BACKCROSSES OF DIPLOID LOLIUM-FESTUCA HYBRIDS TO FESTUCA

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ABSTRACT
Fertile diploid hybrids of *Lolium* x *Festuca* -backcrosses were produced by colchicine-treatment without chromosome doubling. The hybrids have new combinations of their characters, not known in the natural species.

INTRODUCTION
Intergeneric hybrids between *Lolium* and *Festuca* have been known since 1790 (Terrell, 1968). In 1898 they were first produced artificially by M'Alpine. These hybrids were sterile. Fertile ones are produced as amphidiploids by use of colchicine (Essad, 1956; Hertzsch, 1959). In 1973 it was shown, that perennial ryegrass (*L. perenne* L.) is an intergeneric hybrid between Italian ryegrass (*L. multiflorum* Lam.) and meadow fescue (*F. pratensis* Huds.) (Nitzsche, 1973). Generally, in hybrids between Italian ryegrass and meadow fescue there is strong natural selection for Lolium characters, whether the material is at the diploid or tetraploid level. Varieties from *L. multiflorum* x *F. pratensis* hybridisations are mostly registered as *L. multiflorum* varieties, the *F. pratensis* characters do not occur, like in the Italian ryegrass variety 'Liberta', which is originally a *L. multiflorum - F. pratensis* hybrid. Hence from intergeneric hybrids of Italian ryegrass and meadow fescue the variability of *Lolium* can be widened. Much more interesting would be the new variability in meadow fescue, which does not vary so much. In order to achieve a character transfer, backcrossing (BC) seems to be the method. But in contrast to backcrossings to *Lolium* the backcrossing to *Festuca* results on the diploid level in sterile BC_1's. So additional manipulation for fertility is necessary for further work. In this paper I deal with the results on backcrossing and character distribution of our diploid *L. multiflorum -F. pratensis* hybrids.

L. multiflorum, L. perenne and *F. pratensis* are phenotypically similar. The differentiating characters between the used species, according to literature, are given in Table1.

KEYWORDS
Intergeneric hybrids, diploids, colchicine treatment, *Lolium, Festuca*

MATERIAL AND METHODS
F_3-plants from the material mentioned in Nitzsche, 1973 were backcrossed to *F. pratensis* variety “Steinacher”. The resulting BC_1, as earlier said, was sterile and therefore the tillers were treated with colchicine as given in Nitzsche, 1973 (0,2%, 8^h, 20°C). After controlled selfing in pollination chambers in the greenhouse the next generation became fertile without doubling of chromosome number and was backcrossed once more to *F. pratensis*. This procedure was repeated three times up to the BC_3. Colchicine treatment for inducing fertility.

From the BC_3-generation *L. multiflorum* x (*F. pratensis*)"""" hybrid strains were developed by selfing and intercrossing. In 28 strains 449 plants for selfing and intercrossing were compared, in 45 strains 629 plants could be compared for character distribution as well. The characters tested were plant height, ear length in cm, glume in mm, flowers per spikelet, leaf width, awn and type of leaf occurrence. All these data were compared to the values given in literature for species determination of *L. multiflorum, L. perenne* and *F. pratensis.*

Finally in a field test for yield agronomic value was determined. Plots of 46 BC strains and two *F. pratensis* varieties as controls were used to determine dry matter yield in 3 cuts.

RESULTS
Single characters. The single characters measured on the BC_3-strains are given in table 2. The correlation between selfing and open pollinated progenies are given in table 3.

1. 1) Plant height. For plant height the BC_3 are higher than the values given in systematics for perennial ryegrass or meadow fescue, they only agree with Italian ryegrass. Of the 28 lines 24 data points are above the bisector angle, they have a positive heterosis effect, in 4 the inbreds are higher, which demonstrates inbreeding depression. By sign test this difference is highly significant, open pollinated progeny plants are the higher ones.

1. 2) Ear length. The ear length with 18 to 20 cm agree with both parental species and with perennial ryegrass, although single values surpass the meadow fescue border. Of the 28 lines 19 have a heterotic effect, in 9 the inbreds are longer.

1. 3) Glumes. The glumes are smaller than those of Italian ryegrass, but the agree with both other species. The glumes show a negative heterosis. Out of the 27 lines 7 have an heterotic effect, in 20 the inbreds are longer. By sign test this difference is generally significant.

1. 4) Flowers per spikelet. The number of flowers per spikelet are smaller than those of Italian ryegrass, but it agrees with both other two species.

1. 5) Leaf width. The parameters of leaf width agree with *L. multiflorum*, but they are higher than those of the other two species (Fig. 1) Of the 28 lines 24 have an heterotic effect, in 4 the inbreds are higher. By sign test this difference is highly significant.

1. 6) Awn and youngest leaf. The grasses have awns or not, the youngest leaf is folded or rolled. Both characters are more or less qualitative. In the BC_3 they mostly agree with *L. perenne*.

2) Combinations between characters. In the combinations open pollinated and selfing progenies are not separated. So parameters differ a little from those given above. The 2-dimensional graphs give the areas covered by the species *L. multiflorum* (marked by upward sloping lines), *F. pratensis* (marked by downward sloping lines) and *L. perenne* (marked by horizontal lines) (Fig. 2). Additionally the backcross-progenies are marked with black rectangles.

These rectangles fall within the distribution of *L. multiflorum* in 4 cases; *F. pratensis* in 2 cases; *L. perenne* in 4 cases. In 3 cases the distributions are outside of the defined grass species and are therefore new combinations.

The rough appearance of the plants is more or less similar to meadow fescue. Nevertheless the shape varies between *Lolium*- and *Festuca* -types as differentiating characters introduced to meadow fescue. Hence new variation can be introduced to meadow fescue.

3) Yield of new types. 46 strains of the backcross-progenies and two meadow fescue varieties (Cosmos 11, Lifesta) were tested for dry matter yield in a 3x3x16 latin rectangle over three cuts/year. The variances in the different cuts are not homogenous, the comparisons

were made by rank orders in a nonparametric test [Fig. 3] (Schmidt, 1962). The yields of six strains are higher than the better meadow fescue variety. The best are now under official certification procedure.

DISCUSSION

Colchicine without chromosome doubling treatment for inducing fertility is not a commonly used technique. Nevertheless in the breeding program described here this method was reproducible and successful. The transfer to other materials seems reasonable and should be tried if necessary. The tetraploid level is not always superior to the diploid and this technique can overcome the problems of polyploids. What really happens is unclear. Whether homologous chromosomes will be developed is not known, while *Lolium*- and *Festuca* -chromosomes always form bivalents in meiosis.

The results presented here demonstrate clearly that intergeneric hybrids between *Lolium* and *Festuca* can not only be developed to provide new variation in *Lolium*, but, with a higher input, also to provide new variation in the *Festuca* complex. New variation surely will not only occur in the differentiating characters, it must also be expected in all the other characters (including agronomic characters) and combinations of the species. The agronomic characters such as longevity, yield pattern (hay/pasture-type), resistance against diseases or environmental factors may be of greater interest. A scientific paper can deal with model characters only, but for practical purposes the method should be extended to application in polygenic agronomic characters.

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Table 1. Differentiating characters* of the grass species

Character	*Lolium multiflorum*	*Lolium perenne*	*Festuca pratensis*
plant height	< 127 cm	8 - 90 cm	30 - 70 cm
ear length	17 - 44 cm	3 - 31 cm	10 - 20 cm
glume length	5 - 18 mm	3,5 - 15 mm	3 - 7 mm*
flowers per spikelet	11 - 22	2 - 10	3 - 13
leaf width	2 - 11 mm	1 - 6 mm	2 - 5 mm
awn	yes	no	no
type of youngest leaf	rolled	folded	rolled

*HEGI (1935), other *Festuca* -characters from HACKEL 1882, *Lolium* -characters from TERRELL 1968.

Table 2 Plant characters measured on the BC_3

character	Mean	standard deviation	Mean	standard deviation
	selfing progeny		open pollinated progeny	
height	94,87	± 0,77 cm	106,5	± 0,30 cm
ear length	18,18	± 0,23 cm	20,1	± 0,12 cm
glume	3,61	± 0,04 mm	3,37	±0,02mm
flowers per spikelet	7,81	± 0,04	7,44	± 0,06
leaf width	7,88	± 0,06 mm	8,79	± 0,03 mm

Table 3 Correlation between selfing and open pollinated progenies

character	r	confidence interval
height	0,448	from 0,090 to 0,703
ear length	0,582	from 0,266 to 0,784
glume	0,734	from 0,490 to 0,871
flowers per spikelet	0,386	from 0,015 to 0,664
leaf width	0,452	from 0,095 to 0,706

Table 4 The correlation coefficients between the characters

character	height cm	ear cm	glume mm	flow,/ear	leaf width
height	•	0,596	0,164	0,227	0,505
ear length		•	0,139	0,327	0,463
glume			•	0,0517	0,015
flow,/ear				•	0,201
leaf width					•

Figure 1
Relation of selfing to open pollinated progenies in leaf width,

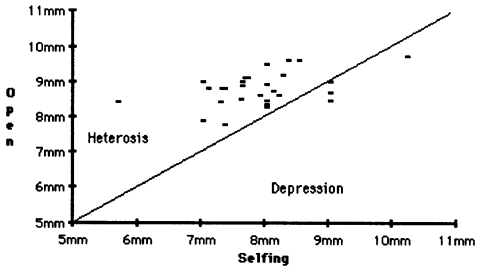

Figure 2. plant height and flowers per spikelet

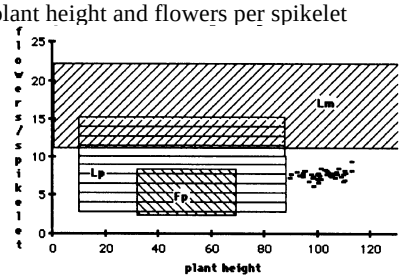

Figure 3. yield distribution of grass plots