ppm indolyl acetic acid, 10 per cent coconut milk). The procedures of crossing and embryo culture were similar to those described by Gröber et al. (1974).

Results

Most of the plants of *F. arundinacea* showed strong gametic incompatibility with *D. glomerata*. Pollen germination and tube growth were irregular and hence no fertilization occurred (Table 1). It was not possible to overcome the gametic incompatibility by means of treatment with ϵ-aminocaproic acid, gibberellic acid or pre-pollination with killed pollen from the female species. In certain plants of *F. arundinacea*, however, the gametic barriers were not so strong. In these plants, embryos developed after fertilization, but endosperm development was always strongly disturbed (missing or lagging, granulous and hard structures). In order to prevent abortion, the embryos were excised and cul-

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tured on artificial medium. In this way five plants were obtained. The five F_1 hybrids arose from two mother plants of Population No. 2 of *F. arundinacea* (Table 2). The incompatibility varied not only between single individuals but also between different ecotypes or varieties (Table 2). The population of the pollinator also influenced the results.

Developmental disturbances were observed not only in the endosperm or embryo but also in the growing F_1 plants. Two plants died after being transplanted to soil. Two other hybrids showed poor vegetative growth (Table 3). They remained some years vegetative and did not develop inflorescences despite vernalization and treatment with indolyl acetic acid. The chromosome numbers of these hybrids were somatically unstable. (2n = 14-56). Different counts were determined within individual root tips. Only hybrid No. 5 showed normal development; it was highly viable, grew well and had a constant number of chromosomes, 2n = 35.

The F_1 hybrids showed typical characteristics from both of the parents, e.g. from *D. glomerata*: greyish green leaves, youngest leaf folded, missing auricles, white ligules; and from *F. arundinacea*: stiff leaves, enclosed leaf sheaths, pilose base of lamina (see Table 3). The hybrid No. 5 developed many vegetative tillers and inflorescences as well (Fig. 1). The inflorescences were found to be intermediate when compared to the parents. This hybrid was completely sterile after free pollination as well as after pollination with both parental species. It was propagated vegetatively.

Table 1. Pollen germination, pollen tube growth and development of embryos in several mother plants of *F. arundinacea* Schreb. after pollination with *Dactylis glomerata* L. (1974-1977)

Female parent Population No.	Mother parent	Male plant Population No.	Treatment[a]	Pollen germination tube growth[b]	Embryo-development[b]
2	2/1	2	without	++	+
	2/9	4	pre-poll.	++	o
3	3/2	3	EACA	o	o
4	4/1	2	EACA	o	o
5	5/2	2	EACA	o	o
	5/3	2 + 3	without	+	o
6	6/1	2	GA_3	o	o
	6/2	3	without	o	o

[a] pre-poll. = Pre-pollination of the mother plant with killed pollen of the female species; EACA = Spraying of ϵ-aminocaproic acid on the stigmata before pollination; GA_3 = Spraying of gibberellic acid on the stigmata before and after pollination

[b] o = No pollen germination or tube growth within the stigmata, no embryo development; + = Tube growth disturbed within the stigmata, embryo development disturbed because of missing endosperm; ++ = In some cases pollen tubes entered into the ovule

Table 2. Results of crosses between several populations of *Festuca arundinacea* Schreb. ♀ and *Dactylis glomerata* L. ♂, 1974-1979

Female parent Population No.	No. of plants emasculated	No. of florets emasculated	Male parent Population No.	No. of plants with embryos	No. of F_1 embryos cultured	No. of F_1 hybrids obtained
1	3	258	2 + 3	0	–	–
2	9	4464	1 + 2 + 4	3	80	5
3	2	567	1 + 3	1	12	0
4	5	816	2	1	1	0
5	3	798	1 + 2	0	–	–
6	3	586	2 + 3	0	–	–
7	2	492	1 + 2	0	–	–
8	1	64	1	1	1	0
9	3	511	1 + 2	0	–	–
Σ	31	8556	4	6	94	5

Discussion

Interspecific and intergeneric hybrids have often been produced between closely related fodder grasses. Crosses between the remotely related species *Festuca arundinacea* Schreb. and *Dactylis glomerata* L., however, have not successfully been done anywhere as far as we know. Previously we had supposed that our success in crossing these species might be attributed to the pre-pollination of the mother plant with killed pollen of the female species (Matzk 1976). Later, however, we found that applied treatments before or after pollination had no influence on gametic incompatibility (Matzk et al. 1980). Instead, an idiotypically conditioned, specific crossability of the parents could be proved.

Fig. 1. *F. arundinacea* × *D. glomerata* hybrid in comparison with plants of the parental species (from left to right: *F. arundinacea*, two cloned plants from hybrid No. 5, *D. glomerata*)

Table 3. Description of the F_1 hybrids between *Festuca arundinacea* Schreb. and *Dactylis glomerata* L.

Hybrid No.	Crossing year	No. of the ♀ parent	Chromosome number 2n	Phenotype	Remarks
1	1975	2/1	Not studied	Seedling very poor growing; leaves very small; low viability	Died in March 1976
2	1975	2/1	14 to 56 (mostly 28)	Many narrow tillers and leaves; leaves greyish green, shallowly nerved, base of lamina weakly pilous, without auricles, ligules white and shallowly fringed, youngest leaf folded; leaves monostichous; vigorous root system; remained three years vegetatively despite vernalization and treatment with indolyl acetic acid and gibberellic acid; in 1979 two inflorescences emerged with only one sterile spikelet each	At present still existent
3	1975	2/1	28 to 42 (mostly 42)	Few big and stiff shoots; leaves strong nerved and stiff, base of lamina weakly pilous, without auricles, ligules white and tapering, lamina and youngest leaf folded; poor root system; remained four years vegetatively (even after vernalization and hormone treatments)	Died in October 1979
4	1979	2/1	Not studied	Seedling very poor growing; leaves very small; low viability	Died in November 1979
5	1979	2/4	35 (constantly)	Vigorous plant, good tillered; leaves wide and long, stiff, strong nerved, lower surface bright, youngest leaves folded, base of lamina weakly pilous, without auricles, leaf sheats closed, ligules white and tapering; inflorescence a panicle, intermediate to parents, middle high, short awns; anthers undehisced, few pollen, plant sterile	Vegetatively propagated for polyploidization attempts

Similarly, Thomas et al. (1977) succeeded in crossing *Hordeum vulgare* and *Triticum aestivum* without application of immunosuppressants (e.g. ϵ-aminocaproic acid) or gibberellic acid, contrary to the results of Bates (1976), Islam et al. (1976) or Kruse (1976).

The occurrence of large differences in the crossability of different cultivars was demonstrated in crosses between barley and wheat (Islam et al. 1976; Thomas et al. 1977; Fedak 1978a), between barley and rye (Fedak 1978b; Pickering and Thomas 1979) as well as in the present study between *F. arundinacea* and *D. glomerata*. These differences are unpredictable because the exact reasons of an 'idiotypically specific crossability' are unknown. At present we can not say, whether it is possible or not to preselect exceptional plants or strains with good crossability on the basis of easily visible characters. According to Matzk (1980), the interspecific gametic incompatibility does not depend on the self-incompatibility reaction. Generally, it appears that the rate of success in interspecific crosses can be increased by using many different idiotypes, rather than by crossing extensively a few specific cultivars.

Characteristics from both of the parental species are combined in the produced hybrids between *F. arundinacea* and *D. glomerata*. The viability of the five F_1 hybrids and their vegetative growth varied considerably. Developmental disturbances were observed in our seedlings and young plants of *F. arundinacea* × *D. glomerata* as well as in barley × rye hybrids by Fedak (1978b) and Pickering and Thomas (1979). Moreover, strong aneusomaty was found, the same being reported for barley × wheat hybrids (Thomas et al. 1977; Fedak 1978a) and for maize × *Tripsacum* hybrids (James 1979).

At present only one hybrid between *F. arundinacea* and *D. glomerata* is well tillering and viable. This hybrid has the chromosome number 2n = 35 and is sterile. We are going to double the chromosome number by means of colchicine with the aim of producing fertile alloploids. Future studies will show whether or not a new valuable fodder grass can be realized from this combination. The possibility of inducing apomictic propagation (Gröber et al. 1974) in this material is also taken into consideration. As great variability is a prerequisite for breeding new alloploids

(Cauderon 1978), more F_1 hybrids between *F. arundinacea* and *D. glomerata* have to be produced.

Literature

Bates, L.S. (1976): Chemical manipulation of crossability barriers. In: Barley Genetics 3, (ed.: Gaul, H.), pp. 271-273. Proc. Third Intern. Barley Genetics Symp. Garching 1975. München: Karl Thiemig

Bates, L.S.; Campos, V.A.; Rodriguez, R.R.; Anderson, R.G. (1974): Progress toward novel cereal grains. Cereal Sci. Today 19, 283-285

Cauderon, Y. (1978): Alloploidy. In: Interspecific Hybridization in Plant Breeding (eds.: Sanchez-Monge, E.; Garcia-Olmedo, F.), pp. 131-143. Proc. 8th Congr. Eucarpia Madrid 1977. Madrid: Escuela Téchnica Superior de Ingenieros Agrónomos

Cooper, K.V.; Dale, J.E.; Dyer, A.F.; Lyne, R.L.; Walker, J.T. (1978): Early development of hybrids between barley and rye. In: Interspecific Hybridization in Plant Breeding (eds.: Sanchez-Monge, E.; Garcia-Olmedo, F.), pp. 275-283. Proc. 8th Congr. Eucarpia Madrid 1977. Madrid: Escuala Téchnica Superior de Ingenieros Agrónomos

Dehne, J.; Franke, R.; Leike, H. (1980): Aspekte der Art- und Gattungsbastardierung bei Getreide. Arch. Züchtungsforsch. 10, 77-84

Dionne, L.A. (1958): A squash method for pollen tubes in *Solanum* styles. Am. Potato J. 35, 422

Fedak, G. (1978a): Barley – wheat hybrids. In: Interspecific Hybridization in Plant Breeding, Proc. 8th Congr. Eucarpia Madrid 1977, (eds. Sanchez-Monge, E.; Garcia-Olmedo, F.) pp. 261-267. Madrid: Escuela Téchnica Superior de Ingenieros Agrónomos

Fedak, G. (1978b): Barley monoploids and hybrids from barley × rye crosses. In: Interspecific Hybridization in Plant Breeding, Proc. 8th Congr. Eucarpia Madrid 1977, (eds. Sanchez-Monge, E.; Garcia-Olmedo F.), pp. 269-273. Madrid: Escuela Téchnica Superior de Ingenieros Agrónomos

Gröber, K.; Matzk, F.; Zacharias, M. (1974): Untersuchungen zur Entwicklung der apomiktischen Fortpflanzungsweise bei Futtergräsern. I. Art- und Gattungskreuzungen. Kulturpflanze 22, 159-180

Islam, A.K.M.R.; Shepherd, K.W.; Sparrow, D.H.B. (1976): Addition of individual barley chromosomes to wheat. In: Barley Genetics 3, Proc. Third Intern. Barley Genetics Symp. Garching 1975, (ed. Gaul, H.) pp. 260-270. München: Karl Thiemig

James, J. (1979): New maize × *Tripsacum* hybrids for maize improvement. Euphytica 28, 239-247

Kruse, A. (1976): Reciprocal hybrids between the genera *Hordeum*, *Secale* and *Triticum*. Hereditas 84, 244

Matzk, F. (1976): Attempts to overcoming of incompatibilities in interspecific and intergeneric crosses with grasses. Incompatibility Newsl. 7, 65-74

Matzk, F. (1980): Relationships between interspecific incompatibility and self-incompatibility in grasses. Incompatibility Newsl. 12, 88-94

Matzk, F.; Gröber, K.; Zacharias, M. (1980): Ergebnisse von Art- und Gattungskreuzungen mit Gramineen im Zusammenhang mit den natürlichen Isolationsmechanismen zwischen den Arten. Kulturpflanze 28, 257-284

Naether, J. (1971): Verfahren für die genetische Analyse der sporophytisch bedingten Selbstinkompatibilität auf diploider Stufe und ihre Anwendung in der Hybridzüchtung. Dissertation, Quedlinburg

Norstog, K. (1973): New synthetic medium for the culture of premature barley embryos. In Vitro 8, 307-308

Pickering, R.A.; Thomas, H.M. (1979): Crosses between tetraploid barley and diploid rye. Plant Sci. Lett. 16, 291-296

Thomas, J.B.; Mujeeb, K.A.; Rodriguez, R.; Bates, L.S. (1977): Barley × wheat hybrids. Cereal Res. Commun. 5, 181-188

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