Proceedings of the EUCARPIA FODDER CROPS SECTION MEETING

BREEDING FOR VIGOUR IN FORAGE CROPS

September 5th–9th, 1988

Research Institute for Irrigation

SZARVAS (Hungary)

Proceedings

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E U C A R P I A

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PREFACE

The 14th meeting of the Fodder Crops Section of Eucarpia was held at Szarvas, Hungary from the 5th to the 9th of September 1988. This was the first full section meeting to be held in Hungary and was at the kind invitation of the Institute for Irrigation Research.

The local organising committee had arranged a comprehensive programme of scientific papers and posters on the theme of the meeting "Breeding for vigour in forage crops". This topic attracted fifty-three participants from sixteen different countries. The meeting, which was opened by a welcoming address from Dr Marjai, the Director of the Institute for Irrigation Research and Dr Szucs, the Deputy Assistant Under-Secretary of the Ministry of Agriculture and Food, was held in the University of Agriculture. Excellent facilities were provided for the lectures, poster sessions and workshops. For the workshops a common topic "The environment and selection for vigour" was discussed. All participants appreciated the opportunity that these sessions provide to freely discuss problems of mutual interest.

As well as the scientific proceedings visits were made to the grass and lucerne breeding field laboratories of the Institute to see some of the research and breeding work in progress. The necessity for adaptation of genetic material to the environmental conditions of the Great Hungarian Plain was very clearly demonstrated.

In addition to the scientific programme our hosts arranged visits to local places of interest to see some of the natural and cultural heritage of Hungary, notably the gallery of Ruzicskay, the Arboretum of Szarvas, the State Farm of Mezohegyes and the National Park of Oroshaza. We most gratefully acknowledge the generous hospitality and efficient organisation that went into the making of a most successful meeting.

M D Hayward,
President, Eucarpia Fodder Crops Section,
Aberystwyth,
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September 1988

PAPERS

SELECTION FOR SEED YIELD IN EGYPTIAN (BERSEEM) CLOVER (*TRIFOLIUM ALEXANDRINUM* L.) VARIETY FAHL.

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SUMMARY

Modified mass and family selection for seed yield of berseem clover (*Trifolium alexandrinum* L.) c.v. Fahl were applied for two generations. Two hundred plants (5% intensity of selection) were selected for seed yield in the first season, 1985/86. In the second season, 1986/87, selection between and within half-sib families was practiced. In addition, equal parts of seeds from each of the 200 selected plants were bulked to form the C_1 modified mass selection. After establishing the same procedure was adopted to form the C_2 generation. The cycles 1 and 2 of half-sib families and modified mass selection along with the base population were evaluated for forage and seed yields. The realized gains from modified mass selection were 6.03 and 9.51% for fresh forage yield, 5.57 and 10.86% for protein yield and 13.23 and 16.19% for seed yield in cycles 1 and 2, respectively, over the base population. The realized gain from family selection as a percentage from the base population mean amounted to 11.32, 13.35, 17.47 and 3.15% for forage yield, protein, and seed yield and seed index, respectively.

The broad sense heritability as estimated from the variance components were 89.66, 63.03, and 76.67% for dry forage, and seed yield and seed index, respectively.

Although, all five traits (fresh, dry, protein, and seed yield and seed index) had positive correlation with each other, correlations between seed and forage yields were weak. Furthermore, close association were found among forage yields.

INTRODUCTION

Egyptian clover, Fahl cultivar is one of the essential winter forages in Egypt. It is a single cut cultivar, hence is grown as a catch crop before sowing cotton. It is valued for superiority of dry matter production during the short period of growth, because of its rapid growth and large forage yield in comparison with the first crop from multicut varieties.

Although plant breeders have made significant improvement in yields of many crops, however, limited work has been done on seed production or forage yield potential in Egyptian clover. This may be due to small floral parts which makes artificial hybridization difficult. Besides, large self-sterility limits the use of inbreeding. Therefore, Egyptian clover breeders have used mainly selection procedures for improving forage and seed yield in their breeding programs.

Mass selection was recommended to be effective in improving highly heritable characters (Bennett, 1959), while it was not efficient with the characters of low genetic variance (Allard, 1960). Several workers reported that mass selection was effective for the improvement of forage yield in multi-cut Egyptian clover varieties (Abou-El-Shawareb, 1971; Koraiem et al., 1980; Omara and Hussein, 1982; Radwan et al., 1983; Bakheit, 1985; Younis et al., 1986; Mikhiel, 1987). In addition, Omara and Hussein, (1982) and Bakheit (1985) found that family selection was more rewarding than mass selection for forage yield in Meskawi Egyptian clover.

Forage crops in Egypt especially clovers should produce forage and seed yields during its growing season. Very little information is available about the relationship between seed and forage yields in Egyptian clover as well as the effect of selection for seed yield and related fodder characters. Burton and DeVane 1953; from an investigation with tall fescue concluded that if selection pressure was exerted for the highest possible seed yield, it could only be achieved at the expense of some of the forage yield. However, Cowan (1955) working with tall fescue, reported the possibility to select for high seed yield, with high forage yield, within the same clones. Schaaf, Rogler and Lorenz (1962) found that in crested wheat grass there was no significant positive correlation between seed yield and forage production. El-Hattab et al. (1969) obtained weak correlation of 0.26, 0.21 and 0.42 between forage and seed yields in Miskawy, Saidi, and Fahl variety of Egyptian clover, respectively.

The present work describes the results of two different methods of phenotypic directional selection (mass and family selection) for seed yield and related forage yield characters in Fahl Egyptian clover.

MATERIALS AND METHODS

Parental materials:

A seed sample of Fahl variety obtained from Forage Crops Section, Field Crops Res. Institute, Agricultural Research Center was used for this study. In 1985/86 season at the experimental Farm of Assiut University, seeds of Fahl variety were sown in 200 rows (plots) 3.15 m long. Seedlings were thinned to one plant per hill. The spacings used throughout this investigation were 15 cm between plants within rows and 20 cm between rows except for the last season (evaluation season). All cultural practices were carried out at optimum level for maximum productivity. The best plants in each plot or row (5%) for seed yield/plant (200 plants) was saved.

Modified mass selection procedure

Equal parts of seeds from each of the 200 selected plants were bulked to form the first cycle of modified mass selection

(C_1). The same cultural practices, selection procedure and intensity of selection were adopted as the same as described previously. Equal parts of seeds from each of 200 selected plants were bulked again to form the subsequent cycle (C_2).

For estimating the response to selection the base population and two mass selection cycles (C_1 and C_2) were compared in 1987/88 season in a randomized complete block design with six replications, three for forage yield characters and the other three replications for seed yield characters. Plot size was four square meters. Seeds were hand-drilled in rows, 20 cm apart, at a seeding rate of 4000 seeds for each replicate equivalent to 35 kg/hectar. All cultural practices were applied according to the recommendations of berseem clover production. Ninety days from sowing the plots for forage yield were clipped back by hand sickle and data were recorded on fresh forage yield/plot and were converted into tons/hectar. Dry matter percentage was determined from plot samples of about 300 gm of fresh forage. Protein percentage was determined by the micro-Kjeldahl method as outlined by A.O.A.C. (1980) to estimate the total nitrogen. Nitrogen percentage was multiplied by 6.25 to obtained crude protein. At seed maturity stage, the plots were harvested and data were recorded on seed yield/plot and were converted to kg./hectar Data were statistically analysed according to Steel and Torrie (1980). Duncan's Multiple Range Test was used for comparisons among means.

Family selection procedure:

In 1986/87 season, each of the 200 selected plants were established as half-sib families. Each family consisted of 22 spaced plants. The best ten plants in seed yield from the best ten families were selected out of the 200 families (first cycle of family selection C_1).

In 1987/88 season, base population and the selected ten families were evaluated in a randomized complete block design with six replications, three blocks for forage yield characters and the other three replications for seed yield characters. Plot size was a half square meter (1 m x ½ m). Seeds were hand-drilled in rows, 20 cm apart, at a seeding rate of 500 seeds/plot (35 kg/hectar). Data for forage and seed yield characters were recorded as described in mass selection in 1987/88 season.

The analysis of variance and the expected mean squares for all traits were performed as outlined by Miller et al. (1958). The genotypic (σ^2_g) and the phenotypic (σ^2_p) variances were calculated according to Al-Jibouri et al. (1958). Phenotypic (P.C.V.) and genotypic (G.C.V.) coefficients of variability were calculated according to Burton (1952) and heritability (broad sense) was estimated as $h^2 = \sigma^2_g/\sigma^2_p \times 100$. Genotypic, phenotypic and environmental correlation coefficients were calculated from the components of variance and covariance as outlined by Johnson et al. (1955).

The predicted response from selection of the superior 5% plants in C_1 families was estimated at $i \sigma_p h^2$ whereas, the correlated response in trait (Y) when selection is applied to (X) (seed yield/plant) is $CRy= i\ hx\ hy\ r_A\ \sigma p_y$ according to Falconer (1960), where CR_y= the correlat response of the trait (Y), i= the intensity of selection = 2.063, hx= the square root of the heritability of the trait (X), hy= the square root of the heritability of the trait (Y), r_A= the genetic correlation between (X) and (Y) traits, and, σp_y= the phenotypic standard diviation of the trait (Y).

RESULTS AND DISCUSSION

a. Modified mass selection for seed yield:

The analysis of variance showed no significant differences in forage yield between the base population and the mass selected populations (Table 1). However, there were an increase of 6.03 and 9.51% in fresh forage yield, 6.26 and 9.06% in dry forage yield, 5.57 and 10.86% in protein yield and 4.72 and 5.56% in seed index in cycles 1 and 2, respectively over the base population (Table 2). While comparison between seed yield of the base and C_1 populations indicates that a significant response to

Table 1. The analysis of variance of forage and seed yield of the base, first (C_1) and second (C_2) cycles of mass selection of the Fahl variety of berseem clover.

Source of variation	d.f.	Mean squares				
		Forage yields			Seed yield	
		Fresh Tons/ha	Dry Tons/ha	Protein kg/ha	Seed yield kg/ha	Seed index (1000-seed weight
Replication	2	4.20	0.37	15840	36581**	0.008
Base Vs. selection	1	9.18	0.45	33020	44400**	0.067
C_1 vs. C_2	1	1.36	0.05	6730	1396	0.002
Error	4	4.99	0.26	14056	1117	0.033

** Singificant at the 1% level of probability.

selection has been achieved. A genetic advance of 13.23% from the mean of the base population was obtained after one cycle of phenotypic directional selection. However, no significant differences were detected between the first (C_1) and second (C_2) cycles of selection. The genetic advance computed as a percentage of the means of the base and the C_2 populations was 16.19%. No significant gain was observed from mass selection for forage yields, that could be attributed to selection for seed yield. Hence, a significant response to mass selection for seed yield was obtained after the first cycle of selection. Such response could be a reflection of the correlation between forage and seed yields. The present results for seed yield are in general agreement with those obtained by Omara and Hussein (1982), where significant response to mass selection for forage yield was obtained after the first cycle of selection. However, no significant differences were detected between the first and second cycles of selection. Otherwise, these results for forage yield are in general agreement with those obtained by Johnson and Goforth (1953) in sweet clover, Abou-El-Shawareb (1971), Ali (1971), Radwan et al. (1972) and Bakheit (1985) in Miskawy berseem clover.

Table 2. Means and realized gain (%) of forage and seed yield for different generations of mass selection of the Fahl variety of berseem clover grown in the 1987/88 season.

Generations	Forage yield			Seed yield	
	Fresh Tons/ ha	Dry Tons/ ha	Protein kg/ha	Seed yield kg./ha	Seed index (1000-seed weight,g)
Base population	27.55a	6.07a	1491a	1013a	3.60a
First cycle of mass selection	29.21a	6.45a	1574a	1147b	3.77a
Seconc cycle of mass selection	30.17a	6.62a	1653a	1177b	3.80a
+Realized gain %					
For cycle 1	6.03	6.26	5.57	13.23	4.72
For cycle 2					
from cycle 1	3.29	2.64	5.02	2.62	0.80
from base population	9.51	9.06	10.86	16.19	5.56

Means followed by the same letter in the same column are not significantly different at the 5% probability level as determined by Duncan's Multiple Range test.

+Realized gain % for $C_1 = \bar{C}_1 - \bar{C}_0/\bar{C}_0 x100$; $\bar{C}_0$ = mean base population
for $C_2 = \bar{C}_2 - \bar{C}_1/\bar{C}_1 x100$; from cycle 1
for $C_2 = \bar{C}_2 - \bar{C}_0/\bar{C}_0 x100$; from base population.

b. Family selection

The analyses of variance of the forage and seed yields of the ten families and their base population, revealed that significant or highly significant differences were present among the selected families (Table 3). Significant differences were observed between the base population and the mean of selected families for protein and seed yield, but not for fresh and dry forage yields and seed index.

Fresh forage yield of the ten selected families ranged from 21.50 to 40.24 ton/hec. with an average of 30.67, while protein yield ranged from 1173 to 2339 kg/hec. with an average of 1690. Furthermore, four families namely; 2, 6, 8, and 9 were significantly higher than the base population after one cycle of

Table 3. The analysis of variance of forage and seed yields for the base, and ten selected families of the Fahl variety of berseem clover grown in the 1987/88 season.

Source of variation	d.f.	Mean squares				
		Forage yields			Seed yield	
		Fresh Tons/ha	Dry Tons/ha	Protein kg./ha	Seed yield kg/ha	Seed index (1000-seed weight)
Replication	2	0.57	0.28	17891	26947	0.075
Families	10	81.41**	4.54**	300722**	53336*	0.083*
Base vs. selected fam.	1	26.81	1.36	107301*	86286*	0.035
Between families	9	87.47**	4.88**	322210**	49705*	0.088*
Error	20	7.09	0.40	23024	17592	0.026

* and ** Significant at the 5% and 1% level of probability.

family selection. With regard to dry forage yield it ranged from 4.79 to 9.36 ton/hec. with an average 6.77 and the three families i.e., 2, 6 and 9 were significantly higher than their base population (Table 4). In addition, seed yield and 1000-seed weight for the ten selected families ranged from 1005 to 1379 kg/hec. with an average 1190 and from 3.57 to 3.93 g. with an average 3.71, respectively. Furthermore, three families, namely, 3, 5 and 6 for seed yield and two families (3 and 6) for seed index were significantly higher than the base population after one cycle of family selection (Table 4).

Table 4. Means of forage and seed yields for the base population and the ten selected families of the Fahl variety of berseem clover.

Family cod number	Forage yields			Seed yield	
	Fresh tons/ha	Dry Tons/ha	Protein kg./ha	Seed yield kg/ha	Seed index (1000-seed weight,g.)
1	21.50a	4.79a	1173a	1173abc	3.63ab
2	35.31e	7.79e	1978e	1039a	3.77bc
3	30.00bcd	6.64cde	1630cd	1379c	3.93c
4	31.50cde	6.67cde	1645cd	1110ab	3.37a
5	27.62bc	6.14bcd	1556bcd	1330bc	3.57ab
6	40.24f	9.36f	2339f	1323bc	3.93c
7	25.17ab	5.43ab	1336ab	1005a	3.77bc
8	33.81de	7.19cde	1823de	1095ab	3.80bc
9	33.50de	7.31de	1826de	1211abc	3.73bc
10	28.10bc	6.36bcd	1590bcd	1237abc	3.63ab
Base population	27.55bc	6.07bc	1491bc	1013a	3.60ab

Means followed by the same letter in the same column are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

Expected and realized gains from selection of seed yield are presented in Table 5. The results indicated that, after one cycle of family selection, the realized gain for seed yield reached 17.47% from the base population. Likewise, the expected gain from selection based on the superior 5% plants in C_1 family selection was 16.61%. The realized correlated response to selection for seed yield reached 3.12, 7.08, and 6.05% in fresh, dry and protein yields, respectively, and 1.94% in 1000-seed weight after one cycle of family selection. Comparing the results of expected and realized gain from selection, it could be concluded that, generally there was a quite good agreement between predicted and realized gain in seed yield. But for forage yield and seed index, the realized response was large than the expcted one.

Table 6. Phenotypic (r_p), genotypic (r_g) and environmental (r_e) correlation coefficients among characters in ten selected families of the Fahl variety of berseem clover.

Traits	Correlation	Forage yield		Seed yield	
		Dry	Protein	Seed yield	Seed-inex (1000-seed weight)
Fresh forage yield	r_p	0.987	0.986	0.124	0.400
	r_g	0.997	1.010	0.100	0.362
	r_e	0.876	0.702	0.271	0.675
Dry forage yield	r_p		0.998	0.219	0.452
	r_g		1.007	0.214	0.455
	r_e		0.907	0.308	0.484
Protein yield	r_p			0.202	0.445
	r_g			0.175	0.473
	r_e			0.400	0.334
Seed yield	r_p				0.254
	r_g				0.277
	r_e				0.208

Phenotypic, genotypic, and environmental correlations between each pair of the five attributes were computed and presented in Table 6. The results indicated that the genotypic correlation coefficients between each pair of traits of forage yields (fresh, dry, and protein yields) were higher than their corresponding phenotypic correlations. These results revealed that the environmental factors affected both variables taken at a time at random indicating lack of association at environmental level. High genotypic correlations also suggested that there was inherent relationship between the characters in question. However, contrary results were obtained for correlations between seed and forage yields. Although, all five traits had positive correlation with each other, however, a weak correlations were found between seed yield and forage yields (0.12). Furthermore, close association were found among forage yields traits (0.99). These results are in agreement with those reported by El-Hattab et al. (1969) and Schaaf et al. (1962).

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Breeding for continuous grazing : Genetic variability for vegetative growth rate parameters in cocksfoot (*Dactylis glomerata* L)

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SUMMARY

As LEMAIRE pointed out in the last meeting at Lusignan, more attention should be payed on the turn over of the leaf material to improve the genetic adaptation of fodder grasses for grazing : what are the genetic variability and relations between the growth parameters as leaf appearance rate (LAR), leaf elongation rate (LER) and leaf expansion duration ? to what extent are they determining of the yield components (lamina length, width, surfacic mass and weight, tiller weight) and what is their stability towards environmental conditions.

A first approach has been done during the regrowth cycle of 31 genotypes of cocksfoot cultivated in spaced plants and under artificial conditions at two temperatures, 7° C and 14° C, with four replications by temperature.

The results showed that the growth criteria are not so variable than the direct components of lamina weight but much more influenced by temperature, mainly LER, bringing on significant genotype x temperature effects. So, in the experimental conditions of the trial, lamina weight remained better explained by components as length or aera lamina than growth parameters. However, the lack of correlation between LAR and LER suggests to go on observations but this time, in sward and according to a frequent cutting management, taking into account the relations with tillering rate.

INTRODUCTION

More and more breeding works on fodder crops try now to have a better interpretative physiological approach of the genetic variability analysis. In a review on tall fescue breeding, SLEPER (1985) mentionned some novel ways of breeding for yield increasing, i.e. the carbon exchange rate, the dark respiration and the leaf area expansion rate. No clear relations with yield have been yet found for carbon exchange rate, although consistent genetic variability and heritability have been displayed. With dark respiration, low selection on ryegrass has been related to higher tillering rate (WILSON, 1975 ; ROBSON, 1982). Finally, selection for high leaf area expansion rate has also been successfully associated to leaf elongation rate, lamina width and tiller yield but negatively to tillering rate (ZARROUGH et al., 1984).

In this last way, LEMAIRE (1987) also pointed out in last meeting of Lusignan that more attention should be payed by breeders on morphogenetic processes to improve more adapted genotypes. Due to quite close relation between dry matter growth and intercepted radiation amount in non-limiting conditions, rather poor genetic improvements have to be expected by breeding for total yield (GOOSE et al., 1986). But, before canopy reaches its optimum leaf area index, the genetic variability of the leaf area expansion rate could be valorized, for instance, by genotypes selected for high leaf material turn over if grazing has to extend in the future.

This paper reports first results found in cocksfoot where large variations exist for some components of the leaf area expansion rate. The aim of the experiment was to determine during one cycle of regrowth what are the genetic variability and relations between some leaf growth rate parameters, to what extent are they determining of the yield components and what is their stability towards environmental conditions, specially temperature variations (HUREAU, 1987).

MATERIEL AND METHODS

31 genotypes of cocksfoot (*Dactylis glomerata* L.) screening a large range of variability for tillering, leaf length and width, have been chosen in the nursery of Lusignan Station. After cloning, plants were disposed in two culture cells, each at a controlled temperature and light intensity of 7° C - 8500 lux and 14° C - 10000 lux respectively, both under a 16 hours photoperiod and according a 4 randomized block design. The substrate was a sterilized mixture of compost, sand and silt-clay soil. Any nutritive supply was given during the experiment. For each design, the plants were set out at intervals of 15 cm on 21 cm spaced rows.

Observations were made along a re-growth cycle (33 days at 14° C, 66 days at 7° C) allowing to survey the growth of four successive leaves, at a 3 observations per week rate, on 2 marked tillers per plant. Observations included the measures of lamina and sheath length as well as leaf and leaflet date of emergence. So, could be determined :

- Lamina elongation rate (LERl),
- Cumulated lamina elongation rate of a tiller (LERt), calculated by adding the length of the sheath with all its alive lamina,
- Mean duration of lamina elongation of a tiller (LED),
- Leaf appearence rate (LAR), as time spacing emergence of two successive leaflets, i.e. leaflet-phyllochrone.

At the end of the re-growth cycle, 5 adult lamina were cut off on the highest leaf level of each plant. The length (LL), width (LW), area (LA), dry matter weight (LDMW) and surfacic mass (LMS) were measured. Dry matter weight per tiller (TDMW) was then infered from the number of tillers per plant (by counting) and total dry matter weight of plant.

All the controlled effects have been tested with analysis of variance. Genotypic and genotype x temperature variance, within and between temperature resp., have been estimated from corresponding mean square expectations (all effects considered as random) and expressed as genotypic (gcv %) and genotype x temperature (gtcv %) coefficients of variation. Correlations between temperatures and between variates are phenotypic.

RESULTS

Measure of growth rate

Given the experimental observations, the leaf growth rate was taken as linear until leaflet emergence after which growth very quickly stops.

To characterize the genotype leaf growth rate, cumulated lamina growth rate of a tiller (LERt) has been preferred. This measure, including leaf appearance rate, may give better estimation of the tiller ability of a genotype to recover rapidly an important leaf area after cutting. Moreover, these two variates remain well correlated at both temperatures as well as with the last value of LERt (LERf) (table 1). So, a single measure of all the present lamina and sheath at the end of a re-growth cycle would give a quite satisfying estimation of the leaf growth of a tiller.

Temperature effect

Temperature increasing strongly influences the growth rate of leaves (table 2). Like this, leaf elongation rate is more than doubled as temperature increases from 7° C to 14° C while leaf expansion duration and leaf appearance rate are more than half reduced. On the size and dry matter weight components, the temperature effect is weaker. Due to this antagonism effect of temperature on leaf growth rate parameters, lamina length and area have been found just slightly larger at 14° C than at 7° C. On the other hand, lamina surfacic mass has decreased, which explains that the lamina weight remains inchanged at the two temperatures. Tiller weight has been strongly increased at 14° C, but, given the stability of lamina weight, it would be due to an important increase of sheath weight.

Genotypic and genotype x temperature effets

A quite important genotypic variability is displayed at the two temperatures, highly significant for most of the variates (table 3). However, the range of the genotypic variation is more or less large according to the parameters : low for leaf appearance rate, elongation rate and leaf expansion duration, intermediate for lamina lenght, width and surfacic mass, high for lamina area, lamina and tiller weight. Temperature also acts on the range of genotypic variability.

For leaf elongation rate and tiller weight, it is highly increased at 14° C whereas for leaf appearance rate, genotypic effect is no more significant. It is possible that the observations frequency (three times a week) has not been sufficient, given the high growth rate at 14° C, to accurately estimate the leaf appearance rate at this temperature. Similarly, the non significant effect of the leaf elongation rate at 7° C would be also due to experimental error but, this time, in the lamina lenght measures in slow growth rate conditions. For tiller weight, we have to suppose that temperature not only enhances the contribution of sheath in the tiller yield but also increases its variability, so that sheath and lamina weight variations would be almost independent with a large part of uncontrolled variations at 14° C for the former.

The growth rate parameters, as well as surfacic mass to some extent, are once more mainly at the origin of the largest genotype x temperature effects, with phenotypic correlation coefficients between temperatures sometimes significant due to low errors (LAR - LED - LMS). For leaf elongation rate, the correlation remains highly significant because the genotypic effect is much more important than the genotype x temperature effect at 14° C. Among the lamina size parameters, width strikingly appears as a quite constant genotypic variate, not influenced by temperature.

The correlations between variates show there is a general tendency of the components to explain better the immediately next composite parameters than more physiologically distant ones, but with some differences according to temperature (table 4). Tiller and lamina weight are related at 7° C but not at 14° C proving, as mentionned above, that sheath weight contributes for a large part to tiller weight but independently of lamina weight and with a rather important non-genetic variation. At 14° C, a set of successive parameters, LERt - LL - LA, are determining better and better the lamina weight. But this axis is broken off at the lamina area level at 7° C so that lamina weight appears more directly close related to lamina length than to area. As the lamina width and surfacic mass contributions to lamina area and weight resp. have not increased, it suggests that the lamina area determination under slow growth rate condition is rather bound to important error variation. At a same level of contribution of the tiller yield (growth, size, weight) most of the components seems to be not or just slightly, correlated. Even between leaf appearance rate (estimated as phyllochrone so that the correlation is positive) and leaf expansion duration, and given the lack of significant genotypic effect of LAR at 14° C, the significant but non absolute correlations show that the number of growing leaves per tiller can vary around two in cocksfoot. In fact, there is a highly significant genotypic effect for the delay between leaflet appearance of the n leaf and n + 2 leaf emergence, ranging of - 0,41 to + 3,45 days. The lack of correlation between leaf appearance rate and leaf elongation rate is even much more striking, it would mean that tillering rate, at least potential tillering rate, would be independent of the rate of leaf elongation.

DISCUSSION

The results show that the growth rate parameters of leaves in this experiment on cocksfoot exhibit not a so large, although sometimes substantial, genotypic variability than the more composite traits as Lamina size or weight. Moreover, the main characteristic of the growth rate variates is to be very sensitive to temperature increasing, which was not unexpected from parameters highly dependent of sum of temperature, with a mainly interactive genotypic variability. So, under the artificial conditions of the trial, growth rate was not a so good predictor of tiller or lamina yield than direct components as lenght or area lamina. The light intensity, mainly at 14° C, may have been little insufficient to allow optimum photosynthesis. Indeed, there was a balancing effect of the size and weight lamina components between temperatures, furthermore, leaf senescence has not been observed at the end of the re-growth. So, added to rather large errors of lamina and mainly tiller weight, it could explain that direct phenotypic relations between growth rate and dry matter yield have not been more obviously displayed. In this way, the non-optimum photosynthesis conditions could be also, to some extent, responsible of the apparent independence between most of the components variations, especially those of leaf appearance and leaf elongation rate, instead of close negative expected correlations. The lack of correlation between these two leaf growth rate variates is probably more due to lack of leaf appearance rate genotypic variability than actual independence. Moreover, it checks that in carbon supply limiting conditions, in the same way than just after cutting, the leaf appearance rate and consequently the tillering rate, is much more reduced than the leaf elongation rate (LEMAIRE, 1985). So, to observe actual negative correlation, we would have had probably to work at a higher level of carbon supply as ZARROUGH et al. (1984) did it on tall fescue, showing a negatively associated effect of leaf area expansion rate selection on leaf appearance rate and tillering rate. Another evidence of the trophic competition meaning of the correlation is also provided by ROBSON (1982) : sparing carbon in low dark respiration selected lines of perennial ryegrass breaks off the correlation so that tillering rate can increase but without be followed by any change of leaf elongation rate.

Tillering rate could not be accurately estimated in this short-time experiment but we will have to take into account this variate for next trials which could be consequently done on long-term observed swards under intense defoliation rate. So, more unambiguous conclusions could be drawn about the relations between tillering, leaf appearance and leaf elongation rate and their contribution to total yield. For breeding purposes, heritability of each component has also to be considered. Some successfull previous attempts to select high or low leaf area expansion rate indicate a significant part of additive genetic effects (REEDER et al., 1984). But, as no *a priori* relations between yield contribution and heritability of the components are to be expected, breeding strategy will have to be optimized. One aspect of this will be to know what is the stability of all these relations, according to environmental conditions (temperature, nitrogen and water supply), time (early stage - adult relations) and space (isolated plants - sward relations). From this last point of view, measures of leaf growth rate are often time - consuming and the feasibility will not be the least important factor.

In conclusion, all plant breeders are dealing with breeding method optimization and are involved in genetic variability researches. But, about fodder grasses, more than anybody have we not to ignore the physiological point of view and the limits of genetic variability that it implies. The morphogenetic approach with a comprehensive genetic study of its components as suggested above could be promising to know to what extent can we valorize genetic variability of forage grasses, for what agronomic purposes and with what selection tests. In this mind, continuous grazing and cinetic of optimum leaf area index recovering would be a quite interesting field of application.

RESUME

Lors du dernier Congrès Eucarpia à Lusignan, LEMAIRE avait souligné l'importance qu'il faudrait accorder à la vitesse de renouvellement du couvert foliaire pour améliorer l'adaptation au pâturage des graminées fourragères : Quelle est la variabilité génétique et les relations entre des paramètres de croissance foliaire comme la vitesse d'apparition des feuilles, leur vitesse d'élongation et leur durée d'expansion ? dans quelle mesure déterminent-ils les composantes du rendement (longueur, largeur, surface, masse surfacique et poids du limbe ainsi que le poids total des talles) et quelle est leur stabilité vis-à-vis des conditions environnementales ?

Une première approche a été réalisée pendant un cycle de repousse de 31 génotypes de dactyle cultivé en plantes isolées et en conditions artificielles à 2 température, 7° C et 14° C, avec 4 répétitions par température.

Les résultats montrent que les critères de croissance sont moins variables que les composantes directes du poids du limbe mais beaucoup plus influencés par la température, conduisant ainsi à des interactions génotype x température significatives. Dans nos conditions expérimentales, le poids du limbe est donc resté mieux expliqué par des composantes comme la longueur ou la surface plutôt que par les paramètres de croissance foliaire. Néanmoins, l'absence de corrélation entre la vitesse d'élongation et d'apparition des feuilles suggère de poursuivre les observations, en conditions denses et sous un régime de coupes fréquentes cette fois, en prenant en compte les relations avec le tallage.

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Temperature	7°C			14°C		
	LER l	LER t	LER f	LER l	LER t	LER f
LER l	-			-		
LER t	0,81	-		0,91	-	
LER f	0,85	0,84	-	0,81	0,85	-

Table 1:
Phenotypic correlations between three estimates of leaf elongation rate : per lamina (LERl) per tiller (LERt), per tiller at the end of the regrowth cycle (LERf), for two temperatures.

Temperature		7° C	14° C	F
LAR	(days)	23	9	1855,66**
LER t	(mm/day)	5,1	13,7	1100,17**
LED	(day)	37	16	1164,88**
LL	(mm)	206	253	71,72**
LW	(mm)	6,2	6,0	1,68 NS
LSM	(mg/cm^2)	4,0	3,1	191,12**
LA	(cm^2)	8,80	11,38	50,80**
LDMW	(mg)	34,4	35,1	0,06 NS
TDMW	(mg)	69,0	160,0	23,96**

Table 2.
Effect of temperature on mean values for growth rate, size and dry matter weight components of leaves in cocksfoot.

	7° C		14° C		interaction	
	e CV %	g CV %	e CV %	g CV %	gT CV %	r
LAR	7,1	3,5*	6,5	2,3^{NS}	8,2*	0,31^{NS}
LER t	13,5	1,9^{NS}	9,1	7,2**	5,2**	0,56**
LED	7,1	5,4**	6,6	3,8**	18,5**	0,37*
LL	10,8	8,6**	9,0	8,4**	1,6^{NS}	0,61**
LW	6,7	6,7**	6,0	6,3**	3,2^{NS}	0,72**
LSM	13,3	8,1**	6,1	5,2**	6,6**	0,40**
LA	15,6	9,8**	12,6	10,2**	6,6^{NS}	0,50**
LDMW	23,9	15,4**	16,7	11,8**	0,^{NS}	0,68**
TDMW	16,1	10,2**	59,1	25,4*	23,4^{NS}	0,17^{NS}

Table 3.
Error (e CV %), genotypic (g CV %), genotype x temperature effect (gT CV %) coefficients of variation and phenotypic correlations (r) between temperature for growth rate, size and dry matter weight components of leaves in cocksfoot cultivated at 7° C and 14° C.

		LAR	LER t	LED	LL	LW	LSM	LA	LDMW	TDMW
14° C	LAR	-								
	LER t	0,01	-							
	LED	0,46**	0,39*	-						
	LL	0,22	0,72**	0,56**	-					
	LW	-0,21	0,21	0,15	0,17	-				
	LSM	0,16	0,15	0,41*	0,22	0,12	-			
	LA	0,15	0,69**	0,58**	0,87**	0,54**	0,15	-		
	LDMW	0,19	0,68**	0,66**	0,83**	0,50**	0,52**	0,91**	-	
	TDMW	-0,03	0,02	0,19	0,20	0,12	0,24	0,17	0,22	-
7° C	LAR	-								
	LER t	-0,20	-							
	LED	0,72**	0,14	-						
	LL	0,13	0,78**	0,38**	-					
	LW	-0,12	0,39*	0,09	0,26	-				
	LSM	-0,05	0,32	0,23	0,37*	0,23	-			
	LA	-0,01	0,50**	0,37	0,53**	0,63**	0,04	-		
	LDMW	0,10	0,68**	0,47**	0,86**	0,67**	0,50	0,74**	-	
	TDMW	-0,02	0,61**	0,27	0,75**	0,63**	0,29	0,67**	0,86**	-

Table 4.
Phenotypic correlations between growth rate, size and dry matter weight components of leaves in cocksfoot at 7° C and 14° C.

The closest correlations between components determining step by step the tiller or lamina weight are underlined.

Breeding for Vigour

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Summary

At the meeting of the fodder crop section of EUCARPIA in Lusignan in 1987 a valid definition for vigour could not be found. In this review some breeding methods which may result in vigorous cultivars are described. High yielding varieties can be achieved too by breeding for resistance against diseases and pests, harsh climatic conditions, cutting management etc. But a resistant variety is useless unless it fails to grow vigorously. Vigour is the prerequisite for successful cultivars. This paper therefore presents some aspects of breeding for vigour in forage crops especially in grasses considering synthetics, male sterility, and the developing of chance hybrids and amphiploids.

At the meeting of the fodder crop section of EUCARPIA in Lusignan in 1987 an attempt was made to define vigour. After intensive discussion the following definition of vigour was accepted: "Vigour is the capability of the plant to draw the available environmental resources and to transform these resources into biomass within a range of time which is defined according to farm practices "(ROTILI and PICARD 1987). While the object of that meeting was the exploition of variability for adaptation the main theme of the meeting in Szarvas is: Breeding for vigour in forage crops. This is a comprehensive title, for many breeding methods have been developed in order to increase the vigour of the plants including the improvement of resistance against diseases, harsh climatic conditions, cutting management etc. But since a resistant cultivar is nearly useless unless it is vigorous the prerequesite for successful breeding is vigour. Although a resistant variety may be vigorous just because of its resistance this paper does not deal with all those methods breeders have applied to improve resistance against those factors just mentioned. This review is rather restricted to some aspects of breeding methods by which viability, plant growth or vigour in a narrow sense of the word can be improved.

Vigour is a quantitative trait controlled by many genes and it is well known that heterozygosity favours plant growth and vigour. Besides that it is well known that most of the forage crops are more or less crosspollinators. Consequently the knowledge of quantitative and population genetics should be taken under consideration when new breeding methods shall be developed. Further the requirements of the official institutions must not be neglected. A new cultivar will not get its certification unless it is uniform and stable. In conclusion a vigorous variety can be established if the breeder is able to increase the degree of heterozygosity without worsen uniformity.

Nearly all cultivated species of forage crops have been examined for heterotic effects and there is no doubt that increased vegetative growth can be observed in many F1 progenies (cit. in KOBABE 1983). The highest degree of heterozygosity is to be expected in the F1 generation and the propability to obtain good vigour is highest in F1 varieties. If the parents are well selected the F1 offspring will be homogene too. So far a F1 variety is an ideal cultivar but unfortunately in most cases the breeding systems of the forage plants do not allow an economic production of F1 seed. Therefore one has to look for alternative methodes. Because of their operational simplicity synthetic varieties are wide spread in fodder crops. Using a polycross the general combining ability is exploited. Although polycrosses are convenient they still have disadvantages. Different degrees of selfpollination of the genotypes could cause bias. The number of genotypes that enter the synthetic vary but scientists recommend 5-10 components (SIMMONDS 1979).

The production of synthetics can not work sufficiently when the selected genotypes fail to multiply identically. The components must therefore be inbred lines or plants which can be propagated vegetatively very easily as for instance perennial ryegrass. Inbred lines can exist only if selffertilizing is possible. But selfcompatibility is just that trait which has to be avoided by the breeder. That is why breeders prefere to work with clones which can be maintained over years as long as it is necessary. But the disadvantage is that there are several species which are not perennial. The vegetative propagation of Lolium multiflorum is rather cumbersom. It is hardly impossible to store selected genotypes over a longer period. This problem can be solved by tissue culture as it is practised in Aberystwyth, in Göttingen, Stuttgart-Hohenheim and elsewhere. The regeneration of plantlets from young inflorescences or buds makes it possible to multiply each genotype. Another advantage of this technique is the possibility to store the plantlets for months in a refrigerator. So the space for keeping the basic genotypes for a synthetic becomes very small. Before utilizing this technique for producing synthetics it is necessary to investigate the liability to somaclonal mutation. If there occur those mutations they likely will change the general combining ability and the synthetic can not be kept stable. Three thousend clones of inbred genotypes achieved by tissue culture have been selfed in a trial in Göttingen. Inbreds were involved because segregations due to mutations can be detected best when the parents are homozygous. The result, however, can only be presented next year.

In an ideal synthetic selfcompatibility must not occur. But in practice it can not be excluded that some clones used as components are partial selffertile. Obviously selffertility favours inbreeding and reduces vigour. Since JENKIN (1931) described a pollen sterile type in Lolium perenne and NITZSCHE (1971) found a male sterile phenotype in Tápiószele/Hungary in Lolium multiflorum the discussion is still going on whether male sterility can successfully be utilized in forage grass breeding. The level of crosspollinating can probably be increased by male sterility, when selfpollinating of those clones which form the synthetic can not be excluded completely. The introduction of male sterile clones may perhaps compensate the genetic controlled rates of selfings. Theoretical calculations have shown that this effect of compensation depends upon the inheritance of the male sterility (genic, cytoplasmatic or both) and of the rate of selfing (KOBABE 1978).

Computer calculations using a one gene and a two gene model indicated that the efficiency of male sterile clones in synthetics is rather low. If, for example, the basic Syn-0 generation consists of two clones with the genetic constitution AA and aa and if the rate of selfing is 0.5, the percentage of heterozygous genotypes in the following syn-generations will approach 33 % only. But after changing the composition of the Syn-0 to 1 AA normal : 1 aa normal : 4 AA male sterile : 4 aa male sterile the heterozygotes will increase up to 47 %. The rate of increasing of hybridity depends upon the selfing rate; the lower the latter the lower the response of heterozygosity. Further, this system is restricted to male sterility which is inherited cytoplasmatically. Restorer genes will destroy this system very quickly.

In spite of all efforts ever made to utilize male sterility in fodder grass breeding in order to produce vigorous F1 varieties the number of certified F1 cultivars are low. Instability of the male sterility under different environments and the difficulty to maintain and to multiply male sterile progenies generatively may be the reasons why F1 varieties are not released into the market in a broader scale. ENGLAND (1976) has made a very interesting proposal at the meeting of EUCARPIA 1976 in Budapest. He presented a method using the selfincompatibility in Lolium and he has shown how to propagate desired genotypes although they are highly selfsterile. But when applying this system breeders have to work very thoroughfully and must carefully avoid contamination with pollen comming from elsewhere. Since the increase of vigour and grain yield is much more important in cereals than in forage crops this system is now attempted to be applied on rye (WRICKE 1986). Simultaneously the development of pure F1 variety in rye by the help of male sterility has nearly finished (GEIGER 1986, GEIGER and SCHNELL 1973).

Although some years ago a Dutch breeder has released a F1 cultivar of Lolium utilizing male sterility this seems to be an uncertain way. In any case there was no convincing success until now and the production of F1 seed in an commercial scale is as expensive as before. FOSTER (1973a,b) proposed a less expensive method of producing vigorous F1 hybrid varieties of herbage grasses. The seed of two parental populations which give superior F1 hybrids should be sown in a 1:1 blend. The seed grower will not distiguish between this mixture and seeds for the multiplication of a normal variety. The seed product harvested from the two blend populations will consist of up to 50 % so called interpopulational F1 hybrids. The remainder are seeds of each parental population. Since 50 % are hybrids such a variety is also called semi hybrid variety or chance hybrid variety. The percentage of F1 hybrid seeds are dependent upon several factors affecting fertilization. First of all the coincidence of flowering time of the two parental components is very important. Further the number of inflorescences, the number of florets per spikelet, the gamete frequence etc. can reduce the ratio of hybrid seeds. Since in grass mature grains do not remain in the ears as they do in cereals different extent of seed shattering is another factor which can influence the percentage of hybridity. Serious objections have been made by WRIGHT (1972). There is obviously no difference between a chance hybrid variety and a synthetic. The mean performance of a semi hybrid and a synthetic is expected to be equal by reason of the rules of population genetics. But forage crops are usually sown very tightly in order to get swards. Competition will therefore occur in the establishment phase of grass sward. Since the hybrid plants of the chance variety are much more vigorous, they soon will eliminate the weaker parental fraction. Theoretically this kind of competitions can also be observed in common synthetics and the critical objections are not yet dispelled.

In order to get some practical information an experiment with Lolium multiflorum was carried out at the Department for Forage Crop Breeding in Göttingen. Equal portions of germinable F1 hybrid seed produced by crossing a male sterile clone with an inbred pollinator were mixed with seeds of an inbred line. Four such different blends were sown in small plots in a randomized block design with three replications. The morphological habit of the components used in this experiment was, of course, well known. Simultaneously, both components of each combination were sown separately in order to get young plants. These seedlings were planted alternately in rows (hybrid, inbred, hybrid, inbred etc.) spaced 4 cm. Sowing and plantig took place in autumn. The next year after cutting a piece of 30 cm length out of each plot was taken and these clusters were separated into single tillers. These shoots were potted and later planted into the field. After a few months the adult plants could be identified very easily. The results indicate clear superiority of the hybrids (Fig.1)

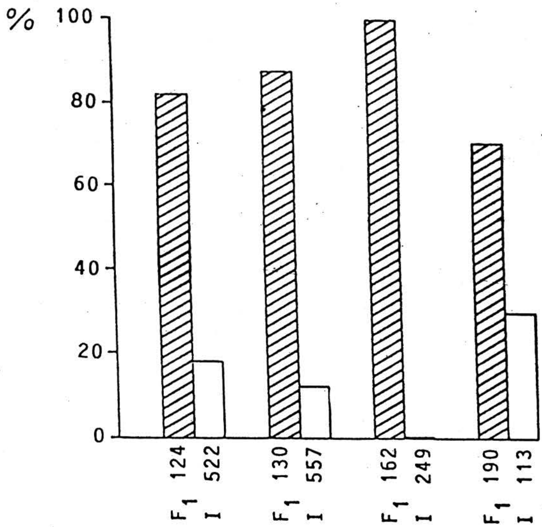

Fig. 1 Percentage of surviving hybrids (F1) and inbreds (I) of four mixed seed samples (1:1) after the first cut

In average there were only 15.1 % of the inbreds left. Since in the spaced planted rows the single plants could be identified over the whole period of vegetation, it was not necessary to cultivate single shoots. After the second cut nearly 99 % of the hybrids have survived while only 58.7 % of the inbreds were still alive (Fig. 2). Some weeks later after the third cut these figures read 95 % and 23 % (Fig. 3). The spaced planted trial does not appraoch practical usage but it shows clearly the superior vigour of the hetrozygous hybrids. The procedure for identification of the components of the tightly sown plots is certainly tedious and lengthy and it depends upon the ability and readiness of the single tillers to develop roots. By the application of tissue culture some difficulties can be overcome because it is much more easy to regenerate a plantlet from a fertile shoot than to achieve rooted shoots from adult plants after digging them up. Apparently the method of the future will be the application of electrophoresis. Experiments are planned to be carried out in Göttingen.

Wide crossings especially between georaces and different species have been made to combine complementary traits of the two parents. The aim, however, is not only the combination of distinct characters but also the development of cultivars which exhibit high vigour. This expectation is due to the wide genetic distance between the two partners. Breeders and scientists were often led into temptation to cross tall fescue (Festuca arundinacea) and Italian ryegrass (Lolium multiflorum) in order to synthesise a new amphiploid species.

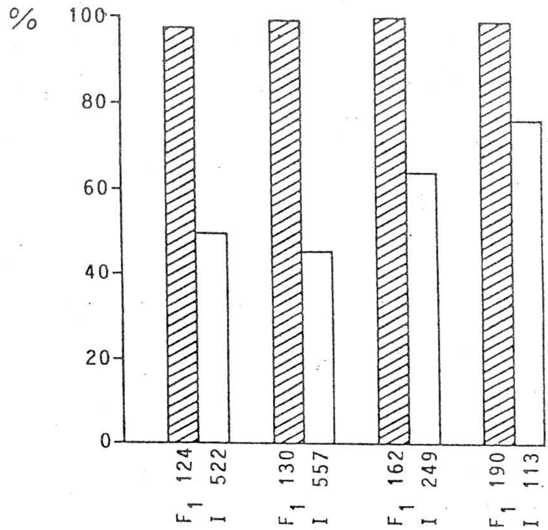

Fig. 2 Percentage of surviving hybrids (F1) and inbreds (I) of four plots with mixed single plants (1:1) after the second cut

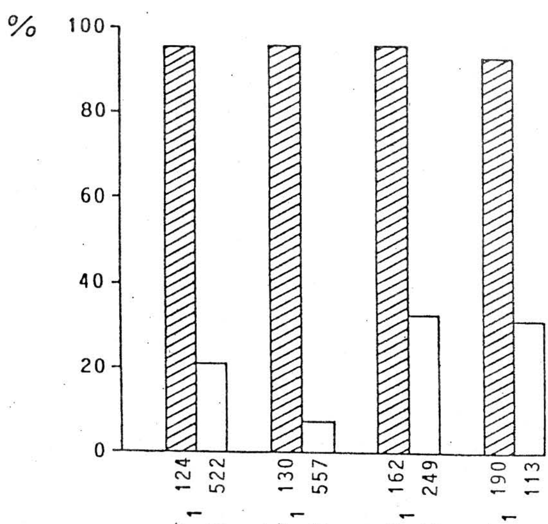

Fig. 3 Percentage of surviving hybrids (F1) and inbreds (I) of four plots with mixed single plants (1:1) after the third cut (KOBABE and KOCKELMANN 1988)

These new genotypes are vigorous and of agronomic value, but meiotic irregularities lead to chromosome loss and subsequent genetic instability in later generations. Another candidate for species crossings in grass breeding ist giant fescue (Festuca gigantea). Encouraging experiments were recently carried out in Aberystwyth (MORGAN, THOMAS and LEWIS 1988)

Although wide crossings are to be expected to result in vigorous progenies, only the products of near related species (Lolium perenne and Lolium multiflorum) are on the market. Theoretically a higher degree of hybridity can be achieved, when the parents of such crossings are tetraploid hybrids, each of them with two different alleles in one locus. If the inheritance is disomic and if the rate of selfing ist 0.5, half of the offspring will be tetra-allelic while the others will be di-allelic. The latter will, of course, reduce the degree of heterozygosity. In case of complete self-incompatibility all the genotypes will have four different alleles. Assuming tetrasomic inheritance in addition to the tetra-allelic plants tri-allelic types will occur in the offspring. The percentage of di-allelics will be very low and the desirable multi-allelic plants will approach up to 90 % depending upon the rate of selfing (BREESE, LEWIS and EVANS 1981, LEIN 1988).

New techniques were developed in the last years. Tissue culture became routine in plant breeding. Somaclonal variation - due to genetic changes during the callus phase in tissue culture may be utilized in the near future. The next step is plant regeneration from cell suspension cultures, protoplasts fusion and gene transfer. Perhaps the selection of disease resistant cells in a petri dish will soon be possible in forage crops. But the question is if these modern techniques will support breeder's work to increase vigour. It is a challenge of today for all those who are working in the fields of plant breeding and genetics to investigate the new chances for increasing vigour by the means of tissue and cell cultur.

Zusammenfassung

Auf der Tagung der EUCARPIA-Sektion Futterpflanzen im Jahre 1987 in Lusignan hat sich gezeigt, daß eine eindeutige Definition von Wüchsigkeit (vigour) nicht gegeben werden kann. Im vorliegenden einführenden Referat werden Zuchtverfahren angesprochen, durch deren Anwendung wüchsige Sorten entwickelt werden können. Letzten Endes führt natürlich auch die Züchtung auf Resistenz gegen Krankheiten und Schädlinge sowie gegen ungünstige Witterungsbedingungen und auf Anpassungsfähigkeit an Nutzungssysteme (z.B. häufiger Schnitt) zu ertragreichen Sorten. Aber eine resistente Sorte ist kaum brauchbar, wenn sie nicht wüchsig genug ist; kräftiges Wachstum ist als Voraussetzung für eine gute Sorte anzusehen. Es werden daher einige Aspekte über Zuchtverfahren bei Futterpflanzen insbesondere bei Gräsern dargestellt, wobei synthetische Sorten, männliche Sterilität, die Entwicklung von Chance-Hybriden und Artkreuzungen berücksichtigt werden.

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VIGOUR, HIGH YIELD AND QUALITY OF BRASSICA FODDER PLANTS. IS IT POSSIBLE TO COMBINE?

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Abstract

The most succesful form of intercrop in Polish climatic and soils condition is winter catch crop cultivation. Besides the traditionally cultivated winter rye and vetch, plants from the Brassica genus could be used in this sequence of crop rotation (Jelinowska, Jelinowski, Sypniewski, 1968; Renius, Lütke Entrup 1985).

The need of the new plants suitable for winter catch crop makes the main point of evaluation of our Brassica collection and hybrids obtained in the result of interspecific crossings among napus, campestris and oleracea sp. especially (Balicka, Barcikowska, Chwałek, Młyniec, Szyld 1978, Zwierzykowska 1981).

Following are the main features of plants connected with their utilization as winter catch crops: 1. Vigour, 2. Winter hardiness, 3. High green and D.M. yield, 4. Quality of green matter: 4.1. High D.M. %, 4.2. High protein % of D.M., 4.3. Low N-NO_3 % of D.M. 4.4. Low glukosinolates contens uM/g D.M.

The description of each form based on spaced plants grown in the field and glass house and also in dense sowing in field experiments: on the field of the National Genetic Resources Department of the Plant Breeding and Acclimatization Institute in Radzików near Warsaw, on the field of Plant Genetic Institute in Poznań. We are working in close collaboration with Plant Cultivation, Manuring and Soil Science in Puławy.

Results, some are still in elaboration show that:

1/ High evaluation of vigour in autumn is, in general not combined with good winterhardiness and high evaluation of vigour in spring. It concerns especially forms of B. campestris ssp, pekinensis and hybrids derived from crossings where ssp. pekinensis was the female parental form (Młyniec Röhm-Rodo wald, Zielińska, 1982)

2/ Low content of glukosinolates in green parts of plants is generally speaking combined with low vigour (specially in spring) in general with low winterhardiness and rather poor deaseases and pests resistance (it concerns mainly B.napus types) Młyniec, Heimann 1985)

3/ As far as nitrates ($N-NO_3$) content is concernd - vigour seems to be combined with higher rate of nitrogen metabolism in plants and in consequence - lower content of $N-NO_3$ in green matter. B.campestris forms can be used as the best example. It seems also, that the differences in nitrate content depends in Brassica plants not only on the rate on nitrogen fertilization, but is also genetically conditioned (Młyniec, Blaim, Płoszyński 1986).

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THE EFFECT OF SELECTION FOR DISEASE RESISTANCE ON VIGOUR OF RED CLOVER (Trifolium pratense L.) AND ITALIAN RYEGRASS (Lolium multiflorum Lam.)

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Summary

At the Swiss Federal Research Station for Agronomy several fodder plants are selected for resistance against the following diseases: stem nematodes, powdery mildew and sclerotinia root rot on red clover; powdery mildew, snow mould and crown rust combined with vascular wilt on Italian ryegrass. Most selections show a slower development in the planting year, recover in the first year of full production and yield even better in the second year compared to the population from which they were selected. Recurrent selections can lead to varieties with resistance to several diseases and improved yield.

1. Introduction

It is well known that diseases of grasses and forage legumes cause losses of yield and quality. Since it is not commun to treat fodder crops with pesticides breeding for disease resistance is very important. In Switzerland the most important disease are clover root rot (Sclerotinia trifoliorum (Erikss.), clover stem nematode (Ditylenchus dipsaci [Kühn] Filipjev), vascular wilt of ryegrass (Xanthomonas graminis Egli, Goto and Schmidt), crown rust of ryegrass (Puccinia coronata Corda) powdery mildew of red clover (Erysiphe trifolii Grev.) and ryegrass (Erysiphe graminis D.C. ex Mérat), Drechslera leafspots (Drechslera dictoides [Drechsler]

Shoemaker and Drechslera siccans [Drechsler] Shoemaker) and snow mould (Fusarium nivale (Fr.) Ces.) of ryegrass.

Clover root rot, clover stem nematode and vascular wilt and snow mould kill the plants rapidly and often cause high yield losses. Weeds grow in the open spots leading to a reduction in fodder quality. Crown rust, powdery mildew and Drechslera leafspot weaken the plants and reduce fodder yield, quality and palatability.

In most cases, breeding for resistance imposes a severe selection pressure on a plant population. The rate of surviving plants can be below one percent. It is possible that a vigourous selection for resistance influences other caracters trough linkage with unfavourable genes, epistasis or other genetic interactions. In this connection yield, quality, endurance and palatability are very important.

The following investigations emphasize the influence of some resistance selections on yield and endurance of our breeding material using red clover (type of Swiss Mattenklee) and Italian ryegrass (descendants of Swiss ecotypes).

There is practically no literature on this subject in fodder plants.

2. Methods

Table 1 lists the disease nurseries which are routinely used in the selection process. Trials were done in the field by comparing the resistance selections with the variety from which they originated (= standard). Plots were 1,5 x 6 m with four replications per treatment. Three locations in the Swiss plateau were used, namely Reckenholz (Zurich) and Oensingen (Solothurn) at 450 m and Ellighausen (Thurgovie) at 560 m a.s.l. Oensingen is 75 km west, Ellighausen 65 km east from Reckenholz.

3. Results

Table 2 shows the results of the cuts in the planting year (A), the first year (H_1) and the second year (H_2). The numbers are relative values (standard equals 100). In red clover they represent the sum of three cuts for A, four cuts for H_1 and one to three cuts for H_2. In Italian ryegrass they represent three, six and one to four, respectively. The yield in H_2 is an expression of endurance, because it is positively correlated with the number of plants per unit of surface.

3.1. Red clover (Table 2 and Figure 1)

3.1.1. The selections for resistance to stem nematode developped slower, reaching the unselected material only in the third year and giving a relative total production of 97 %. Single plants tillered equally or even better than unselected ones, but their stems were shorter. As can be seen from Figure 1, the distributions of the yearly yield sums in A and H_1 were clearly on the lower side of the unselected material. In H_2 there were some very good results from the selections, showing the influence of better endurance.

3.1.2. The selection for mildew resistance lead to lower yields in A and H_1. However in H_2 they matched the unselected material. The total remained two percent below the unselected material.

3.1.3. In the selections for root rot resistance the 2n clover was less vigourous in A but equal to the unselected material in H_1. The 4n red clover matched the unselected material in A and H_1. Both showed a higher yield in H_2, indicating a successful selection for Sclerotinia resistance and endurance.

3.2. Italian ryegrass (Table 2 and Figure 2)

3.2.1. The selections for mildew resistance were equal to the unselected material in all respects.

3.2.2. In the snow mould selections some populations developped slower with a relative mean yield in A of only 97 %. However they surpassed unselected material by three percent in H_2. Overall they yielded two percent more than the unselected material.

3.2.3. The resistance selections for cr... rust and vascular wilt were carried out on the same plants. In the greenhouse plants were first inoculated with Xanthomonas graminis. Surviving plants were then inoculated with Puccinia coronata. Only in H_1 the selections compare favourable with the unselected material.

4. Discussion

Most selections for disease resistance in redclover and Italian ryegrass had lower yields in the planting year (A). Except for resistance selections of red clover to powdery mildew and stem nematode, they recovered in the first year of full use (H_1). In the second year (H_2) only the selections of Italian ryegrass that combine resistance to crown rust and vascular wilt were clearly inferior to the unselected material. It seems that most resistance selections consist of genotypes that develop slower, endure longer and yield equal to the unselected material. The selections contain interesting variability that could be exploited to get outstanding material. Recurrent selection for resistance and vigour has to be used. Successful examples are our new tetraploid varieties Vanessa (red clover), Cervus and Ellire (Italian ryegrass) with increased yield and good levels of resistance against different diseases (Figure 3 and 4, NÜESCH 1987a and 1988b). Concerning fodder quality DODM (Digestible Organic Dry Matter) and protein analyses were done. No particular differences between resistance selections and unselected material were found, except for the usual fact, that yield and quality are negatively correlated.

5. Zusammenfassung

In der Futterpflanzenzüchtung an der Forschungsanstalt Reckenholz werden die folgenden Resistenzslektionen durchgeführt: Stengelälchen, Mehltau und Kleekrebs bei Rotklee; Mehltau, Schneeschimmel, Kronenrost und Bakterienwelke bei Italienisch-Raigras. Diese Selektionen führen meistens zu langsamerer Entwicklung im Aussaatjahr (A), zu normalen Erträgen im ersten Hauptnutzungsjahr (H_1) und, mit Ausnahme der kombinierten Kronenrost-/ Xanthomonasresistenz, zu besser ausdauernden Beständen (H_2). Die wiederholte Selektion in aufeinanderfolgenden Generationen dürfte zum

Überwinden des mangelhaften Ertragspotentials und der ungenügenden Ausdauer führen, und es können Sorten entstehen, die sowohl bezüglich Resistenz als auch Ertrag verbessert sind.

6. Literature

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Table 1 Nurseries for disease resistance selection in red clover and Italian ryegrass

crop	pathogen	inoculum source
red clover	Ditylenchus dipsaci	artificial in greenhouse (ca. 40 nematodes per seedling)
	Erysiphe trifolii	natural, greenhouse or field
	Sclerotinia trifoliorum	artificial, mycelial suspension, greenhouse
Italian ryegrass	Erysiphe graminis	natural, greenhouse
	Fusarium nivale	natural (Einsiedeln altitude 900 m)
	Puccinia coronata	artificial and natural, greenhouse and field
	Xanthomonas graminis	artificial by cutting plants with infected scissors, greenhouse

Tabelle 2 Mean yield in relative numbers of different selections for resistance in red clover and Italian ryegrass (unselected material = standard = 100)

Selections	Relative values of yield in: *)			
	A	H_1	H_2	$A-H_2$
1. Red clover				
1.1. Stem nematode	96	97	101	97
1.2. Powdery mildew	97	97	101	98
1.3. Clover root rot				
2n material	95	99	103	99
4n material	99	101	104	101
2. Italian ryegras				
2.1. Powdery mildew	101	100	99	100
2.2. Snow mould	97	103	101	102
2.3. Crown rust and vascular wilt combined	98	101	93	99

*) A = year of planting
H_1 = first full year
H_2 = second year
$A-H_2$ = sum of all cuts

As each of these numbers comes out as a mean of many different trials it is not possible to give indications of significance.

Figure 1 Relative yield of resistance selections in red clover
(Unselected material = 100)

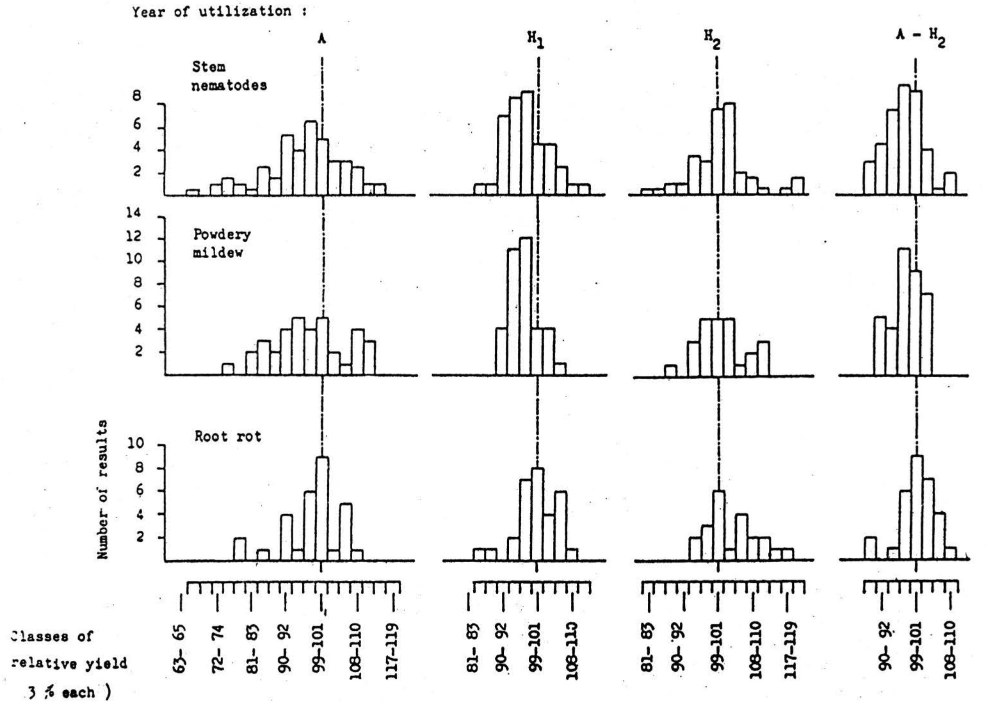
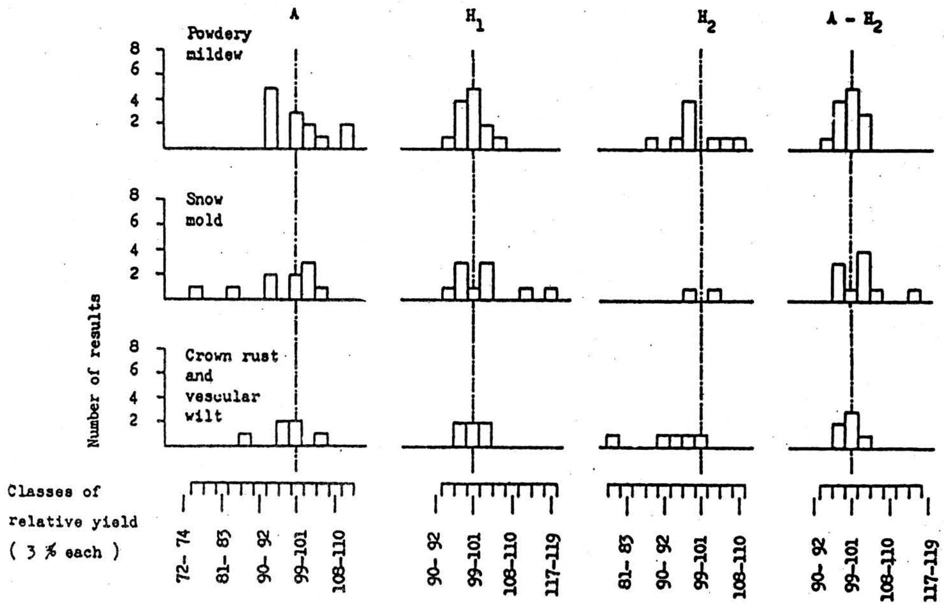


Figure 2. **Relative Yield of resistance selections in Italian ryegrass.**
(Unselected material = 100)

Year of utilization:



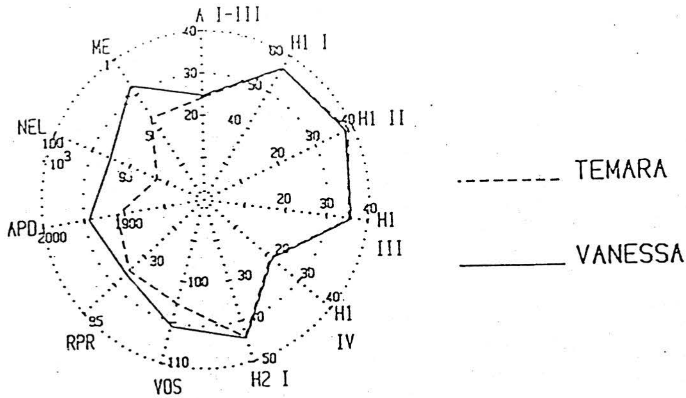


Figure 3 Comparison of 4n red clover VANESSA with 4n TEMARA. A I-III yield in planting year (q DM/ha/cut), H_1 I-IV = cuts I to IV in first year, H_2 I first cut in second year, VOS = yield of digestible organic matter (q/ha), RPR = on rough protein, APD = on protein absorbed in intestine (kg/ha), NEL = net energy for milk production (MJ/ha), ME = attack of powdery mildew, 1 = no attack, 5 = medium.

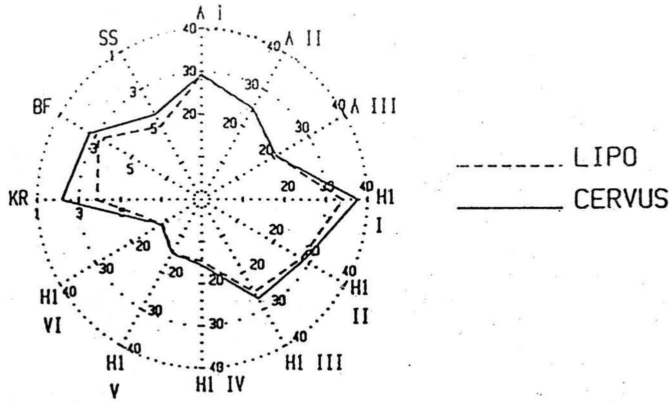


Figure 4 Comparison of 4n Italian ryegrass cv. CERVUS with LIPO. A I-III yield in planting year (q DM/ha), cuts I to III, H_1 I-IV first years yield of cuts one to six, KR = attack of crown rust, BF = leaf spots, SS = snow mould, 1 = no attack, 5 = medium.

Text for Figures

Figure 1 Relative yield of resistance selections in red clover (unselected material = 100)

Figure 2 Relative yield of resistance selections in Italian ryegrass (unselected material = 100)

Figure 3 Comparison of 4n red clover VANESSA with 4n TEMARA. A I-III = yield in planting year (q DM/ha/cut), H_1 I-IV = cuts I to IV in first year, H_2 I first cut in second year, VOS = yield of digestible organic matter (q/ha), RPR = on rough protein, APD = on protein absorbed in intestine (kg/ha), NEL = net energy for milk production (MJ/ha), ME = attack of powdery mildew, 1 = no attack, 5 = medium.

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PROBLEMS OF BREEDING FOR VIGOUR IN FORAGE GRASSES AND CLOVERS IN FINLAND

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Summary. The natural prerequisites for grassland farming are quite good in Finland. However, growing conditions limit the number of mowings to two or three, even in the intensive cultivation of vigorous varieties. Animal husbandry that is based on grassland farming has also long been the mai. production line throughout the whole country. The situation has been altered by measures to restrict overproduction in animal husbandry. Currently, the area of grasses is only 33 % of arable land area. The majority of grasses are situated in eastern, central and northern Finland where the possibilities for cereal cultivation are limited. The breeding objective for grass plants has long been targets that affect vigour: 1. winter-hardiness; 2. large, leafy main harvest and aftermath; 3. good seed yield; 4. resistance to foliage diseases, virus diseases and pests; 5. culture assurance, 6. adaptation to mechanical cultivation technique; and 7. good chemical quality. The problems in breeding work are: 1. regional variation of weather conditions during winter and the growing season; 2. limited resources; 3. limited gene pool; 4. universally little research into the technology of breeding grass plants. These problems are not insurmountable. Breeding can develop vigorous varieties for grassland farming areas, above all, by means of regional selection.

Introduction

Finland is the world's northernmost country which intensively practices agriculture up to the 67 degree parallel of latitude. The natural prerequisites for grassland farming are favorable. Since the 1970s, animal husbandry based on grassland farming has been the main production line throughout the entire country, also. Overproduction of dairy products and meat in Finland, as in other developed countries, has led to strict measures to reduce production. In 1967, the area of forage grass was still 49 %, or 1.352.000 hectares of arable land. In 1987, the corresponding area was 33 %, or 726.000 hectares of arable land. Agricultural policy has directed animal production to north of the Kokkola-Imatra line where at present, the major grass areas are (Figure 1). Along with the decrease in grass area, there has been a concurrent increase in yield levels of forage grasses due to the common cultivation of short-lived grasses and varieties better suited to prevailing conditions, and to improved cultivation technique. Extensive research during the 1960s showed 4-6 year pasture leys and 3-4 year silage and hay grasses to be economically more profitable in Finnish conditions (e.g., JÄNTTI and HUOKUNA 1965). Practical cultivation has confirmed these results.

Finnish breeders of forage grass plants rarely mention vigour as a breeding objective, although it is actually the principle character heading the list of the more important breeding targets which are: 1. hardiness; 2. large, leafy main harvest and aftermath; 3. good seed yield; 4. resistance to foliage diseases and virus diseases; 5. resistance to pests; 6. culture assurance, of adaptation to (a) varying weather conditions during different growing seasons (b) adaptation to mixed cultivation (c) cultivation on different soil types; 7. adaptation to current mechanical cultivation technique; 8. good chemical quality from the feeding aspect.

When attempting to develop vigorous grass plants the difficulties are: 1. variable weather conditions throughout different parts of the country during winter and the growing season; 2. limited resources for the breeding of grass plants; 3. limited gene pool; 4. universal paucity of research into the breeding technology of forage plants.

Weather conditions in winter and the growing season

Finland is long in length. As one goes further north from the southern coast or further east from the western coast, the thermal autumn is shorter, the period of snow cover longer and the winter colder, the growing season is shorter and the effective temperature sum is lower (Figure 2). During the growing season, rainfall is smallest on the southwestern and southern coasts. Clay soils are predominant in the southernmost part of Finland and lighter mineral soils are characteristic to central and eastern Finland and peat soils to Lapland. The variety of plant species diminishes northwards and the importance of grass plants increases, as a lower heat sum and daily mean temperature and shorter growing season and low evaporation suffice for grasses as opposite to cereals (MUKULA and RANTANEN 1987, RANTANEN and SOLANTIE 1987). Intensive grassland farming is limited, however, by both the short growing season, thermal autumn and long winter. Of the most commonly cultivated forage grasses, timothy can be recommended for the entire country, meadow fescue for cultivation zones I-IV, English rye-grass and cocksfoot only for zones I-II, as well as red clover for zones I-IV and the southern part of zone V (Figure 1). The limitations are chiefly due to insufficient winter-hardiness. In Finnish conditions it is important for grass plants to harden sufficiently well before the winter. In intensive cultivation, vigorous plants often do not manage to harden on time. Instead, their growth continues for too long and they thus become the target of winter damage, which, for its part, varies in different areas of the country. Regional breeding must therefore be attempted. There are further more considerable variations in the average weather conditions between different years.

In silage production, the intensive growth of forage grasses would be of advantage. However, growing conditions restrict current grass plant varieties to 3 mowings at the Oulujoki-Naarva line and to 2 mowings at the Muonio-Salla line (Figure 2, PULLI 1984).

Resources for breeding grass plants

The breeding of grass plants was begun by the Hankkija Institute for Plant Breeding in 1913, and by the Agricultural Research Centre Department of Plant Breeding in 1924. The

Hahkiala teaching and experimental farm practiced breeding from 1964 to 1967. Since 1967, it has had an agreement on cooperation with the Swedish Svalöf Plant Breeding Institute concerning their materials for selection in Finnish conditions.

The breeding institutes have one breeder who is responsible for the breeding of all forage crops. As of March 1988, the Department of Plant Breeding has empolyed a second plant breeder who is based at the Kainu Research Station (Figure 1). The main emphasis in actual breeding has been on cereals. Grass plant materials have been and still are relatively small, especially per one species. Many plants have been subjected to breeding. At present, a greater attempt is being made to concentrate on the most important plant species: timothy, meadow fescue, cocksfoot, English rye-grass and red clover. The breeding objective has been to breed different varieties for southern and central Finland, as well as for northern Finland. Since 1966, Hankkija has had breeding materials at the Viskaal experimental field at Muhos, and the Department of Plant Breeding has had materials since 1977 at its Lapland and Kainu Research Stations, and since 1983, 9 other research stations have had small amounts of reference materials for breeding (Figure 1). Beginning this year, the Department of Plant Breeding's actual breeding materials for timothy, meadow fescue and red clover will be in Sotkamo and in Jokioinen, which also has cocksfoot and English rye-grass materials. The help of other research stations is still needed for selection of population, seed culture as well as for preliminary and official testing.

In breeding for vigour, the order of importance of various breeding objectives changes according to plant species (Table 1). Breeding for hardiness and resistance has been chiefly via natural selection in field conditions. Artificial testing has been possible to a very limited extent. An attempt to expand breeding for resistance using laboratory methods is planned. Tissue culture methods have so far not been applied to grass plants.

Since 1928, 13 varieties of 5 grasses and 8 varieties of grassland legumes have been put on the market. Of these varieties, 14 are on the National Board of Agriculture's 1988

List of Recommended Varieties. It is to be mentioned that fodder brome grass, white clover and alfalfa are species not recommended for cultivation in Finland. The varieties have been mainly developed by mass, individual and family breeding methods, and also some polycross testing has been employed to estimate transmission ability.

The available gene pool

Because winter-hardiness is the primary breeding objective to be taken into account, it is natural that an attempt has been made to primarily utilize the material of Finland's climate or that of a corresponding climate (Table 2). If the materials of countries with more favorable climates than that of Finland's are utilized as cross parents or acclimatized, it easily becomes necessary to perform many time-consuming back crossings or await the long period of development through natural selection. In natural selection, the most winter-hardy, viable and reproductive individuals remain alive, though these are nearly always not the best of fodder crops. This is often the case for local Finnish varieties of timothy and red clover. The lack of local varieties of English rye-grass and cocksfoot is a problem when breeding for winter-hardiness. Where are the genes for winter-hardiness to be found? In individual materials, all plants subjected to breeding show considerable variation in their growth types, leafiness, etc. Selection utility in crop productivity is generally not to be expected. It is greater at first but lower later. Are the reasons for this a balancing effect by natural selection and the nature of the gene action responsible for the character and the association of this genetic control with the fitness of population (HAYWARD and ABDULLAH 1985).

Universally little research into the technology of breeding grass plants

The technology of practical plant breeding is the practical application of the research results of the sciences of genetics and plant breeding. Just as the product development department of an industry must produce a new and good product at the least possible cost, in breeding, a variety is to be produced. Because of perennation in grass plants, research into a working technology is very expensive and time-consuming. Therefore, research, in the actual sense of the word, is very limited. Each breeder must only try to optimally utilize the resources at hand and trust in practical experience, even in the absence of scientific proof.

Conclusion

In future the value of vigorous grass plants has increased based on their economic profitability to farms which continue production. In spite of the problems, there are good possibilities for Finnish plant breeding to breed suitable varieties for areas where grassland farming is practiced in Finland. Selection must take place in the areas in question.

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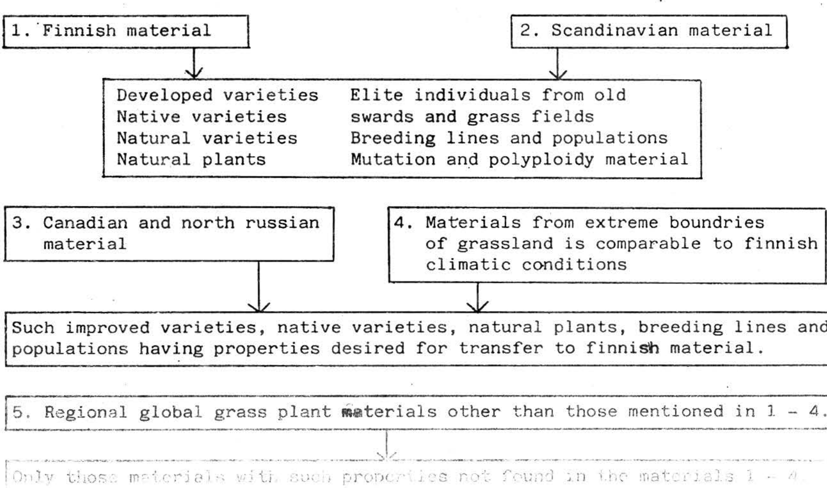
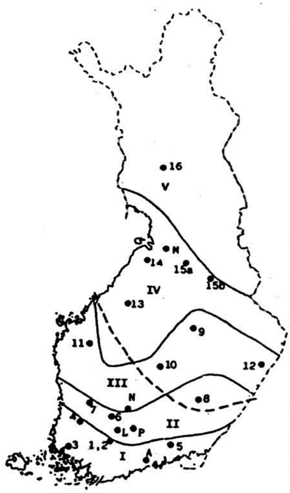
Table 1. Order of importance of the most important contributory objectives for vigour breeding of forage grasses and clovers

Contributory objective for vigour breeding	timothy	meadow fescue	cocks-foot	Eng. rye-grass	red clover
1. winter-hardiness	++	++	+++	+++	+++
2. a. large, leafy main harvest	+	+	+	+	+
b. " " aftermath	+++	++	+	++	++
3. good seed yield	+	++	+++	++	+++
4. resistance to foliage diseases and virus diseases	++	++	++	+++	+++
5. resistance to pests	+	+	+	+	++
6. culture assurance - adaptation					
a. to variations in weather	++	++	++	+++	+++
b. to mixed cultivation	+	+	+++	+	++
c. to cultivation on different soil types	++	++	++	+++	++
7. adaptation to mechanical cultivation	+	+	+	+	++
8. good chemical quality	++	++	+++	++	++

+ = important; ++ = very important; +++ = extremely important breeding objective

Table 2. The gene pool for breeding finnish herbage plants (order of importance 1 - 5)





ARC

1. Department of plant husbandry
2. Department of plant breeding, Jokioinen

Research stations

3. South-West Finland, Mietoinen
4. Satakunta, Kokemäki
5. Kymenlaakso, Anjala
6. Häme, Pälkäne
7. Sata-Häme, Mouhijärvi
8. South Savo, Mikkeli
9. North Savo, Maaninka
10. Central Finland, Laukaa
11. South Ostrobothnia, Ylistaro
12. Karelia, Tohmajärvi
13. Central Ostrobothnia, Toholampi
14. North Ostrobothnia, Ruukki
15. Kainuu a) Vaala (Former), b) Sotkamo (Present)
16. Lapland, Rovaniemi

PRIVATE UNITS

A Hankkija Plant breeding institute, Anttila, Hyrylä
N Nikkilä experimental farm, Kangasala
M Viskaali experimental field, Muhos
L Hahkiala, Hauho
P Potato research station, Lammi

----- = limit between cereals- and "grassland"-Finland

Figure 1. Cultivation zones I-V in Finland and ARC's research stations and private breeding institutes and research stations which perform official variety trials.

Length of winter

S - F 120 - 135 D
N - F 164 - 203 D

Average temperatures

S - F 13.6 °C (V-IV)
N - F 10.5 °C "

S = south, N = north, F = Finland

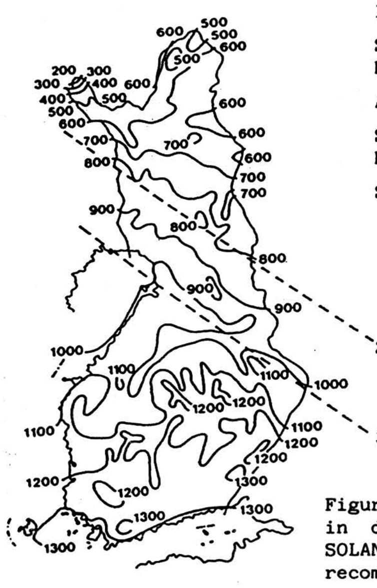


Figure 2. Effective temperature sum accumulation in different parts of Finland according to SOLANTIE (1987) and number of mowings recommended on the basis of temperature sum.

THE CONCEPT OF VIGOUR AND ITS APPLICATION IN A BREEDING PROGRAM OF LUCERNE

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Summary

The concept of vigour is discussed. As a concept, vigour is not measurable. In lucerne, we assume the total dry matter as a good estimate of vigour.

The results concerning the following points are discussed:
a) The prevision of forage yield in dense sward by spaced plants observation;
b) The importance of the density, the experimental arrangement and the material (clones or progenies) utilized in the estimate of the genetic parameters;

We consider the lucerne crop as a system. In general, it is considered as a system a set of elements plus the whole of relationships between them. The whole of these relationships is called structure of the system. In the lucerne crop system the elements are the plants; the structure is represented by the effect induced on the morphology and physiology of the plants by their reciprocal interference. Aim of the breeder is to improve the lucerne crop system. A positive result is possible only if both the constitutive parts of the system are improved: the plants and the structure.

The ideal model of the plant and the ideal model of the structure of the lucerne crop are presented. The scheme of lucerne breeding for vigour and quality is presented as well.

I. - Definition of vigour

The general theme of this meeting is breeding for vigour. Looking at the whole of the contributions in program, it results that breeding for vigour includes all the most important traits and processes of the plant: forage yield, vegetative growth, resistence to various stresses or diseases, seed production and so on. The term vigour is therefor considered as a big container in which all our activity can be put.

If so, this term has no informative value; on the contrary, it can be confounding if its meaning is not clearly defined. In the glossary of genetics and cytogenetics (8) this term doesn't exist. There is, of course, the term heterosis, proposed by Shull on 1940 during a conference at Gottingen. Heterosis is the short form for heterozygosis; Shull used it to express the heterozygotic stimulation of which the hybrid vigour is a manifestation. Practically, the term heterosis is almost always utilized as a synonimous of "hybrid vigour". According to Shull, heterosis (hybrid vigour) is the superiority of heterozygous genotypes with respect to one or more characters in comparison whith the corresponding homozygotes. On the contrary, speaking of breeding for vigour, we use this term without adjectives as a synonimous of productive value. We propose the following definition: vigour is the biomass productive capability of a genotype in the observed environmental conditions. This definition is valid for the cultivated plants. On the contrary, for wild populations, we consider the vigour as synonimous of reproductive value or fitness.

II. - Estimate of vigour

The vigour is a property of the genotype as a whole, and it is more than the sum of the values of its constitutive genes. Vigour is a concept and as concept is not measurable. It is possible to estimate the vigour by measuring different traits. But the total dry matter yield, being the result of the activity of the whole genome, can be considered the best estimation of vigour.

There are many and different criteria to estimate vigour by the dry matter yield. Among them, the most precise is based on the following rule: the vigour of a genotype in a breeding program must be estimated in pedoclimatic and management conditions as close as possible to those in which the future variety will be utilized.

Therefore, first of all a clear definition of the type of variety to constitute is needed: for instance, a lucerne for grazing, for cutting, for dehydration, etc.

But it isn't sufficienty. It is necessary then to state how to measure the dry matter yield of the plants. It is generally assumed that in order to know all the productive potentialities of a plant we have to study it in non-limiting conditions, so that as spaced plant. In fact, the criterion of spaced plants is normally employed. But for the breeder it is not important to know all the yielding possibilities of a lucerne plant in non-limiting conditions; for the breeder is useful to know all the yielding capacities of the lucerne plant related to the lucerne crop, that means as an element of the lucerne crop system. In the lucerne crop there is at least one limiting factor that can not be eliminated: the light. This factor constitutes perhaps the main difference between spaced plants and lucerne crop.

At the surface of the lucerne crop, the light is never a limiting factor; but when the height of the plants reaches 70-80 cm, at their base and in the lowest layers of the crop structure (20-30 cm), the intensity of the light decreases till 500-1000 lux, with effects on the colour and persistence of the leaves in the first 40 cm and also on the number of stems at the regrowth. One of the most important task in the breeding for vigour is to invent the technical solutions allowing to simulate at the best the conditions of the plant in the different types of lucerne crop. These techniques are much more effective than the traditional ones in the practical selection work and, in addition, allow a better estimation of some génetic parameters.

III. - The effect of density on the estimate of vigour and genetic parameters

The first question we asked ourselves was about the importance of the interference effects among the plants in the evaluation of the phenotype.

In a series of experiments, different genetic materials (clones, polycross progenies, inbred families, diallel cross progenies) grown in spaced plants and dense sward were compared.

The results concern different aspects of the problem:

1) the prevision of forage yield in dense sward by spaced plants observation: the value of the choice made in spaced plants.

2) The importance of the density, the experimental arrangement and the material (clones or progenies) used, in the estimate of the genetic parameters.

Concerning the choice of the plants, our results show a low correlation (r=0.4-0.6) between the spaced plants and the dense sward values for the dry matter, plant height, number of stems (12). Besides, the correlation coefficients can change according to the different densities; so, it is very important, when speaking about density, to define exactly the number of plants per square meter. The two characters more important for yield, number of stems, and plant height, respond differently to the variation of density. The number of stems reacts first and in a sharp way, while the height is affected only at density of more than 300 plants/m2 .

As for the regrowth after the cut, in spaced plants the production of new stems is continous till the emission of the first flowers; at 100 plants/m2 the maximal emission of new stems is around the eleventh day after the cut. When the base of the plants enter in shadow, the production of new stems drastically decreases.

In conclusion, in spaced plants the principal factors of forage production are the plant height and the number of stems, while in dense sward, in the conditions of a good lucerne crop, the main factors are the plant height and the size of the stems. In a well structured lucerne crop the empty space left by the dead plants is totally utilized by the contiguous plants; this capacity is a varietal characteristic pertaining to the homeostatic qualities that assure to lucerne crop system a relative stability for forage yield. When these spatial limits are overcome, because of a high mortality, the number of stems becomes very important through the cuts and years also in dense sward. This can explain the low correspondence found between the ranking of clones or progenies in spaced plants and in dense sward as far as dry matter yield was concerned. Finally, we have to underline that the cutting effect on persistence is early absent in spaced plants cut at 50% blooming for the first 4-5 cuts. On the contrary, in dense sward the cutting effect is very selective with about the 20% of mortality at the same period. As for the estimate of genetic parametres, our experiments (13) showed that the value of heritability for dry matter yield and plant height varied with:

1) the density: spaced plants or dense sward;
2) the experimental techniques: pure stand; mixture in alternate row or on the same row;
3) the material used: clones or progenies;
4) the cutting management: cut at 50% flowering or at green bud stage; syncronic for the whole material or at a given biological stage for each clone or progeny.

The same was true for the combining abilities. The experimental technique (spaced plants or dense sward) modified the relative proportion of the different variances (G C A , S C A , error) for dry matter yield (11). In particular, the percentage of G C A variance calculated on the total variance is much higher in spaced plants than for dense sward. As concluding remarks on this part concerning the effect of density on the estimate of vigour and genetic parameters, we would underline some points.

During the last thirty years important theoretical contributions to breeding methods have been produced also for autotetraploid species as lucerne (1,3,4,5,7).

In my opinion, a point was under evaluated: the role of the procedures to employ in order to verify the theory. The conditions of the experiment can modify the nature of conclusions and therefore the whole of conceptual and practical decisions that constitutes a given breeding method. In forage crops, either at the level of methodological research or at the level of the applied selection, the plant is in conditions (spaced plants) very different from those in which the new variety will be situated. This too large gap and a too dogmatic concept of the value of the method can explain at a great extent the difficulties of obtaining positive results in the breeding for vigour. Then must the technique of spaced plants be completely discarded? It doesn't seem the case. In some conditions it can be efficient.

In the difficult pedoclimatic environments the forage production and chiefly the persistence are based on resistence ability. On the contrary, in the easy environments, where the man can counteract great part of the limiting factors, the production is due to the capacity of the plant to transform in biomass the natural and artificial availabilities. So there are two different kinds of agriculture demanding two different types of biological machineries: the first one has to resist to the environmental stress, the other has, to exploit at its best the great resource of a rich habitat. The tecnique of spaced plants can give positive results when hardiness has a predominant role; but it is ineffective in rich or non stressing conditions, where the resistence factors play a secondary part in comparison with those directly involved in the expression of forage production. In fact, the factors of vigour are not the same in spaced plants and in dense sward.

In conclusion, it is possible to employ different procedures verify an hypothesis; furthermore, different criteria can be used to measure quantitative traits and to estimate their genetic parameters. When obtaining different results using different criteria, which one can we take as true?

Theoretically, all the results are true if the procedures have been correctly applied; at the same time, not all the true results have the same effectiveness in reaching the chosen aim, that is a certain type of cultivar defined in relation to the natural and artificial environmental conditions.

IV - The lucerne crop system

Vigour of the plants and vigour of the lucerne crop: is the vigour of a lucerne crop the direct consequence of the plant vigour? To answer this question we can observe that on a given surface the same forage yield can be obtained by variating, within some limits, the plant number. Besides, on a given surface and with a given set of plants it is possible to get forage yields very different symply by modifying the position of individuals and their spatial relationships.From these considerations two concept come out, the concept of totality and of autoregulation that allow interpreting the lucerne crop as a system. What is a system. In general it can be defined as a set of elements plus the whole of relationship between them. The whole of these relationships is called structure of the system. In the lucerne crop system the elements are the plants; the structure is the expression of the relationships between them at level of different morphological characters. These relationships change either through the phenological phases within each productive cycle or through the subsequent productive cycles as well. The aim of the breeder is to improve the lucerne crop system. A positive results is possible only if both the constitutive parts of the system are improved: the plants and the structure. Indeed, an optimal structure of the lucerne crop is necessary but not sufficient in order to secure a high forage total yield. The same is true for the plants: a good genotype is indeed necessary but not sufficient. So, primarily a breeder has to know the lucerne crop system; then he can work at improving both the genotype and the structure. We have studied many experimental lucerne crops (some hundreds, in several research programs) in order to know their productive, factors. They were established with materials genetically very different: cultivars, polycross progenies, selfed families, studied either in pure stand or in mixture (11,13,17). We can summarize the results as it follows :

1) the lucerne crop appears to evolve through the cuts both for the biomass production and for the number of constitutive elements. At the eighth cut, the modification of the system concerns chiefly the number of elements; the most performing plants at the first three cuts are on average the most persistent as well. This means that mortality doesn't occur at random: at a same degree of resistance to deseases and stresses, the persistency of an individual plant is conditioned by either its vigour or its position inside the lucerne crop system. The death of a plant is the final result of the negative effects of interplant interference cumulated through the cuts.

2) The mortality in a lucerne crop is a function of the genetic heterogeneity of the populations: all the mixtures presented a higher mortality than the corresponding components in pure stand. To explain these results we formulated the following hypothesis: all the plants have the same persistence when cut at flowering. The experimental verification of such hypothesis showed that the longevity of a plant is determined, at a great extent, by the level of reserves cumulated in the roots (18, 19). This stoking is maximum at the flowering stage. In a population, the higher the genetic heterogeneity, the larger the phenotipic variability in earliness. For this reason, at the cutting time, the roots will present in such a population a level of reserve recovery very different. The plant with a low level of recovery are, on average, more sensitive to cutting effect. Such effects can cumulate through the time bringing to the death of the plant. But while all the plants seem to have the same persistence if cut at flowering, there is a great variability when cutting is anticipated at the green bud stage. When we speak about the root reserves, are referring to the total sugar and to the crude protein content (19). The selection can utilize such variability; our cultivars, Equipe and Lodi, are indeed the result of a selection made in irrigous conditions, at high density and in an early cutting regime (50% green bud = about 5% blue bud).

V - Mechanisms of evolution of a lucerne crop and their causes.

In order to know the nature of the relationship between plants in the lucerne crop, we divided it in groups of interference. A group of interference is formed by the whole of individuals interferring each other by contiguity and shading effects.

The relationship existing among the individuals of a group of interference can be of the following types (26) domination (+ , -), cooperation (+ , +), opposition (- , -), neutralism (o , o). Several lucerne populations have been studied associated following an experimental scheme, defined as "ecological diallel scheme". The results showed that the associations effects are similar to situation of domination, generally said competition (11,12,13,17,21). This situation present an almost perfect compensation during the first period of the life of the lucerne crop. Afterwards, the cumulation of the negative effects of domination brings little by little to an high overcompensation that prelude to the death of the weakest partners. The situations of domination explain why:

1) the lucerne crop has a pluristratifed structure;
2) a mixture of populations never overcomes the most performing partner in pure stand;
3) the mortality is a function of the genetic heterogeneity of the population;
4) the rank of the clones or populations is the same in pure stand, binary mixture and global mixture.

According to the most diffused explications of the phenomenon of domination, the gain in mixture compared to pure stand is due to a high domination ability.

Such hypothesis doesn't seem in agreement with the experimental data: we have seem that a plant in association increases or decreases its biomass according to the vigour of its partners. Therefore, it doesn't exist individuals more or less dominator in absolute value. Our hypothesis on interference phenomenon is based on the notion of biological density of which Yamada and Horiuchi (20) have given the following definition: the biological density is the numerical density pondered by the vigour of individuals. Such a definition is not satisfying because it takes into account only the plant. We think that the environment as well must be taken into account. For that reason, we have proposed the following definition: biological density of a lucerne crop is the ratio of the actual biomass to the potential biomass (11,12).

$$\text{Biological density} = \frac{\text{Actual biomass (demand of individuals)}}{\text{Potential biomass (availability of physical, biological and tecnical environment)}}$$

This ratio varies from 0 to 1 during a cycle of production; the zero value corresponds to the moment immediately after the cut, when the aerial biomass is still absent. The value 1 (one) is the result of the fact that the effective biomass, at a given time, exploits all the availabilities present in the environment. At values near 1 the plants rapidly enter in crisis and consequently the growth of biomass is stopped. In these conditions, it is possible to observe a lower growth of a limited numb of individuals and at the same time an important reduction of the number of plants.

It is noticeable that the action of environment is often determined by a single factor (limiting factor), as for instance water availability during the summer. As for the light, its availability for each plant of the lucerne crop is a function of its height. The plants that are very small if compared with their neighbourings receive a quantity of light strongly reduced. These individuals are not in condition to increase their biomass: the value of their biological density is 1. These individuals do not accumulate but only consume their reserves till the death of the plant. As a consequence, for the population well equipped from the genetic point of view,the environmental availability has to be high in order to exploit at the best their productive potentialities, otherwise, the biological density, increasing rapidly towards the value 1, would prevent the increase of the biomass. So we could suppose that for each popolation one optimal environment has to exist allowing the complete exteriorisation of their potentialities The same could be said about the individual plants.

As a consequence of the above considerations, a plant or a popoulation yields, in a given mixture, more than in pure stand when it finds in that mixture a lower biological density than in pure stand. It is not a question of domination ability, it is a question of partner effect, the partner being a component of the environment, displaying its effect as density effect (11,21).

What is the mechanism of action of the biological density inside the lucerne crop? After each cut, among the plants of a same group of interference. The individuals with a higher rate of growth during the first 10-15 days will take an advantage. Such a plant will have a dominator role and will limit more and more through the days the light to the other elements of the group.

At the cutting time, the dry matter of the dominating plant will be conditioned by the difference between the biological density of the interference group the said plant belongs to and the biological density of the theoretical group made by individuals all identical to that we have considered (pure stand). If such a dynamic in real, the genetical heterogeneity, producing an infinite number of micro-environments with the corresponding values of biological density, is the main cause of the so called situations of domination. Why does a given plant become dominating? Because it approaches more than the other plants of its group to the ideal model of plant for those given conditions of time, space, interference and management. If we recall to mind the concept of vigour as defined before, we can say that the variability for vigour of the individual plants of a group produces a variability of biological density values.

In synthesis, the vigour appears to be the motor the biological density as well as the result of it.

VI - Ideal models of plant and lucerne crop structure

The analysis of the relationship between plants in the lucerne crop brings to some consequences on the lucerne breeding. In particular, makes clear that one of the most important objectives for the breeder is to improve the structure This means to modify the relationship between individuals from situations of domination (+ , -) to neutralism (o , o). This last type of situation being always, an ideal standard in autotetraploid and allogamous forage plants, allows us to establish an ideal model of structure (monostratified structure) as that reported in table 1.

TABLE 1

Some properties of the lucerne crop producing the ideal structure: monostratifed structure

A. Total synchronism of individual plants for :

1. Time of regrowth
2. Time of internode elongation
3. Time of the green bud stage

B. Maximum homogeneity of individual plants for:

1. Resistence to early cutting: 50% green bud
2. Number of stems and lenght of main stems after each cut
3. Response to temperature and water supply through the different seasons.

To improve the lucerne crop, it is necessary to work on the two elements of the system: the structure and the plant. The longevity of a lucerne crop is not only the result of an improved structure but also of the degree of resistence of the plant to early cutting (about 50% green bud). An ideal model of the plant is proposed in table 2.

TABLE 2

Some characteristics of the ideal model of the lucerne plant for selection in irrigous conditions and early cutting regime (density: 400 pl/m2; hight intensity: under 1000 lux at the soil level at fifty percent of green bud).

1. Green bud stage: early in spring and in successive cuttings.
2. Regrowth: early and conspicuous after each cut.
3. Leaves: early production of the first 10 leaves per main stem associated with a little internode elongation.
4. Main stem at the green bud stage: length over 80 cm at the summer cutting also.
5. Plant/Rhizobium symbiosis: high nodule production from the spring to the autumn cuttings.
6. The highest resistence to early cutting (50% green bud).
7. Very positive response to summer temperatures and water supplies.
8. The highest persistence of the leaves in the first 6-8 nodes.

VII - Scheme of breeding for vigour and quality

The models of plant and lucerne crop structure are heuristic models; they are point of orientation, pole star, never realizable at the empiric level. The scheme of breeding proposed in table 3 would give the possibility to improve either the plant or the structure of the lucerne crop system. This scheme has two main features the exploitation of interplant interference effects during all the steps of selection and the use of a phase of selfing. We have already explained the importance of the interference effect. What about the role of selfing? From our result (9,10,16):

1) the selfing allows a sufficient homogeneity of the morphophysiological traits. This fact is very important for the structure of the lucerne crop;

2) the use of selfing permits to take into account the tolerance to inbreeding in the choice of plants. A good level in this tolerance could allow the building of a semi-hybrid variety similar to double hybrid; in any

case it is useful in synthetic varieties narrow based (4-6 parental clones).

3) Both the means and the variability increased with the level of inbreeding in diallel crosses derived from partly inbred parents. In the same materials, the GCA and SCA variances increased untill the S2 level and remained stable at the S4 level; GCA was always much higher than the SCA.

4) At the So and S1 levels no mother plant reacted positively to selection, while at the S2 level all the plants responded positively. In succeeding generations, further progress in accumulation of favorable genes and gene combinations appeared to stop. An explanation may be found by analyzing fertility. Our data has shown 80% of 285 vigorous plants at the S3 level to be almost selfsterile (14). At the S2 level this percentage was only 38%. It is evident, therefore, that self-sterility drastically limits inbreeding and selection. It would seem that when a given threshold of homogeneity is reached, it becomes very difficult to select plants having both a good concentration of favorable genes for vigour and self+sterility as well. Presumably selection in S3 and S4 simply maintains heterozygosity. According to this hypothesis, in order to accumulate favorable genes and gene combinations after two generations of selfing, a high degree of heterozygosity would have to be reconstituted by crossing. After that, selection and selfing could be made again.

5) Theoretically, the vigour of single crosses between autotetraploid parents should decrease as their degree of inbreeding increases. However in our experiments, where selection was practised, the mean of single crosses increased with inbreeding. This gain was transmitted to the Syn 2 generation of synthetic cultivars, indicating that the selection in interference conditions of vigorous plants within vigorous progenies during the selfing phase was successful.
The last part of the scheme of breeding deals with the constitution of new populations and new synthetic cultivars. We have underlined that the new cultivars have to be constituted with four to six parental clones S2 derived from at least three different parental populations. Our recent results have allowed a deeper understanding of this problem (15) Studying the evolution of vigour through the generations of multiplication of different experimental synthetics, we found that all synthetics increased in dry matter from Syn 1 to Syn 2. On the contrary, in Syn 3 some synthetics showed a decrease in yield when compared with their respective Syn 2. No effect of the number of constituents was observed on this trend. The evolution from Syn 1 to Syn2 is in agreement with the theory concerning the autotetraploids, the loss in Syn 3 can be explained with the assumption that in Syn

2 the maximum level of heterozigosity is reached for some synthetics. This depends on the allelic richness of the whole set of parental clones we utilized. When the parental clones derived from the same population are partially inbred a greater, number of constituents may not be sufficient to prevent inbreeding depression in SYN 3. It could be necessary to use clones derived from parental populations different in genetic origin. In this case, a narrow based synthetic variety should be the best solution. Finally, these results suggest that in autotetraploid plants the information obtained by the progeny test has to be taken with caution because of a possible different level of inbreeding of the parental clones.

Resumé

La vigueur, en tant que concept, n'est pas mesurable; on peut seulement l'extimer. Chez la luzerne la production de matière sèche est la meilleure extime de la vigueur. Les résultats expérimentaux concernant les points suivants sont discutés: 1) la validité de la prévision de la vigueur en colture dense à partir des plantes isolées; 2) l'importance de la densité, des techniques expérimentales et du materiel utilisé (clones ou familles) dans l'extimation des paramètres génétiques.

La luzernière est étudiée en tant que système. Un système est defini comme un ensemble d'éléments plus les rapports qui s'installent entr'eux. La totalité de ces rapports est appelée structure du système. Dans la luzernière les éléments sont les plantes; la structure est l'expression des rapports entre les plantes au niveau des differents charactères morphologiques. Ces rapports changent soit au cours des differentes phases phenologiques de chaque cicle productif soit à travers les successifs cicles productifs de l'année.

Le but final de la sélection est l'amélioration de la luzernière. L'efficacité de la sélection est liée à l'amélioration des deux composants du système: la plante et la structure. Les models idéals de la structure sont proposés; un schema de sélection pour la vigueur et la qualité est proposé aussi.

TABLE 3

Scheme of lucerne breeding for vigour and quality

→ Parental Populations A, B, ...F

I - Selfing phase

1. Study of 2000 plants per parental population: Density about 400 plants per square metre
2. Choice of mother plants after 7-8 early cuts (50% green bud)
4. Study of families S_1, S_2 etc.:density 400 plants per square metre
5. Choice of the plants within the families S_1, S_2, etc. after 7-8 early cuttings

II- Panmictic phase

1. Polycross by hand without emasculation
2. Progeny test at the density 400 plants per square metre
3. Selection after 14-16 early cutting (50% green bud) in two years
4. Constitution of new populations by hand without emasculation:

New Populations (→ back to Parental Populations)

- A_1; B_1; C_1; ....
- A_1B_1; A_1C_1; ....
- $A_1B_1C_1$; $A_1B_1D_1$;.........
- $A_1B_1C_1D_1$; $A_1B_1C_1E_1$......
- ....
- ....
- $A_1B_1C_1D_1E_1F_1$

(from $A_1B_1C_1$ onwards:) new experimental cultivars (4-6 parental clones derived from at least 3 different parental populations.

Technical procedures

The study of parental populations, selfed families and polycross progenies is made in special cold greenhouse: 1200 m2, 4-6 metre high. Plots having the useful sizes: 80 cm long, 25 wide, 60 cm heigh.At the stage of cotyledons well opened the seedlings are transplanted at the density of 400 plants square metre. The first cut is made at sixty-seventy percent of flowering. The other successive cuts are made at fifty percent of green bud.

Light density: under 1000 lux at the soil level at the fifty percent of green bud.

The choice of plants within the parental population and within each in the subsequent generations is base on the values $\geqslant \bar{x} + 2s$ concerning dry matter weight, height and number of stems.

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THE RECENT RESULTS OF ALFALFA BREEDING FOR RESISTANCE AT THE RESEARCH INSTITUTE FOR IRRIGATION

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Summary

In addition to selection for productivity the most important purpose of our breeding work was the genetic progress in the increasing of resistance level.
According to our program, besides the improvement of resistance to Fusarium oxisporum and Verticillium albo-atrum causing the wilting disease, similarly important is the resistance to drought, frost, frequent cutting and other stress factors attached to intensive utilization e.g. irrigation. According to domestic claims recently we have analysed the germplasms registered in the USE. Establishing of strains which are resistant, to the above-mentioned fungi, to Corynebacterium insidiosum, to Phytophthora megasperma and from aphid to Acyrthosiphon pisum, to Therioaphis maculata, and which are suitable from an agronomic point of view was also begun into Syn-1 generation.
According to Bakheits' work, who was preparing his P.H.D. thesis during 1977-1980, there was a significant progress in the improvement of our breeding for resistance and in production of numerous RV_2 RF_2 generations in our institute. The establishing of combined resistant strains to fungi, causing the wilting disease, has been performed for ten years now together with a breeding team from GDR.

Materials and Methods

Progenies of 28 field resistant plants were selected for resistance to Verticillium in the GDR. Seeds obtained from Verticillium resistant plants were sent to our institute for producing of combined resistant strains. Seedlings were selected here for Fusarium resistance under laboratory and field conditions.
From each Verticillium resistant strain we prepared 300 seedlings for inoculation and a 100 ones for control.
In August of 1986 plants, belonging to groups I and II, were reinfected after green-house inoculation and selection, then they were transplanted in a field experiment together with their controls. From the control plants only the most vigorous ones were planted.

Results

For easier survey six strains, repsesenting the average, were picked out from the 28 breeding lines.
As Figure I shows, there were less stands in the infected and in the control plots depending on the strains. Decrease in the control plots was due to drought at the end of summer, to frost sensibility of immature plants and to some infection from the adjacent infected plots.
By July 1987 stand decreased remarkably, as a consequence of effects of ecological stress factors and above all, the inoculation of Fusarium. The degree of infection was significant in comparison to the controls, but it was more significant in relation to the original strains (5-25 % depending on strain). LSD=0,01 %
The stand of spring 1988 was corresponding to that of July 1987. In summer 1987 plots of each strain were separated isolated and the most vigorous plants were crossed. Already in 1987 the progenies were considered as combined resistant strains which are resistant not only to the wilting disease but to other stress factors (drought, frost). In our breeding program, at the establishment of synthetic cultivars we use

these strains as a component, in the belief that it is not similar to the material which is considered classically resistant. In our opinion, it is better in some agronomical characteristics and we are not sure that his resistance level is more lower than the resistance level of strains, produced by the classical method. Examinations relating to this subject are now going in. We perform the further evaluation of Syn-1 generation this year.

The recent results of our breeding for Fusarium resistance confirm the previous experiences. Using the above-mentioned resistant strains as a component in synthetics, we have produced new cultivars which have a great productivity and which are resistant to ecological factors and to fungi causing the wilting disease. Our new variety is ÖKI-1, which was registered in 1986.

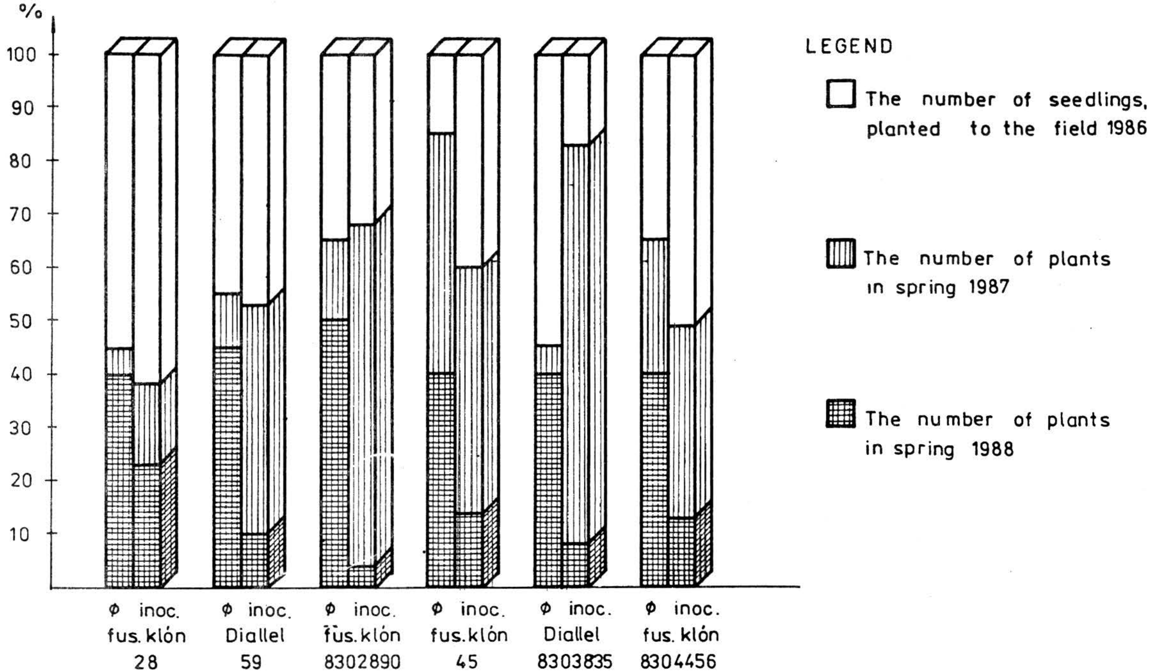
The proper productivity and the longevity of this cultivar is explainable by the fact that eight out of its 36 components, have combined laboratory and field resistance to Verticillium and Fusarium.

According to examinations carried out in GDR, this variety has a lower susceptibility to Verticillium (Velke index) then other Hungarian variety candidats and varieties.

The recent resistance research in Canada carried out in the classical sense, has supported that progenies, obtained by synthesizing of resistant plants, have a different resistance level. According to examinations, there are real resistant plants and so called "escapes", tolerant or sensitive plants. These types were separated with biochemical methods by Christie et al., working from the principle that some fungicidal fenols are synthesized in alfalfa.

The pattern of accumulation of fenols an their diytribution in plants is different, depending on the resistance level to Verticillium. Christie found the highest level in the resistant Vertus cultivar and the lowest one the Apollo variety. We are going to try whether this method can be used in the case of Fusarium.

THE NUMBER OF PLANTS IN FIELD RESISTANCE EXPERIMENT.
PERCENTAGE.



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AGRONOMICAL PERFORMANCES OF ALFALFA (MEDICAGO SATIVA L.) AS AFFECTED BY DIFFERENT AMOUNTS OF INBRED SEEDS IN THE INITIAL SEED LOT.*

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SUMMARY

A study was conducted at Perugia (Italy) in 1983-85 to evaluate the agronomical performance of alfalfa (Medicago sativa L.) as affected by a wide range of inbred seed percentages. Nine seed mixtures having ratios of inbred seed to hybrid seed (S_1:F_1) of 1:9, 2:8, 3:7, 4:6, 5:5, 6:4, 7:3, 8:2 and 9:1 plus two controls (100% S_1 seed and 100% F_1 seed) were sown in micro-plots at a seeding rate of 1,600 seed m^{-2}. In 1983 data were collected on: dry matter yield per plot 21 Jun., 20 Jul. and 2 Sep. In 1984 data were collected on: dry matter yield per plot 16 May and seed yield per plot 20 Aug. In 1985 data were collected on: dry matter yield per plot 30 May and seed yield per plot 19 Aug.

Sharp decreases in dry matter yield per square meter became evident only when the S_1 percentage in the initial seed lot reached or exceeded 70% of the total. As a consequence, within broad limits it can be stated that alfalfa forage and seed yield is not strongly related to the level of selfing of the seed crop in which the seed lot is produced.

* An extended version of this lecture will be submitted for publication elsewhere. Research supported by the National Rersearch Council of Italy, Centro di Studio per il Miglioramento Genetico delle Piante Foraggere (Director: Prof. Franco Lorenzetti) c/o Istituto di Miglioramento genetico vegetale, Università degli Studi di Perugia, Borgo XX giugno N.74, 06100 Perugia, Italy.

INTRODUCTION

Alfalfa (Medicago sativa L., 2n=4x=32) is considered to be a widely allogamous species in nature. Early studies using the recessive flower color markers to measure the degree of crossing indicated that an average of 15% of selfing generally occurs (LESINS, 1961; MAYER, 1962). The more recent data of PEDERSEN (1967), KEHR (1973, 1976), LORENZETTI and VERONESI (1981), VERONESI AND LORENZETTI (1982) and KOJS et al. (1986) indicated that the amount of selfing can reach 40-50% and can vary as a consequence of both environmental and agronomical factors.

the present research was conducted to study the influence of a wide range of mixtures of inbred and hybrid seed on agronomic performance (forage and seed yield) of alfalfa.

MATERIALS AND METHODS

During the three-year period, 1983-85, an alfalfa trial was conducted at Perugia (Italy) using 9 seed mixtures having ratios of inbred seed (S_1) to hybrid seed (F_1) of 1:9, 2:8, 3:7, 4:6, 5:5, 6:4, 7:3, 8:2 and 9:1 plus 2 controls (100% S_1 seed and 100% F_1 seed). Seeds were sown 15 Apr. 1983 in micro-plots (60 x 40 cm) at a seeding rate of 1,600 seeds m^{-2} (32 $kg \cdot ha^{-1}$), the seed density normally used in Italian alfalfa stands. The 11 entries will be referred to as A (100% F_1), B (10% S_1), C (20% S_1), D (30% S_1), E (40% S_1), F (50% S_1), G (60% S_1), H (70% S_1), I (80% S_1), J (90% S_1) and K (100% S_1). Controlled S_1 and F_1 seed lots were produced from 30 vigorous plants chosen from a three-year-old stand according to the procedures referred to by VERONESI et al. (1985). Seeds were scarified and each seed was sown 1 cm deep in the centre of a square space (2.5 x 2.5 cm) according to the procedures referred to by VERONESI and LORENZETTI (1983). Each micro-plot had 384 seeds arranged in 24 rows with 16 seeds per row. Utilizing 4 rows around the perimeter as a border, it was possible to sow 16 rows of 8 seeds each of experimental materials for each micro-plot (5,632 seeds in total). A complete randomized block design with four replications was employed.

In 1983 data were collected on:

-dry matter yield per plot ($g \cdot m^{-2}$) 21 Jun., 20 Jul. and 2 Sep.

In 1984 data were collected on:

-dry matter yield per plot ($g \cdot m^{-2}$) 16 May;

-seed yield per plot ($g \cdot m^{-2}$) 20 Aug.

In 1985 data were collected on:

-dry matter yield per plot ($g \cdot m^{-2}$) 30 May;
-seed yield per plot ($g \cdot m^{-2}$) 19 Aug.

RESULTS

Total dry matter yield (DMY) per square meter (sum of 5 cuts) is reported in Fig. 1A; it ranged from 1,504 $g \cdot m^{-2}$ (K) to 2,332 $g \cdot m^{-2}$ (A); therefore plots seeded with 100% S_1 (K) produced 67% of the plots seeded with 100% F_1 (A). On the basis of the statistical analysis, two groups of entries were clearly evident, a more productive group (entries A,B,C,D,E,F and G) and a less productive group (entries H, I, J and K).

Total seed yield (SY) per square meter (sum of 2 years, 1984 and 1985) is reported in Fig. 1B; it ranged from 124 $g.m^{-2}$ (K) to 306 $g.m^{-2}$ (C). The entries fell into the same two groups as already reported for DMY (Fig. 1A); entry K (100% S_1) yielded 46% of entry A (100% F_1), confirming the presence of a strong depression connected with the inbred origin of the plants.

DISCUSSION AND CONCLUSIONS

The lower dry matter yield (DMY) of S_1 with respect to F_1 plants is very clear, since the S_1 plants of entry K (100% S_1) gave a DMY of 67% with respect to that of F_1 plants of entry A (100% F_1). The high level of inbreeding effect is in accordance with the data reported by CARNAHAN and PADEN (1967), KEHR (1976) and VERONESI et al. (1985). A sharp decrease in DMY becomes evident only when the S_1 percentage in the initial seed lot reaches or exceeds 70% of the total (entries H, I, J and K). It is worth noting that, as reported in the introduction of the present paper, several investigations have shown that the percentage of S_1 seed in open pollinated alfalfa seed lots can reach but generally does not exceed 50% and it is often lower.

The response of the entries for seed yield (SY) is quite similar to that shown for DMY; from entries A (100% F_1) to G (60% S_1) the SY is not statistically different while the depression of entry K (100% S_1) with respect to entry A is even higher than that relative to DMY.

In general, these results appear to demonstrate that alfalfa crops seeded with seed lots characterized by quite high differences in S_1 seed percentages show similar behaviour both for forage and seed production. As a consequence, within broad limits and in accordance with KEHR (1976) it can be stated that alfalfa forage yield is not strongly related to the

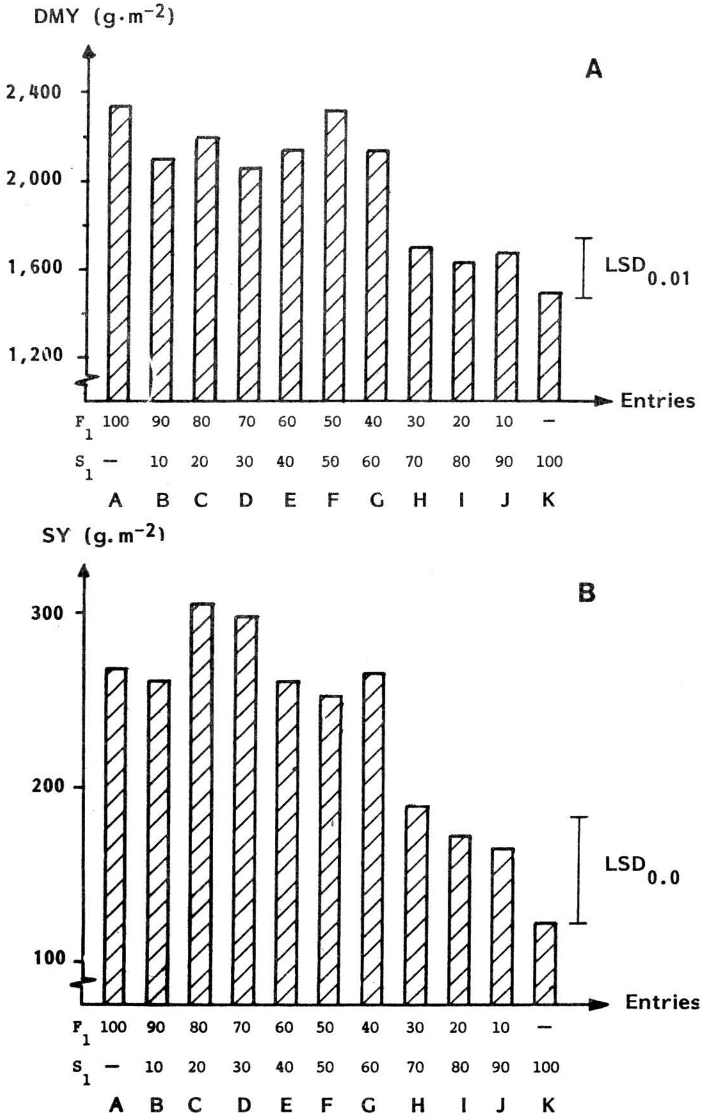

Figure 1 - A: total dry matter yield per square meter (sum of 5 cuts);
B: total seed yield per square meter (sum of 2 years).

level of selfing of the seed crop in which the seed lot is produced.

RÉSUMÉ

Une recherche a été menée à Pérouse (Italie) au cours des années 1983-85 pour évaluer l'influence qu'exerce un pourcentage différent de plantes pour l'autofécondation sur les caractères d'intérêt agronomique dans la luzerne.

On a semé, sur des microparcelles ayant une densité d'ensemencement de 1600 graines par m^2, neuf mélanges de graines ayant des rapports de graines pour l'autofécondation (S_1) à graines de croisement (F_1) de 1:9, 2:8, 3:7, 4:6, 5:5, 6:4, 7:3, 8:2 et 9:1 ainsi que deux lots de graines de controle (100% de graines S_1 et 100% de graines F_1 respéctivement).

Les données relatives à la production de substance sèche par unité de surface ont été relevées trois fois au cours de l'année 1983 (le 21 Juin, le 20 Juillet et le 2 Septembre), une fois au cours de l'année 1984 (le 16 Mai) et une fois au cours de l'année 1985 (le 30 Mai) tandis que le 20 Août 1984 et le 19 Août 1985 ont été relevées les données relatives à la production de graines par unité de surface.

Des diminutions substantielles dans la production de la substance sèche ont été relevées seulement quand le pourcentage des graines S_1 dans le lot de graines initial était supérieur ou égal à 70%. Par conséquent on peut dire que les productions de fourrage et de graines d'une culture de luzerne ne sont pas étroitement liées à la quantité de graines pour autofécondation présentes dans le lot de graines utilisées pour faire la plantation même.

ACKNOWLEDGMENTS

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WORKSHOPS

Environment and the selection for vigour

Workshop session Nr. 1
Chairman: J. Sjodin

- Selection for herbage and seed yield

It was generally felt that seed yield is a very important breeding objective. However, the first priority is dry matter yield. During the process of selection material with a high dry matter yield, but a low seed yield should be rejected. One participant felt that growers should be paid more for a variety with a low seed yield.
In some countries the problem exists that the seed cannot be produced in the area where the variety was bred and is being used. The special characteristics that were bred into the variety are lost because the variety is multiplied in a different environment. The problem seems to be more serious if the variety is moved in the north-south direction than in the west-east direction.

- Breeding for specific or wide adaptation

There was a general consensus that varieties should be bred for a wide adaptation in order to satisfy the wishes of the seed industry. One participant felt that a variety with a specific adaptation was less prone to re-selection. By breeding for wide adaptation, the performance of the variety is adversely affected, but this is the price to pay. Varieties with a specific adaptation are superior to varieties with a wide adaptation.
Geographic adaptation and adaptation to management are distinguished. An example of the latter is the breeding of varieties for satisfying the requirements for the inclusion in the various variety lists.

- Breeding in monoculture or in mixture

Most breeding work is done in mono-culture as the variety will be tested in monoculture by the official authorities to decide on the inclusion of the variety in the national variety list.
However, the variety is mostly used in mixture and the performance in mixture should therefore be incorporated during the process of selection. A balance between the official requirements and the farmers requerements should be found. Examples of breeding in mixtures are the selection of single plants of one species in the sward of another species and the breeding for adaptation to each other of ryegrass and white clover.

Workshop session Nr. 2
Chairman: H. Scheller

Topics:

1. Reasons for limitation of fodder crop production in the different regions of Europe.

The participants gave short statements about the conditions in their home countries and the main reasons for crop limitation.

2. Correlation of environment of the breeding station and success of breeding.

The influence of climate and soils of breeding stations was discussed. It seems, that especially for extreme environments breeding work must be done in comparable environment.

3. Breeding work for frost-resistance.

The participants emphasize the necessity of breeding for freezing tolerance in grasses. Methods for testing were discussed.

Workshop session Nr. 3
Chairman: F. Veronesi

1. Several participants gave statements about problems, mainly with vigour caused by climatic conditions. Limits are very often caused by lack of winterhardiness, so, we discussed methods to increase freezing resistance.

2. Considering vigour as a composite trait, it is necessary to select, if possible, under real conditions. However, it could be very useful to make a broad improved population where all researchers could make use of the material for specific adaptation.

3. Mass selection or phenotypic recurrent selection could be the most useful methods to achieve this objective.

All participants agreed on the possibility of giving more time in future conferences to this kind of workshop but the topic to be discussed must be more concrete and specific.

POSTERS

EFFECT OF RHIZOBIUM STRAINS ON THE GROWTH IN VITRO OF FUSARIUM OXYSPORUM VAR. MEDICAGINIS

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Éva BAKONDI-ZÁMORY - Crop Protection and Soil Conservation Service, Budapest
Borbála KŐVÁRI - Research Institute for Fodder Production, Bicsérd
Erzsébet TÓTH - Research Institut for Irrigation, Szarvas

Effects of 7 Rhizobium meliloti strains and 2 Rhizobium japonicum strains (Rm-1, Rm-2, Rm-3. Rm-4. Rm-5, Rm-6, Rm-7, Rj-1, Rj-2) on the growth of Fusarium oxysporum var. medicaginis were in vitro studied.

The Rhizobium strains were solved in potato dextrose agar and poured into Petri dishes. Discs of 5 mm Ø cut from the Fusarium oxysporum var. medicaginis culture were placed on the solid agar surface inoculated with Rhizobium. Four discs were put into each Petri dish. Cultures were assessed after 7 days of incubation. Growth of Fusarium oxysporum var.medicaginis colonies was measured. It was found in the screening test that the Rm-6 and Rm-7 strains fully inhibited growth of Fusarium oxysporum var. medicaginis. On the other hand, the other 5 Rhizobium meliloti and 2 Rhizobium japonicum strains showed only partial antagonistic effect.

Rhizobium strains showing full inhibition in vitro will be further tested under glasshouse and in the field.

BREEDING MEADOW FESCUE FOR VIGOUR AND PERSISTENCY

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Meadow fescue (*Festuca pratensis* L.) is a high yielding, palatable and winter hardy fodder grass, which can be grown either in pure stand or in mixture with white clover and other grasses. However meadow fescue is sensible to summer drought and not very persistent. Is it possible to combine vigour and yield stability during the growing season and over the years ?

Persistency is largely influenced by environmental conditions and it is not easy to find an accurate and simple screening test for this character. Diseases such as bacterial wilt (*Xanthomonas campestris* p.v. *graminis*), leafspot (*Drechslera* sp in particular *D. sorokiniana*) and crown rust (*Puccinia coronata*) can be responsible for poor persistency.

In the recurrent selection programme conducted at Changins, seedlings are inoculated in the greenhouse with crown rust and bacterial wilt; only tolerant plants are transferred to the field for observation during three years. *Drechslera* seems to be endemic in the breeding garden. The best plants are then cloned and observed again for two years before being intercrossed in a polycross. Progenies are evaluated in microplots at three locations. The best families are used as basic material for a new cycle of selection.

Temperature and drought influence the yield and also the content of non structural carbohydrates. In the field a relation between drougth period, growth stage and persistency was observed. However further investigations are necessary to understand the mechanisms which affect the survival of plants during summer. Regrowth expressed as leaf appearance rate and tillering capacity seems to be an important breeding criterion.

It should be noted that families and new varieties are tested in field plots in association with white clover to asses their competitive ability. Varieties bred according to the method described above appear to be more persistent than the original material.

BREEDING FOR VIGOUR IN A MEDITERRANEAN ALFALFA POPULATION: HALF-SIB PROGENIES EVALUATION.

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Alfalfa (<u>Medicago sativa</u> L., 2n=4x=32) can play an important role in Sardinian forage production if a few varieties adapted to the typical Mediterranean environment of the island are available. The aim of the present research is to synthetize such varieties starting from local adapted materials once ascertained if genetic variability for traits of agronomic interest is present.

In spring 1987, 550 plants of the old local variety "Mamuntanas" were collected at random in a three-year-old stand and spaced transplanted in a field nursery. The "Mamuntanas" variety was chosen as the most suitable on the basis of the results of a comparative trial previously carried out at the Agronomy Institute, University of Sassari. In summer 1987 Half-Sib (HS) seed was produced on 100 randomly chosen plants out of the 535 plants at disposal.

One-hundred HS seed lots were sown in April 1988 (1 linear meter plots, replicated three times, rows spaced 50 cm apart and a seeding rate of 50 viable seeds per linear meter). Due to the large number of entries, a triple lattice design was used.

In summer 1988 data were collected twice (July 1st and August 2nd, respectively) on dry matter yield (DMY, g per linear meter), flowering score

(1=minimum, 9=maximum) and average height (cm) of the HS entries.

Analysis of variance showed the presence of significant differences (p <= 0.01) among entries for all the traits, with DMY ranging between 152.1 (entry N.2) and 295.4 g per linear meter (entry N.6), flowering score ranging between 2.8 (entry N.57) and 6.8 (entry N.41) and plant height averaging between 54.5 (entry N.76) and 70.6 cm (entry N.6). Positive and significant (p<= 0.01) correlations were present between DMY and flowering score (r=0.43), between DMY and height (r=0.61) and between flowering score and height (r=0.32).

These results seem therefore to point out the presence of quite a high genetic variability within the "Mamuntanas" variety which could be suitably utilized in breeding programs.

BREEDING OF FODDER GRASSES FOR WINTER HARDINESS AND DROUGHT RESISTANCE IN SIBERIA

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SUMMARY

The specific genofond of winterhardy and drought-resistant fodder grasses has been formed in Siberia. There have been developed selection varieties, with local ones also widespread. Widely used are provocative backgrounds to produce winterhardy forms. The ultra-early ripening varieties combining high biomass and seed productivity have been bred in the zones with a short frost-free period.

The main crop-producing areas in Siberia are known to suffer from severe frosts in winter-time, with the forest-steppe and steppe regions being also deficient in moisture (especially during the first half of summer) and the sub-taiga and taiga regions lacking warmth. A short frost-free period in combination with unfavourable hydrothermal conditions result in a low bioclimatic potential which is 0.46 to 0.64 of the mean index existing in the USSR. Sharp temperature drops in winter, a thin snow cover and return spring frosts in restoration of perennial grasses vegetation often lead to their death.

A number of local and selection varieties showing fairly high resistance to unfavourable environmental conditions has been bred in Siberia. Generally recognized are the varieties: alfalfa - Omskaya 8823, Flora, Barnaulskaya 17, Kamalinskaya 930, Kamalinskaya 530, Tayozhnaya, Tulunskaya Gibridnaya, Onokhoyskaya 6 and Zabaikalka; awnless bromegrass - SibNIISKHoz 189, Kamalinsky 14, Tulunsky, Antey, Ostaninsky.

The majority of varieties has been developed on the basis of local wild-growing forms, with varieties from another regions introduced in hybridization to improve the quality and productivity level. When breeding for cold resistance, promising proved to be the specimens from: in the chambers - the Khakass Autonomous Region (98%), Novosibirsk Region (96%), the Buryat Autonomous Soviet Socialist Republic (88%), Omsk Region and Altai Territory (85%); under field conditions - The Buryat Autonomous Soviet Socialist Republic and the Khakass Autonomous Region (98%), Krasnoyarsk Territory (96%), Novosibirsk Region (95%). The cold-resistant material revealed in the preliminary stages of breeding is to be additionally tested against provocative backgrounds. For example, our varieties of alfalfa Tayozhnaya and Tulunskaya Gibridnaya, awnless brome Tulunsky and Antey have been selected against special provocative backgrounds.

The varieties grown in the arid steppe regions of Siberia and

Transbaikal usually show fairly high resistance to Siberian drought. Among them are: alfalfa - Omskaya 8823 and Flora (Omsk Region), Barnaulskaya 17 and Biyskaya 3 (Altai Territory), ПС-8 (Novosibirsk Region), Onokhoyskaya 6 (the Buryat Autonomous Soviet Socialist Republic), Zabaikalka (Chita Region); awnless brome - SibNIISKHoz 189 (Omsk Region), M-78 (Novosibirsk Region), Ostaninsky (the Buryat Autonomous Soviet Socialist Republic).

Winter hardiness and drought resistance are concurrently shown by the varieties bred and grown in the southern steppe areas of Omsk Region, Kulunda zone of Altai Territory and the Minusinsk hollow of Krasnoyarsk Territory (the Khakassia) as well as in the southern Transbaikal areas (the Buryat Autonomous Soviet Socialist Republic and Chita Region). They have been developed from the material naturally selected over a long period of time under severe climatic conditions of the zone and subjected to a prolonged breeding in the said areas, with intraspecific and interspecific hybridization widely used.

The following drought-resistant varieties have been bred to be grown in Siberia under arid conditions: pea for fodder - Omsky 7 (Omsk Region), Kormovoy 50 (Altai Territory and the Buryat Autonomous soviet Socialist Republic), millet for forage - Chernosemyannoye 1 (Novosibirsk Region), Abakanskoye kormovoye (Novosibirsk Region and the Khakassia), Kormovoye 45 (Altai Territory), velvet mohar - Omsky 10 (Omsk Region), Stepnyak 1 (the Khakassia).

By way of interspecific hybridization of garden and field peas we have managed to develop an ultra-early variety of field pea - Skorospely 16 (the Tulun Breeding Station) to be cultivated in zones with a short frost-free period. It is famous for early ripeness as well as for high potential productivity and resistance to excess moisture in the period of maturation and harvesting.

INFLUENCE OF SEED WEIGHT ON SEEDLING VIGOR OF TWO ACCESSIONS OF BIRDSFOOT TREFOIL (LOTUS CORNICULATUS L.)

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ABSTRACT

Aims of the work have been a) to assess the influence of seed weight on seedling vigor in two accessions of birdsfoot trefoil characterized by different 1000 seed weight: Polcanto ($\bar{x}$=1.312 g), a high productive population from Central Italy, and PI 302921 ($\bar{x}$=2.398 g), a highly vigorous population from Spain b) to start a breeding program to increase seedling vigor in Polcanto.
2002 seeds of Polcanto and 182 of PI 302921, singly weighed, were randomly sown in jiffy pots (0.5 cm deep) at the beginning of April 1987. The following vigor indeces were recorded on each seedling:
1) Date of emergence of cotyledons (days from sowing date),
2) Date of emission of the 1st, 2nd, 3rd and 4th leaf (days from sowing date),
3) Date of emission of the 1st and 2nd couple of tillers (days from sowing date),
4) Green mass evaluated each week from May 22 to June 12, scoring each plant from 1=minimum to 9=maximum,
5) Dry Matter Yield (g/plant) evaluated at the end of June.
Significant differences were found between populations for all vigor indeces except for green mass at the 1st and 2nd sampling dates. Great variability was also found within each population. Significant correlations between seed weight and all recorded characters were only found in Polcanto: a high seed weight appeared to confer best vigor indeces. Though significant, these correlations were of scarce statistical relevance since R^2s were always low (from 0.09 to 0.01). Nevertheless, t tests for significance of regressions of seed weight on recorded characters showed that b s were always significantly different from 0.
In conclusion, since low correlation coefficients between seed weight and seedling vigor indeces are present only in Polcanto, it is better to select for vigor indeces <u>per se</u>. The wide variation within Polcanto for recorded vigor indeces suggests that progress can be achieved in a breeding program aimed to increase seedling vigor.

ENZYMATIC POLYMORPHISM IN COCKSFOOT (Dactylis glomerata L.) PROGENIES AT DIFFERENT LEVELS OF INBREEDING

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The segregation of the three isozyme genetic systems could be represented by the different dry matter yields of the three families involved in this study. In tables 1, 2 and 3 are summaryzed, separately for the three families the distribution and the frequency of alleles in the 3 isozyme loci among the diffeerent generations tested.

In particular for Family n^{o} 5 (Tab. 1), in which dry matter yield was more affected by inbreeding depression, we found a reduced number of alleles in two (GOT-1 and PX-1) loci studied, and the PGI-2 locus always homozygous in all the selfed progenies. The S_0 generation on the other hand appears to be much more polymorphic, with 4 different alleles at the PGI-2 locus, 3 at PX-1 and 2 at GOT-1.

Family n^{o} 6 was very tolerant to selfing for dry matter yield over the selfing generations with respect to S_0 (Fig. 1), and the distribution of alleles for PGI-2 and PX-1 was wide and rich various individuals showed 3 different alleles per locus after 2 cycles of selfing. Indeed for the homozygous phenotype GOT-1, this was found in all selfed progenies. The S_0 population showed a high degree of heterozygosity, with 3 codominant alleles for GOT-1 and PGI-2, and 2 for PX-1.

In terms of dry matter yield, Family n^{o} 12 was less affected by inbreeding depression, since it scored the best performance in S_3 (Fig. 1). The allelic pool in this family was the richest found in our conditions, with a high degree of allelic diversity for the 3 loci tested: 3,4 and 3 alleles for GOT-1, PGI-2 and PX-1 respectively. In the S_3 generation in particular, Family n^{o} 12 presented the lowest frequency of homozygous phenotypes.

The results here presented seems to substantiate the potential usefulness of the biochemical approach for analyzing the genetics of the vigour in the out-pollinated species Dactylis glomerata, when submitted to weveral cycles of selfing.

However for a better understanding of the effect of selfing in an autotetraploid species like cocksfoot, it will be necessary to evaluate also the progenies of subsequent generations of selfing.

Table 1 - Distribution and frequency of alleles in the 3 isozyme loci among different generations tested (polycross and selfing) for Family n° 5.

ENZYMATIC SYSTEMS	ALLELES		S_0	S_1	S_2	S_3
GOT-1	2	HOMOZYGOUS	23.53	12.50	*	33.33
		Heterozygous:				
		- balanced	11.76		50.00	33.33
		- unbalanced	64.70	87.50	50.00	33.33
PGI-2	4	HOMOZYGOUS	25.00	100.00	100.00	100.00
		Heterozygous:				
		- balanced				
		- unbalanced	70.83			
		- triallelic	4.16			
PX-1	3	HOMOZYGOUS	58.33	41.66	42.86	*
		Heterozygous:				
		- balanced	29.16	16.66	14.29	16.66
		- unbalanced	12.50	41.66	42.86	83.33
		- triallelic				

* probably unrepresentative sample size.

Table 2 - Distribution and frequency of alleles in 3 isozyme loci among the different generations tested (polycross and selfing) for Family n° 6.

ENZYMATIC SYSTEMS	ALLELES		S_0	S_1	S_2	S_3
GOT-1	3	HOMOZYGOUS	45.45	100.00	100.00	100.00
		Heterozygous:				
		- balanced	18.18			
		- unbalanced	36.36			
		- triallelic				
PGI-2	3	HOMOZYGOUS	3.70	15.38	58.97	*
		Heterozygous:				
		- balanced	18.52		5.13	
		- unbalanced	33.33	65.38	33.33	
		- triallelic	44.44	19.23	2.56	
PX-1	3	HOMOZYGOUS	50.00	62.50	35.14	*
		Heterozygous:				
		- balanced	33.33	37.50	27.02	
		- unbalanced	16.66		24.32	
		- triallelic			13.51	

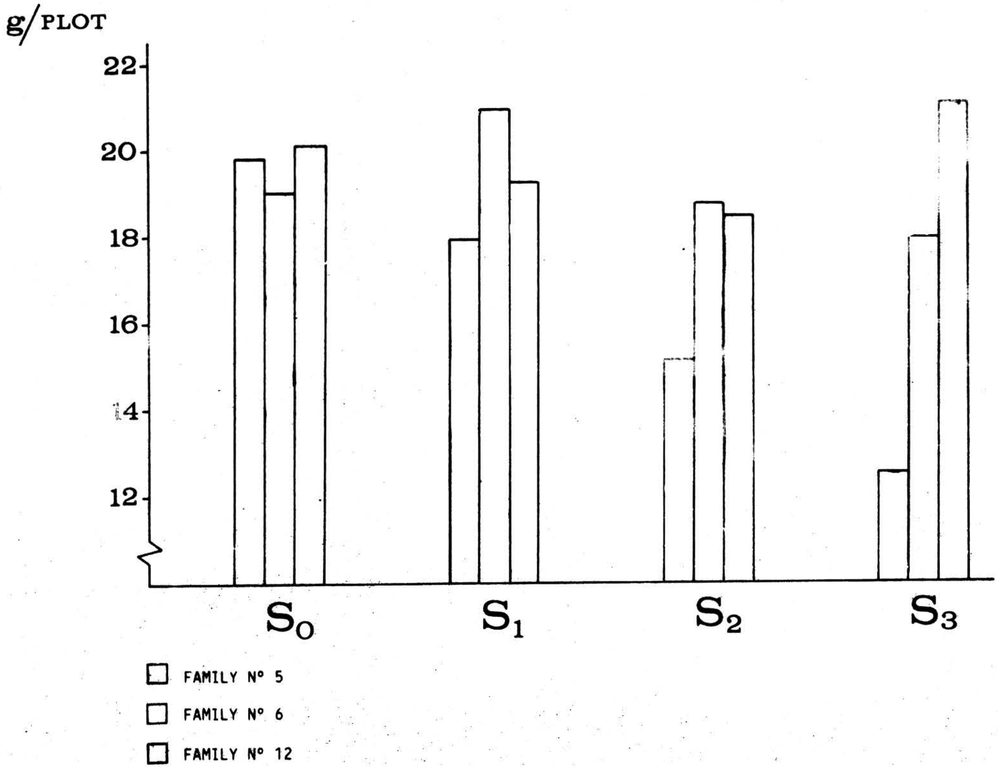
* unrepresentative sample size.

Table 3 - Distribution and frequency of alleles in the 3 isozyme loci among different generations tested (polycross and selfing) for Family n° 12.

ENZYMATIC SYSTEMS	ALLELES		S_0	S_1	S_2	S_3
GOT-1	3	HOMOZYGOUS	30.43	*	15.38	*
		Heterozygous:				
		- balanced	30.43	22.73	23.08	16.66
		- unbalanced	39.13	50.00	61.54	83.33
		- triallelic		27.27		
PGI-2	4	HOMOZYGOUS	40.00	6.06	*	3.57
		Heterozygous:				
		- balanced	5.71	18.18	30.77	42.85
		- unbalanced	42.85	75.75	69.23	53.57
		- triallelic	11.43			
PX-1	3	HOMOZYGOUS	53.85	24.07	15.38	14.81
		Heterozygous:				
		- balanced	26.92	29.63	53.85	48.15
		- unbalanced	15.38	37.04		37.04
		- triallelic	3.85	9.26	30.77	

* probably unrepresentative sample size.

FIG. 1 - SELFING EFFECT ON DRY MATTER YIELD (g/plot) IN THE THREE FAMILIES ANALYZED.



SCREENING OF VIGOUR OF PHLEUM PRATENSE L. UNDER GREENHOUSE AND FIELD CONDITION

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PROBLEM

Rapid screening methods are helpful in the long lasted breeding process in grasses (1,2,3). From other hand, the grasses interact very strongly with environment and management. The question was how useful the results from greenhouse test and from short field test could be for prediction of Phleum pratense performance during 3 years of utilization.

METHOD

46 clones have been evaluated for green matter yield and tillering power using the following methods:

a) greenhouse trials during winter time
b) field trials during one vegetative period
c) field trials during 3 years utilization.

The technical arrangement of the testing has been the same in all types of methods. Thirteen plants at 3 tillers in rows (7cm x 10cm) at 4 replication have been planted. 5 cutting system of utilization per season has been used. In the greenhouse 16000 lux for 16hr/day have been conducted. The correlation of the results between methods have been calculated.

RESULTS

The relationship of results from different methods is presented in tab.1

Table 1: Regression coefficient between methods of testing

Methods	Yield			Tillering		
	1979	1980	1981	1979	1980	1981
a x c	0,58	0,54	0,21	0,53	0,48	0,19
b x c	0,84	0,67	0,81	0,70	0,51	0,74

$r_{0,05} = 0,28$ $r_{0,01} = 0,36$

The results were depended from genotypes (Tab.2). Some clones have got exellent repeatability but in other clones the repeatability was poor - specialy in method "a". Clone 1 was the best in each methods.

Table 2: Ten most vigorous clones in "c" method and their repeatability in screening methods "a" and "b".

c	a			b		
clones	1979	1980	1981	1979	1980	1981
1	+	+	+	+	+	+
2	+	-	-	+	+	+
3	+	-	-	+	+	+
4	+	+	-	+	-	-
5	-	-	-	-	+	+
6	-	-	+	-	+	+
7	-	-	+	+	-	-
8	+	+	-	+	+	-
9	-	-	-	-	-	+
10	-	-	-	+	+	+

+ among the groub of 10 best clones
- below the 10 best clones

By using screening methods in Plant Breeding and Acclimatization Institute Exp.Station Bartążek new variety Phleum pratense "Kaba" was bred and registered in 1988.

CONCLUSION

1. One year field test generally quite well predicts the yielding and tillering of Phleum pratense clones compering to 3 years utilization.
2. Greenhouse test might be informative for the breeder but results strongly depend on genotype.

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FROST- AND WINTERTOLERANCE OF RYEGRASSES

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The relationship between winterdamage and dry matter (DM) yield of 348 selections and varieties of perennial and Italian ryegrass was analysed during two consecutive years with a severe winter.
The main conclusions are :

1. In comparaison with normal winters, the yearly DM-yield dropped with about a quarter after a long winter (negative soiltemperatures until half March). This was mainly due to the delay of the spring growth with two to four weeks.
2. The more the winterdamage was severe, the lower was the DM yield of the first cut. However, the regrowth of the damaged plots was very well and, at the end of the year, the total DM yield was almost independent of the winterdamage.

A parent-offspring analysis with perennial ryegrass revealed a heritability (narrow sense) of the wintertolerance of approximately 0.4.

A method of artificial testing of the frosttolerance was developped. The relation between the (artificially tested) frosttolerance and the wintertolerance (fieldperformed) was fairly positive with diploid perennial ryegrass. The most frosttolerant genotypes were generally the most wintertolerant and a high yield potential was maintained. Tetraploid genotypes reacted otherwise : they coupled a good wintertolerance to a weak frosttolerance.

The length of the hibernation period influenced the frosttolerance of five varieties of perennial ryegrass : the more spring came closer, the more they came frostsusceptible.

ANALYSIS OF AERIAL PART AND ROOTS IN LUCERNE. DRY MATTER YIELD. TOTAL SUGAR AND CRUDE PROTEIN CONTENT THROUGH PHENOLOGICAL STAGES AND CUTTINGS.

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Introduction

The factors of productivity in the lucerne crop have been studied in a series of experiments at the Institute of Lodi. On these basis, a model of the lucerne crop and lucerne plant was defined (Rotili, 1988). The research program was developped in recent years in order to improve these models as long as the role of root reserve recovery for forage production and persistency is concerned; some previous results concerning the study of aerial part and roots of lucerne crop was already discussed (Rotili et al. 1985).

Materials and Methods

Four cultivars of different origin: Sewa, Egypt; Equipe, Lodi Northern Italy; Victoria, Spain; Julus, Sweden; are studied in boxes/plot of 38 cm in diameter and 80 cm in height (30 plants/box) for dry matter yield, total sugar and crude protein content either in aerial part or roots. Two regimes of cut are adopted: early cut (50% green bud) and normal cut (50% flowering). Phenological stages of regrowth (4-5 nodes in the main stems), green and blue bud are studied as well on individual plant basis. The early cut management was studied over 7 cuts of a year; the normal cut through 2 years (6 and 5 cuts respectively) plus 3 samples taken in winter time.

Results

Dry matter yield. Early cut regime: the trend of aerial biomass production shows a general decrease from the 1st to the 8th cut for all the cultivars. The drop is particularly sharp from the first to the second cut (reduction of 50-70%). Within each productive cycle, the production at regrowth stage is higher for Equipe and Victoria; Julus reaches the phenological stage of 4-5 nodes more slowly than Equipe and Victoria. Finally, cv. Sewa shows, except for the first cut, the least value at regrowth stage. As for the root D.M., a general increase till the second and third cut is evident, followed by a decrease in all cv. except Sewa. Equipe and Victoria show the greatest values in root D.M., Sewa the lowest. It is noticeable that an important and early regrowth is accompanied by a marked decrease in root D.M.. Equipe shows the most effective response having an important and early production both at the regrowth and at the green bud stage, with the highest values in root D.M..

Normal cut regime: a general decrease in aerial D.M. from the first to the last cut is evident in both years. This decrease is slighter in Equipe than in other cv.; at the end of the first year (october), the Egyptian cv. Sewa shows the highest yield while Julus the lowest. Within each productive cycle, Equipe is the most performing at regrowth and green bud stage, except at the end of the growing season when Sewa, less affected by the photoperiod, yields more. As for the root D.M. we can distinguish two groups: Sewa and Julus, with low values, and Equipe and Victoria with high subterranean biomass. In general, root D.M. increases all over the first year. In the second year it decrease after the first cutting. The sampling in wintertime shows that a part of the root D.M. is lost (22-40%). Within each cycle, the root biomass decreases during the regrowth after cutting and recovers after the blue bud stage. The complete recovery of root D.M. during a productive cycles is never achieved in the second year. The ratio between aerial and root D.M. decreases from the first to the last cut at values less than 1 at the end of the season, except for Sewa.

Total sugar and crude protein content of roots.

Early cutting: total sugar content of the roots shows a variation around 9% through the cuttings. Within each productive cycle, a significant decrease at the regrowth is evident at the first cut and after the 4th Crude protein content of roots decreases from the first to the second cut. No evident decrease is observed at the regrowth.

Normal cutting: the root total sugar content doesn't increase through the cuttings. Within each cycle the highest sugar content is found between green and blue bud stage. The crude protein content has a trend similar to that of root D.M.. Only a slight decrease is observed at the regrowth stage, while the lower value of crude protein content is found at the green bud stage.

Mortality

The cut at the green bud stage causes a very high mortality in all cultivars excepted Equipe, which was selected for the resistance to early cutting. When cut at the flowering stage, Equipe and Victoria show a low mortality while Sewa and Julus are more sensitive.

Conclusions

The early cut (50% green bud) rapidly brings the lucerne crop to the destruction. The results of this experiment show that there is a large variability for the resistence to the early cut (green bud).

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A. Sliesaravicius

Production and charasteristic of Interspecific and Intergeneric Hybrids between Lolium and Festuca

Utilization of rich in the aspect of selection varieties of genus Festuca crossed with genus Lolium gives an opportunity to produce new plant forms for practical selection.

Crossings were carried out with the castration of maternal plants, which were grown in Sherer's climatizer at temperature 24/18^{o}C with a photoperiod of 18 hours. Embryos were separated in the 11-12 th day after pollination and when they were germinated on liquid nutrient medium 85 % of shoots were produced when perennial ryegrass was crossed with meadow fescue. Was impossible to isolate embryos earlier than 8 days. In this case 4 days old ovaries were separated, which produced 20 % of plants. By method of isolated embryos the following hybrids were obtained: L.perenne L. (4x) x F.varia Haenke (6x), L.perenne L. (4x) x F.arundinacea subsp orientalis (6x), L.multiflorum L. (4x) x F.pratensis var.apennina (4x), L.multiflorum L. (2x) x F.arundinacea var. cirtensis (10x).

Interspecific hybrids in combination perennial ryegrass x italian ryegrass according to their fertility were not inferior to perennial ryegrass, they were characterized by quick regrowth after mowings and according to the productivity of fodder mass exceeded a regional variety of perennial ryegrass "Veja".

Interspecific hybrids produced by crossing of meadow fescue with reed fescue were almost sterile, their seed formation was 0,5-3,8 %.

Analysis of meiosis has showed a partial conjugation of these varieties, which indicated their definite genotypical congeniality.

Intergeneric hybrids when tetraploid forms of meadow fescue were crossed with perennial ryegrass were characterized by quick regrowth, hightened leafliness, according to the productivity of fodder mass exceeded parental varieties, were fertile.

Zygmunt Staszewski and Zbigniew Bodzon

Heterosis of seed setting in lucerne

Summary

The significant heterotic effect in seed setting was observed in different crossing combinations among inbred lines. For example the EF11 x EF2 hybrid which produced the greatest quality of seeds was composed of rather low seed setting parents (Table 1). The lowest seed setting and GCA were observed when related components were crossed and triple hybrids in comparison with double hybrids displayed lower GCA effects.
The values for topcross progeny are given in table 2. The clones in the number of twenty selected in field conditions as a best setters displaved great variability in seed setting and GCA values when evaluated in the tipcross. Nine best clones shown positive GCA effects (Group I), four were even to standard (Group II), and eight of them were significantly worse than standard variety (Group III).
Seed setting characteristics of the hybrids composed of the clones belonging to I and II groups were compared in field trials to their Syn. 1 progeny (Table 3, Fig. 1). Clones displaying higher GCA in general produced higher yielding hybrids (with in group I).
The comparison of the means of 4 best and 4 worst F_1 hybrids and their progeny is given on Fig.1. No correlation has been found between yields of F_1 hybrids and its progeny. It may prove that yields of hybrids were high due to non - additive effects which were not transmitted to next generation.
Synthetic variety Radius composed of 9 best clones in three years lasted trials in four locations produced seed yields 156 % in comparison to the standard variety.

Table 3

GCA of hybrids F_1 (clone x clone)

Hybrid formula	Seed yield per 50 stems		Seed yield per 50 racemes		Seed setting of hybrids F1			
					Pod No. per raceme		Seed No. per pod	
	g	GCA	g	GCA	No	GCA	No	GCA
518 x 127-1	39.0	20.2	8.9	4.6	17.8	3.0	4.1	1.3
127-1 x 328	32.0	13.2	5.6	1.3	19.0	4.2	3.3	0.5
126-1 x 518	22.0	3.8	4.8	0.5	16.0	1.2	2.7	-0.1
337 x 398	22.0	3.8	4.4	0.2	17.4	2.6	2.5	-0.3
398 x 304	20.5	1.7	3.6	-0.7	12.9	-1.9	2.6	-0.2
126-1 x 127-1	17.0	-1.8	4.6	0.3	13.6	-1.2	3.3	0.5
73-1 x 127-1	14.0	-4.8	4.5	0.2	14.8	0.0	3.1	0.3
127-1 x 304	8.0	-10.8	2.9	-1.4	12.4	-2.4	2.4	-0.4
398 x 423	22.0	3.8	5.4	1.1	18.1	3.3	3.0	0.2
328 x 423	18.0	-0.8	3.4	-0.9	13.8	-1.0	2.4	-0.4
327-2 x 304	19.5	0.7	4.1	-0.2	14.8	0.0	2.8	0.0
304 x 327-2	16.0	-2.8	3.4	-0.9	15.5	0.7	2.4	-0.4
327-2 x 127-1	7.5	-11.3	2.5	-1.8	10.1	-4.7	2.7	-0.1
75-5 x 171	5.0	-13.8	2.5	-1.8	10.6	-4.2	2.3	-0.5
LSD (p=0.05)	11.5		3.3		7.35		1.15	

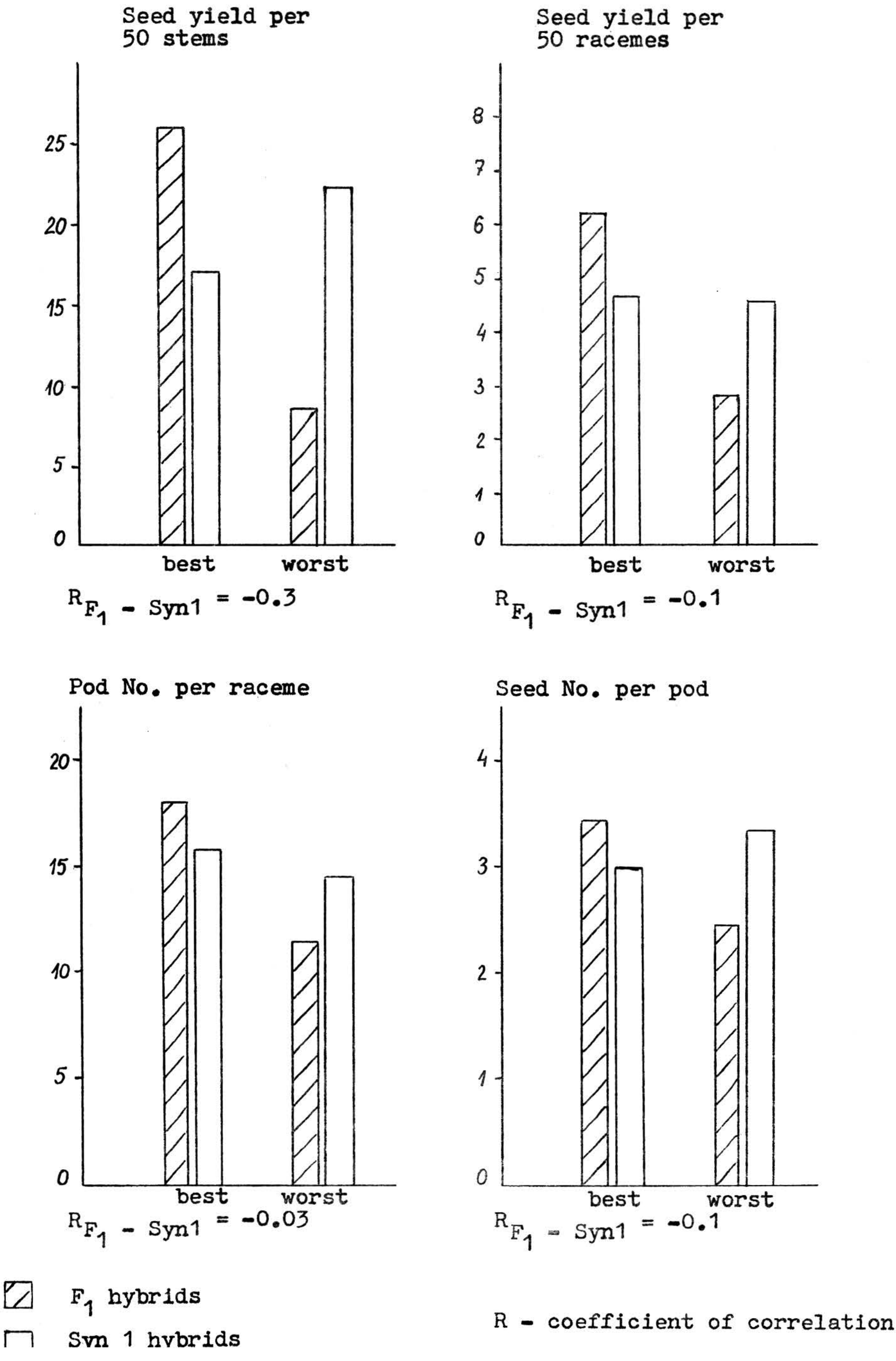
Table 4

Comparison of the yield of synthetic variety and standards (1983-1986 y.)

	Mean seed yield 3y., 4 locations in Poland	Mean dry matter yields, 3y., 4 locations
Tula	110-530 kg/ha	102 %
Kometa	100 %	100 %
Radius	156 %	100 %

Figure 1

Seed setting of F_1 hybrids and Syn 1 progenies



MALE STERILITY IN TALL FESCUE /FESTUCA ARUNDINACEA SCHREB./

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Introduction

Male sterility has been investigated in different species of fodder grasses.Spontaneous male sterile plants have been found in orchard grass-Dactylis glomerata /MYERS 1946;FILION and CHRISTIE 1966 and CHRISTIE 1973/,timothy-Phleum pratense /JENKIN 1931;TOWNLEY-SMITH 1969/,meadow fescue-Festuca pratensis /BURKERT and SCHLENKER 1975;PAWLUK 1986/,ryegrass-Lolium perenne /BURKERT and SCHLENKER 1975;NITZSCHE 1971;PIROG and PIASTKA 1977/.Male sterile sources have been developed by means of intergeneric crosses /Lolium x Festuca,WIT 1973/,induced by chemical mutagens in Festuca pratensis,Phleum pratense and Dactylis glomerata /KULESZOW and KREMNINA 1972 and 1973;KREMNINA and KULESZOW 1976/.To select the spontaneous sources of male sterility in tall fescue and study its inheritance was aim of our work.We have also studied seed setting of self pollinated clones with respect to maintain male sterility.

Material and methods

The material used in this study consisted 54 of tall fescue clones originated from different cultivars.Searching for male sterile plants was conducted at the time of anthesis,by visual inspection.The plants with anthers shedding pollen were considered to be male fertile.The plants having thin,light-green coloured and indehiscent anthers were classified as male sterile.Male sterile plants additionaly were examined under microscope for pollen viability using acetocarmine stain.The heads of male fertile plants were selfed to check their seed setting ability. Part of the heads of male sterile plants were open-pollinated to produce F_1 offsprings,while part of them were selfed to be a control.Plants F_1 were grown up to flowering to detect segregation for male fertile and male sterile phenotypes.The plants were grown in greenhouses under two different temperatures 18-20°C and 25-30°C.

Results

In 1987 three of male sterile /MS/ and four of partialy male sterile /PMS/ clones were selected /table 1/.The anthers of MS plants contained the only small amount of sterile pollen grains while the anthers of PMS had both sterile and fertile ones.When the selected clones were grown under higher temperature /25-30°C/ MS plants unchanged the percent of unviable pollen grains while fertility of PMS plants increased.PMS plants produced very small amount of pollen while control male fertile /MF/ plants produced reach amount of pollen.Selfpollinated inflorescences of MS and PMS plants did not set any seeds.either in 1987 nor in 1988,but pollinated with pollen of MF plants produced numerous F_1.MS and MF plants were scored in F_1 /table 2/.Presence of MS plants in F_1's generation proved that male sterility of selected clones is a hereditary trait.In 1987,heads of 47 male fertile clones were bagged before flowering to check their seed setting under self pollination. Majority of those clones were self-sterile and set from 0 to 3 seeds per bagged head. Although, several of clones with relatively good self-fertility were selected /table 3/.

Summary

In 1987 three of male sterile clones of tall fescue were selected. Male sterility of those clones remained stable when checked under temperature 15-20°and 25-30°C. Male sterile plants produced seeds when crossed to pollen producing plants. It was proved that male sterility is inherited in generation F_1. Partial male sterility observed in four clones could be a result of heterozygous stage of genes restoring fertility. Self-fertile clones were selected as a initial material for breeding of nonrestoring inbred lines.

Table 1.

Male sterile /MS/ and partialy male sterile /PMS/ clones of tall fescue selected at Radzików in 1987

Clone no.	Clone origin	Phenotypes	Pollen viability in %	
			15-20°C	25-30°C
1569	breeding strain from Radzików	MS	0	0
1570	"	MS	0	0
1586	"	MS	0	0
1510	Hokuryo	PMS	8	25
1511	breeding strain from Skrzeszowice	PMS	5	15
1542	breeding strain from Radzików	PMS	10	30
1567	"	PMS	10	25

Table 2.

Fertility of first generation obtained on male sterile clones.

Cross	No. of flowering plants F_1		
	Total	MS	MF
1569 MS x MF plants	98	34	64
Percent	100.0	34.7	65.3
1570 MS x MF plants	102	27	75
Percent	100.0	26.5	73.5
1586 MS x MF plants	115	45	70
Percent	100.0	39.1	60.9

Table 3.

Seed setting selfed tall fescue clones.

Clone no.	Clone origin	Seeds per one bagged head	
		No.	%
1485	Demeter	27.5	30.0
1477	KO-4 ecotype no.39 from Konczewice	22.4	24.5
1478	SE-1 stock no.131 from Szelejewo	20.2	22.1
1543	Brudzyńska	15.8	17.2
1495	Hokuryo	12.7	13.9
1503	KO-2 ecotype no.144	11.8	12.9
1546	Aberystwyth	10.3	11.2
1486	Tawn	9.0	9.8
1529	Brudzyńska	8.9	9.7
1532	Brudzyńska	8.3	9.1
Average of 47 clones		4.8	5.2

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CALLUS FORMATION AND PLANT REGENERATION FROM INFLORESCENCE SEGMENTS OF ITALIAN RYEGRASS (LOLIUM MULTIFLORUM LAM.)

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ABSTRACT

This study was aimed at recognition of callus formation and plant regeneration possibilities in italian ryegrass (*Lolium multiflorum* Lam. 2n = 2x = 14).

Callus cultures were initiated from young inflorescence segments of field grown plants from two Polish cultivars: "Skrzeszowicki" and "Tur". The inflorescences (1 - 10 cm in length) were cultured on Murashige and Skoog medium (MS) supplemented with 4 mg/l 2,4-dichlorophenoxyacetic acid (2,4-D).

Callus induction frequency for "Skrzeszowicki" and "Tur" explants was 68.5 % and 50.0 %, respectively. The best response was obtained from inflorescences 1 - 4 cm in length. Callus was excised from primary explants after 4 - 5 weeks and subcultured on MS medium with 2 mg/l 2,4-D. Two types of callus were observed - a creamy compact nodular callus and soft, yellow-greenish, hydrated one.

Calli which regenerated multiple shoots usually grew faster than those non-regenerating. Those calli which started

regeneration from roots usually did not produce shoots, even under prolonged culture. The frequency of phenotypic variants among the regenerated plantlets increased with the time of callus culture before the regeneration. 144 and 30 normal, green plants from "Tur" and "Skrzeszowicki", respectively, were regenerated. Regenerated plants originated both via differentiation of shoot primordia and somatic embryos.

After the plants were established, root tips were examined for somatic chromosome number. 26 diploids (2n = 14) and 4 tetraploids (2n = 28) in "Skrzeszowicki" and 102 diploids and 42 (29.2 %) tetraploids in "Tur" were found. The doubled chromosome number was most frequently obtained in plants after an 8 - 12 week subculture period in which callus approached senescence.

Diploid and tetraploid regenerants produced viable pollen grains (pollen stainability ranged from 82.0 % to 99.0 %) and set seeds under open pollination (between plants at the same ploidy level). However, seed set in tetraploids was relatively low (2.3 - 32.5 %) when compared to that of diploids (22.7 - 78.9 %).

CONCLUSIONS

1. Young inflorescence segments are excellent explants for obtaining callus efficient for plant regeneration,

2. Tissue culture method appear to be a promising tool for chromosome doubling in diploid italian ryegrass.

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