EUCARPIA

European Association for Research on Plant Breeding

Breeding High Yielding Forage Varieties Combined With High Seed Yield

Report

of the meeting of the Fodder Crops Section at the Centre of Agricultural Research in Merelbeke - Gent (Belgium) 8 - 10 September 1981

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Organizing Committee

A. Van Slycken
R. De Groote
M. Rousseau
G. van Bogaert, secretary

Prepared for printing by : Ir. G. van Bogaert

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Preface

In contrast with the cereal agronomist, the fodder plant breeder is mostly concerned with the vegetative aspects of the plant. Improvement of leafiness, tillering capacity and persistency may tend to lower the ability to produce seeds and the very characteristics which are interesting to the farmer can be a problem for the seed producer. On the other hand, it is now well established that outstanding varieties will hardly be commercialized if the seed production is not satisfactory.In this connection, the Fodder Crops Section of Eucarpia decided to hold its 1981 meeting on "Breeding high yielding forage varieties combined with high seed yield".

Following a kind invitation put forward by Ing. G. van Bogaert, the meeting was held in Gent (Merelbeke) from September 8th to September 10th, 1981. It was attended by more than 60 participants from 15 countries.

The main subject was divided into three sections :

- Physiological aspects of seed production
- Relationship between dry matter and seed yield
- Selection for high seed production.

Each section was introduced by one or two main papers followed by a number of short papers. The lively debate that ensued between participants led to a fruitful exchange of mutual experiences.

During the meeting, visits were organized to the experimental fields of the Plant Breeding Station at Merelbeke and to a dairy farm. It was a real privilege for the Eucarpia Fodder Crops Section to hold its meeting in the region of Gent, which was always an important centre for the improvement of plant cultivation as already noted by Sir Richard Weston, who visited the country at the beginning of the 17th century and contributed to the development of clover growing in Europe. The demonstrations in the field confirmed this reputation of intensive and efficient agriculture.

We are very indebted to our colleague Ing. G. van Bogaert, Secretary of the Organizing Committee, who arranged the meeting in such efficient way. The kind support and warm hospitality received from the Ministry of Agriculture the Centre of Agricultural Research and the Government Plant Breeding Station are also gratefully acknowledged.

Nyon, Switzerland, October 1981

S. BADOUX

President of the Eucarpia
Fodder Crops Section

E U C A R P I A - M E E T I N G

FODDER CROPS - SECTION

R.v.P. - Merelbeke

Mr. President, Ladies and Gentlemen,

I am feeling both happy and grateful, having today the opportunity to welcome you at the Government Agricultural Research Centre of Ghent.

I am feeling happy, because I am always delighted sharing the company of an international group of colleages, having an equal concern of problems, and meeting each other nearly as friends.

I am feeling grateful, because your board has chosen this place for your meeting.

Ghent is indeed the "cradle" of grassland and fodder crops research in Belgium. By saying Ghent, I mean both the Faculty of Agricultural Sciences and our own Research Centre, which originated in 1932 from this Faculty, through the founding of the R.v.P. by Prof. Em. Van Godtsenhoven, first Director of R.v.P., later assisted by Govaert, Prof. Slaats and Reyntens, second Director, now retired, and myself.

We are convinced of doing valuable work in this Centre, in the field of your interest, and we are looking forward to know your opinion at the end of your meeting.

A few words about our Centre.

Together with 5 other Institutes, we build up the Research Administration of the Ministry of Agriculture, headed by Mr. Gailly, present here.

The equivalent Centre in the Southern, French speaking part of the country is the C.R.A. - Gembloux, wellknown for its Plant Breeding Station for cereals.

In order to give you a general idea of the efforts made by the Ministry of Agriculture for scientific research, I shall mention only a few figures.

20 % of the budget of our Ministry is devoted to research, mostly classified as applied research, of immediate use to farmers, horticulturists, fishermen, fish-industries, and last but not least to the consumers.

The money is partly used for the proper institutes of the Ministry and partly for subsidizing research projects of University Faculties, agricultural industries, farmers organisations etc.

A few words now, concerning our own Research Centre.

It is, officially speaking, a Centre of "level 1", which is structured in Research Stations "level 2" (e.g. R.v.P., R.v.V.), on their turn, divided into sections "level 3", (e.g. R.v.P. has 3 sections, breeding, grassland agronomy, seedtechnology and production).

The C.A.R. - Ghent is composed of 10 research stations and a "Public Relations" department.

Three of them are dealing with plant breeding :

R.v.P. : grasses, fodder crops, some industrial crops (marketing)

R.v.S. : ornamental plants

R.v.Pop. : poplar breeding.

The name "Centre" has been used from 1939 onwards. As a matter of fact in that year the 2nd and 3rd research station was established, viz R.v.V. and R.Z.S., Animal Nutrition and Dairy Research Station.

You will find in your documentary notes a leaflet, mentioning the ten research stations.

We employ 72 staff members with an university degree and in addition 336 technicians, manual workers and administration staff.

With regard to the distribution of financial means and personel, among the different branches of agriculture, I shall give you a few figures, related to the past year.

- Animal production : (including : grassland & fodder crops research)	48 %
- Plant production : (agricultural crops) (including : plant pathology and entomology)	23 %
- Ornamental plant breeding and growing :	19 %
- Sea fisheries :	10 %

I'd like to draw your attention to the fact that we are not dealing with research on cereals, sugar beets, fruit and vegetable growing, which is confined to other institutions, e.g. our colleagues in the Centre of Gembloux or the Sugarbeet Institute at Tienen.

Mr. President, Ladies & Gentlemen, I hope this introduction may be sufficient in order to give you a general impression of the importance of this Centre.

Now, with your permission, a few words with respect to your meeting.

I am aware of the fact that an economical seed production of the good cultivars of grasses and leguminous fodder crops is of vital importance. Otherwise the efforts of the plant breeder would remain sterile.

Already, as a student, in 1943 - '44, I was introduced to the matter by Prof. Slaats, who charged me for the so called thesis on the subject : "Aspects of breeding Red clover".

As many of you know, the pod of the Red clover flower, may have one, two or even three seeds. I had to study among others the inheritance of this character. A high percentage of "two-seeded" - pods might indeed improve the seed yield per ha.

As a conclusion, I wrote at that time :
"Through isolation, it would be possible to obtain an amount of seed, having the heriditary ability of producing plants with "two-seeded" - pods. As a result the seed production would increase, where as the plants produced, would be equally vital and productive, if not better". End of conclusion anno 1945.

I recently heard from Mr. van Bogaert that there is still interest in this aspect of the breeding work with Red Clover. (Plant Breeding abstracts 1980).
Of course, the problems you will discuss during these three days, will be much more important than that little one, I had to deal with in my student time.

I am sure, Mr. President, that your meeting and your discussions here at Melle and Merelbeke, will be useful and fertile. I am sure of that, because in my own experience I became more and more convinced of the necessity of such limited gatherings.

I am taking only one example, which was an important one for me. As a very young grass-breeder, I became acquainted with the polycross-method, developed by Dr. K.J. Frandsen, (from Denmark) during an international meeting of grassland-research-workers. Then it was 1948.

That final word, Mr. President, was merely to wish you very good luck with your meeting and a considerable number of useful experiences.

But allow me, to thank very sincerely Mr. van Bogaert, secretary of the organising committee and a plant-breeder with international reputation, for his considerable efforts for the preparation of your meeting.

Also many thanks to Mr. De Groote, Public Relations - Director, for a number of practical arrangements, and to Mr. Buysse, Director of the Animal Nutrition Station for his hospitality.

A. VAN SLYCKEN.
Director of the Government
Agricultural Research
Centre - GENT.

WELCOME ADDRESS

M. Rousseau

Director of the Governmental Plant Breeding Station, Merelbeke, Belgium

Mister President, Ladies and Gentlemen !

It is a great honour and a pleasure for me to welcome you at this Eucarpia meeting for forage plants.

Mr. Van Slycken gave you a general survey of the structure and the activities of the Center of Agricultural Research of Gent. For my part, I will give you an idea of our aims, our various research projects and of the means available to our Plant Breeding Station of Merelbeke.

Research into the breeding of forage plants started in Belgium by the foundation of our Institute in 1932 and I take this opportunity to tell you that we commemorate next year the fiftieth anniversary of its foundation. Its initial assignment was the breeding, the study and the marketing of bred varieties of forage crops.

The foundation of the Plant Breeding Station met a necessity, on the one hand because the grassland hectarage in Belgium covered, and still covers, over one half of the agricultural surface, and on the other hand because there was a complete lack in our country of private companies specialising in the breeding of forage plants.

The Belgian merchants who, at that time, were wholesalers in herbage seed, did not have the material means, nor the philosophy, to undertake their own breeding. Hence they had to obtain their supplies on the international seed market.

When, by the end of the forties, the first varieties of our Station, had been bred and were ready for production and marketing to farmers, the majority of the Belgian trade still preferred to continue with the import and sale of foreign seed, instead of selling improved new varieties and stimulating seed growing in their own country.

Finally, government grants - both for the production and the use of the Station's varieties, known as R.v.P. varieties, for improvement of poor grassland - made those bred varieties competitive with the imported seed.

The managing board of the Station has always aimed at producing varieties intended for Belgian agriculture. We have never been concerned with the behaviour of our varieties abroad, nor engaged in exploiting international markets.

Due to the success of our varieties, however, we were led to grant multiplication rights to particular countries, at their request.

Another objective we are engaged in, is that of stimulating any breeding initiative from the private sector.

We have, for example, put at the disposal of those interested, tetraploid material of fodder beets, as well as herbage strains usable as amenity grasses, both produced by this Station.

As far as work organisation is concerned, the activities are conducted by three departments, viz: breeding, seed production and technology, and grassland and green fodder crop research.

The varieties bred include, among the grasses, Perennial and Italian ryegrass - to which special attention is paid due to their importance for Belgian grassland - as well as timothy, meadow fescue, cocksfoot and smooth stalked meadow grass. The clovers studied comprise white clover and red clover. Among the other fodder plants investigated are fodder beets and turnips. Rape seed, chicory and salsify range among the crops which retain also our attention.

In our breeding work, we use normal accepted methods, but besides we pay much attention, specially for grasses and clovers, to the persistency and the adaptability to the different farming systems.

In recent years we also take into account digestibility. We do not know if we will succeed in breeding varieties combining high forage yields with a high digestibility, but we remain hopeful.

The second department deals with seed production and technology, including growing methods, use of fertilizers and herbicides, etc.

This department is also involved in the production, the certification, the supply of basic seed and the precontrol of the basic seed lots grown both in Belgium and abroad.

Most of the basic and prebasic grass seeds are produced in Belgium, whereas those of red clover are obtained in France. The basic seed is sold to Belgian merchants, who have it multiplied in Belgium or abroad, and to selected foreign agents.

In the countries where our varieties are officially listed, the Station grants sole multiplication rights, but never sole sales rights to selected agents in those countries, in order not to harm the interest of the Belgian seed trade.

The third department of the Station deals with grassland and forage research, and has up to now, played a large part in the improvement of Belgian grassland. Its creation dates back to the foundation of the Station.

Initially, the orientation of that department was purely phyto-sociological.
I enumerate the main topics dealt with in the past -

a) the botanical survey of the most important grassland areas of the country;
b) the finding of the most efficient and most economical methods for improving grassland of mediocre quality;
c) the study of optimum fertilisation in function of the grassland use;
d) the study of the role of white clover in grassland productivity;

e) the effect of high rates of nitrogen fertilisation on both the fodder quantity and quality of the grassland.

At the present time, the following topics are being studied.

A comparison between set-stocking and rotational grazing with respect to milk and meat production.

A comparative study among varieties, involving not only the yield but also the fodder quality. The latter is determined by digestibility tests in vitro and in vivo (sheep), as well as by intake tests with bulls.

Which are the means for realizing our breeding and research programme ?

As we are a government Station, the financial support largely depends on the national budget.

Another source of income is the Station's own funds, which are supplied annually by the royalties received from the seed companies multiplying our varieties. This facilitates the appointment of the staff, the purchase of equipment and the acquisition of land when the government grants are insufficient.

A third source of funds is the National Institute for Industrial and Agricultural Research. This institution has subsidized the Grassland and Forage Research Department since its foundation by giving grants for staff recruitment and purchase of equipment.

Our Institute owns about 40 ha, of which 15 were recently purchased and financed by own funds.

It employs 60 people and 7 of them belong to the scientific staff.

This general view may be an introduction to your visit of the plant breeding station this afternoon; this visit will take place under the guidance of Mr. van Bogaert. I wish you further successful meeting and an agreeable stay in Belgium.

PHYSIOLOGICAL ASPECTS OF SEED PRODUCTION IN PERENNIAL RYEGRASSES

P.D. Hebblethwaite and J.G. Hampton
University of Nottingham School of Agriculture,
Sutton Bonington, Loughborough, Leics. LE12 5RD. U.K.

ABSTRACT

Seed yield in perennial ryegrass is the product of seeds per unit area and individual seed weight. Yield variance in control plots from 30 trials over a 10 year period was best explained by changes in the numbers of seeds harvested per unit area, and was only poorly related to individual seed weight. Of the individual components of seeds per unit area, yield was always more strongly related to seeds per spikelet rather than fertile tiller number per unit area or spikelets per tiller.

This paper therefore presents these data and indicates the physiological and environmental basis for these responses. Ways in which the practical scientist and seed grower can exploit the findings of the physiologist with particular reference to chemical and other husbandry manipulation of the crop are discussed.

YIELD IN GRASS SEED CROPS

Yield in grass seed crops can be divided into two stages:

1) Establishment of the yield potential
2) Utilisation of the yield potential

Yield potential is defined as the number of florets per unit ground area of the crop at anthesis. It is dependent on the number of fertile tillers and the number of florets per fertile tiller, and hence upon the developmental processes of tillering and apical development. The utilisation of the yield potential is determined by the events at and after anthesis; the development processes of pollination, fertilisation and seed growth. These processes determine the number of seeds per spikelet and mean weight per seed (Hebblethwaite, Wright and Noble 1980).

The potential and actual seed yields of a typical S24 perennial ryegrass seed crop are shown in Table 1. The calculated yield potential is based on the number of fertile tillers per unit ground area, the number of spikelets per fertile tiller at maximum tiller number, the mean number of florets per spikelet at first anthesis and the thousand seed weight of the harvested seed (Hebblethwaite *et al*, 1980). Actual yield was less than 10% of the theoretical potential because of a 40% loss of fertile tillers from the maximum and a seed set of only 13%. As this is normal for ryegrass crops, there is a vast potential for increasing seed yield if more of the potential yield can be utilized.

This paper therefore examines these two important yield components and factors which influence them.

FERTILE TILLERS

Langer (1980) citing data from Field-Dodgson (1971) and Spiertz and Ellen (1972), suggested that in perennial grasses, fertile tiller numbers were the most important component of yield. However, Hebblethwaite, Hampton and McLaren (1981) found that in 1979 and 1980, fertile tiller numbers in S24 perennial ryegrass were only poorly related to seed yield (accounting for only 7% of the variance) while the number of seeds harvested per m^{-2} accounted for 91% of the variance. These results are further substantiated by data collected from trials over the past 10 years at Sutton Bonington (Hebblethwaite, *et al*, 1978; Wright and Hebblethwaite, 1979; Hebblethwaite *et al*, 1980) (Table 2).

From this data, we postulate that in perennial grasses, seed yield increases as fertile tiller numbers increase up and until a threshold level is reached at around 2000 tillers m^{-2}. From this point an increase in fertile tiller numbers does not necessarily increase seed yield. This plateau is maintained at least until tiller numbers reach around 4000 m^{-2}, but the point at which further tiller numbers begin to decrease seed yield has not been determined. The physiology of tillering and the management techniques required to achieve a fertile tiller population of between 2000-4000 m^{-2} have recently been reviewed (Hebblethwaite et al, 1980; Langer, 1980).

SEED SET OR NUMBER OF SEEDS PER SPIKELET

Unlike cereals where grain number is determined by the time of anthesis (Gallagher, Biscoe and Scott, 1976), grasses have low self-fertility with cross-fertilization being compulsory in most cases (Gregor, 1928). Consequently they are more subject to genetic variability, and to the vigours of the environment during pollination and seed set. The grass plant is bred for vegetative production and in this context seed production ensures the continuation of the cultivar. This continual selection for vegetative characteristics may have entailed a decrease in the reproductive capacity of grasses (Lambert, 1963). However, it has been demonstrated that the seed producing capacity of a variety could be raised by selection for improved seed set, greater lodging resistance, improved seed retention and a spread of flowering time without impairing the forage producing attributes (Griffiths, 1965; Bean, 1965; McWilliam, 1980) but progress is likely to be slow as the cross pollination requirements of ryegrass make it difficult even to synthesise populations possessing the desired characteristics. Seed production is therefore always likely to occupy a secondary position in breeding programmes (Griffiths et al, 1966). It therefore seems that the crop in its present form is just unable to support seeds on more than half of its floret sites. A number of possibilities could account for this.

a) Environment

The importance of environmental factors and their influence on anthesis, pollination, seed set and seed development has been recently reviewed (Hill, 1980). Emecz (1960) and Hill (1971) have shown that low temperature, low light intensity and rainfall may hinder or even inhibit anthesis. Temperature during anthesis is a major factor in determining daily anthesis patterns (Hill, 1980), and consequently the potential for good pollination and seed set. A recent analysis of climate data and S24 perennial ryegrass seed yield components for 1971-80 at Sutton Bonington showed that mean screen minimum temperature during June (anthesis) for the ten seasons accounted for 72% of the variance in the number of seeds m^{-2} and 48% of the yield variance (Hampton unpublished). Hill (1971) found that low night temperatures decreased subsequent flowering intensity and reduced the number of florets open at peak anthesis in perennial ryegrass, while Vough (1975) has reported that night temperatures below 12.8^{o}C followed by a cloudy day inhibit pollen release in cocksfoot, tall fescue, brome grass and timothy.

The effects of temperature, wind run, culmulative moisture deficit, relative humidity, rainfall and sunshine hours on anthesis, pollination and seed set in grasses requires further study.

b) Floret fertility

It is possible that not all florets are potentially fertile, either because of pest damage (Johnston 1960), or they are morphologically sterile and incapable of developing seed (Johnston, 1960, Hill 1980). Hill (1971) and Burbidge, Hebblethwaite and Ivins, (1978) have shown that approximately 60% of florets are capable of being fertilized. However, by final harvest, a large percentage of these have also been lost either due to shedding, loss of light seed during cleaning and harvesting, or abortion of developing seeds. There are two possible reasons for abortion of developing seeds:

1) Seed growth may be inhibited hormonally

2) The crop may be unable to support seed growth at all the pollinated sites, and some may abort enabling the remainder to form viable seeds. Rowson and Evans (1970) have shown that the presence of mature ovaries and anthers in the basal florets of wheat spikelets can inhibit the setting of grain in the more distal parts. In grasses, the percentage of florets which set seed decreases from the base to the apex of the spikelet and this may indicate inhibition similar to that described in wheat (Burbidge and Hebblethwaite 1978). Basal florets are also better placed in relation to assimilate supply. It is however, not possible to identify a particular cause without further detailed research. The extent to which nitrogen and other husbandry techniques affect floret fertility has been reviewed elsewhere (Hebblethwaite *et al*, 1980; Hill 1980).

c) Transfer of assimilates, water and minerals

It is possible that most floret sites are fertilized and could produce a seed, but that the supply of assimilates, water and minerals available for transfer to the seed is limiting. This, however, is difficult to understand, as the crop has been shown to store large quantities of water - soluble carbohydrates in the stems and leaves (Spiertz and Ellen 1972), even during the seed development phase. The crop also produces large numbers of florets, especially at high levels of applied nitrogen (Table 1), indicating an adequate sink capacity.

If the supply of assimilates is limiting, it is presumably because grasses give high priority to stem, leaves and secondary vegetative tillers for storage of assimilates, and consequently the developing seeds are in direct competition with other sinks. Clemence (pers. comm.) has established that secondary vegetative tillers are a major sink for assimilate produced by the parent tiller. The greater proportion of these assimilates however, come from photosynthetic sites below the flag leaf. Moreover, carbon fixed by secondary tillers may well flow freely to the parent tiller when it has reached an adequate size. The ear, on the other hand, derives a significantly greater part of its imported carbon from the upper stem and flag leaf, is itself the most photosynthetically active of all sites (Ong et al, 1978) and exports very little carbon relative to other organs (Clemence, pers. comm.).

It seems therefore that assimilates are not limiting, but that translocation to the seed from storage or directly from photosynthesis of the flag leaf or ear during seed development may be. As yet, there is little understanding of the factors determining priority of translocation to different organs of the grass seed crop.

Priority is shown within the inflorescence itself. Anslow (1964) has shown that within the inflorescence of ryegrass, the basal spikelets develop slightly heavier seeds than the more terminal ones and within spikelets, seed from the basal florets are heavier than comparable ones developed in terminal florets. Therefore, the location of a floret determines its chances of setting and developing a seed. The development of individual seeds in Italian ryegrass was found to be directly affected by the number present in each inflorescence, and seeds towards the base of the spikelet were found to have higher 1000-grain weights than those above (Griffiths et al, 1973). Earliest ears to emerge in the field also develop the heaviest seed (Anslow, 1964). Grains in upper spikelets of wheat have also been shown to grow more slowly than those below them and receive much less assimilate from both flag and penultimate leaves (Rawson and Evans, 1970; Evans, Bingham, Jackson and Sutherland, 1972). Within the ear of barley rapid growth of central and basal primordia may also limit the supply of assimilates to primordia at the apex tip (Gallagher, 1976) and this could occur in grasses.

Trials at the University of Nottingham (Hebblethwaite and Ivins, 1978) showed that the level of nitrogen applied at ear initiation had no effect on the number of seeds per spikelet or on 1000-seed weight, which is not surprising as all applied nitrogen was already taken up by the plant and possibly utilized for vegetative growth by the stage of seed development. However, nitrogen applied at ear emergence significantly increased 1000-seed weight and seed set, which possibly indicates that nitrogen shortage during seed development is occurring. A number of workers have also found increases in 1000-grain weight as a result of late nitrogen applications (Evers and Sonneveld, 1954; Griffiths et al, 1973) indicating that shortage of nitrogen to the developing seed could be important. Work on wheat has shown that high nitrogen supply between spikelet formation and ear emergence gives greater floret fertility (Liew, 1968) and it seems that ryegrass responds in the same way. However, as delaying nitrogen until after ear emergence also decreases the number of fertile tillers and floret sites (Hebblethwaite and Ivins, 1978), increases in 1000-seed weight and seed set could be a direct result of less competition between developing florets for minerals, water and assimilates.

Lambert (1967) has shown that irrigation can also increase seeds per inflorescence and 1000-seed weight in Phleum pratensis. Irrigation can not only increase yield and numbers of fertile tillers per unit area in S.23 ryegrass but also numbers of seeds per unit area and 1000-seed weight (Hebblethwaite 1977), indicating that water may be limiting and that the crop has several moisture sensitive stages.

d) Lodging

Lodging of perennial ryegrass seed crops in the field normally starts at around first ear emergence and is severe by anthesis (Burbidge, 1977). It is associated both with bending of the lower internodes and with angular growth at the stem nodes. In experiments where the crop has been mechanically supported with wire, increases in seed yield of up to 61% have been obtained (Hebblethwaite, Burbidge and Wright, 1978). In these experiments, prevention of lodging resulted in a higher number of seeds per unit ground area. It has been suggested that ears at the base of the lodged canopy are in a less favourable position for pollination and subsequent seed growth and development than are ears at the top of the canopy (Anslow, 1963).

Because of the prime importance of the agronomic characteristics of herbage varieties, plant breeders are unlikely to be able to make a significant contribution to overcoming the problems of lodging in herbage grasses. However, Griffiths (1965) has shown that clones with a higher lodging resistance could be selected from within S.23 perennial ryegrass. Grazing and cutting can be of some value in controlling lodging (Green and Evans, 1956; Roberts, 1965), but the success of these approaches depends largely on subsequent conditions.

Prevention of lodging has been achieved with Ancymidol (Wright and Hebblethwaite, 1979), a pyrimidine derivative developed for use on ornamentals (Dicks and Rees, 1973). Application of Ancymidol resulted in increases in seed yield of up to 70% (Wright and Hebblethwaite, 1979). The increase in seed yield was associated with a greater number of seeds per unit ground area and per spikelet. By preventing lodging, the crop was able to divert a greater proportion of its total dry matter into the production of seed (Hebblethwaite and Wright, 1979). However, the cost of this chemical prohibits its application on a commercial scale and consequently more recent work has been looking at the potential of PP333 (I.C.I. Plant Protection Division). Application of this chemical has been found to increase seed yield by up to 50% (Table 3). Once again these increases could be explained by significant increases in the number of seeds harvested per unit area and were only poorly related to individual seed weight, number of fertile tillers per unit area and number of spikelets per tillers. Increases in seed numbers per unit area resulted from better seed set (Hebblethwaite, Hampton and McLaren, 1981). Details of the action of this chemical on lodging, tillering, plant growth and development are given elsewhere (Hebblethwaite, Hampton and McLaren, 1981).

e) Optimum time of harvest

Differences in tiller age and time of ear emergence between the component ears of the seedhead population result in differences in date of maturity (Anslow, 1964). In perennial ryegrass, early-emerging ears have a higher number (Anslow, 1963) and weight (Anslow, 1964) of seeds per ear than later-emerging ears, and hence these make the greatest contribution to seed yield. A considerable amount of research effort has been directed toward identifying criteria which could be used to define optimum time of harvest, and use of changes in moisture content, endosperm consistency and seedhead colour have all been advocated (Hyde, McLeavey and Harris, 1959; Anslow, 1964; Hill and Watkin, 1975 ; Pegler, 1976). In perennial ryegrass, seed viability is attained 7-14 days after anthesis (Hyde, McLeavey and Harris, 1959; Hill and Watkin, 1975 ; Pegler, 1976). However, at this time the seed has a high moisture content and low thousand-seed weight. In addition, respiration of the seed during storage may produce sufficient heat to reduce viability (Griffiths et al, 1967). Because percentage seed set and individual seed weight decline from the basal to the terminal florets within the spikelets, as harvesting is delayed so losses of seed associated with shedding become progressively more important (Anslow, 1963; 1964).

Delaying the harvest of S.24 perennial ryegrass (from 40% to 30% moisture content) has resulted in an increased 1000-seed weight (Hebblethwaite et al, 1980). This is attributable either to an indirect effect of shedding of the lighter seeds from the distal florets within the spikelets, resulting in a higher mean weight per seed, or to an increase in seed weight *per se*. However, the increased 1000-seed weight was insufficient to compensate for the reduction in the number of seeds harvested per spikelet. Hence optimum time of harvest, for maximum seed yield, depends upon the balance between loss of seed by shedding from over-ripe inflorescences, and gain in yield of seed from later-maturing inflorescences. Further information on the achievement of this balance can be obtained from Andersen and Andersen (1980).

CONCLUSION

In ryegrass seed crops, better utilisation of the yield potential could most effectively be achieved in two ways: by prevention or delaying of lodging until after anthesis so that seed set can be improved, by increasing resistance to seed shattering.

The latter may well be accomplished by selection (McWilliam 1980), but success with the former is in our opinion more likely to come from the use of growth regulators.

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Table 1. Potential and actual yield components of S.24 perennial ryegrass 1977 (Hebblethwaite *et al* 1980)

Potential yield components	At first anthesis		TSW	Calculated potential yield
Fertile tillers m^{-2} = 3600	Spikelets per tiller	Florets per spikelet	at final harvest	
	18.3	6.6	1.8g	7.8 t/ha
Actual yield components	**At final harvest**		**TSW**	**Actual yield**
Fertile tillers m^{-2} = 2100	Spikelets per tiller	Seeds per spikelet	at final harvest	
	18.2	0.9	1.8g	0.6 t/ha

Table 2. Relationship between seed yield (Y) and: seeds m^{-2} (NS), seeds per spikelet (SS), spikelets per tiller (ST), number of fertile tillers (FT) and thousand seed weight (TSW), S.24 perennial ryegrass, Sutton Bonington, 1971-80

Relationship giving best fit	Statistical significance	Variance accounted for (%)
a) Lodged crop (variance d.f = 16)		
Y=12.4(±2.2)+327.7(±149.9) NS	••	62.6
Y=271.3 ±(113.3)+723.8 (±171.5) SS	•	21.8
Y=-54.9 (±40.6)+ 2129.5 (±761.2) ST	NS	4.6
Y=0.1 (±0.1) + 767.6 (±299.1) FT	NS	2.0
Y=-19.1 (±347.2) + 1139.7 (±646.8) TSW	NS	-6.2
b) Non lodged crop (variance d.f = 8)		
Y=16.8 (±0.7) + 160.8 (±75.6) NS	•••	98.6
Y=641.9 (±187.1) + 625.1 (±417.5) SS	••	54.5
Y=-214.3 (±58.3) + 5830.6(±1055.4) ST	••	58.2
Y=0.5 (±0.3) + 580.9 (±783.5) FT	NS	20.8
Y=-694.3 (±2342.5) + 3294.7(±4446.6)TSW	NS	-11.3

Table 3. The effect of application of PP333 at floret initiation on seed yield and seed number of S.24 perennial ryegrass

Year	Rate ($l\ ha^{-1}$)	Seed yield ($kg\ ha^{-1}$)	Seed no. ($\times 10^4 m^{-2}$)
	0	1926	10.51
1979	1	2589 (34*)	14.72
	2	2880 (50)	16.37
	SED (27 d.f)	148	1.82
	0	997	5.53
1980	1	1264 (27)	7.45
	2	1346 (35)	7.64
	SED (27 d.f)	74	0.51

* % increase over untreated control

Source: Hebblethwaite, Hampton and McLaren, 1981.

RELATIONSHIP BETWEEN VEGETATIVE AND REPRODUCTIVE TRAITS IN RED CLOVER

B. A. Dennis

Department of Crop Husbandry and Plant Breeding,
The Royal Veterinary & Agricultural University,
DK-2630 Taastrup, Denmark.

INTRODUCTION

The seed yield of a red clover plant represents the cumulative expression of four principal components: the number of flower heads per plant, the number of florets per head, the percentage of florets setting seed and unit seed weight. These components differ in terms of relative contribution to total seed yield, in extent of additive genetic variation and in potential response to selection. Breeding for improved seed production will consequently require a knowledge of the importance of individual components, of the interactions between components and of their relationship to agronomically desirable traits such as forage yield and quality. In this paper the interrelations between certain vegetative and reproductive traits are discussed in relation to the indirect effects of a two-way selection programme for fertility in a tetraploid red clover population (Dennis 1975, 1980).

COMPONENTS OF SEED YIELD

Studies in diploid and tetraploid red clover populations have shown seed yield to be positively correlated with seed set, heads per plant and seed weight, whereas the number of florets per head shows little variation and no appreciable correlation with seed yield. In terms of the relative contributions of the different components, seed yield per plant is largely determined by the number of flower heads per plant and to a lesser extent by seed set. Seed weight has generally been found to have little influence on total seed yield (Wioncek et al. 1976, Dennis 1980).

Relatively high heritability values (h_N^2) have been reported for seed yield (0.35-0.79) and for its principal components (heads per plant 0.20-0.40, seed set 0.26-0.88) (Uzik 1971, Wioncek et al. 1976, Dennis 1980). Sufficient genetic variation would appear to exist both in yield and component traits to warrant selection for improved seed production. The response to such selection will, however, depend on the extent to which negative interactions occur between seed yield components.

Although seed yield is greatly dependent on the number of inflorescences per plant, there is a certain amount of evidence to suggest the presence a negative correlation between heads per plant and seed set. Studies in half-sib families of tetraploid red clover have shown a negative genetic correlation of $r_G = -0.41$, and five generations of two-way selection for seed set showed that although positive selection had no effect on the number of heads, low seed-setting plants consistently produced a greater number of heads than plants selected for high seed-setting capacity. A similar negative relationship between seed set and inflorescence number has been reported by Wioncek et al. (1976) and Eskilsson and Bingefors (1972), and there would thus appear to be a risk that the efficiency of selection for improved seed set could be reduced by a decrease in the number of seed heads.

CORRELATIONS WITH EARLINESS OF FLOWERING

Earliness of flowering has been found by several authors to be positively correlated with seed production; early flowering types set more seed than late-flowering types, resulting in an overall selection for earliness (Taylor, Dade and Garrison 1966, Dovrat and Waldman 1966, 1969). Dennis (1980) found flowering date (the date of peak flowering) to be negatively correlated with seed yields in both diploid and tetraploid red clover ($r = -0.41^{***}$, -0.39^{***}, respectively). Path coefficient analysis showed this negative relationship to be due not to any negative effect of flowering date on seed yield *per se*, but to indirect effects on seed set, tillers per plant and unit seed weight. Late-flowering plants were characterized by lower seed weight, fewer reproductive tillers and lower seed set.

Early flowering varieties of red clover, in addition to producing more seed, have been found to be less vigorous and less persistent than late-flowering types (Bird 1948, Taylor, Dade and Garrison 1966). Selection for improved seed production might thus favour earlier flowering genotypes, with a resulting loss of vigour and persistence. This showed up very clearly in our selection programme in which positive selection for seed set increased earliness of flowering by 1 day and decreased dry matter productivity.

DRY MATTER PRODUCTIVITY IN RELATION TO SEED YIELDING ABILITY

Most evidence seems to indicate that dry matter yield in red clover is positively correlated with seed yield, but negatively correlated with fertility or seed set. Uzik (1971) reported a genetic correlation of $r_G = -0.016$ between seed yield and plant weight. Path coefficients showed this relationship to be the result of a direct positive effect of plant weight on seed yield which was partly offset by indirect negative effects of plant weight on the number of reproductive tillers, florets per head and seed set. The tetraploid population studied in our experiments showed a positive phenotypic correlation (r_P = 0.16) between dry matter yield and seed set, but this was apparently due largely to environmental effects as the genetic correlation was slightly negative, although non-significant (r_G = -0.03). Selection for improved seed set in this material led to a 4% decrease in dry matter yields and also to a 6% decrease in plant height. Dry matter productivity under sward conditions also tended to be lower in the high seed-setting line and higher in the low line relative to the parental population.

HIGH DRY MATTER YIELDS AND/OR HIGH SEED YIELDS ?

Sufficient genetic variation exists in both seed yield and its major components to justify selection for improved seed production, although selection for improved fertility (or any other component) alone is unlikely to provide the most efficient means of increasing seed yields. The negative correlations observed between components and between reproductive and vegetative traits were sufficiently low to permit simultaneous selection for several characters, and there appears to be no reason why high forage yields and high seed yields cannot be combined in the same variety.

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Genetic variability in the components of seed yield of Ryegrass species

Gisela Bugge

Institute of Plant Breeding, University of Göttingen, W. Germany

The quantity and quality of the forage produced have in the past decades been the main criteria for selection in the breeding of forage grasses. Perennial and late flowering varieties are very often deficient in reproductive efficiency. But only a good seed yield can determine the success or acceptability of a variety.

The first necessary step for the improvement the seed yield of grass varieties is an investigation of the reproductive system. With this objective we started our programme in co-operation with the "Norddeutsche Pflanzenzucht". I wish to report results of the first year's experiment. 382 clones of Perennial ryegrass and 30 ecotypes and 6 varieties of Italian ryegrass were used in the present investigations. From each clone of Perennial ryegrass 10-15 spikes were investigated. Single plants of the ecotypes and varieties of Italian ryegrass were spaced 30 cm apart at random in square blocks replicated 6 times in one experiment and in another in pots in 2 replications. The following seed production characters were determined for 6 ears per plant: inflorescence length, spikelets per spike, florets per spikelet, seed weight per inflorescence and 1000-seed weight. Further more inflorescence number, seed weight and fertility per plant were also recorded.

The results demonstrate significant differences in all seed production characters studied between clones and ecotypes of Italian ryegrass. The standard error which indicates the variation within a variety or ecotype was different in the characters investigated. The number of inflorescences per plant showed the highest variability in the field test, (variation coefficient 40 %). In the pot experiment the variation coefficient for this character was lower (18 %). This points to a large environmental influence. In the other characters the standard errors were lower, especially in the number of florets per spikelet. The number of florets per spikelet differed hardly within a spike. Only on the bottom and on the top of the ear a slight of variation of florets (1-2) was observed. And also between the six spikes per plant studied, only a small variation was recorded. This indicates that this is the best stable seed production character.

The values of the variation coefficient for seed yield per ear and per plant were greater than those of the other characters. The floret fertility had also a large influence on the seed yield. Herbage grasses have a longer flowering period than the cereals. Fertility and seed set are strongly dependent on the environmental conditions.

The knowledge of the relation between the components of seed yield is more important than an isolated consideration of the individual characters. The dependence of the seed yield on the characters studied are given in the table.

<u>Table</u>: Phenotypic correlations between components of fertility and seed yield in Italian ryegrass (plants in pots)

	Length of spike (cm)	Spikelets/ spike	Florets/ spikelet	Seed yield/ spike	Seed yield/ plant
Number of tillers	0.08	0.15	-0.46**	-0.36**	0.14
Length of spike (cm)	-	0.60**	-0.03	0.05	0.08
Spikelets/ spike		-	-0.13	0.14	0.21
Florets/ spikelet			-	0.69**	0.35**
Seed yield/ spike				-	0.69**

** Significant at the 1 % level

In our investigations we could not find any influence of inflorescences number per plant on the seed yield per plant. We found that with increasing number of tillers per plant the seed yield per inflorescence decreased. This consequently leads to a decrease in the number of florets per spikelet.

The length of ears had indeed a positive influence on the number of spikelets per spike (r = 0.6), but it was not correlated with the seed yield per inflorescence and per plant.

These data demonstrate that of all components only the number florets per spikelet and per spike had a positive influence on the seed yield. The number of florets per spikelet (see table) was significantly correlated with the yield per inflorescence (r = 0.69) and per plant. And a high seed yield per plant is dependent on a high seed yield per inflorescence as shown by the correlation coefficient of $r = 0.69^{**}$.

However the seed yield is not only dependent on the number of florets per inflorescence but also on the fertility (percent fertile florets per spike). In our investigations the average fertility was 41 %, ranging from 3 to 90 % and showed significant differences between the genotypes. In other grass species also fertility is found to be a highly variable character (SLINKARD 1965, LOWE and MURPHY 1955). We obtained a close correlation between fertility and seed yield. The correlation coefficient was highly significant (r = 0.72). LOWE and MURPHY (1955) found similar results in Bromus inermis.

The investigations reported here show:

1. Seed yield could be improved by selection of genotypes with high number of florets per spikelet and a high fertility. However more investigations are necessary,

above all, on the breeding behaviour of seed yield components and of fertility.

2. Genotypes with a higher number of inflorescences per plant and larger inflorescences did not have an improved seed yield. It is not desirable that seed yield be increased through an increase of the size of the reproductive system, because then it is possible that genotypes with these characters may show an adverse effect on growth after the first defoliation treatment, and in the long term may affect perenniality. A major consideration of the breeder who attempts to improve the seed production of a grass variety must be to preserve the varietie´s attributes in forage production.

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Use of male sterility for dry matter yield improvement in Lucerne. Genetic variability for seed yield.

G. Génier and P. Guy

Station d'Amélioration des Plantes Fourragères
I.N.R.A. 86600 Lusignan (France)

Introduction

The dry matter yield amelioration is perhaps the most difficult problem the plant breeder has to solve. We cannot but admit, just like Bocsa (1980), that the genetical progress, as far as yield is concerned, are not very important or even null in France, Hungary, Sweden, ...

The high levels of production, which are already achieved (15 t/ha/year in good conditions) can partly explain this failure. Perhaps some other reasons are connected with floral biology and genetic of lucerne. Lucerne is an allogam plant, and is very sensible to inbreeding. The multiplication of a variety may entail a decreasing of vigour by inbreeding ; this may originate in a high level of selfing in certain conditions (Kehr 1973, Lorenzetti 1981) or in a narrow genetical basis (multiplied hybrid).

These facts and experimental results concerning isolated plants (Guy 1966) and dense parcels (Bötjös 1976) have incited us to use cytoplasmic male sterility in order to improve the dry matter yield. But we shall have to produce seeds. Important differences exist (30 to 50 %) in seeds yield, according to the origin or to the variety itself. Some authors have opposed dry matter productivity with seed productivity. Today, many experimental results reveal a small but positive correlation betwwen these two characteristics. This situation is rather favorable for the plant breeder in the case of wide basis synthetic varieties ; nevertheless, we may wonder what is will be like in the case of an entomophil plant, male sterile.

I. Male cytoplasmic sterility : origins, results

Today four independent cytoplasmic sources are used in France : the first one originates in a material which was used in the U.S.A. at the beginning, and from which we have been able to isolate C 21.4, ms T 11, ms 19.5, ... ; the second one comes from U.S.S.R. : ms R 12, ms R 21 ; the third one comes from Poland : Po 213 ; the last one has been isolated in Lusignan : Lu 18. The whole material is being studied by plant breeders who have been brought together in the ACVF.

We have tested on isolated plants the crosses between all the clones ms and all the maintainer clones. We can only compare separately the ms between each others and the maintainers between each others. The breeding value of the parents for the green yield is very variable. (cf table 1).

Some crosses : (Po 213 x A 11 x F 11(2)) x OR 11 and (21-4 x 1552) x A 11 give better results than the control Europe for two cuts.

Up to this day, sixty or so structures F_1 (double hybrids or hybrid structures having a wider basis) have been tested on parcels. The dry matter productivity results which have been obtained represent in some cases a progress compared to the multiplied synthetic varieties ; yet they are less satisfying than the previsions that were expected (+ 10 to 15 %) on the basis of better hybrid F_1 performances registered in the nursery.

1. The case of double cross

9 DH from a schema such as (ms x maintainer) x (SH with good agronomical value) have been tested without any previous selection aiming at a good SCA between the two partners.

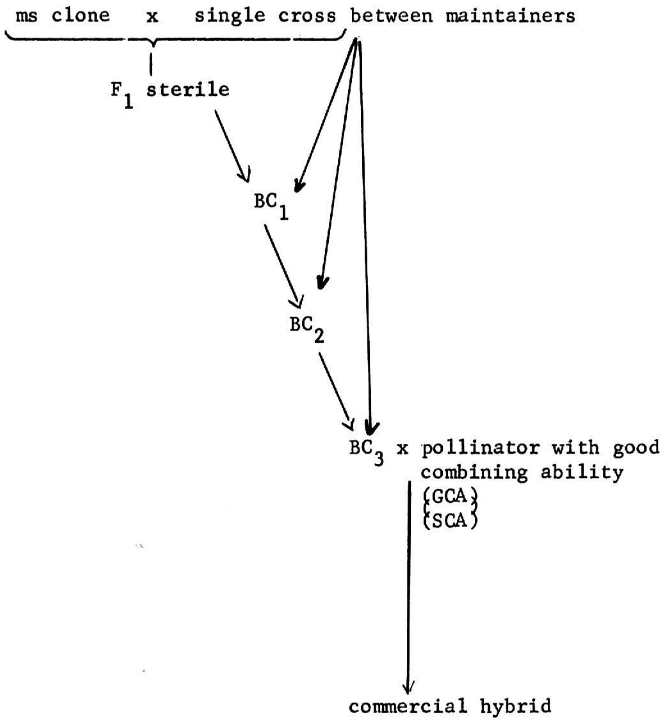
The yearly dry matter productivity evolves between 79 and 113 % from Europe's one ($\bar{x}$ = 90 %, σ_x = 11 %).

2. The case of the F_1 structures whose pollinator has a wider basis

In many cases it has been envisaged to use a still existing commercial variety as pollinator, in order to produce seeds economically simultanate production of 2 varieties).

The present collected agronomical results are only fragments. Given 7 F_1 hybrids, the annual dry matter productivity (A_1, 1980) evolve from 95 to 110 % of Europe's productivity ($\bar{x}$ = 101 %, σ_x = 5). For the present, these structures seem to be more promising.

The pattern existing for the commercialisation of hybrid varieties does not raise any problem in its conception.



II. The production of hybrid seeds

"Alfalfa is a naturally outcrossing perennial that depends upon bees for pollination" Busbice 1972. Can we hope that the insects collecting pollen are to ensure a good pollination of the ms ? Don't the ms or maintainer characters affect the general fertility of plants ? Its seems that the firm Teweless (U.S.A.) has had to face the problem very soon. Bőjtős (1976) stresses the fact that, as far as Lucerne is concerned, the presence of sterility engenders difficulties in seeds production.

We have tested the seed production of ms clones and of different ms hybrid structures. The seed productivity of ms is weak, sometimes very weak. However, certain ms structures reach the worse classic french varieties (cf table 2).

Can we explain these differences in yields ? In our conditions, we have been able to point out that the pollinatoring insects are attracted by the full of pollen and fertile plants while Honey bees are indifferent to them. The clones ms receive 7 times less pollinators than Europe (Gilbert, 1978). The male sterile structures, which are complex, receive twice less pollinators than Europe (Ecalle and Robert, 1981). The most attractive ms are on the same level with the less attractive varieties. This stage of entomophile pollinisation is essential, but every further stage of the seed growth has its genetical control (pool/flower, seed/pool) ; this fact concerns the mother plant as well as the father plant. Bőjtős (1979) has pointed out the importance of pollination for the ms seeds production. Given the high sensibility of fertility to the environment, it is difficult to estimate the criteria of this fertility. The ms and the maintainer are very variable. This variability can reach the control.

One of the most steady criteria of selection is probably the number of seeds per pod and this stands for the fertile plants as well as for the sterile ones ; we must notice that its correlation with the seeds yield varies from + 0,33 to + 0,65, it depends on the experiments.

Conclusion

It seems that the use of cytoplasmic male sterility can make it possible to increase the dry matter yields to a few per cent.

The production of hybrid seeds is to undergo a double handicap :

- a part of the soil is occuped by the pollinator,
- the plants ms are not very attractive for the pollinating insects.

The use of a registred variety as pollenator and an active breeding for seed production should make it possible to reduce the cost of hybrid varieties. These ones are to remain reserved to the most intensive agriculture.

Table 1. Combining ability (spaced plants) of ms and maintainers clones (green yield kg/pl)

ms clones	20/6/79	18/8/79	maintainer clones	20/6/79	13/8/79
P_o 213	2,05	0,167	OR 11	1,66	0,101
C 21-4	1,97	0,162	1552	1,56	0,127
M_s T_{11}	1,61	0,149	A_{11}x F_{112}	1,56	0,130
M_s 19-5	1,41	0,189	T_o 51	1,51	0,130
M_s 49-T	1,33	0,142	K 5-7	1,33	0,151
G I E	1,32	0,115	A_{11}	1,33	0,160
M_s R 21	1,18	0,102	OR 215	0,95	0,127
Lu 18	1,06	0,086			
M_s R_{12}	0,60	0,079			
$\bar{x}$	1,39	0,132		1,39	0,132
control Europe	1,54	0,128		1,54	0,128

Table 2. Seed production of male-steriles structures

. EPR experiment (sowing year 1980)

	%	extremes
Control Europe	100 = 6,36 g/plant	
$\bar{x}$ varieties (list A)	92 %	73 à 114 %
$\bar{x}$ heterozygotes structures ms	65 %	49 à 88 %

. ACVF experiment (total results $A_o + A_1$) (1978 + 1979)

Control Europe	100 = 24,45 g/plant	
ms clones	24	3 à 76

Relationship between dry matter and seed yield in grasses

Sigurd Andersen

Dept. of Crop Husbandry and Plant Breeding,
Royal Veterinary & Agricultural University,
Thorvaldsensvej 40, 1871 Copenhagen V, Denmark

Griffiths et al. (1980) reported large differences in seed yield between individual plants in different grass species and varieties. This might suggest that good seed-producing varieties can be bred by the simple selection of plants with high seed yields. Many plant breeders, however, expect a negative correlation between dry matter production and production of seed.

Such negative correlation between dry matter and seed is difficult to demonstrate, as only varieties with a high production of forage are accepted for certification and distribution. The variation in dry matter production of commercial varieties is rather small, and information about seed yield is limited, unless seed of a variety is produced for sale.

The correct classification of varieties in terms of productivity is a big problem. Some varieties give high dry matter yields in one country or in some environments, whereas yields are lower in other countries or under other conditions. The yield of seed depends much on the management of the seed crop, and a high variation was found in field trials of varieties for seed production (Nordestgaard & Juel 1979).

Factors contributing to seed yield or limiting seed yield.

The components of seed yield are number of fertile tillers (inflorescences), florets per inflorescence, seed per floret, % fertility (florets developing into seed) and 1000-seed weight. Griffith et al. (1966, 1980) found a positive correlation between seed yield per plant and a) % fertility, b) number of inflorescences, c) yield per inflorescence and d) 1000-seed weight. The correlation was also positive between yield per ear and a) fertility, b) florets per inflorescence and c) 1000-seed weight.

We have only very limited information about the correlation between dry matter yield and these components of seed yield, but we may expect a negative correlation between the number of fertile tillers and feeding value. Digestibility is likely to be lower in a variety with a high proportion of fertile tillers.

Although it would seem possible to breed varieties with a high seed yield per ear, i.e., high number of florets, many seeds and a high seed weight, attempts to combine high seed yield and high forage production in one variety may well encounter difficulties due to intraplant competition. Different parts of the plant compete for available sources of carbohydrate, and new tillers of high yielding forage varieties have a high competitive ability.

The factors mentioned above contributed directly to seed-yield, but other factors may limit the yield, e.g., prolonged time of anthesis. It is very important that the flowering time is short and that anthesis occurs in all inflorescences at the same time. Andersen & Andersen (1980) have reviewed the importance of choosing the right time for harvest. They showed that maximum yield can be achieved at a very few days only. If harvest is done too early, we "lose" unproduced dry matter of seed, if we cut too late, we lose seed by shattering. We will never be able to harvest the total potential yield, but the loss of yield increases with the spread in ripening time.

Severe lodging at anthesis will limit fertilization of the florets, and in a severely lodged crop seeds will develop badly in shoots near the ground and will often be severely infested with fungus. Early lodging may be considered as bad, whereas lodging near harvest time could protect the crop against shattering.

All species of the grass family are liable to shatter. Festuca rubra shows a relatively low shattering ability whereas Lolium multiflorum and Festuca pratensis always shatter heavily. Within species intervarietal differences in seed retention have been demonstrated by Griffiths et al. (1966, 1980).

Investigations on seed contributing factors in Lolium perenne.

At the Danish Agricultural University we had experiments with seed production 1980 and 1981. 27 diploid varieties of Lolium perenne were sown in large plots without replications 1980, and we found large differences in seed yield between early and late varieties:

	9 early varieties	9 medium varieties	9 late varieties
Kg seed/ha, average	1401	1146	864

The same varieties were tested again in 1981, but yield differences were small and earliness appeared to be of less importance than in 1980.

In order to study the effect of other factors contributing to seed yield, we divided the varieties into three groups according to the size of one of the following factors 1) seed/ear, 2) 1000-seed weight and 3) % shattering. Each group contained 9 varieties, and included 3 early, 3 medium and 3 late varieties. Group means are given below.

Mg seed/ear	Kg seed/ha	% shat-tering	Kg seed/ha	1000-seed weight	Kg seed/ha
82	1222	35.5	1082	2.52	1247
70	1107	30.4	1169	2.26	1136
61	1082	25.0	1161	2.03	1028

As a supplement to field trials in large plots, 12 varieties were planted in 1 m^2 plots with 100 plants per plot. These varieties were tested in the same way as varieties from the field plots, and gave the following results. Tiller number and yield were determined in samples from 0.36 m^2:

Number of tillers	Seed gr.	Mg seed/ear	Seed gr.	% shat-tering	Seed gr.	1000-seed weight	Seed gr.
804	19.4	27.3	20.6	25.3	20.2	2.09	17.2
731	15.3	22.9	16.7	22.8	15.8	1.70	16.8
650	15.4	18.7	13.0	18.1	14.2	1.57	14.2

These results show that a high number of tillers, heavy ears and a high 1000-seed weight were important components for a high yield. A curious thing was that a high degree of shattering was associated with high yields in the small plots.

Shattering was measured by shaking approximately 300 ears for one minute on a machine originally constructed and used for cleaning fodder sugar beets. The ears of a sample were sorted into five groups according to ripeness and given a score from 1-5. They were cut and treated when the stage of ripeness was between 2.75 and 3.50. The following scale was used to determine the stage of ripeness:

1. Completely green inflorescence
2. Rachis green, spikelets not completely green nor completely yellow
3. Rachis and spikelets not completely green nor completely yellow
4. Rachis not completely green nor yellow, spikelets completely yellow
5. Completely yellow inflorescence.

The stage of ripeness was averaged over all spikes in the sample except very small, green inflorescences. The standard deviation around this average was used as an indication of the unevenness of-ripening.

Some preliminary results from 1981 are shown below. The varieties were divided into three groups as in 1980, and there are 11 or 12 diploid varieties in each group. Results for 6 tetraploid varieties are also included.

Mg seed/ear	Kg seed/ha	% shat-tering	Kg seed/ha	Unevenness of ripening	Kg seed/ha
Diploid varieties					
108	1340	44,7	1030	0,90	1120
92	1100	31,0	1200	0,62	1140
73	1280	20,2	1350	0,38	1330
Tetraploid varieties					
142	1050	38,5	1050	0,41	1050

In this experiment high seed yielding varieties were characterized by high seed yields per ear, low shattering ability and even ripeness, but within the groups variation in seed yield was very high.

Field experiments with Lolium perenne.

The seed yield of 10 varieties of Lolium perenne was determined in nine Danish experiments 1975-1977, six of these experiments included three different harvest dates for each variety (Nordestgaard & Juel 1979). The highest yield was produced by the early varieties Verna (1540 kg/ha) and Melino (1490 kg), and the lowest yield by the late variety Pelo (1130 kg), but otherwise there was no correlation between earliness and seed yield. An early variety, Gremie, yielded only 1270 kg whereas the late variety Vigor produced 1300 kg. Unfortunately forage yields were not determined in these experiments but the same varieties were tested in other trials in one or several countries. A comparison of the yield of dry matter with results from the experiments with seed production shows the following relationship:

Number of varieties:	3	3	4
Yield of dry matter (estimated relative figures):	103	100	98
Yield of seed, kg pr ha	1310	1400	1330

The classification according to yield of dry matter is mainly based on publications from Danish experiments (Sorter af landbrugsplanter), but results from trials in Great Britain (Farmers leaflets nr. 16), The Netherlands (Beschrijvende Rassenlijst) and Germany (Beschribende Sortenliste) have also been consulted.

The results will depend very much on the classification of Verna and Gremie. The number of varieties is too small to allow any conclucion, but the figures do not indicate the presence of any strong correlation between seed yield and dry matter production or earliness.

Seed production at farms

As we have only little information about the correlation between yield of dry matter and yield of seed from the same experiments, we may try to compare figures from different sources. The Danish list of varieties (Sorter af landbrugsplanter) gives relative values for dry matter production, and the Danish Associations of Seed Producers issues annual statistics for relative seed yields of different varieties in commercial fields (Sortsundersøgelse). In table 1 figures are gathered from the official test of varieties of Lolium perenne, yield from seed fields, and figures from own trials 1980-81. The yield of dry matter is calculated as relative figures and as average of the yield of first and second years ley. The seed yield of each variety is average of more than 10 seed fields, and the varieties used for calculations are mainly old varieties, as we do not have information of seed yield of new varieties which had been tested recently and approved for certification.

The seed yield of early varieties is generally higher than the yield of late varieties. The varieties are not very different in yield of dry matter for forage, but two varieties yield less than average and two varieties produce more. The low yielding are Dux (medium) and Victoria (medium). The high yielding varieties are Melino (medium) and Vigor (late). The yield of seed is somewhat higher of the varieties Dux and Victoria than of Melino and Vigor, but the relative high yield of seed of Melino and Vigor shows that it should be possible to breed varieties with a high dry matter production and a high seed yield.

A classification was also made according to degree of persistance in Danish variety trials. Four varieties with low persistance, Dux, Lenta, Presto, and Belida, were compared with four varieties with relatively high persistance, Cropper, Verna, Amado, and Melino. The yield of dry matter is almost the same for these two groups, but the seed yield was higher in varieties with a low persistence. Intraplant competition between fertile tillers and new vegetative tillers probably affects plant longevity and seed yielding ability more than the yield of dry matter.

The variety Gremie is listed separately. Gremie is classified as extremely persistent, but the yield of seed was found to be relatively low in this survey as well as in the trials carried out by Nordestgaard & Juel (1979). This could be due to the low seed retention in this variety; the degree of shattering was found to be as high as 52% in our trials.

The importance of 1000 seed-weight and unevenness of ripening is not very clear, but some varieties with a low yield of seed also possessed small seeds.

Table 1. Yield of dry matter of Lolium perenne in official Danish variety trials compared with yield from seed fields.

Group and number of varieties	DM	Seed yield		Per-sist	Ripe-ness	Shat-ter.	S-W
1	2	3	4	5	6	7	8
9 early, diploid	100	105	942	5½	0,90	32	2,41
9 late, diploid	99	92	532	7	0,73	31	2,12
6 tetraploid	99	106	103	5	0,62	35	3,90
2 diploid low DM	92	117	142	4½	0,81	25	2,20
2 diploid high DM	104	103	320	7½	0,72	32	2,04
4 early, low persistence	99	113	601	4	0,87	26	2,44
4 early, high persistence	101	101	485	6½	0,90	32	2,37
1 early, high persistence	99	85	16	8	1,08	52	2,42

Explanation to the columns:

1. The group early varieties includes varieties with medium earliness.
2. Relative values for yield of dry matter in Danish trials
3. Relative values for seed yield on Danish farms 1973-79.
4. Number of seed fields.
5. Score for persistence in variety trials.
6. Unevenness of ripeness. Average of 3 experiments.
7. Percentage of shattering. Average of 3 experiments.
8. 1000 seed-weight in experiments 1980.

A vertical line indicate significant difference (5%) within a group.

Yield of dry matter and yield of seed of Lolium multiflorum and Dactylis glomerata are compared in table 2. It is difficult to show any negative correlation between dry matter and seed production in these species.

The yield data in table 1 indicate that there could be a negative correlation between dry matter and seed yields, possibly between persistence and seed production, but the correlation is not very high. There are

Table 2. Relative yields of dry matter of Lolium multiflorum and Dactylis glomerata in official Danish variety trials compared with seed yields from commercial seed fields.

Species and number of varieties in each group	Yield of dry matter	Seed yield	Number of seed fields
Lolium multiflorum			
3 diploid, low DM yield	96	95	512
3 diploid, medium DM yield	100	100	108
3 diploid, high DM yield	104	92	140
2 tetraploid	98	108	93
Dactylis glomerata			
3 with low DM yield	94	97	69
3 with medium DM yield	98	102	265
3 with high DM yield	100	99	153

examples of persistent varieties which produce high yields of dry matter and high yields of seed, e.g. the results for the Lolium perenne variety Melino in Danish variety trials and in Danish seed fields.

An example of the opposite is the Lolium multiflorum variety Lemtal which had a relative figure of 105 at the official tests for production of dry matter, but a relative figure of 80 for seed yield.

Another example is found outside the grasses, in Trifolium repens. The variety Milkanova was selected from Milka and the improvement in yield of dry matter is 5%, whereas the decrease in seed yield is 13%. (Sorter af landbrugsplanter, Sortsundersøgelse).

Conclusion

Several components contribute to seed yield: number of fertile shoots florets and seed/floret, % seed set, and 1000-seed weight. Other factors limit seed yield: Variation in flowering time, lodging and shattering of seed. The variation in these factors is high between individual plants. The plant breeders could easily select for higher yield, but we must expect competition within the plant between tillers and inflorescences. A selection for high seed yield could lead to a selection for lower competitive ability of tillers and a lower yield of forage dry matter.

We have very limited information concerning the relationship between dry matter productivity and seed yield as plant breeders will not normally release a variety onto the market unless the dry matter yield is high and the yield of seed is at a satisfactory level. Our experience and present knowledge indicate a modest negative correlation between yield of seed and yield of dry matter or persistence. The correlation is not high enough to eliminate the possibility of breeding varieties with a high production of dry matter and a high yield of seed.

Suitable climatic conditions are necessary for seed production. The seed yield of a variety depends both on the climate in which the variety is grown and on the management of the crop. This problem has not been discussed in this paper, but we must expect an interaction between variety and conditions of growth.

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Relationship between dry matter and seed yield in leguminous forage plants.

F. Lorenzetti

Istituto di Allevamento Vegetale, Cattedra di Genetica Agraria, Università degli Studi di Perugia (Italy)

Introduction

Good varieties must be good seed producers because even the best variety has no value until its seed is not available to the farmers at a reasonable price.

Until now forage plant breeders have tried to improve forage yield and quality, leaving to others, mainly the agronomists, the task of solving problems related with seed production of improved varieties. Consequently, the pertinent literature is based on genetics for forage improvement and agronomy for seed production.

I have participated at all but one meetings of our Section since 1967, and in reviewing the reports, I have not found any paper on seed production; the relationship between forage and seed yield has been totally ignored. It is interesting to note that the subject was not even considered at the Dublin meeting of 1972 where the main topic was: "Evaluation of breeding material in herbage crops".

The same problem exists with the Proceedings of the International Grassland Congresses, where the Section "Breeding and seed production" is rich on forage improvement but poor on seed production.

In order to obtain first hand information, I requested help from many colleagues, but found from their responses for which I thank them very deeply, a general lack of experimental data.

The purpose of my report is to verify the fact that information is actually meagre and if the philosophy which has guided our research work on forage and seed production is still valid.

Dry matter and seed yield in leguminous forage plants.

The amount of dry matter transferred to the seeds represents less than 10% of the crop in leguminous forage plants; in annual food legumes, seed dry matter may represent as much as 50%.

The relationship between dry matter and seed yield can be considered from three main points of view:

1) the possibility of simultaneous selection for dry matter and seed yield;
2) the amount of self-fertilization in relation to forage yield;
3) dry matter and seed yield in the crop grown for seed;

In the following pages the subject will be discussed considering the most important perennial legumes for European agriculture: 1) lucerne (Medicago sativa L.),2) white clover (Trifolium repens L.),3)red clover (Trifolium pratense L.), 4) birdsfoot trefoil (Lotus corniculatus L.). The original idea was to consider also,sainfoin (Onobrychis viciaefolia Scop.) and sulla (Hedysarum coronarium L.), but was abandoned because of a total lack of information.

Knowledge of seed production components and their impact on seed and dry matter yield, is the first step in understanding breeding strategy.

Seed production components in leguminous forage plants.

Seed potential of a forage legume crop depends on the number of ovules per square meter. For practical reasons this potential is mainly evaluated on the basis of flowers per square meter which,in turn, depends on the following components: 1) plants per square meter; 2) stems per plant; 3) inflorescences per stem; 4) flowers per inflorescence. These components interact with each other quite strongly and the number of combinations giving the same result is enormous. Also, they are largely dependent on environment and management as it is shown by the following examples.

In lucerne stems/acre, racemes/stem and racemes/acre were not significantly affected by the varieties used (Pedersen et al., 1972). With 5 and 20 Kg/Ha of seed Guy (pers. com.) has obtained 8 and 4 stems per plant, 60% and 32% stems bearing inflorescences; 5.4 and 3.5 inflorescences per stem. In the same species Bonciarelli (1962) with 5, 10 and 14 plants/m^2 counted 22, 13 and 12 stems per plant while the numbers of racemes per stem were 27, 25 and 22 respectively. No differences were observed in the number of flowers per raceme.

In red clover with 2 and 6 Kg/Ha of seed Stoddart (1961) observed 44 and 90 plants per square meter, 14 and 5 tillers per plant, 3.2 and 2.4 heads per tiller with a total of 2060 and 1038 heads per square meter, respectively.

In table 1 data on flowers per square meter, observed in common fields, are reported; seed production potential is actually enormous ranging from more than 1000 Kg/Ha in white clover to an astonishing 12000 Kg/Ha in lucerne. The first steps to pass from potential to actual yield are pollination and seed development to maturity. Pollination is universally believed <u>the</u> key to herbage legume seed production. In California lucerne seed producers pay more than $100/Ha to beekeepers for 5-7 beehives.

Fertilization and subsequent seed development are commonly expressed in many different ways: 1) pods per flower, 2) seeds per flower, 3) seeds per pod, 4) seeds per ovule. It would be practical to standardize the method using, for example, pods per flower <u>and</u> seeds per pod <u>or</u> seeds per ovule, the latter being more reliable from a biological point of view. How much the ratio seeds/ovules depend on fertilization and/or post fertilization abortion is a matter to be clarified. The amount of seed which is actually harvested also depends on seed weight and the ratio between harvested and produced seed; the first character is quite stable, while the percentage of seed harvested varies depending on species, weather, maturity and harvesting equipment.

At the end of the seed production process the actual yield is only 6-35% of the original potential.

It is difficult to quantify the relative weight of seed production components. To demonstrate this I have prepared table 2 specifically to show that from literature in general, profuseness of flowering and pollination-fertilization appear to be the main components of seed production.

Each component of table 2 can be improved by genetic and/or agronomic means, the latter including pedoclimatic conditions and insect control.

It appears from table 2 that herbage legumes seed production is mainly dependent on agronomic situations. By only accepting this point of view, it is possible to explain why seed production of lucerne varieties adapted to north central, north eastern and the Corn Belt of the USA goes from 1 to 10 depending if seed multiplication is made in the area of adaptation or in California and Oregon.

The importance of non genetic factors in herbage legume seed yield is also underlined by results of experiments carried out in Britain with S 100 white clover (Evans and Davies, 1978). In this case the estimated yields resulted in the ratio of 1:1.5:2 in three experiments harvested in the same year, and within a distance of 1 Km, with only slight differences in management and assessment techniques.

With reference to white clover it has been said that seed yield is mainly influenced by soil type followed by weather and then management (Lay, 1980). Soil type is as important for herbage legumes seed production, as weather is for grasses.

In herbage legumes not only the number of potential seed sites is enormous in comparison with actual yields, but also dry matter yield transferred to seeds is a very low fraction of the total. Therefore, in the plant itself we find both conditions to greatly improve seed production. In order to obtain high seed yields we need plants with a phenotypic architecture quite different from plants that are able to give high forage yield, but it is impossible to obtain the two ideotypes simultaneously. We must select genotypes which under different sets of agronomic and environmental conditions are able to give

Tab. 1 SEED YIELD COMPONENTS IN LEGUMINOUS FORAGE PLANTS

	LUCERNE	WHITE CLOVER	RED CLOVER	BIRDSFOOT TREFOIL
Plants per square meter : Tillers per plant : inflorescences per tiller	Very variable with environment and management			
A) INFLORESCENCES/M^2	3,750	400	600	400
Flowers per inflorescence	16	75	105	7
B) FLOWERS/M^2	60,000	30,000	60,000	2,500
Ovules per flower	10	6	2	40
C) OVULES/M^2 (SEED POTENTIAL)	600,000	180,000	126,000	100,000
Ripen seeds/ovules (%)	8	50	25	40
D) SEEDS/M^2	48,000	90,000	31,500	40,000
1000 seeds weight (G)	2	0,6	1,6	1,2
E) SEED YIELD/M^2 (G)	96	54	50	48
Harvested seed/produced seed (%)	70	70	80	60
F) SEED HARVESTED/M^2 (G)	67,2	37,8	40	26,8
seed harvested/ha (KG)	672	378	400	268

Tab. 2 RELATIVE WEIGHT (%) OF SEED PRODUCTION COMPONENTS IN LEGUMINOUS FORAGE PLANTS AND MORE IMPORTANT FACTORS FOR THEIR IMPROVEMENT.

COMPONENT	RELATIVE WEIGHT (%)	MAIN FACTORS
PLANTS/M^2	35	AGRONOMIC
TILLERS/PLANT		AGRONOMIC
INFLORESCENCES/TILLER		AGRONOMIC
FLOWERS/INFLORESCENCE		GENETIC
EGGS/FLOWER	1	GENETIC
SEEDS/EGG	55	AGRONOMIC
SEED WEIGHT	2	GENETIC
SEED HARVEST	7	AGRONOMIC

high forage or high seed yield. It follows that selection for forage yield associated with seed yield is selection for plasticity.

Forage and seed yield during selection work.

Selection for seed production has given contrasting results.
In lucerne intervarietal variability for seed yield has been found wider than for hay yield (Bocsa,pers. com.).
In selection experiments in some cases there has not been found any relationship between seed yield of parental clones and seed yield of the progenies (Chesneaux et al., 1970, Heinrichs, 1965). In other cases differences in combining ability for seed production, (Bolton, 1948, Nielsen and Nielsen and Mortensen, 1963), or close association between seed yielding ability of parents selected in dense stand and seed yield of progenies were observed (Nielsen et al., 1966).Combining ability estimates were found to have been influenced by environmental conditions in which crosses were made (Haaland et al., 1975). In practical selection work an increase of 57% over base population was obtained (Nielsen and Andersen, 1973).
Heinrichs (1965) has not found any relationship between seed yield and dry matter yield, therefore concludes that the two characters can be selected independently.In other experiments selection for seed yield has brought about an increase in dry-matter yield (Bolton, 1948, Nielsen et al., 1966). Seed yield has been found to be associated also with plant height (Nielsen and Mortensen, 1963), or with both the main components of forage production: plant height and stem number (Liang and Riedl, 1964; Rumbaugh et al., 1970).
Experiments carried out in France and in other countries (Guy, pers. com.) have shown constantly a positive correlation between seed and dry matter yield so that Guy et al. (1975) believe that selection of tall plants,resistant to lodging,with many tillers and high fertility, and with long inflorescences should permit the obtaining of high forage combined with high seed yield.
Forage yield of a group of clones grown in six midwestern Experiment

Stations of USA did not correlate with seed yield of the same clones grown in Idhao and California (Rumbaugh et al., 1970). Prediction of seed yields at diverse localities would be difficult without actual tests (Pedersen and Hurst, 1963).

In white clover high heritabilities were observed for seed production and its components (Brigham and Wilsie, 1955; Van Bogaert, 1977); a large variability has been observed for profuseness of flowering and seed production (Ahlgren and Sprague, 1940, Dessureaux, 1950, Evans and Davies, 1978).

In 45 crosses a positive correlation, low but significant (r=0.3) was found between seed and dry matter yield showing that high seed yield is not incompatible with high dry matter yield (Brigham and Wilsie, 1955).

Some authors maintain that white clover forage and seed production are in competition because from each stolon node a new stolon or a flower head can originate, but never both. In this way, plants which flower profusely produce few stolons and therefore are less peristent and productive (Gibson, 1957; Thomas, 1980).

In red clover, seed production has shown heritabilities from low (Taylor et al., 1966) to high (Uzik, 1971). In this particular species seed production is associated with earliness but early types are less productive and persistent than later ones (Williams, 1927; Bird, 1948). Higher seed production of early clones accounts for the shifts observed in red clover varieties which have multiplied in southern locations (Taylor et al., 1966, 1979). It has been shown that this shift can be avoided by harvesting seed after a pre-cut (Stanford et al., 1962). In plants of the same maturity group, a positive correlation
Nüesch
has been observed between seed and dry matter yield (Neush, pers. com., Sjodin, 1980).

In tetraploid red clover, which has very peculiar seed production problems, selection for seed production is effective (Julen, 1971, Dennis, 1980). Selection for seed production has brought about the reduction of plant height and vigour, as well as a shift toward earliness; the increased self-fertility of selected genotypes has not influenced forage yield of progenies.Seed yield resulted positively correlated with stem number (Dennis, 1980).

In birdsfoot trefoil large differences have been observed on vigour and seed yield but two cycles of selection were ineffective (Peacock and Wilsie, 1960). Also in this species seed yield is associated with dry matter yield (Miller et al., 1975). Tomes (1981) has obtained a steady increase in seed yield in four cycles of selection which was accompanied by a lower productivity due to a reduction in persistence.

Amount of selfing in seed production and dry matter yield.

With self-incompatible species (white clover, red clover, birdsfoot trefoil) all plants must originate by cross fertilization and therefore have, in this respect, the same yield potential. In species with a rather high rate of self-fertilization (i.e. lucerne) the relationship between forage yield and seed production are more complex so that in lucerne, many researchers were concerned with the relationship between self-fertility,seed yield and forage yield.

Seed yield has been found to be positively correlated with self-fertility and pollen production; therefore because of the heavy inbreeding effects observed in lucerne, dry matter yield potential must be carefully controlled during selection for seed production (Busbice et al., 1975, Melton, 1979). In other experiments self-fertility has been found positively correlated with cross-fertility (r=0.71); no correlation was observed between self-fertility of parental clones and vigour of the progenies (Wilsie, 1951).

In 18 clones of lucerne, seed production of progenies was correlated with cross-fertility and seed production of parental clones (r=0.48 and 0.61, respectively). Forage yield did not correlate with fertility or with seed yield of parents. It was concluded that selection for seed production is effective and does not influence forage yield (Pedersen, 1953). In all above researches lucerne was considered a predominantly cross-fertilized species with an amount, in natural conditions, of 10-15% of self-fertilization.

In 1961 Lesins showed that the amount of self-fertlization can be as high as 40-50% and concluded that in many areas the problem of the amount of self-fertilization in lucerne had to be reconsidered. Later on, in 1964, Hanson et al., on the basis of extensive trials carried out throughout the USA, found that lucerne seed produced under isolation cages with bees was highly self-fertilized. Other studies at population level comparing distribution curves for quantitative traits of random progenies of the same variety obtained by 1) controlled selfing; 2) controlled crossing and, 3) open pollination, have shown that lucerne seed produced in central Italy is a mixture of cross- and self-fertilized seed in the ratio of about 2:1 (Lorenzetti and Brandi, 1978).

Spaced plants of selfed progenies of lucerne show an inbreeding depression in the order of 30% in terms of dry matter yield; it follows that a different amount of selfed seed in lots of the same variety produced under different environmental and pollination situations, could influence forage and seed yield of the following crop.

In *Vicia faba* a high presence of pollinators has been suggested in the field where commercial seed is produced to avoid negative inbreeding effects in the next generation (Frusciante and Monti, 1980).

The question on the effect of the amount of selfed seed on forage yield of ordinary meadows is a matter still open to discussion.

Relative to Ladak (=100) mixtures 3:1 and 1:1 of Ladak and S_1 seed from the same variety yielded 96 and 90 respectively (Tysdal e Kiesselbach, 1944). A mixture of S_3 and open pollination seed in the ratio of 60% to 40% can yield as much as open pollinated plants of the same population (Parrini, 1963).

In pearl millet (*Pennisetum americanum* L.K. Schun)the average production of 9:1, 4:1 and 1:1 mixtures of hybrid to inbred seed did not differ from that of 100% hybrid seed when seeded at the standard rate of 4 seeds/2.5 cm of row (Burton, 1948).

Competition among plants of different vigour may explain these results (Tysdal and Kiesselbach, 1944, Burton, 1948, Parrini, 1963, Hanson et al., 1964). In many environments, central Italy for example, at sowing time farmers put in the soil 1500-2000 lucerne seeds per square meter, while at the end of the first year only 250-300 plants can be found (Vivenza, 1914); the disappearing plants are mainly of selfed origin (Kehr, 1973, 1976). Preliminary data obtained in our Institute shows that in two year old meadows, only vigorous plants similar to plants from controlled crossing, can be found (fig 1)

If we accept that in all lucerne seed stocks a 20-25% of superior genotypes are always present and that forage yield ultimately depends on them, we can explain why differences among progenies observed in spaced plants disappear in dense stand and, more important, why breeding lucerne for productivity has not succeded in improving adapted populations (Lorenzetti, 1967).

Competition minimizes inbreeding effects and reaches two important objectives: 1) a rather stable forage yield and 2) a uniform genetic basis for new seed production.

A better knowledge of the genetic composition of lucerne seed lots and its effect on forage yield seems to be a prerequisite in explaining the failure of breeding for productivity and consequently, in indicating new ways for seed production and breeding.

Dry matter and seed yield in the crop grown for seed.

Maximization of seed yield in herbage legumes crops requires, first of all, a high number of potential seed sites, and therefore flowers, per square meter. The main objective for good management of seed production is to promote maximum node and subsequent flower-head development over the shortest time span to ensure high yields and minimum seed loss at harvest. In white clover high temperature and long days results in high rates of node and flower head development (Clifford, 1980).

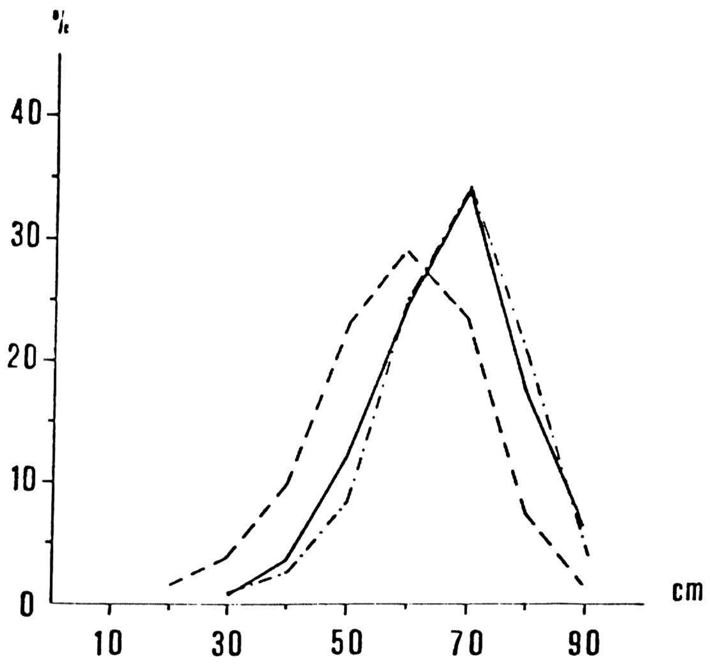

Fig. 1 - Distribution curves of the heights (cm) of lucerne plants from selfing (- - -), crossing (——) and two year old meadow (- · -)

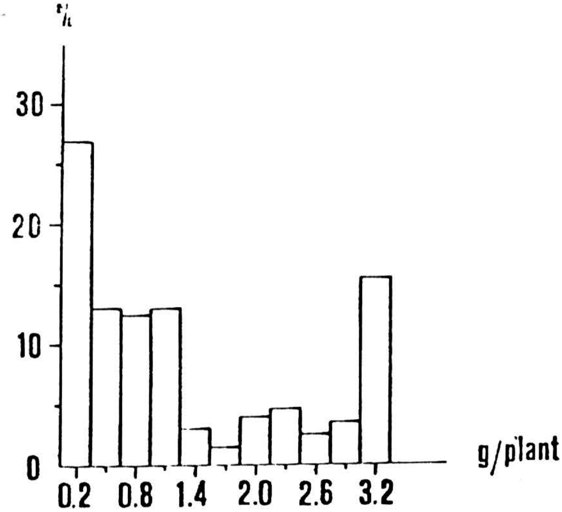

Fig. 2 - Green matter yield (g/plant) of the regrowth in a lucerne stand (1600 seeds/m²) obtained with a mixtures of seeds from controlled selfing (30 %) and crossing (70 %)

It is difficult to combine high forage and high seed yields in the same crop because:

1) high forage yields can be obtained only in very dense stand, which also gives better quality products while profuse flowering is typical of spaced plants;
2) pedoclimatic conditions which favour forage yield are not the same which favour seed yield. In fact, the best season for forage yield is spring, while the best for flowering is summer.

The conflict between seed and forage yield is usually solved by special techniques for seed yield which are based on:

1) a lower rate of seed distributed in spaced rows, or utilization for seed production of old, thinned meadows;
2) utilization of the first cut for forage and the regrowth for seed production.

The above points can not be generalized because, for example, late varieties of red clover produce much more seed on spring growth than on regrowth (Stoddart, 1961).

Without going into details it must be said that agronomical interventions interact with varieties so that for each population a suitable seed production technique should be studied in each particular environment.

In conclusion, high dry matter and high seed yield can be combined in the same variety but not in the same crop. Managemnt for seed production is so different from management for forage production that the two types of products must be considered as alternatives in a modern agriculture. Seed as a by product of ordinary meadows is an indication of an archaic agriculture which does not fully utilize the advantages of the more advanced technology.

A review of the principles and practices on which management for forage and seed production are based can not be done here; it requires the expertise of physiologists and agronomists who should become much more involved with the problems of seed production if they are to be satisfactorily solved.

Conclusions

In leguminous forage plants selection for seed yield does not seem incompatible with selection for forage yield. The indeterminate growth habit of the species allows potential inflorescences to be proportional to size and, therefore, to forage yield of the plant. It is significant that seed yield has been found almost always associated with forage yield.

Differentiation of axillary buds can be maximized by environment and agronomic practices which must be tailored to individual varieties. Forage legumes are still "wild" species for seed production because breeding work for this character has not been carried out in a consistent amount.Furthermore, the genetic structure of herbage legume varieties is such that their seed yield potential should be intact. Synthesis of 6-12 unrelated genotypes selected on the basis of their combining ability is far from extreme selection for particular traits which may reduce fertility (Mather and Harrison, 1949, Cooper 1960). Specific selection for high seed yield contains the risk to bring about undesirable characters such as earliness and low persistence and productivity.

Bred varieties seem the best material to start selection for seed yield; in this case the breeder knows exactly the attributes which have to be maintained.

Herbage legume breeding should improve forage production both from a quantitative and qualitative point of view, maintaining the original seed potential of the breeding material. In this way it would be possible to combine in the new variety high forage yield and a satisfactory level of seed yield; only then, should specific researches for improving seed production be undertaken considering genetic, agronomic and physiological aspects of the problem.

SEED YIELD COMPONENTS IN LEGUMINOUS FORAGE PLANTS

	LUCERNE	WHITE CLOVER	RED CLOVER	BIRDSFOOT TREFOIL
Plants per square meter : tillers per plant : inflorescences per tiller	Very variable with environment and management			
A) INFLORESCENCES/M^2	3,750	400	600	400
Flowers per inflorescence	16	75	105	7
B) FLOWERS/M^2	60,000	30,000	60,000	2,500
Ovules per flower	10	6	2	40
C) OVULES/M^2 (SEED POTENTIAL)	600,000	180,000	126,000	100,000
Ripen seeds/ovules (%)	8	50	25	40
D) SEEDS/M^2	48,000	90,000	31,500	40,000
1000 seeds weight (G)	2	0,6	1,6	1,2
E) SEED YIELD/M^2 (G)	96	54	50	48
Harvested seed/produced seed (%)	70	70	80	60
F) SEED HARVESTED/M^2 (G)	67,2	37,8	40	26,8
Seed harvested/ha (Kg)	672	378	400	268

RELATIVE WEIGHT (%) OF SEED PRODUCTION COMPONENTS IN LEGUMINOUS FORAGE PLANTS AND MORE IMPORTANT FACTORS FOR THEIR IMPROVEMENT

COMPONENT	RELATIVE WEIGHT (%)	MAIN FACTORS
PLANTS/M^2	35	AGRONOMIC
TILLERS/PLANT		AGRONOMIC
INFLORESCENCES/TILLER		AGRONOMIC
FLOWERS/INFLORESCENCE		GENETIC
EGGS/FLOWER	1	GENETIC
SEEDS/EGG	55	AGRONOMIC
SEED WEIGHT	2	GENETIC
SEED HARVEST	7	AGRONOMIC

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Simultaneous selection for herbage and seed yield in Setaria sphacelata (Schumach.) Stapf and Hubbard ex Moss.

A.J.P. van Wijk
D.J. van der Have B.V./Plant Breeding Station
P.O. Box 1
4410 AA Rilland, The Netherlands.

Introduction.

Setaria sphacelata (Schumach.) Stapf and Hubbard ex Moss (setaria) is a grass species with a good herbage productivity in Western-Kenya (Bodgan, 1959). It is a tufted perennial with tall, erect stems, which can grow to a height of 2 m. Setaria phenotypically resembles Phleum pratense L. (timothy). Out of many local and introduced forms of setaria an ecotype from the Nandi district in Kenya emerged as the most outstanding (Bogdan, 1959). Seed of this ecotype was produced and commercialised under the varietal name Nandi setaria in 1957 (in 1961 the variety was named Nandi I). The major shortcomings of setaria in comparison with grasses from temperate areas are the poor nutritive value and the low seed yields.

As variation in length of day in tropical areas varies from nil at the equator to slight elsewhere inflorescences of setaria are produced during the entire growing season. Independent of stem elongation during inflorescence development, setaria shows stem elongation in vegetative tillers as well. Setaria therefore has a stemmy appearance, which partly explains the lower nutritive value of setaria.

Dirven et al. (1979) compared seed components of some tropical and temperate grasses as reported in the literature and concluded that the smaller number of fertile tillers per unit area is the main factor responsible for the much lower seed yields of tropical grasses. (yields of Nandi I rarely exceed 30 kg pure germinating seeds per ha). Another factor responsible for the low seed productivity is the impaired synchronization of flowering within the variety. Due to the absence of a clear photoperiodic response prolonged head emergence occurs between and within plants, as each tiller may produce an inflorescence depending on its stage of growth (Boonman, 1973).

To overcome the above described deficiencies, a breeding programme was initiated at the National Agricultural Research Station in Kitale, Kenya (1° North latitude) in 1971.

In 1972 a study was set up to gain more insight into the plant characteristics determining herbage quality, herbage and seed yield and to define the phenotypic characteristics upon which selection had to be based to improve these (Van Wijk, 1980). This article gives a summary of this study.

Material and methods.

Out of a spaced plant population of 4000 plants of Nandi I 121 plants were taken at random and planted in 3 replicates after vegetative propagation. In 3 crops during 1974 and 1975 in vitro digestibility (D vitro) according to Tilley and Terry (1963) and various plant characteristics were measured on tillers of similar growth stage. In the same crops yield of clean seed (Y CL) and yield of germinating seeds (Y GS) and its components (number of inflorescences, inflorescence length and 1000-grain weight) were determined per plant. At seed harvest the whole plant was cut and weighed. In 1976 the 121 plants were cut at 3, 6 and 9 weeks regrowth and their dry matter yield (Y DM) and yield of digestible organic matter (Y DOM) were determined.

The open pollinated progeny of the 121 plants was studied at 3 locations. Y DM, Y DOM, Y CL and Y GS were determined per half-sib family.

Selection indices in which the aggregate breeding value was composed of herbage and seed yield were obtained from the phenotypic and genotypic (co)-variances (Hazel, 1943) as estimated from the clonal replication. The value of each variate in the index was determined according to Cunningham (1969). The variate with the lowest value was omitted from the index. The index was then calculated anew on the basis of the remaining variates. Selection indices were also estimated as the multiple regression of herbage or seed yield of the half sibs on the characteristics of the parent plants as measured in 1974 and 1975. The selection of equations with a smaller number of independent variates than the full equation was carried out according to the method of Daniel and Wood (1971).

Results and discussion.

The comparison between tillers at a similar growth stage revealed that tillers of early-heading plants had a higher D vitro than those of late heading plants. High digestible tillers were further characterized by short length, narrow leaves and low weight.

In the present study the average time span between the first and last sampled plants was seven weeks. The difference in D vitro between early and late plants is explained by an ageing effect, which was stronger in late-heading plants as the continuous stem elongation was extended over a longer period. Moreover, late heading plants developed more leaves, which were exposed to ageing for longer than those of early-heading plants.

A negative correlation was found between D vitro and Y DM when the whole plants were compared at 3,6 and 9 weeks of regrowth, which agrees with the above-mentioned findings. A wide variation for D vitro and Y DM was observed at each regrowth period. This made the selection possible of plants that had high values for both characteristics. However, the increase achieved in Y DOM was largely due to an increase in Y DM rather than in D vitro. It seems therefore more rewarding to select for Y DM than for D vitro when improving Y DOM.

Of the seed components measured, the number of inflorescences proved to be the most important determinant of seed yield. Y CL evinced a low and varying viability, which was expressed by the very low correlation between Y CL and % germination. Plants with a high Y CL were early heading and large in size (expressed by fresh weight of the plant at seed harvest) and possessed more inflorescences with a higher number of lighter seeds per unit head length than low yielding plants. Selection for increased Y CL will thus bring an increase in the reproductive system rather than an improvement in its efficiency.

In view of the foregoing it was expected that selection for seed yield would not have an adverse effect on herbage yield. Y DOM at 3,6 and 9 weeks was strongly correlated with fresh weight of the plant at seed harvest. The latter characteristic was a good indicator of seed yield. Herbage and seed yield showed a high genotypic correlation as calculated from the clonal replication of the 121 plants:

Y DM - Y CL $r_g = 0.73$

Y DOM- Y GS $r_g = 0.66$

Three sets of relative economic weights were attached to the characteristics of the aggregate breeding value in the selection index; this choice was made arbitrarily in view of the unrealistic figures based on cost analysis of herbage and seed production:

	A	B	C
Y DM or Y DOM	1	1	5
Y CL or Y GS	5	1	1

Fresh weight of the plant and inflorescence number were the most influential variates in the index whose aggregate breeding value consisted of Y DM and Y CL as estimated from the clonal replication. When the least influential variates were eliminated step by step, headnumber remained in sets A and B and fresh weight in C. The stepwise elimination in the index whose aggregate breeding value was composed of Y DOM and Y GS resulted in an index solely consisting of fresh weight.

In the index, estimated from the parent - offspring relationship by the multiple regression of the offspring yield on the characteristics of the parents, fresh weight of the plant exerted the largest influence on herbage yield. The greatest influence on seed yield was exerted by seed yield itself.

Fresh weight of the plant at seed harvest thus proved to be the most influential characteristic determining herbage and seed yield. In view of the high genotypic correlation both characteristics could be improved simultaneously. It should be realised that the correlation between herbage and seed yield was observed at 1° North latitude. At places farther from the equator, where differences in daylength are greater during the year, a photoperiodic response may occur that affects the established relationships.

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Breeding for herbage and seed. An example from within-variety variation in Rhodes grass (*Chloris gayana* Kunth).

J.G. Boonman

Zelder Plant Breeding Station, 6595 NW Ottersum, The Netherlands

INTRODUCTION

Many studies are available which show great differences in seed yield

a) between varieties

b) within populations

Between-variety variation is often expressed in terms of heritability (h^2). The greater the differences, the larger the heritability and from this it is often concluded that breeding for seed yield "shows promise". However, within-population variation is governed also by other processes. It is, therefore, erroneous to generalize conclusions from a) to b) or vice versa.

The within-population variation in seed yield is fairly easy to establish also. A less easy task is to confirm the same over a number of seasons or locations and to exclude the effects of environment. Even then, only part of the genetic variation that remains is relevant for the purpose of breeding, i.e. the construction of varieties based on plants with uniform maturity and herbage potential.

This part of the variation, here named net variation, is a small part of the gross variation, that we visually observe at anyone time.

If success is to be achieved it is important to distinguish the two clearly:

GROSS GENETIC VARIATION IN SEED YIELD

(due to differences in:)

maturity

herbage potential (vigour)

head number	NET GENETIC VARIATION IN SEED YIELD
seed set	
seed weight	

EXAMPLE of RHODES GRASS in KENYA

An illustration of the above is given here for Rhodes grass, from work described in more detail elsewhere (Boonman, 1978). Rhodes grass is among the most important grasses of the (sub)tropics. It combines a relatively high seed yield with an excellent herbage potential, the latter being partly due to the stoloniferous habit of this grass so that the ground is covered fast.
Important breeding work has been going on for decades mainly in Kenya, Southern Africa and Australia.
Tropical grasses grown at the Equator are of interest here because the constant daylength, temperature and rainy-season accentuate the true physiological differences between plants, without interference from processes such as vernalization and photoperiodism. Tillers grow, elongate, flower and die any time of the rainy season.
The work was started when I was struck by the enormous variation found within popular varieties. To exploit this variation most fully, it was thought important to evaluate the important properties and the relationships between them, first on individual plants, then on selected clones and finally in a series of test-varieties, all chosen from the same source populations. These source populations were the commercial varieties "Mbarara" (early), "Masaba" (late) and "Pokot" (very late). The plants being stoloniferous, they were grown individually in plots covering at least 2,5 m^2.
It was subsequently learned that much of the apparent variation was of little relevance but also that much unknown variation could be exploited to great advantage.
Fig. 1 shows a within-variety variation in heading date of more than 35 days between the first few percent of the plants coming into head and the last. Over a number of years and locations it could be observed that early heading plants had already shed their seed by the time that the late plants were still elongating.
At the same time a large variation was found between these plants in their herbage potential. This was less surprising than the finding that earliness of heading was largely dictated by herbage potential. It is evident from Fig. 1 that early heading plants were proportionally much stronger in the more vigorous sections of the population and vice versa.
It goes without saying that the gross variation in maturity and vigour had to be eliminated prior to a realistic evaluation of the variation

in seed yield.
Only high vigour plants (target-plants) were, therefore, selected and transplanted in groupings according to their maturity class, each covering a time span of about 10 to 14 days (Table 1).
It is evident that even within plants of high herbage potential differences in maturity class have a great effect on the average seed yield, dropping steadily from "Early" to less than half in "Very Late". This decline in seed yield was partly caused by a drop in head number (Table 1), partly by a reduction in seed setting.
Having eliminated the differences due to variation in vigour - (the poorest plants produced only a 5% seed yield (Table 1) - and maturity, it became possible to investigate the true differences between plants, thus all of similar maturity and vigour. The best plants of Table 1 were set out in replicated clonal plots of 4 m^2 and evaluated over 3 seasons. The results for the "Early" and "Intermediate" classes of "Mbarara" and "Masaba" are shown in Table 2.
No less than a 3-fold variation in seed yield was found between clones of the same maturity class, the variation in head number again being smaller than in seed yield.
The final step was to assemble test-varities based on the best clones and compare them against the original varieties from which they had been selected. The results are shown in Table 3, for the averages over three years.
Herbage yield was increased in all selections, independent of maturity class. Seed yield, however, showed a markedly negative relationship again with maturity class. The "Early" selections were clearly superior with yields of 131, 159 and 227 for "Masaba", "Pokot" and "Mbarara", respectively. The later the heading class, the lower the seed yield, even far below 100.
Table 4 shows that the improvement in seed yield was largely due to an improvement in seed setting. This component is no doubt the most essential part of the net variation in seed yield as it does not seem to be so much affected by other plant properties.
Selection has widened the range in heading date from 33-14 = 19 days in the original varieties to 41 in the new selections (Table 3). Two new cultivars have been released successfully in 1976, "Elmba" as an early selection from "Mbarara", and "Boma", an early selection from "Masaba".

They combine improvement in seed yield and in herbage yield but also in seedling vigour and persistence under frequent clipping.

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Table 1

VARIABILITY BETWEEN TARGET PLANTS

maturity class	seed yield	head number
EARLY	100	100
INTERMEDIATE	67	100
LATE	58	81
VERY LATE	49	79
poor plants	5	10

Table 2

INTRA-VARIETY VARIABILITY between TARGET CLONES
(over 3 years, average = 100)

source-variety	maturity class	seed yield	head number
Mbarara	EARLY	50 - 163	69 - 130
,,	INTERMEDIATE	51 - 195	67 - 139
Masaba	EARLY	55 - 162	72 - 125
"	INTERMEDIATE	59-130	77- 119

Table 4

SEED YIELD COMPONENTS of NEW SELECTIONS (standards = 100)

head number	seed set	1000 seed weight	seed yield
109	118	98	124

Table 3. The effect of within-variety selection (3-year averages)

			days from first heading	seed yield	herbage yield
MBARARA	selection	"EARLY"	0	227	111
,,	,,	"INTERMEDIATE"	7	162	115
,,	,,	"LATE"	14	123	108
,,	,,	"VERY LATE"	23	96	110
,,	original variety		14	100	100
MASABA	selection	"EARLY"	13	131	104
,,	,,	"INTERMEDIATE"	16	120	113
,,	,,	"LATE"	24	95	101
,,	,,	"VERY LATE"	28	58	110
,,	original variety		19	100	100
POKOT	selection	"EARLY"	31	159	120
,,	,,	"INTERMEDIATE"	32	117	111
,,	,,	"LATE"	39	85	116
,,	,,	"VERY LATE"	41	68	107
,,	original variety		33	100	100

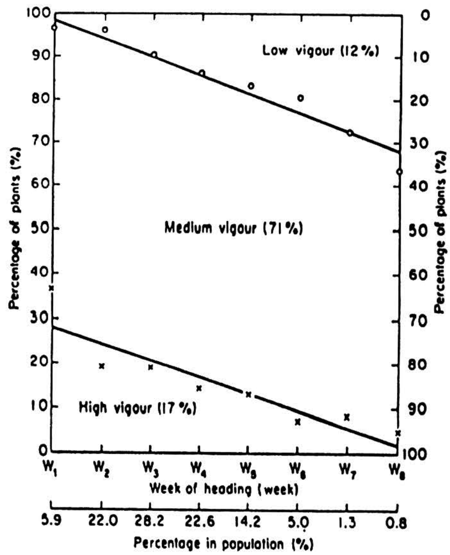

Figure 1. Relationship between heading date and vigour (rate of herbage regrowth) in Rhodes grass plants.

Relationships between dry matter yield and seed yield in annual legumes under dry conditions

S. Ceccarelli and B.H. Somaroo

The International Center for Agricultural Research in the Dry Areas

P.O. Box 5466, Aleppo (Syria)

Legumes forage crops have been intensively bred to maximize dry matter yield, but very few data are available on the relationships between dry matter yield and seed yield, although it is obvious that the ultimate success of a new cultivar depends upon both the availability and the cost of the seed.

The annual legumes play a potentially important role in the ICARDA's Region (extending from Morocco to Pakistan, and from Turkey to South Yemen) to replace the traditional cereal-fallow rotation with a cereal-forage rotation. The ultimate benefit of substituting the fallow with a forage crop would be a greater availability of animal feed coupled with an improvement of soil fertility.

At the beginning of the Forage Improvement Program's activity, a large number of annual legumes of different genera (Vicia sp., Pisum sp., Lathyrus sp., Medicago sp., and Trifolium sp.) was collected. This collection is presently evaluated for adaptation, dry matter yield and seed yield. The latter is an important attribute because large amount of seed of promising accessions must be rapidly produced for both large scale testing and demonstration purposes in order to achieve a prompt impact at farmer's level.

In this paper we present the results of two years evaluation of different accessions of five self-pollinated annual legumes (Vicia sativa, Pisum sativum, Lathyrus sativus, Medicago aculeata and M. rigidula). No data are available on the relationship between dry matter yield and seed yield in some of these species. Some work has been recently done on Vicia sativa in the Soviet Union (Debelyi et al., 1979) and it has been shown that early ripening can be combined with high seed

yield and adequate green matter. In Pisum sativum seed yield is correlated with pods per plant and seed per plant, while is negatively correlated with 1000 seed weight (Malik and Hafez, 1977). In the same species a mutant for dichotomous stem bifurcation gave increased pod and stem production (Gottschalk, 1977) and, regardless of water availability, the total dry matter weight of seed remains a near-constant proportion of the above-ground vegetation (Harvey, 1980). Although indirectly, most of these data suggest a positive correlation between dry matter yield and seed yield.
To our knowledge the relationship between the two characters in these species has never been investigated under dry conditions.

Materials and Methods

The number of accessions evaluated in 1980 and in 1981 was 66 and 61 in Pisum sativum, 91 and 51 in Lathyrus sativus, 39 and 51 in Vicia sativa, 91 and 25 in Medicago aculeata and 110 and 65 in M. rigidula. The experimental design was the randomized block with three replications in 1979-80 and the cubic lattice in 1980-81.
Plot size was 2.5 m x 1.4 m (3.5 m^2) in both years, including 8 rows at 17.5 cm distance.
The first year the materials were sown between November 22 and November 27, 1979 at a seeding rate of 80 Kg/Ha for P. sativum, V. sativa and L. sativus, and of 15 Kg/Ha for the medics. In the second year the materials were sown between November 6 and November 17, 1980 at a seeding rate corresponding to 30 plants/m^2, except for the two medics which were sown at the same seeding rate used in 1979-80.
Before sowing 60 Kg/Ha of P_2O_5 were incorporated in the soil, in the case of P. sativum, V. sativa and L. sativus. For the two annual medicago 20 Kg/Ha of nitrogen and 60 Kg/Ha of P_2O_5 were applied in 1980, and 40 Kg/Ha of P_2O_5 in 1981.
Half of the plot was harvested at the beginning of pod formation for dry matter yield evaluation, and the other half was harvested at ma-

turity for seed yield.

In 1979-80 flowering time was also recorded and data expressed in days from sowing to beginning of flowering.

The accessions evaluated in the two years were unrelated. As a matter of fact, the microplot evaluation represents the second step in the annual legumes breeding program. Each year new germplasm is evaluated in replicated or unreplicated nursery-rows, depending upon seed availability, and single plants or entire rows are selected. The progenies of the selected material are evaluated in microplots, and in the third step the best material is promoted to advanced yield trials.

Both in 1979-80 and in 1980-81 the microplots have been evaluated under rainfed conditions at Tel Hadia, 30 Km South of Aleppo. Total rainfall was 413.2 mm in the first year and 372.3 mm in the second, while the long-term average for the experimental site is 356 mm.

Results and Discussion

The average dry matter yield and seed yield observed on the five species in 1979-80 and in 1980-81 are shown in Table 1 together with the average flowering time observed in 1980. The different yields in the two years are due both to different seeding rates and climatic factors. Two species, V. sativa and M. rigidula showed a higher seed yield in 1981, in spite of a decrease in dry matter yield. This may suggest that a different experimental approach may be more efficient to a correct evaluation of the full potential of both dry matter and seed yield of the germplasm collection. All these species have in general a good potential for both dry matter yield and seed yield under dryland conditions.

It may be interesting to note that M. rigidula gave in 1981 the highest dry matter yield and ranked second for seed yield. M. rigidula, as well as M. aculeata, is an annual medic native of the Middle-East and has never been exploited. In the Aleppo-type of environment both these species have proved to be superior to Australian cultivars.

From these data, as well as from other experimental evidence, P. sativum and M. rigidula appear to be the most promising species to produce high quantities of dry matter yield under rainfed conditions. Also, it appears that M. aculeata and L. sativus were the earliest species in 1980, but earliness does not appear to be correlated with neither dry matter yield nor seed yield.

The correlation and determination coefficients between dry matter yield and seed yield are shown in Table 2. Positive and significant correlation coefficients were observed in all the species in 1981, and in P. sativum, L. sativus and M. aculeata in 1980. Higher correlation coefficients were found in 1981, and considerable differences were found for the same species in the two years. For example, both in V. sativa and in M. rigidula the correlation coefficients (r=.25 and r=.11) were not significant in 1980, and were highly significant (r=.41 and r=.37) in 1981.

Since the genotypes can be considered in both years a random sample drawn from the germplasm collection, the difference between years may reflect an environmentally dependent association between the two characters. Even in the presence of significant correlation coefficients, the determination coefficients were always low, the maximum value being 47%. Therefore, although there is a tendency of high dry matter yield being associated with high seed yield, genotypes with all combinations of the two characters were present in most species. As an example, the relationship between the two characters is shown graphically in Figures 1 and 2.

The two continuous lines are the means of the two characters and the broken lines show the interval of one standard deviation over the corresponding mean.

The two figures show again the high variability of the individual genotypes around the regression line even when a significant correlation was present. Low and high seed yielding genotypes were present in P. sativum, both at low and high levels of dry matter yield.

Genotypes with low dry matter yield and high seed yield were not found in V. sativa, but all the other three combinations were present. In each species a few genotypes were present which combine a relatively high (one standard deviation over the mean) dry matter yield and seed yield: the percent of such genotypes is reported for each species in Table 3.

In both years the highest proportion og genotypes which combine high dry matter yield with high seed yield was present in V. sativa, P. sativum and M. aculeata, whilst in M. rigidula the evaluation of a large number of accessions may be required to find superior genotypes for both characters.

Table 4 shows the relationships, found in 1980, between flowering time and both dry matter yield and seed yield. A negative and significant correlation between flowering time and dry matter yield was found in P. sativum and in M. aculeata. In both cases, however, the determination coefficients were low (16% and 6%, respectively). The correlation between flowering time and seed yield was much closer, which indicates that early flowering genotypes tend to have higher seed yield. This was particularly true in P. sativum and V. sativa.

The overall indication of Table 4 is that under the rainfed conditions of Northern Syria, selection for early flowering would led to an increase of both dry matter yield and seed yield in some annual legumes such as P. sativum and M. aculeata, as expected when drought is one of the major climatic constraints. Selection of early genotypes also would have the advantage to provide animal feed earlier in the spring.

The results reported in this paper are in agreement with those reported for other fodder legumes (Lorenzetti, 1981) indicating that dry matter yield and seed yield behave either as independent characters or as positively associated characters.

It may be argued that this type of evaluation is not necessarly the most efficient way to select genotypes which combine high dry matter yield with high seed yield because high forage yielding genotypes which would also give high seed yield under a different set of environmental and agronomic conditions will not be detected. On the other hand, the evaluation of both dry matter yield and seed yield at an early stage of the breeding program appears to be an efficient strategy to select:

1) the genotypes which, under the climatic conditions of Northern Syria, combine high forage yield with high seed yield. The seed of these genotypes can be rapidly multiplied and distributed to Regional Programs for large scale testing and on-farm trials;
2) the extreme genotypes for high forage yield which require further testing to assess their seed yield potential under a different set of agro-climatic conditions;
3) the extreme genotypes with high seed yield which may be used in subsequent stages of the program to incorporate this character in other breeding material.

These extreme genotypes will be used in more advanced stages of the breeding program, when the exhaustion of the variability available in the germplasm collection will require new variability being created by a crossing program.

From a methodological point of view, a more efficient microplot evaluation may be required to assess the full potential for both dry matter and seed yield under appropriate agronomic conditions.

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Summary

The relationship between dry matter yield and seed yield was studied in 1979-80 and in 1980-81 on various accessions of *Pisum sativum*, *Vicia sativa*, *Lathyrus sativus*, *Medicago aculeata* and *M. rigidula*. The total number of accessions was 397 in the first year and 252 in the second year. The material was tested in replicated microplots at Tel Hadya (30 Km South of Aleppo) under rainfed conditions (413.2 mm in 1979-80 and 372.3 mm in 1980-81).

Except for *Vicia sativa* and *M. rigidula* in 1980, positive and significant correlation coefficients between dry matter yield and seed yield were found in both years, ranging from .36 to .68. The correlation coefficients were higher in 1980-81 than in 1979-80 for all species. However, even when the correlation coefficients were significant, the determination coefficients were low, ranging from 13% to 47%. This indicates that in these species dry matter yield and seed yield behave, to a large extent, as independent variables, and accessions with different combinations of both characters are available. Therefore, selection of varieties combining high seed yield and high dry matter yield should not offer major difficulties.

Table 1. - Flowering time (days from sowing), dry matter yield (Kg/Ha) and seed yield (Kg/Ha) of five annual legumes grown under rainfed conditions.

Species	Flowering time (days)	Dry matter yield (Kg/Ha)		Seed yield (Kg/Ha)	
	1980	1980	1981	1980	1981
Pisum sativum	134	7787	4064	2472	1486
Vicia sativa	136	4517	3052	993	846
Lathyrus sativus	129	5707	2624	1802	698
Medicago aculeata	126	3055	2526	673	521
Medicago rigidula	134	4114	6856	1013	1055

Table 2. - Relationship between Dry Matter Yield (Kg/Ha) and Seed Yield (Kg/Ha) in five annual legumes grown at Tel Hadia 1980 and 1981) under rainfed conditions.

Species	1980		1981	
	r	R^2	r	R^2
Pisum sativum	.36**	.13	.60**	.35
Vicia sativa	.25	.06	.41**	.17
Lathyrus sativus	.38**	.14	.57**	.32
Medicago aculeata	.51**	.26	.68**	.47
Medicago rigidula	.11	.01	.37**	.14

** $P < 0.01$

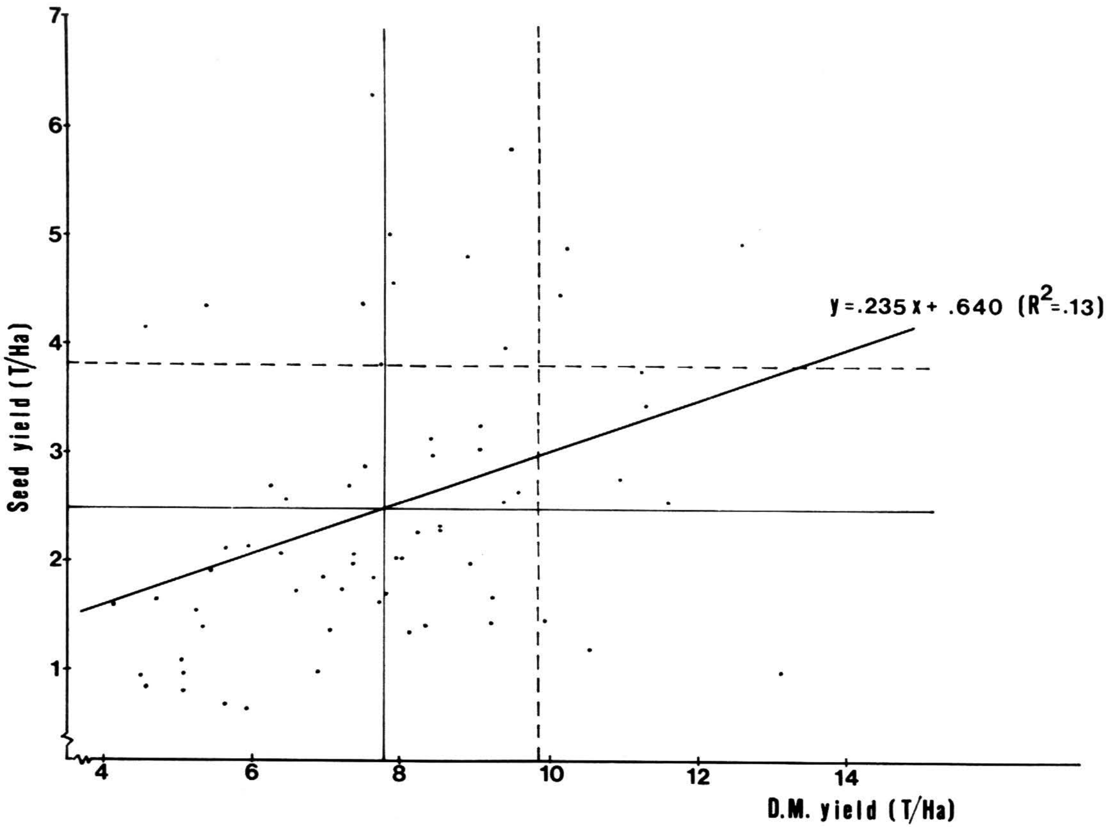
Table 3. - Percent of genotypes exceeding the population mean by more than one standard deviation for both dry matter yield and seed yield.

Species	1980	1981
Pisum sativum	4.55	9.84
Vicia sativa	5.13	7.70
Lathyrus sativus	1.10	3.10
Medicago aculeata	4.40	8.00
Medicago rigidula	0.91	1.50

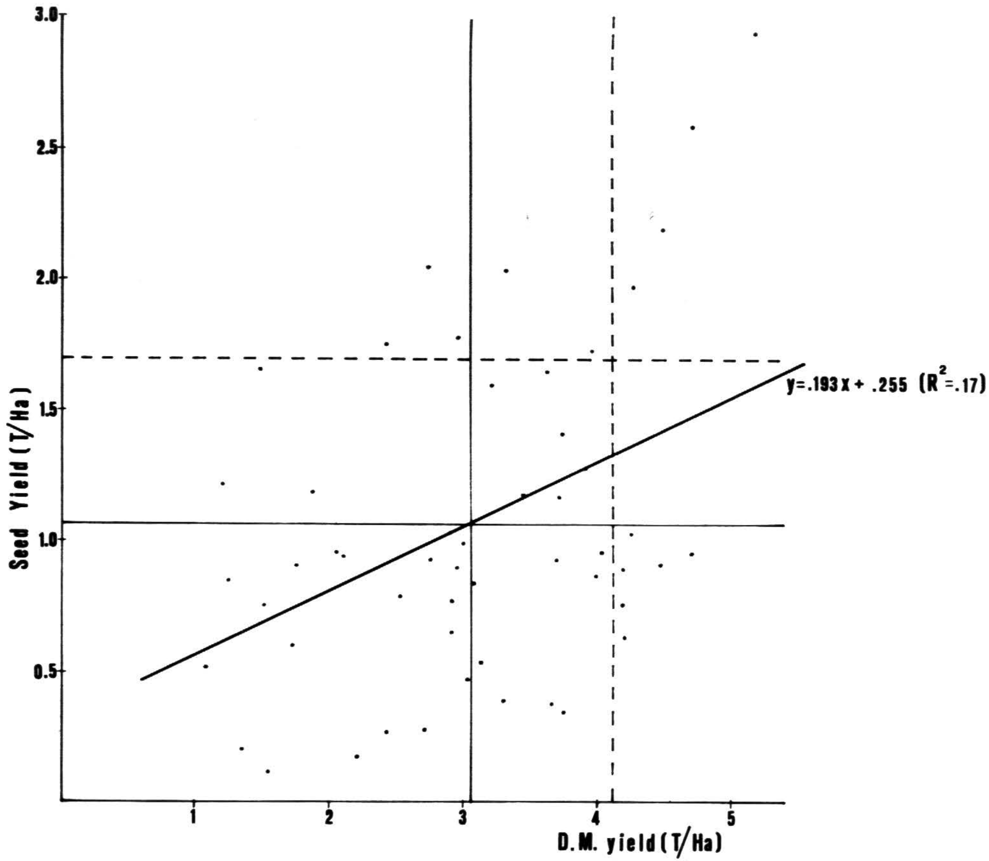
Table 4. - Relationship between Flowering Time (FT), Dry Matter Yield (DY) and Seed Yield (SY) in five annual legumes under rainfed conditions (Tel Hadia, 1980)

Species	FT - DY		FT - SY	
	r	R^2	r	R^2
Pisum sativum	-.39*	.16	-.65**	.42
Vicia sativa	-.10	.01	-.60**	.36
Lathyrus sativus	-.19	.04	-.09	.01
Medicago aculeata	-.24*	.06	-.27*	.07
Medicago rigidula	.15	.02	-.43**	.18

* $P<0.05$; ** $P<0.01$



Relationship between Dry matter Yield and Seed Yield in 66 Genotypes of *Pisum sativum* (Tel Hadia 1980)



Relationship between Dry matter Yield and Seed Yield in 52 Genotypes of Vicia sativa (Tel Hadia 1981)

RELATIONSHIP BETWEEN DRY MATTER YIELD AND SEED YIELD IN GRASSES.

Ir. G. van BOGAERT
Government Plant Breeding Station, MERELBEKE, Belgium

Different authors summed up the characteristics necessary for a variety to be related as good. The capacity for producing an acceptable seed yield is seldom mentionned. This is because most species are cultivated for their seeds or fruits, hence the requirement for high productivity coincides with a high seed yield.

In those species which are cultivated for their vegetative parts, namely the forage plants such as grasses and clovers high productivity corresponds with the capacity to produce high dry matter yields, so the capacity of producing high seed yields is considered as being of secundary importance.

Everyone, who is concerned with the breeding or the seed-trade of forage plants is well aware of the fact that a variety producing insufficient seed will never achieve the distribution it might otherwise deserves. Typical of this are the varieties of tetraploid red clover. On the other hand certain varieties, although of a rather moderate agronomic value, have achieved good distribution because of their high seed yielding capacity and the resulting low seed price.

In addition there still exists the widespread belief that high seed yields do not well combine with high dry matter yields.

We set about evaluating this opinion by comparing the seed yield of many genotypes of Lolium perenne, Lolium italicum and Festuca pratensis with the dry matter yield of their progenies. Table 1 shows the mean dry matter (D.M.) yield of the 10 highest and the 10 lowest yielding progenies taken out from different progenytests, compared with the mean seed yield (S.Y.) of their corresponding mother plants.

TABLE 1 : Relationship between seed yield (S.Y.) and dry matter (D.M.) yield.
Mean values of dry matter for the 10 highest and 10 lowest yielding progenies with the corresponding seed yield of the motherplants.

Experiments	Number of progenies	Most productive progenies		Least productive progenies			
		D.M. kg/ha	S.Y. gr/pl.	D.M. kg/ha	S.Y. gr/pl.	Relative figures D.M.	S.Y.
Lolium perenne							
Early							
ah 742	81	29054	13.0	23919	12.2	82.3	94.0
ah 781	49	39500	25.3	32940	19.2	83.4	76.1
ah 782	72	38743	18.8	35371	19.8	91.3	105.5
ah 783	42	40108	18.1	37829	22.0	94.3	121.4
Late							
aw 761	81	29180	15.5	25752	15.3	88.2	98.9
aw 771	100	32660	13.0	29034	16.9	88.9	130.1
Festuca pratensis							
ch 721	49	25535	13.1	23241	12.6	91.0	95.5
ch 792	64	21623	8.3	20499	7.2	94.8	87.6
ch 793	64	21563	7.0	20133	10.4	93.4	149.6
Lolium italicum							
b 792	90	33170	13.1	30127	13.4	90.8	102.0

In the second column of this table is the number of progenies in each experiment. The last two columns give the relative yields of the lowest yielding groups of progenies, the highest yielding ones being taken as 100.

This date neither demonstrates any relationship between the yield of dry matter and seed yield nor does the range of seed yield within each group of 10 mother plants (table 2) show a relationship. The highest or lowest seed yield falling once in the high dry matter group and another time in the low dry matter group.

TABLE 2 : Range in seed yield (gr/plant) of groups of 10 motherplants differing in their dry matter yield (D.M.Y.)

Experiments	Highest D.M.Y.	Lowest D.M.Y.
Lolium perenne		
Early		
ah 742	8.3 - 17.8	6.3 - 17.7
ah 781	9.3 - 33.9	4.9 - 27.8
ah 782	4.1 - 31.3	4.0 - 35.8
ah 783	12.0 - 29.6	3.9 - 29.0
Late		
aw 761	7.5 - 26.5	5.7 - 29.8
aw 771	8.8 - 22.9	5.6 - 22.4
Festuca pratensis		
ch 721	7.7 - 17.1	9.5 - 16.8
ch 792	5.4 - 12.8	4.8 - 10.8
ch 793	3.8 - 13.4	5.9 - 15.1
Lolium italicum		
b 792	4.1 - 20.2	5.0 - 27.1

In presenting those date to you, I took the dry matter yield of the progenies as a basis and compared it to the seed yield of the motherplants. There is another approach possible. This is to take the seed yield of the motherplants as a starting point. The preference for the first approach was inspired by the fact that although the seed was harvested in the same year, the plants were spread over different polycross fields. Differences in harvesting date and in soil fertility could have biased the choice of the plants. However, in considering the alternative approach, where the dry matter yield is compared against seed yield, table 3 shows similar results which do not indicate any correlation between dry matter yield and seed yield.

TABLE 3 : Relationship between seed yield (S.Y.) and dry matter yield (D.M.Y.).
Mean values for the 10 highest and 10 lowest seed yielding motherplants and the corresponding dry matter yield of the progenies.

Experiments	Plants with highest S.Y.		Plants with lowest S.Y.	
	S.Y. gr/plant	D.M. kg/ha	S.Y. gr/plant	D.M. kg/ha
Lolium perenne				
Early				
ah 742	17.9	26107	8.0	26719
ah 781	32.5	38611	13.0	37143
ah 782	30.8	37143	5.4	36865
ah 783	31.6	38690	11.0	38810
Late				
aw 761	27.5	27698	8.5	26884
aw 771	17.5	30768	5.8	30873
Festuca pratensis				
ch 721	19.2	24862	6.9	26050
ch 792	11.7	21111	4.8	20992
ch 793	14.7	20952	4.3	21032
Lolium italicum				
b 792	30.0	31349	5.8	31667

It is generally accepted that genotype dry matter yield does not give sufficient indication of the dry matter yield of its progenies.

The same, however, does not seem to be true for seed yield. The research done in this field shows very good agreement between the seed yielding capacity of a plant and that of its progeny. So Griffiths in the U.K. found a correlation of r = 0,83.

TABLE 4 : Mean and Range in thousand seed weight of groups of 10 motherplants differing in their dry matter yield.

Experiments	Highest D.M.Y. groups		Lowest D.M.Y. groups	
	Mean	Range	Mean	Range
Lolium perenne				
Early				
ah 742	2.175	2.491 - 1.918	1.936	2.287 - 1.714
ah 781	2.261	2.569 - 1.946	2.297	2.719 - 1.979
ah 782	2.039	2.554 - 1.713	2.252	2.438 - 1.934
ah 783	2.013	2.355 - 1.578	1.910	2.967 - 1.755
Late				
aw 761	1.403	1.812 - 1.281	1.462	1.853 - 1.264
aw 771	1.564	1.851 - 1.281	1.472	1.853 - 1.219
Festuca pratensis				
ch 792	2.065	2.185 - 1.734	2.072	2.251 - 1.650
ch 793	1.773	2.312 - 1.331	1.923	2.368 - 1.426
Lolium italicum				
b 792	2.254	2.774 - 1.939	2.121	2.545 - 1.869

Another factor that we should not omit while speaking of seed yield is the seed weight. Some authors claim a relationship between dry matter yield and seed weight may exist. For the same groups of progenies, as in table 1, the thousand seed weight of the motherplants is given (table 4). The figures show that neither the high nor the low yielding progenies are related to a specific seed weight. Also the range in seed weight in either group is not directional. As a result the breeding of varieties producing seed with a high thousand seed weight seems very possible. The heritability of the seed weight is also very high. Panella stated that a low seed weight is an economical and biological disadvantage.

The data I have presented to you, thus indicate that breeding varieties with a high dry matter yield and seed yield should be possible because the two objectives are not contradictory.

As a matter of fact we should urgently attend to improve the seed yielding ability of our forage plants. Indeed the seed price of those crops is influenced by the price of the cereals. Over the years the yield of the latter - thus the seed yield - has been increased steadily. In contrast the seed yields of forage crops has not increased. The result is that it has been more economic for farmers to grow cereals unless they are paid more for the grass seed. Hence higher seed prices which makes farmers reluctant to buy it.

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Breeding hybrid lucerne for high forage yield combined with improved seed yield

Z.Bőjtös

Agricultural Research Institute, Kompolt, Hungary

In the framework of developing hybrid lucerne by cytoplasmic male sterility, a program started in 1968. One of the ms clones had a sterility system which could be considered as a nuclear - cytoplasmic one, of which the evidence was reported firstly by Davis - Greenblatt /1967/. This consideration was based upon the degrees of male sterility in 27 F_1, and some tested BC_1 and BC_2 progenies. Data in our earlier reports were presented on heterosis effect for forage yield in 3-way hybrids showed positive effects only for 55 % of the hybrids. Two of ms single crosses, however, gave outstanding heterosis effects in their 3-way hybrids. As a result of tests for GCA using genetically divergent tester parents, the single crosses could be classified fairly good and fairly poor combiners /Bőjtös, 1974; 1976 a/.

After these studies by using more than 60 very divergent pollen parents to 15 single crosses, about 500 hybrids vere produced. Data of GCA tests were generally confirmed by the field performance of 3-way hybrids. Forage yields of hybrids have proved that this type of lucerne hybrids may outyield about by 10% the open pollinated varieties /Bőjtös,1976 a; 1976 b/.

The best two hybrids were also evaluated in the national variety trials over a 4-year period at 12 locations on two cutting systems. One of them was favourable reviewed in 1981, and approved for certification by name of "KM-Hybridalfa lucerne" supposedly as the first registered hybrid lucerne in Europe. It has ranked first among 8 entries when harvested in 2 to 4-year old stands on a cutting cycle of 28-days at 5 locations. On standard system of cutting, however, when harvested at more suitable stages of maturity for check variety, hay yield of this hybrid was similar to that of the check. Table 1 shows some details of hay yields in official trials /Lázár, 1981/.

The influence of the two cutting frequencies on yield is more evident in a graphic illustration of the relative annual values /Figure 1/. At the end of the 4. harvest year it has been found that the average number of surviving plants of this hybrid was about twice as much as the check and Europe varieties when harvested on 28-day intervals; the same figure was 29 % compared to check on a standard cutting system. Consequently the hybrid had a high persistence enabling it to be utilized in a more intensive cutting cycle.

It is known that quantity of total yield of lucerne is generally increasing with time between cuttings, but harvesting on a calendar-date system may reduce plant vigor and yield owing to of immature stage. Our data seems to prove that harvests on about a 28-day cutting cycle suited more to our hybrid than to the check. This seems to be in full accordance with that criteria applied when selecting the parents. Selection was namely based upon early blooming, rapid recovery after cuttings and shorter dormancy period, high GCA for forage yield, tolerance to diseases caused by Fusarium spp., and persistence. These selection criteria were generally confirmed by presented data. Our data also shows, as it had already been reported that winterhardiness and rapid recovery after cutting and shorter dormancy are not necessarily incompatible characteristics of the lucerne /Busbice-Wilsie, 1965/. It is also possible that the dynamics of leaf loss and the rate of photosynthesis of this type of lucerne are closely dependent on the cutting system /Fuess-Tesar, 1968/.

Observations on potential feeding value and on disease reaction of this hybrid at such cutting cycle are incomplete as yet. However, on the bases of the well known correlation between the stage of maturity at cuttings and feeding value, it may be state that this hybrid exceeds the checks in quality, too. Data of production results of several state-farms have shown that the average protein content and yield together with the carotene concentration of dehydrated meal were more favourable in the hybrid than in the check variety when harvested approximately on 30-day intervals.

Concerning the seed yields of ms plants, data are available that the limited yield on male-steriles may restrict the production of lucerne hybrids. In our breeding program data were obtained on seed yields of cms-19 clone when single crosses were made by hand pollination with 17 maintainer clones. Then single crosses were produced with selected maintainers under pollination cages and on smaller isolated fields by leaf-cutter bees /Megachile rotundata F./.

Fertility of cms-19 clone in hand crosses on the basis of about 12000 flowers showed a good seed yield potential. When pollination was effected by bees, however, there were considerable differences in seed yield of this cms clone in relation to maintainer parents. The maintainers have apparently differed in bee attractiveness /Table 2./. Visually scored nectar production of this cms clone compared to maintainers was namely far superior than those of two maintainers. In these combinations the pollinators showed a certain preference to the ms clone.

10 single crosses /made by hand pollination with cms 19 clone/ were used to produce 152 experimental 3-way hybrids under pollination cages in 4 years. A great number of genetically divergent pollen parents were applied for these crossings. The average seed yield of a single cross in 17 different combinations was consistently outstanding. Here also the same maintainer by its single cross proved to be best seed yielders, which

was superior in producing of single cross /Bőjtös 1979/. Since environmental conditions were the same in these observations, our data indicated that selection for bee preference may be a very important aspect in hybrid lucerne breeding. Though the role of the genetic factors in the components of obtained seed yields was not cleared up, nevertheless it is probable that parents of the best single crosses have favourable factors for seed setting, too.

Using only the best parents in regard of both forage and seed yield productivity, at first a single cross was produced on smaller fields where the average seed yield was 93 kg per hectare. Then commercial 3-way hybrid seed was produced on a 10 hectare and later on a 20 hectare field where the female drill strips yielded on average of 85 % seed of that produced by pollenizer ones /Table 3/. Certainly it is also necessary to develop a more profitable commercial production practices to decrease production costs which studies are under way /Bőjtös,1979/.

At all events it can be concluded that selection for high forage yields and acceptable seed yields of 3-way hybrids can be affected by selecting suitable parents. By using such types of parents and by improveing of seed production techniques we have possibilities for a more profitable hybrid lucerne production.

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Table 1. Total forage yields in 1977-80 of "KM-Hybridalfa" lucerne havested and averaged at 7 and 5 locations on different cutting cycles

Variety	Standard cycles 7 locations		28 - day cycles 5 locations		Relative differences
	Tons/ha /12 % hay/	Relative	Tons/ha /12 % hay/	Relative	betwen cycles
KM-HYBRIDALFA	42,69	98,7	51,71	109,8	+ 11,1 %
T-1 /check/	43,22	100,0	47,07	100,0	-
EUROPE	42,80	99,0	46,65	99,1	+ 0,1 %
L.S.D. .05	3,48		4,46		

FIGURE 1. RELATIVE FORAGE YIELDS OF „KM-HYBRIDALFA" LUCERNE COMPARED TO „T-1" CULTIVAR AND AVERAGED OVER LOCATIONS WHEN HARVESTED IN 2 TO 4-YEAR OLD STANDS ON DIFFERENT CUTTING CYCLES

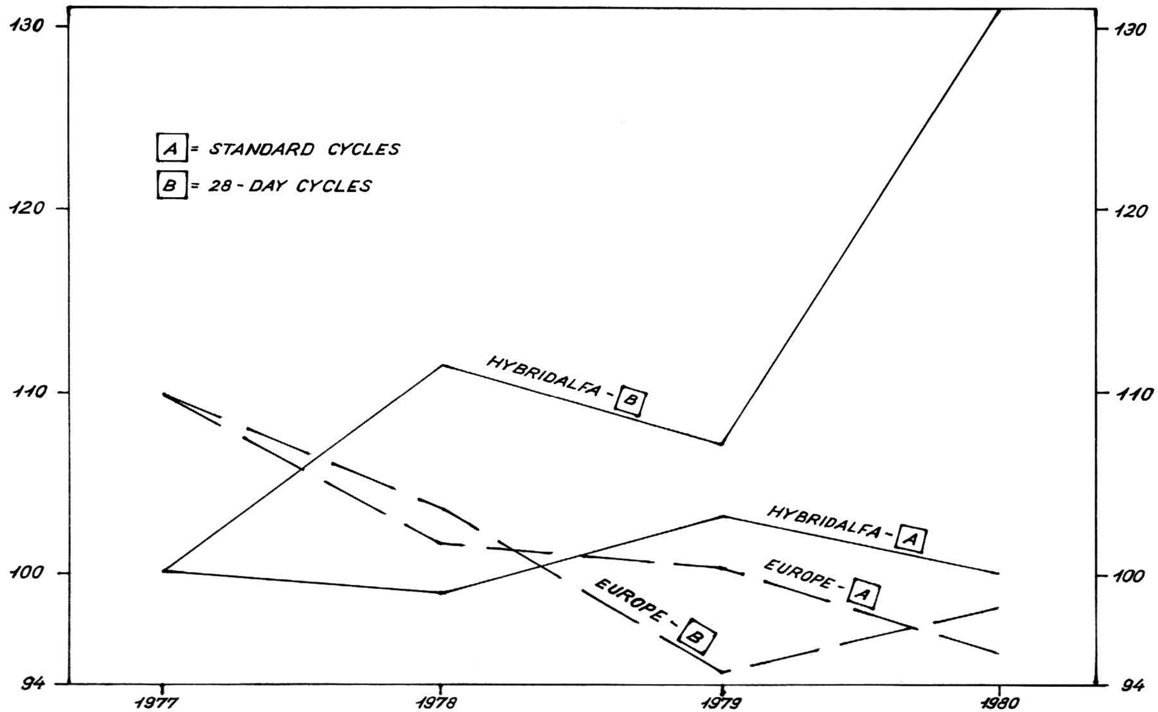


Table 2. Differences in seed set of "cms-19" clone in relation to maintainer parents when pollination is effected by hand or bees

Maintainer parents	Hand pollination seeds per flower	Bee pollination, seed yields				
		Under cages g/cage	In field kg / ha			
		1973	1973	1974	1975	1976
03	2,68	12,1	8	12	-	-
04	3,66	-	83	-	-	-
07	2,92	70,6	140	406	37	250
09	3,53	-	200	432	40	267
11	3,46	-	10	-	-	-
14	3,54	11,6	7	-	-	-
Average /n=17/	3,11					
Range	1,3-4,1					

Table 3. Data on commercial seed production of "KM-Hybridalfa" lucerne

Year and acreage of total field	Ratio of ♀ : ♂	Actual yields on useful land kg/ha		Yields along with 50 % of blank strips kg/ha	
		Female strips	Male strips	Female strips	Male strips
1976 10 ha	1 : 1	240	243	158	160
1977		86	157	57	106
1978		186	203	122	133
Average		171 /85 %/	201 /100 %/	112 /84 %/	133 /100 %/
1980 20 ha	1,7 : 1	136 /80 %/	171 /100 %/	101 /85 %/	119 /100 %/

DEVELOPMENT OF DUAL-PURPOSE BARLEYS : GRAIN AND GRAZING.

M.S. MEKNI, W. ANDERSON

The International Centre for Agricultural Research in the dry Areas - Icarda, Aleppo, Syria.

Barley in the North African and West Asian regions, are often grazed by sheep during the winter months. In the drier areas, across these regions, and in particularly dry years, grazing of the barley, crop can be a significant source of feed during October to January or February period, although at that time, due to reduced growth, the dry matter produced by the animals grazing barley can be small.

This work in the breeding program is preliminary. Its purpose is to identify potential dual purpose genotypes to be passed on to the agronomy section of the cereals program for detailed studies. The main research objectives are :

1. - To assess the effect to different itensities of grazing at different growth stages in low, medium and high rainfall areas.
2. - To identify morphological and physilogical characteristics to be used in early generation selection for dual-purpose barley types.

The parameters observed, scored or measured are :

- Response to grazing (regrowth or recovery from grazing).
- Dry matter produced at the time of grazing.
- Grain yield after grazing.

Materials and Methods:

During 1979-80 season, 69 genotypes were studied. C63, an improved barley selection was used as check. Twenty-four entries including the check were put in each yield trial, therefore there was a total of three dual purpose yield trials.

We used a Randomized Complete Block Design with four replications.

Grazing : Was stimulated by cutting with a mower each plot at late tillering stage.
Height of cutting was at 5 cm above ground level.

Tiller Counts : Tillers were counted per square meter prior to heading.

Dry matter : 1. Estimated using an area meter.
2. Oven drying until obtaining a constant weight.
3. Grain yield : 3 m^2/plot/reps are harvested at maturity.

Regrowth : A visual situation of the regrowth was done prior to maturity as follows :

- Score of 1 : More than 80 % of the visual grain and dry matter yield as judged by height and ground cover in comparison with the non grazed replications are recovered.
- Score of 2 : 60 % to 80 % of the potential grain and dry matter yield of the non grazed checks are recovered.
- Score of 3 : 40 % to 80 % of the grain and dry matter yield are recovered.
- Score of 4 : 20 % to 40 % of the potential grain and dry matter yield are recovered.
- Score of 5 : Less than 20 % of the non-grazed grain and dry matter yields are recovered.

Results and discussions :

- There was a general decline in grain and dry matter yields by late cutting (Table 6).
- There was also a clear trade-off between grazing and grain yield (Table 7).

- The relationship between dry matter at grazing and grain yield may be used to separate forage, grain and dual purpose barley types to characterize potential dual purpose genotypes for their grain and forage potential. At ICARDA this characterization takes place by in relation to two environmental indices for grain and dry matter yield. An index of 1.0 for either character is obtained as the overall mean yield of all genotypes in all environments (Fig. 1). Genotypes having grain yield but lower dry matter yield than 1.0 are grain types ; those having higher grain and dry matter yield than 1.0 are dual purpose types ; those with dry matter yield superior to 1.0 and grain yield less than 1.0 are forage types. The genotypes below the index for both characters are discarded.

Table 6 : Grain yield ungrazed and after one grazing, and dry matter yield of selected dual purpose barley genotypes from 1980 - 1981 trials.

Cross/pedigree	Yield ungrazed kg/ha	Yield grazed° kg/ha	Dry matter kg/ha
Grain types			
1 WI 2197	5059	2092	4761
2 Lignee 1242	4784	3685	4143
3 Hexa	5596	4194	2877
4 Gerbel	5062	3407	4243
5 Europa	5389	2565	5397
6 Lignee 131	5278	2657	4930
Dual purpose types			
1 Comp. Cr. 29	5546	3074	6178
2 Celaya/Cl 3909.2	4586	2343	6470
3 WI 2198	5605	1935	5539
4 11012.2/Weeah	5414	2056	5491
5 Seed Source-72 Sal.	5426	1296	6230
6 As54/Tra//2°Cer/Toll/3/2°Avt/ Ki//Bz/4/Vt/5/Pro	5552	370°	6409
Forage types			
1 Bco.Mr/Mzq	3562	1704	6889
2 RM1508/Por	3448	1713	6337
3 M75-12	3062	1500	6142
4 Api/CM67/3/Apm/Dwarf11-1Y//Por/ Kn27/4/RM1508/11012.2	3960	1139	6201
5 Asse/Nacta	3469	1574	6100
6 Windser	2886	704°	5808

° : Herbicide damage caused the dramatic decrease in yield after cutting.

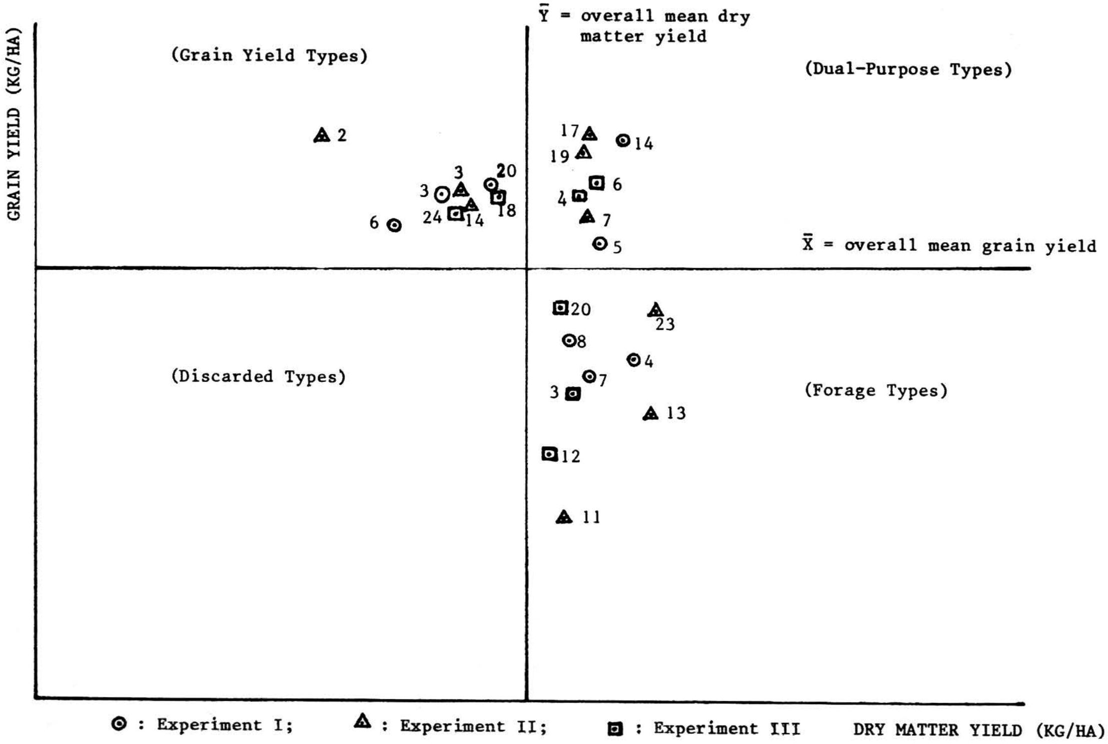
Table 7 : Characterization of some barley genotypes.

% of Env. Index.

	Type	Entry N°	Pedigree/name	% Grain yield	D.M. Yield %
DPBYT Experiment N° 1	Grain type	3	WI 2197	1.15	.84
		6	Lignee 1242 (Montpellier)	1.09	.73
	D.P. type	14	Composite 29	1.27°	1.10
		5	Celaya/CI 3909.2	1.05	1.15°
	Forage type	4	Bco.Mr./Mzq	.81	1.22
		7	RM1508/Pn.	.78	1.13
DPBYT Experiment N° 2	Grain type	2	Hexa	1.27	.58°
		3	Gerbe 1	1.15	.86°
	D.P. type	17	WI 2198	1.27	1.13
		19	11016.2/Weeah	1.23	1.12
	Forage type	13	M.75-12	.69	1.25
		23	Api/CM67....	.90	1.26°
DPBYT Experiment N° 3	Grain type	22	Europa	1.15	.96
		24	Lignee 131 (Montpellier)	1.12	.88
	D.P. type	4	Seed soured-72 Sal.	1.16	1.11
		7	As54/Tra...	1.18	1.14
	Forage type	3	Asse/Nacta	.74	1.09
		12	Windser	.61	1.104

° : Show ≠ between 2 genotypes in same or/and ≠ type.

Fig. 1 Identified grain types, dual-purpose types and forage types during 1980-81 season



HERBAGE GRASSES AND SEED YIELD - A LITERATURE REVIEW

A. VYNCKE
Rijksstation voor Plantenveredeling, Merelbeke, Belgium.

In the last decennia a great number of valuable varieties of herbage grasses have been developed. Many breeding objects received quite rightly full attention : high dry matter yield, palatability, intake, digestibility, tillering capacity, leafiness, seasonal distribution, persistency, winter-, drought-, desease- and treading resistance and so on. Breeding indeed is no easy assignment. Seed yield rarely enterred the program, at least not in these regions. And when it was raised by the seed grower he was told dogmatically that valuable vegetative characteristics and seed yield are negatively correlated. Seed growing indeed is no easy assignment.

Although I have not seen any official list of varieties mentioning the seed capacity of grass varieties, it is likely more will be heard of "Seed potential" in the near future. Quite true, in some countries experienced seed growers and companies have not waited for this situation to arise, but agreed on premia to compensate for the lower seed yields of certain varieties.

According to Danish statistics (Dansk Frøavl 1980) seed yields of grasses have risen in this country from year to year. The mean yields over the three last decades 50 - 59, 60 - 69 and 70 - 79 were as follows in kg per ha (see table nr 1). By calculating 10-years means the yearly variation which in grasses is much higher than in cereals is eliminated and a more accurate mean yield figure for each species is obtained.

TABLE 1 : DANISH SEED YIELDS - kg per ha - 1950-1979

	'50/'59	'60/'69	'70/'79
- Perennial ryegrass(early)	986(100)	1044(106)	1078(109)
- Perennial ryegrass(late)	875(100)	984(112)	1064(122)
- Italian ryegrass	1061(100)	1189(112)	1234(116)
- Timothy	385(100)	380(99)	407(106)
- Cocksfoot	644(100)	734(114)	741(115)
- Meadow fescue	668(100)	711(106)	759(114)
- Red fescue	650(100)	741(114)	847(130)
- Rough stalked meadow gr.	578(100)	670(116)	696(120)
- Smooth stalked meadow gr.	526(100)	726(138)	827(157)

We notice that the yield increase during these last two decades is roughly about 10 to 20% with red fescue and smooth stalked meadow grass coming out top. The Danes say : "It is not easy to give the real reasons for these increases but changes in varietal choice have not been the reason because breeding has always been more mindful of forage yield than of seed yield. There is no doubt the remarkable improvement of seed growing-techniques and these figures emphasize the importance of research accomplished in the field of seed growing. Specialization among seed growers has also been very helpful in increasing yields". We believe these comments apply also to other countries where yields too have increased mainly as a consequence of better seed growing techniques applied by more skilled and experienced growers taking advantage of the results of more and more investigations on sowing times, sowing rates, times and levels of nitrogen application, weed control and harvesting methods.

In the last decennium seedgrowers just like livestock farmers became more and more variety-minded be it for entirely different but quite understandable reasons.

Since long time the necessity is felt in the seed industry to have more reliable data on seed yield levels of the different varieties. "Forty years of testing grass and legume varieties for seed yields" is the title of a publication you will not find in these countries but in Oregon. In the USA and Canada evaluation of seed yield seems to be no less important than evaluation of vegetative characteristics. But interest is growing in this part of the world too.

Evans and Muncey published in 1977 their report of the results of trials between 1972 - 1975 established in the U.K. to assess the seed production performance of a range of perennial- and Italian ryegrass varieties, answering in this way a demand for more information on the seed production characteristics of newly introduced varieties as compared with varieties widely grown for many years.

Consistent results were obtained which - as means of 3 harvest years - showed significant differences from about 15 up to exceptionally 30% in the relative seed yields between several varieties within the same maturity group.

Trials on the seed yielding capacity of 10 varieties of perennial ryegrass were carried out in 1975 - 1977 in Denmark by Nordestgaard and Juel. They showed a considerable difference in the seed yielding capacity of the cultivars. As an average of all trials the seed yield of the poorest cultivar was only 73% of that of the best cultivar. When we arrange the tested cultivars in 3 maturity groups, we see the seed yield ranging from 78 to 100 in the early group, from 84 to 100 in the medium group and from 82 to 100 in the late group. Yield analysis made at one experimental site over 3 years gave the following proportional numbers : fertile tillers per unit of area ranging from 100 to 128, seeds per fertile tiller ranging from 100 to 165, seed weight ranging from 100 to 142 and seed yield ranging from 100 to 147.

Besides the above mentioned comparative trials there is of course also a large amount of yield data of herbage seed crops collected by seed certification authorities and seed multiplying companies from which it appears that some varieties are good seed yielders and others poor seed yielders. No doubt there is significant difference in the genetic variation of the seed yield potential of grasses.

Unlike his cereal breeding colleague who breeds for seed yield, the grass-breeder breeds in the first place for the best possible forage production. He works for the benefit of his customer, the livestock farmer. The benefit of the seed grower is not his concern. He should however bear in mind that among equally good grass varieties the best one always will be the best seed yielder because the most competitive on the market.

Several workers in different countries have investigated the structure of the grass seed yield. The seed yield components to be considered are : number of fertile tillers per unit area, number of seeds per tiller and thousand seed weight. The seed : floret ratio is known as the seed setting ability. The mentioned characteristics are decisive for the ultimate yield of a seed crop. A few other characteristics are as well but generally in an unfavourable sense. They are: proness to early heavy lodging, lack of uniformity in haeding, flowering and ripening, secondary growth in wet weather, and mostly little or no resistance to seed shattering. They often make grass seed growing to a challenge if not, in continuous bad harvest weather, to a night-mare.

TILLERING

Developing leafy varieties of herbage grasses without looking for high tillering capacity seems to be inconceivable. High tillering is no doubt one of the prime objects in each breeding program and although the seed grower may prefer less leafy strains, he will have to live with the characteristics of successful varieties. It is true that for the seed grower vegetative tillers are important only in so far as they turn into inflorescences in due time. The capacity for tillering seems to be genetically determined but the question is whether there is clear evidence of genetic variation in the ability of converting vegetative into fertile tillers. Presumably, according to Ryle (1966), this partition within the plant between tillers which bear an ear and those which continue vegetative growth is inherent in the genotype of the variety and cannot be altered without the risk of losing favourable vegetative characteristics.

We know that flower initiation in most grasses responds to low temperatures and/or short days. Several workers have reported the great importance of agronomic management like time of sowing and of application of nitrogen. Sowing under a suitable cover crop or possibly in late summer or early autumn, avoiding late autumn, besides giving the most possibilities for weed control before winter, seems to be the best practice for ensuring the development of the most and best inflorescences.

I do not believe that there is much need for more fertile tillers than there are potential in the present varieties. Fertile tillers surely are a major factor to a good seed yield, but yield failures are to my mind mostly due to other reasons than to a genetical insufficiency in developing an adequate fertile tiller population.

FLORETS :

The next contribution to seed yielding ability is made by the number of florets per unit area, which can be split up in number of spikelets or primary inflorescence branches per tiller and the number of florets per spikelet or primary inflorescence branch. Quite apart from specific variation there is evidence of external influences on the numbers of spikelets and florets. As to varietal variation, of 6 strains of perennial ryegrass a range of 137 to 176 florèts per head has been found, (Griffiths, 1965) equalling a 100 : 125 proportion.

All authors agree that tillers of perennial ryegrass produced in autumn or early winter not only give more spikelets per head but also more florets per spikelet than tillers produced in spring. Heblethwaite, Wright and Noble (1978) showed that the amount of nitrogen applied to perennial ryegrass had only small effects on the number of spikelets per ear but increasing levels did favourably affect the number of florets per ear, whilst delaying the nitrogen application in spring slightly reduced the number of spikelets per ear but markedly reduced the number of florets per spikelet.

It is quite clear that good agronomic practice in autumn and in spring is very important for establishing the best possible seed yield potentials but there seems to be less evidence with regard to breeding possibilities for increased spikelet and floret numbers.

SEED SETTING ABILITY AND SEED WEIGHT :

The production of a large number of inflorescences each provided with numerous florets is a basic condition for a good seed yield.

However without a high proportion of florets being pollinated, fertilized and developed into normal sized seeds, the available seed crop's potentials can not be realized. Every seed grower knows that external factors, especially weather conditions prevailing from flowering till harvesting time have an enormous influence on the ultimate seed yield. Yet we should not overlook the genetic factors. All investigators are agreed that seed set or floret fertility is of foremost importance in seed yield and that it is a component which has manifested a surprising degree of heritable variation (Griffiths, 1965).

Studying the seed setting ability of individual plants in a late strain of perennial ryegrass, W.E. Davies (1954) found over a period of four years marked differences which showed a range on the percentage of florets setting seed from 12,4 to 76 % with a mean figure of 41,5 %, the correlation from year to year being fairly good.

Also seed weight is a very important component in seed yield, showing a wide field of variation.
In this country van Bogaert (unpublished data) found following 1.000-seed weight ranges :

TABLE 2 : VARIATION IN 1 000 SEED WEIGHT

Perennial ryegrass early	1977 harv.	154	gen.:	1.6 to 2.97 g
Perennial ryegrass late	1976 harv.	38	gen.:	1.12 to 1.65 g
Perennial ryegrass late	1975 harv.	80	gen.:	1.18 to 1.99 g
Meadow fescue	1978 harv.	120	gen.:	1.33 to 2.60 g
Meadow fescue	1979 harv.	64	gen.:	1.89 to 2.85 g
Italian ryegrass	1978 harv.	88	gen.:	1.72 to 2.98 g
Timothy	1980 harv.	160	gen.:	0.32 to 0.75 g

In a preliminary study on heritability of 1,000 seed weight in late perennial ryegrass, the descendance of 7 genotypes with high 1,000-seed weight, the mean being 1.65 g, had a

mean 1,000 seed weight of 1.58 g; the descendance of 7 genotypes with a low 1,000 seed weight, the mean being 1.22 g, had a mean 1,000 seed weight of 1.33 g. Twenty-two genotypes of meadow fescue harvested for seed in 1967 and 1968 showed a very similar variation in 1,000 seed weight in both harvests.
In Italy, in 14 cocksfoot varieties a range of 0.65 to 1.3 g thousand seed weight was found and in 22 diploid cultivars of perennial ryegrass this range ran from 1.15 to 2.6 g. (Falcinelli and Lorenzetti 1980). In one population of perennial ryegrass and two of cocksfoot, seed yield per plant was positively correlated with thousand seed weight and it was suggested that selection for seed production be based on selection for thousand seed weight (Ceccarelli, Veronesi and Falcinelli, 1979).Selection for thousand seed weight may not do forget that both seed set and thousand seed weight have to be considered at the same time lest the improvement of one characteristic be not detrimental to the other one.

So far we have briefly been considering the characteristics which possibly have a favourable effect on seed yield. This seems me to be the place for drawing to the attention Bean's (1972) conclusion of a paper in which is demonstrated that clonal evaluation is an effective method of selecting for parents of higher seed yielding cultivars in timothy and tall fescue. This conclusion says : "A major consideration of the breeder who attempts to improve the seed production of a grass variety must be the need to preserve the variety's attributes in forage production. It therefore seems desirable that seed yield should be increased through an improvement in the efficiency of the reproduction system, where efficiency can be defined as the percentage of florets which produce seeds and the size to which these seeds develop, rather than as an increase in the size of the reproductive system by selection for large numbers of inflorescences and a larger inflorescence size".

A variety which from heading to harvest would behave like a cereal, resistant to lodging, uniformly ripening and with similar seed retention capacity, may sound like a seed grower's fantasy, a dream never to come true. I am afraid that in most cases the seed grower will have to live with the reality of early lodging grass cultivars but yet I wonder whether breeding for more uniformity in ripening and better seed retention could not make seed growing a somewhat more reliable enterprise.
Danish statistics (Dansk Frøavl, 63, 18 p 350), for the yields over the years 1970 - 1979 give a standard deviation in % of the mean yield of 7,1 % for winterwheat and 12.5 % or 76 % more for perennial ryegrass.

LODGING

Whilst lodging in most grasses is considered to be beneficial for saving seeds during harvesting operations, early lodging on the contrary is very harmful for pollinisation, fertilization and further seed development. It may well be held responsible as the major unfavourable factor for poor seed setting. Lewis (1962) found that the seed yield was reduced to 68 % of the control plot by artificial lodging of meadow fescue at an early stage of anthesis, while severe lodging a fortnight later lowered it by only 15 %. In another British experiment (Hebblethwaite,Burbidge, Wright, 1978) with perennial ryegrass, mechanical prevention of lodging resulted in a 61 % increase of the seed yield. It has been shown by Griffits (1965) that clones with a higher resistance could be selected from within a late perennial ryegrass. However because of the prime importance of the agronomic characteristics it is considered unlikely plant breeders to be able to make a significant contribution to overcoming the problems of lodging in herbage grasses.
The growth retardant CCC, which was a success in preventing lodging in wheat, was not with regard to grasses.

Ancymidol, tested in the United Kingdom, seems to open better prospects on condition it can be made available at lower cost (Wright, Hebblethwaite, 1979).

UNEVEN RIPENING

Because of the variation in flowering time among plants in the population, among inflorescences on individual plants and among florets in the same inflorescence, the maturation of a seed crop may occur over a period of two weeks. Each year the seed grower faces the problem of judging the optimal harvest time and of answering that perplexing question : "Shall we start harvesting today or better wait a few days more so as to ensure maximum yield of the best possible quality making a compromise between both". More even ripening could certainly make things easier for determining the most correct harvesting time. A wide range of head emergence may be advantageously invoked by a breeder when so called early off-types are being argued about with seed certification inspectors but to the seed grower it makes him deeply regret his cereal crop because wide spread heading is followed by wide spread flowering and ripening and of course increased risks of seed losses. For the breeder a possible genetic shift in the variety as a consequence of too early or too late cutting must be kept in mind. More uniform ripening goes someway to reducing shattering losses, which seem inevitable in some late perennial ryegrass varieties with an ear emergence spread over 3-4 weeks.

SHATTERING

Seed shattering is a blessing as nature's own mean for survival but a curse to the seedgrower as shattering means financial loss.
The degree of shattering is depending on genetic factors like species and variety and external influences like degree of lodging and weather conditions.

In Phalaris (Mc William, 1979), timothy (Bean, 1965) and Italian ryegrass very marked differences between clones or between ecotypes and bred varieties (Raja Harum and Bean, 1979) have been found. I can remember a late heading timothy strain of our institute which had such a remarkable retention capacity that only revolutionary drum-concave devices would have been able to overcome insuperable threshing problems. Nevertheless I have the impression that unlike in cereals, this problem has so far received too little attention in the herbage grasses.

Yet in the light of combine harvesting, especially direct combine harvesting, high seed retention capacity has become very important in grass seed crops just as well as in cereals. Indeed the problem now with direct combining of grass seed crops is to find a right balance between lower quality resulting from too early harvesting and the loss of seed resulting from delayed harvesting. The higher the seed retention the later can be harvested and the better the seed quality will be without substantial losses occurring. Danish workers (Ellegård, 1971, Andersen and Andersen 1978,) in field experiments on harvesting times, found for perennial ryegrass at optimum yield over the years 1967 - 1974 an average loss of shattered seed of 187 kg/ha being 12 % of the optimum mean yield of 1550 kg per ha over these years.

Considering the development from the wild freely seed dispersing cereals to the present high shattering-resistant varieties, I believe that breeding for more seed retention in grasses is bound to be succesful.

CONCLUSIONS :

Grass seed crops have to compete with cereals of which the yield is steadily increasing.

Only improved grass seed yields or better grower's prices will in the long run be able to stand succesfully that competition. To the seed grower the improvement of these characteristics which now make grass seed growing more risky than a cereal crop is particular important. There seems not to be a necessity for trying to increase the seed-potentials, i.e. the number of floret sites per unit of area. In my opinion these are under normal conditions largely sufficient, the calculation of theoretic seed yields can prove it. Much more important seems to me : higher seed set ability, more uniformity in ripening and less proneness to shattering. Good management will provide enough tillers, enough spikes and spikelets, nature is rarely parcimonious in securing abundant potentials for generative reproduction. The full utilization of these potentials however is an exceptional event occurring only in very lucky circumstances when perfect management and ideal weather conditions work closely together all along the growing season, from sowing to harvesting.

Summary :

Practical seed growing of herbage grasses and comparative trials on seed yield clearly show the varietal variation in the seed yield of herbage grasses. Yield increases during these last two decades seem to derive rather from improved seed growing techniques than from breeding achievements.

Recent literature on seed yield components and other crop characteristics like lodging and seed shattering is examined and discussed. Seed setting ability and seed weight, more even ripening and less proneness to shattering are considered as the main characteristics able to improve the seed yield and to diminish the risks of growing grass seeds.

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Selection for high seed production in leguminous forage plants - A review

W. Ellis Davies

Welsh Plant Breeding Station, Aberystwyth, Wales

Varieties of herbage are universally propagated by seed so that the production of regular seed supplies at an acceptable price to the consumer is a basic requirement of a new variety. This frequently results in a conflict between the twin aims of the breeder - that of producing a variety with increased yield of vegetative material for the benefit of the livestock and the need to produce seed for propagation, while at the same time providing an economic return to the seed grower.

Usage of forage legume seeds has declined generally in Western Europe over the past 20 years. This decline has not been uniform over species. In Britain white clover has maintained a steady usage over this period while red clover has reduced to 10% of its former usage. There are numerous reasons for this, including the increased use of nitrogen fertilizers, change in the economics of different crops and a degree of unpredictability in the performance of leguminous forage plants. Recently, there has been an upsurge of interest in legumes as a result of increasing costs of nitrogenous fertilizers and the general circumstances that have been termed the energy crisis. So far however, there is no evidence that this interest has been translated into an increase in usage of forage legume seeds.

Against this background it is perhaps not surprising that the amount of work directly involved in selection for seed yield has not been very great. Much of the published data has been concerned with the elucidation of component factors that together make up seed yield with only a few examples of studies carried through a selection phase.

This review will be mainly concerned with three species which are deemed to be the most important forage legumes, white clover (Trifolium repens), red clover (T.pratense) and lucerne (Medicago sativa). Each of these presents different problems to the breeder and will be dealt with separately.

White clover

White clover is a widely used species throughout the temperate areas of the world. Within the species there are a range of types from virtually vegetative plants which produce few flowers to those at the other extreme that flower profusely and behave as annuals. These extreme types would be associated with climatic conditions generally at the limits of the species distribution. The breeder has to decide on the balance between vegetative and reproductive growth to be attained in the new variety.

Breeders in Europe have produced many outstanding varieties but their usage is often limited by the small amount of seed grown. In Britain, for example, over 80% of the seed used is New Zealand Huia and the situation in France and other countries is similar. There is thus a paradoxical situation of excellent varieties having being bred and seed of lesser agronomic value being used in practice. It is largely a question of seed supply, linked with the cheaper price of New Zealand seed.

Denmark is one European country which produces seed for export but even though yields appear to be high (1969-78 mean = 380 kg/ha) the area is decreasing on account of the better economic returns from alternative crops. Differences in seed yields which can be ascribed to environmental conditions are shown in Table 1. Kersey is an English variety with a high potential yield yet it produces less than 50% of the average yield of all seed crops in Denmark over the same period. Variations from year to year are quite substantial with a factor of over two in separate years not uncommon.

Table 1. Seed Yield 1969-78 (kg/ha) of Kersey white clover in England and average yields for white clover varieties in Denmark

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	Mean
Kersey England[1]	163	251	138	201	188	213	240	90	150	139	177
All varieties Denmark[2]	568	251	404	292	342	387	404	378	340	438	380

[1]NIAB Seed Notes
[2]Dansk Frøavl 62, 11, 194-197 (1979)

There are also large differences which can be ascribed to differences in varietal potential seed yield (Table 2). There are data for commercial seed crops grown in Denmark over the three year period 1975-77 when the overall average was fairly stable, between 424 and 465 kg/ha. The three top varieties which accounted for nearly all the crops were fairly stable within 8% of the mean, with one exception in 1977 when Milkanova was 12% below the mean. The three other varieties fluctuated much more widely and some gave very low yields although the number of crops was small in some cases.

Table 2. Seed yields of white clover varieties Denmark, 1975-77⁺ (relative yields in brackets, mean = 100)

	1975	1976	1977
Mika Pajbjerg	481 (103)	469 (104)	453 (107)
Milkanova Pajbjerg	480 (103)	414 (92)	374 (88)
Cultura	471 (101)	475 (105)	421 (99)
Blanca RvP	212 (46)	-	366 (86)
NFG Gigant	387 (83)	272 (60)	163 (38)
von Kamekes	330 (71)	624 (138)	-
Average	465 (100)	451 (100)	424 (100)

⁺Sortsundersogelse over host 1975, 1976, 1977
De samvirkende danske Froavlerforeningers

Variation in seed yield of a variety within one year (1975) are of considerable magnitude and for Milka Pajbjerg - this ranged from under 200 kg/ha (9 crops) to 900-1000 kg/ha for three crops (Sortsundersøgelse over host 1975, p.11). This must represent differences in management skills interacting with environmental conditions plus a considerable degree of luck! Variations of this magnitude are not, however confined to white clover; they are also found in red clover, ryegrass, fescue etc.

Although pollination is necessary before seed is produced it is not generally a problem since many insects can operate the flower mechanisms and hives of honey bees can be brought to the crop in adequate quantities.

Seed yield components

The potential seed yield of white clover is the cumulative effect of number of inflorescences per unit area, number of florets per inflorescence, seeds per floret and unit seed weight. There have been several studies on the effect of variation in these components of seed yield.

Perhaps not surprisingly number of inflorescences per unit area has been listed as a major component of seed yield (Roberts & Falconer, 1977; Huxley et al., 1979; Evans & Davies, 1978; Mohamed, 1981). The last two references also indicate that because of the indeterminate habit of growth of the species, flowering may take place over a prolonged period and it is thus important to count ripe heads only. Variation in inflorescence characters have been found including number of florets per inflorescence and seeds per pod (Bogaert, 1977; Evans & Davies, 1978; Mohamed, 1981), number of ovules per floret and percentage fertility (Dessureaux, 1951; Bogeart, 1977). Mohamed (1981) showed that high seed yields may be achieved via different strategies. Thus large leaved varieties with good seed yields compensated for a relatively low inflorescence number per unit area with a bigger inflorescence, with more florets and a high number of seeds per floret. The variety Nora, on the other hand, achieved a high potential seed yields with above average inflorescence density at harvest and a high 1000-seed weight which compensated for a smaller inflorescence size.

Consistently high heritability values (0.67-0.75) were obtained by Bogeart (1977) from his clonal data for number of florets per inflorescence, seeds per pod and ovule fertility. Connolly (1978) reported maternal influences as the cause of variation in two seed characters in a 10 x 10 diallel viz. seed set per 100 florets and seed weight. Apart from date of flowering and flower density (heritability of 0.68 and 0.80 respectively), Mohamed (1981) obtained relatively low heritability values for a range of inflorescence characters (0.26 to 0.38) in an 8 x 8 diallel. In general these characters were predominantly controlled by genes giving additive effects, while dominance effects were relatively small. Maternal and non-maternal reciprocal differences were generally absent in this material.

To summarise it may be said that considerable genetic variation is available in white clover for components that together make up for a good seed yield and would be amenable to selection. Nevertheless environmental conditions and management have an overwhelming effect on the level of seed yield attained but the variety must possess a reasonable high potential seed yield.

Two plant factors mitigate against seed production. The indeterminate habit of growth means that flowering is spread over many months which makes decision making in relation to harvesting difficult. During this time the early formed heads may fall back into the foliage where the moist conditions encourage premature germination. It has been suggested that peduncles which remain erect after fertilization would be advantageous in this respect (Davies, 1970; Bogaert, 1977) but so far this variation has not been observed despite extensive searches (Mohamed, 1981).

Recent work by Thomas (1981) has thrown some light on the sequence of events that take place during the flowering period. When conditions are favourable for inflorescence development, a node on a stolon may produce an axillary vegetative bud or an inflorescence but never both. If one takes the first reproductive node (a) then the next nodes (b) and (c) produce very few inflorescences, and this is followed by a second peak of initiation at (d) and (e). Again there is a decline at node (f) and a tendency for a further burst at nodes (g) and (h). This illustrates why flowering is so protracted and explains the flushes of blooms that are characteristic of the crop. An understanding of the basic hormonal control of the switch from vegetative to reproductive growth would enable this aspect of behaviour to be manipulated (Davies, 1978).

Red clover

Red clover is a short lived perennial. Its problems are entirely different from that of white clover. There are two main types (a) diploid and (b) tetraploid. Because of the advantages in terms of yield, disease resistance and persistency considerably more information has been published on the tetraploids, where seed production problems are more acute.

A separate Eucarpia working group was in fact set up, and met in Svalöf in 1961 to discuss fertility problems of tetraploid clover. Since then there have been regular reports to this section describing progress (Julen, 1971, 1975; Dennis, 1975). More recently a comprehensive account of breeding for improved seed production (Dennis, 1980) has been published. The reader is referred to this paper for a detailed discussion on the effect of components of seed yield.

Seed production has remained an intractable problem and although initially it was thought that there would be rapid response to selection for increased fertility this has not proved to be so in practice. Indeed Julen (1975) recalled that in an earlier 1949 report he had said that tetraploid plants with nearly full fertility had been produced but he had to admit in 1975 that the problem remained unsolved. On a more optimistic note Dennis (1980) concludes that seed setting potential of auto-tetraploid red clover can be greatly improved by the use of suitable selection techniques. There is one proviso - that there should be a marked improvement in pollination conditions.

Selection for increased fertility

I now wish to discuss three experiments in which the main objective has been to increase fertility.

The first is unpublished work by my colleague Dr John Hill. The base material was the Eucarpia tetraploid mixture - which was conceived at the 1961 Group meeting. About 10 lines from various participant breeders were allowed to inter-pollinate and multiplied through several generations. This project was founded on the premise that a more widely based gene pool would result in more effective selection.

In a preliminary study no useful correlation between corolla tube length and percentage fertility was found and selection was subsequently based on percentage fertility of open pollinated field grown spaced plants. A strong selection pressure was applied with not more than 20 plants (out of 800) being selected over five generations. Conclusions were as follows:

(a) large seasonal variations occurred in seed setting ability

(b) although occasionally tetraploid families were found which had seed sets as high as in diploid controls, this lacked consistency. Overall the percentage seed set of the tetraploid material was about 40% of that of early diploid Dorset Marl and 50-60% of that achieved by late S.123 red clover.

It became clear that little consistent additional progress was being made and the experiment was terminated.

The second experiment is that of Dennis (1980) who selected for high or low seeds per head for five generations. Seeds per head had previously shown a high correlation with percentage seed set (r = 0.95***). In the high selection, seeds per head increased from 17.5 to c.30 by the third generation and slowly to 34.8 in the fifth (cf. 43.9 for diploid control). Seed yield per plant was about two-thirds that of the diploid control. The realised heritability was low (0.15) despite the marked increase in seed set. Selection for low fertility had no significant effect. There were over twice as many pollinatiors on the diploid rows compared with the tetraploid.

The third example comes from Sweden where it all started. Julen (1975) reported on the improvement in the tetraploid Sally as a result of selection for seed setting. Relative seed yields of 111, 120 and 148 in generations 0, 1, 2 in comparison with Rea, an earlier tetraploid variety were obtained as a result of this selection. More extensive results were quoted by Sjodin (1979) and in 48 comparisons the seed yield of Rea was 11% below that of Sally (mean 322, range 56-605 kg/ha). By comparison the seed yield of a diploid control variety was 9% better than Sally in 33 comparisons. Julen (1975) comments that selection for seed takes a long time and is also very laborious. It appears to have been successful.

These three examples are taken from northern Europe where the importance of the pollinating insect is a major limiting factor. In southern Europe insect pollination does not appear to be a problem and is less frequently mentioned in the literature. Haragsim (1977) from Czechoslovakia is of the opinion that the importance of bumble bees has been exaggerated.

Uzik's (1979) ideotype would have 4-6 inflorescences per stem, with about 100 flowers per inflorescence and a high percentage of double-seeded pods. The content of nectar and aromatic substances should be high. Other desirable features included simultaneous ripening and resistance to lodging, head shattering, pests and diseases. Tetraploid forms should preferably be developed through meiotic doubling rather than by mitotic doubling, as the products of the former approach are more fertile. In Romania highest seed yields in tetraploids were obtained from high seed yielding diploids (Panfil et al., 1976).

Most of the above has been concerned with tetraploid red clover but parallel problems occur in diploid red clover although in a less acute form. It has been suggested that it would be advantageous to do the selection at the diploid level and then produce tetraploids from this material (Picard et. al., 1970; Toynbee-Clarke, personal communication).

In conclusion, it appears that useful genetic variation exists in red clover for components of seed yield. Positive and negative interactions between different components suggest that selection for one component alone will not be the most efficient means of improvement (Dennis, 1980). Although selection is of long duration, success appears to have been achieved for the tetraploid variety Sally from Sweden which yielded 8% less than the diploid control (Sjodin, 1979).

Lucerne

Lucerne is a perennial, cross pollinated forage species which is widely grown throughout the world. Seed production is not as serious a limiting factor as in white and tetraploid red clover. Reasonable seed yields can be produced in near Mediterranean or continental areas with hot summers. Seed is not grown commercially in north-west Europe on account of inefficient tripping by honey bees which are attracted to the crop by the nectar (Davies, 1971). Seed production problems have been discussed regularly by the Lucerne working group of this section.

The most important problems appear to be to increase average seed yields and to stabilise annual variations.

Seed yields can be improved through breeding and the large variations in potential seed yields of current varieties indicate the possibilities (Varga & Gumaniuc, 1977; Nordestgaard, 1978; Delaude, Guy, Ecalle, 1975).

Components of seed yield

Pedersen et al. (1972) have reviewed the effect of various components on seed yield. Although attempts to find a single index for predicting seed yield were not successful, seeds per pod consistently appeared to be an important component of yield. This finding has been confirmed by recent results (Rumbaugh, 1971; Sowa, et al., 1973; Singh, 1978; Zharinov, 1979). Nielsen (1979) obtained a heritability value of 0.56 for seed yield and due to considerable phenotypic variability a relatively high response to selection was anticipated. Singh (1978), by contrast found very low narrow sense heritability for seed yield and seeds per pod in diallel crosses of seven clones. The SCA values were high compared to GCA and this suggested that very little of the variation was due to additive genetic components. He suggested that further improvement might be brought about by utilization of various interactions and heterosis. These results were obtained from clones that had been selected for high seed yield under predominantly self pollinating conditions.

At one stage there was some concern that selection for high seed yield would results in reduced yield of dry matter (Pedersen et al., 1972; Varga, 1979), but recent research indicates that these aims are not necessarily mutually incompatible (Nielsen, 1979).

In conclusion, varieties with large differences in potential seed yield exist. There is also considerable useful genetic variation available for further improvement. Seeds per pod appears to be one of the most consistent components of higher seed yields.

Finally, the overwhelming effect of environmental conditions and management practices on seed yields must be re-iterated. Weather conditions during growth, pollination and harvesting can swamp any differences in varietal potential seed yield achieved by breeding.

All these legumes are cross-pollinated and there is a need to ensure optimum visitation by effective insect pollinations. This is especially true for tetraploid red clover and efforts should be maintained to induce honey bees to work this crop (Dennis, 1980). The importance of management practices to maximise flower production, and to reduce the effect of pest and disease cannot be over-stressed. Lastly the efficiency with which the potential seed yield is harvested can reduce the actual yield to less than 50% of potential (Gikic, 1973) and so to a large extent nullify any gains achieved.

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Adaptive strategies of italian ecotypes of *Dactylis glomerata* L. and their relationship with seed production.

M. Falcinelli[*], F. Veronesi[**] and F. Lorenzetti[*]

[*] Istituto di Allevamento Vegetale dell'Università degli Studi di Perugia (Italy)

[**] Centro di Studio per il Miglioramento Genetico delle Piante Foraggere del C.N.R., Perugia (Italy)

Introduction

It is well known that economical utilization of grass ecotypes is often prevented by low yielding capacities due to selective pressures which have acted to make them resistant to extreme stress conditions. The knowledge of adaptive strategies is therefore very important to choose basic materials for breeding varieties which combine suitable adaptive value and good productivity levels.

In perennial grasses natural selection operates especially on physiological characters such as heading time, seed yield and dispersal, summer and winter dormancy, dry matter productivity. The relationship between these characters and adaptation were studied in 81 italian ecotypes of cocksfoot (*Dactylis glomerata* L.) with the aim of contributing to the knowledge of adaptive strategies acting in this forage species and to identify germplasm resources for breeding programmes.

Materials and methods

In the past few years 81 populations of *D. glomerata* were collected at sites scattered from north (48°N) to south (38°N) in the Italian peninsula; 27 populations will be referred to as northern populations (N), 27 as central (C) and 27 as southern (S) (Fig.1). All the populations were tested at Perugia (43°05'N); 200 seeds of each population were sown in (50x35x10 cm) boxes in autumn 1977 and 60 genotypes were pricked out in the field, as spaced plant (40x60 cm), in March 1978.

During 1979 data on following characters were collected:

1) dry matter yield (g/plant) at heading time;
2) heading time (days from March 21th);
3) seed yield (g/plant);
4) seed shattering evaluated on three populations rapresentative of each group using the device proposed by Bonin and Goplen (1963). For each population 30 randomly chosen spikes were evaluated at 14, 21, 28 and 35 days from flowering time as follows: shattering percentage: $\frac{\text{weight of shattered seed}}{\text{weight of shattered+non shattered seed}} \times 100$);
5) summer and winter dormancy indirectly measured as vegetative growth with a screening made on August 7, 1979, and on December 18, 1979, scoring the plants as being dormant (with non visible green leaves = 1) and more or less non dormant (with a various amount of green foliage = from 2 to 9).

Results and discussion

Dry matter yields of northern and central ecotypes are similar ($\overline{X}_N$ = 136 g/plant and $\overline{X}_C$ = 131 g/plant) but higher than southern ones ($\overline{X}_S$ = 80 g/plant) (Fig.2). Seed yields show the same behaviour ($\overline{X}_N$ = 25 g/plant, $\overline{X}_C$ = 23 g/plant and $\overline{X}_S$ = 16 g/plant) (Fig.3). This is probably due to the agroclimatic conditions of northern and central regions, characterized by more fertile soils and less dry climates compared to regions of southern Italy.

The northern populations show a marked earliness in heading time ($\overline{X}_N$ = April 24th) most due to the Po valley ecotypes (dashed in Fig.4, $\overline{X}$ = April 15th) which could be connected with management practices used in the past. In effect in the Po valley the first cut is periodically delayed to allow more prolific shed of *Lolium multiflorum* L. (Tyler *et al*., 1969); because of this, the earliest genotypes of *D. glomerata* could have been favoured. Populations collected at intermediate altitudes in northern Italy together with those collected in central and southern Italy, where autumn is the best season for seed germination and seedlings establishement, show a mean heading date at the beginning of May. Such an heading time allows plants to fully utilize for growth the favourable spring conditions and make seed maturity coincident with the beginning of summer, so that seeds can overcome summer dry period without any risk to run into useless germination process.

Data reported in Fig.5 show that seed retention and shattering are very variable characters operating to fit adaptive requirements. Northern ecotypes respond to shatter test also 14 days after flowering whereas southern ones do not shatter their seeds even 35 days after flowering. Data show that in our materials seed dispersal can take place only in the presence of the best environmental conditions for seed germination in all Italian regions.

Summer growth is reported in Fig.6. Northern populations show a mean value ($\overline{X}_N = 3.8$) higher than those of central ($\overline{X}_C = 3.2$) and southern populations ($\overline{X}_S = 1.8$).

The variability of southern ecotypes (C.V. = 0.46) is higher than those of central and northern ones (C.V. = 0.15 and 0.17, respectively).

Winter growth data (Fig.7) show an opposite trend; the mean value of northern ecotypes ($\overline{X}_N = 3.7$) is lower than central ($\overline{X}_C = 5.7$) and southern ($\overline{X}_S = 7.7$) ones and the variability is higher ($C.V._N = 0.40$ vs. $C.V._C = 0.15$ and $C.V._S = 0.14$).

Growth and dormancy rhythms of the 81 Italian populations of <u>D. glomerata</u> are strongly related with rainfalls and temperatures of their area of origin; the correlation coefficient between summer growth in Perugia and May-June rainfalls in the place of origin is 0.70^{**} while the correlation coefficient between winter growth and average minimum temperature of the coldest month (January) is 0.77**. Particularly, summer dormancy seems to be a powerful means of adaptation able to assure survival of perennial grasses in mediterranean environment and this is achieved through the development of dormant buds at the base of reproductive tillers.

It is worth to note that evaluation site, Perugia, is less dry than southern sites in summer and more warm than northern sites in winter. Following Rebishung (1953) and Lorenzetti <u>et al</u>. (in press) it can be thought that the conditions in the pre-stress period are relevant for explaining the different variabilities observed for summer and winter growth.

In northern Italy, autumn conditions have been favourable to hardening for such a long time that almost all plants reach a satisfactory level of cold resistance except for extreme, non resistant genotypes. When the resultant populations are tested under milder environmental conditions, each population reacts to the new situation according to its genetic constitutions giving rise to the explosion of variability observed in the present experiment.

The same considerations hold true to explain the behaviour of the southern group of populations for summer dormancy.

The data as a whole enphasize different behaviours between and within northern, central and southern groups of italian populations of <u>D.glomerata</u> and the existence of perfect mechanisms of adaptation which allow plant survival during the periods of severe stresses; furthermore seed dispersal and dormancy allow germination only when climatic conditions are the best for establishment. The extreme variability observed for all the characters examined shows the possibility to breed new varieties characterized by different earliness and different growth rhythms with the aim to support a better forage distribution during the year.

Summary

In perennial grasses natural selection operates especially on physiological characters as dry matter yield and seed yield per plant, heading time, seed dispersal, winter and summer dormancy. The relationships between these characters and adaptation were studied at Perugia on 81 italian ecotypes of Dactylis glomerata.

The results can be summarized as follows:

a). Dry matter yield and seed yield per plant: northern and central ecotypes, adapted to more fertile soils and less dry climate, gave the highest dry matter yield. Seed yields show the same behaviour.

b) Heading time: unespectedly northern ecotypes were much earlier than central and southern ones.

c) Seed dispersal: northern ecotypes respond to shatter test also 14 days after flowering whereas southern ones do not shatter their seeds even 35 days after flowering.

d) Winter and summer dormancy: in northern ecotypes summer dormancy was considerably lower and winter dormancy higher than in central and southern ones.

The data as a whole show the existence of perfect mechanisms of adaptation which permit plant survival during the periods of severe stresses; furthermore seed dispersal and dormancy allow germination only when climatic conditions are the best for establishment.

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Fig.1.- Collection sites.

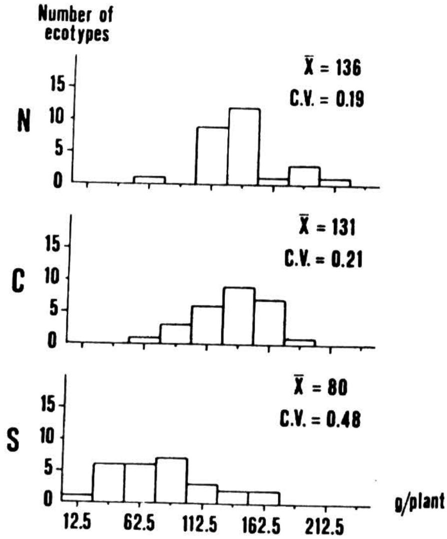


Fig.2.- Dry matter yield (g/plant).

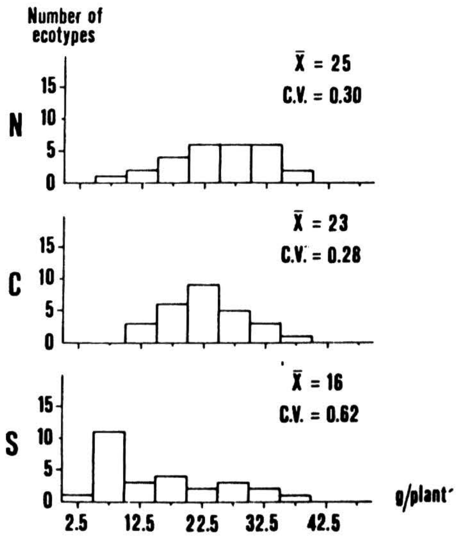


Fig.3.- Seed yield (g/plant).

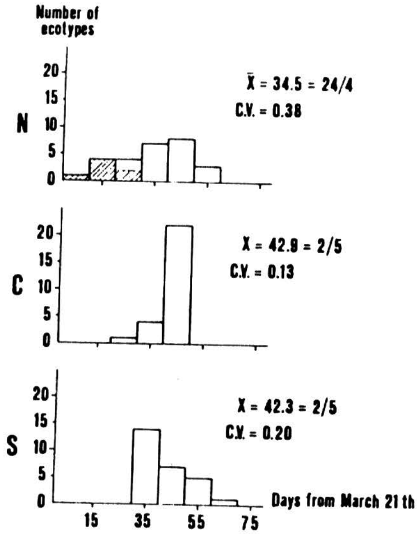


Fig.4.- Heading time (days from March 21th).

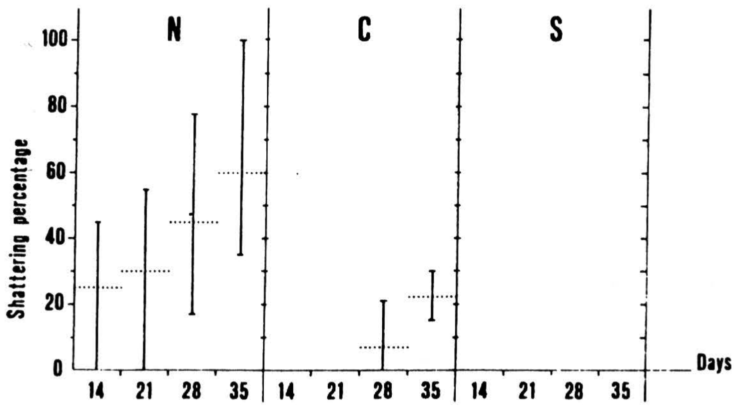


Fig.5.- Shattering percentages of 9 populations of Dactylis glomerata L. at 14, 21, 28 and 35 days from anthesis. Each vertical line represents a plot range of three populations of northern, central and southern ecotypes. The horizontal discontinous lines represent the means.

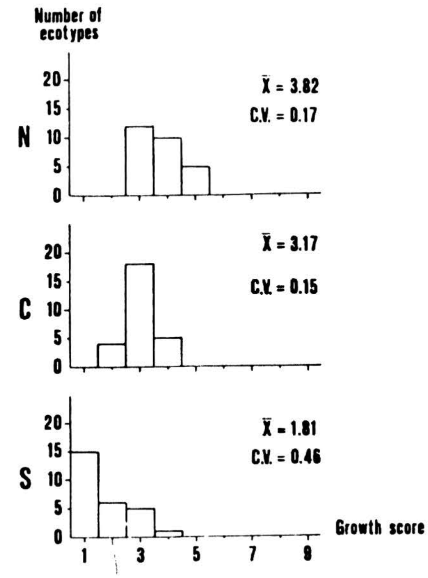


Fig.6.- Summer growth.

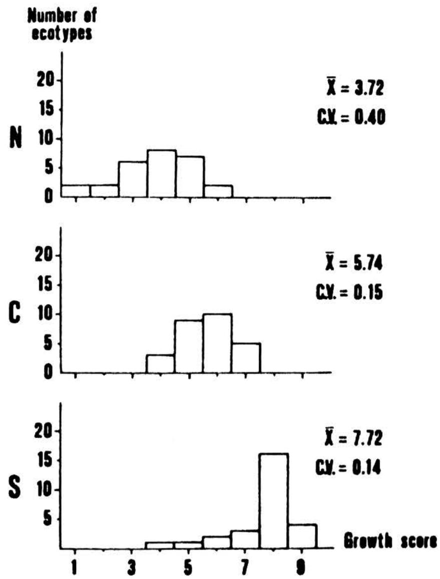


Fig.7.- Winter growth.

EUCARPIA, Fodder Crop Section, Merelbeke, Belgium, 8-10 September, 1981

Selection for seed setting capacity in tetraploids of clover and grasses

Jan Sjödin
Svalöf AB, S-268 00 Svalöv, Sweden

Red clover

In 1942 tetraploid red clover populations were tested in comparative trials at Svalöv for the first time. The results were disappointing both from dry matter yield and seed set point of view. When by time the genetic variability was widened more positive results were obtained and during the last 15-20 years dry matter yield of tetraploids have been 5-10 % higher in the first year ley and 15-25 % higher in the second year as compared with diploids. The higher total yield is based especially on a much better regrowth and general persistance.

In raw tetraploids the seed set is low due to genetical and physiological and to some degree to meiotic disturbances. Natural selection reduce these disturbances the following generations but never eliminate them. Even in advanced generations there are aneuploid frequencies between 15-50 % reported (Ellerström and Sjödin, 1966, 1973; Maizonnier and Picard, 1970). It was early understood that a wide genetic base was a pre-requisite for an increase of seed set and by time when the new 4x populations were based on mass crosses between many populations, each built upon a large number of diploid individuals, the seed set also increased (Julén, 1971). The low seed set as compared with the diploids was, however, still apparent and selections for single characters, supposed to effect the seed set, were carried out. Such factors investigated were e.g. pollen fertility, meiosis regularity based on number of laggards in tetrad stage, length of corolla tube, number of florets per head and number of heads per plant (Julén, 1970; Eskilsson, 1971; Eskilsson and Bingefors, 1972). The results were still not very convincing and better results were later obtained by simply selecting for high number of seeds per head. The cultivar Sally was improved in seed set by this technique (Julén, 1975) and it is today the first Swedish cultivar of 4x red clover that under practical field conditions gives an acceptable seed yield (Tab. 1). Although the comparision is not a direct one it is anyhow apparent that the seed

Table 1. Seed yields from multiplications under practical field condition of Sv Sally 4x red clover in southern parts of Sweden

Year	Number of multiplication	Number of ha	Average kg/ha	Seed yield of 2x Bombi
1974	8	38	321	592
1975	6	31	341	509
1976	6	57	432	380
1977	3	19	342	445
1978	9	63	350	472
1979	10	77	325	405
1980	10	78	161	341

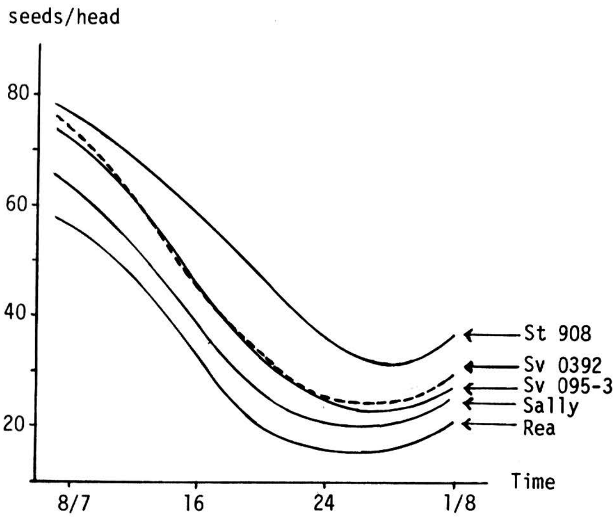
set of the tetraploid is lower than that of the diploid cultivar Bombi, which represents a good seed setter in South Sweden.

Trying to elucidate the most important factors behind seed setting capacity some new lines with very high seed set (Sv 095-3 and St 908) were compared with the parental populations (Sally and Sv 0392 respectively). Furthermore an old cultivar Rea was included. These five populations were analysed with regard to frequencies of visiting bumblebees and bees, intensity of flowering measured as number of opened inflorescences per day, number of heads per plant, length of corolla tube, pollenfertility and number of seeds per head (Tab. 2). Significant differences were obtained with regard to length of corolla tube.

Table 2. Average values of frequencies of visiting insects, intensity of flowering, length of corolla tube, pollenfertility and seeds per head

	Frequency of bumblebees per day	Intensity of flowering	Length of corolla tube	Pollen-fertility	Seeds per head
Rea	8.0	33	10.2	21.9	28.6
Sally	9.0	30	10.0	19.0	32.5
Sv 095-3	7.1	25	9.7	14.2	40.4
Sv 0392	9.4	20	10.6	23.1	41.6
St 908	10.9	31	10.6	23.2	49.7
	no signf	no signf	+++	no signf	+++

The lines selected for high seed set had, however, not as expected the shortest tubes, which has also been observed by Dennis (1975). The other significant differences were obtained for the character on which the selection originally was based - number of seeds per head. No consideration is then taken to the degree of self-fertility. When comparing the population during the flowering time with regard to seeds per head (Fig. 1) Rea shows lower values all through. There are also



clear differences between each of the mother populations and the selection lines from them.

Grasses

Miss Karin Klinga, Genetic Institute, University of Lund is at present investigating the influence of aneuploids from different points of view in 4x grass populations. They usually contain high frequencies

Table 3. Distribution of chromosome number in % of 4x populations of Lolium perenne, L.multiflorum, and Festuca pratensis

Population	Time of sampling	Chromosome number: 26	27	28	29	30
Sv 01413	Seed lot	3	23	59	11	4
L.perenne	Nov-74	6	21	52	21	0
	May-75	2	23	62	9	2
	Sept-75	0	20	69	9	2
	May-76	3	10	81	6	0
Sv 02054	seed lot	6	32	47	14	1
L.multiflorum	Nov-74	1	16	60	21	1
	May-75	2	19	68	8	3
	Sept-75	0	12	82	6	0
	May-76	0	12	85	4	0
St 839	Seed lot	1	11	71	15	1
F.pratensis	Nov-74	0	12	78	10	0
	May-75	0	9	85	6	0
	Sept-75	0	3	92	5	0
	May-76	0	1	96	3	0

of aneuploids (Simonsen, 1973, 1975; Easton, 1973). At Svalöf the frequency obtained was 41 % in one population of Lolium perenne (Sv 01413), 53 % in each of two populations of L.multiflorum (Sv 02054 and Sv 02056), and 27 % and 29 % respectively in two populations of Festuca pratensis (Sv 01243 and st 839). The seed lots were sown under normal field conditions with barley as cover-crop. The frequencies were then tested in the autumn of the seeding year (Tab. 3) and then in the spring and the autumn of the following two years. As observed in 4x red clover (Ellerström and Sjödin, 1966) the number of aneuploids in these grasses are also reduced.

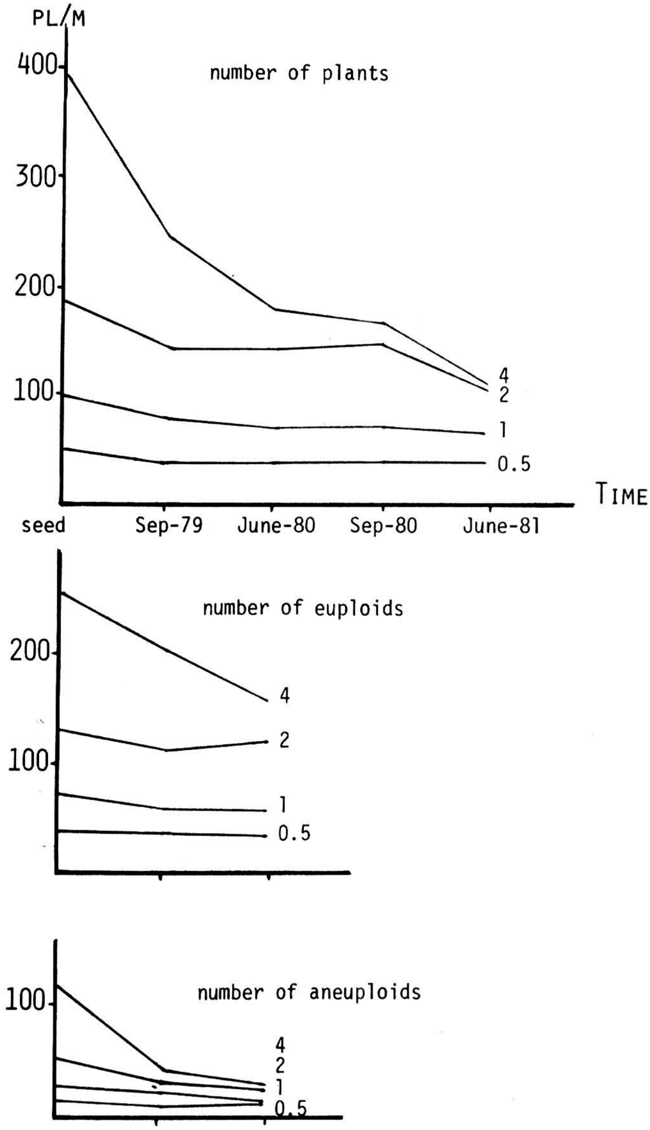
Table 4. Seed fertility (%) and thousand grain weight (g) in eu-, hypo- and hyperploids of five tetraploid Festuca- and Lolium-populations

Species	n	Seed fertility (%)			1000 grain weight (g)		
		Eu-ploids	Hypo-ploids	Hyper-ploids	Eu-ploids	Hypo-ploids	Hyper-ploids
F.pratensis, 4x							
St 839	134	59.3	35.3^{++}	38.3^{+++}	4.3	3.5^{+++}	3.8^{+++}
Sv 01243	40	57.0	38.1	40.9	3.6	3.5	3.2
L.multiflorum, 4x							
Sv 02054	78	49.4	30.5^{+++}	45.7	3.8	3.3	3.8
Sv 02056	65	61.3	52.9	61.9	4.o	3.6	3.7
L.perenne, 4x							
Sv 01413	51	49.2	29.4^{+}	41.1	3.5	3.3	3.5

The seed set, measured as number of seeds per flower, was in the Festuca-material higher in the euploids (Tab. 4). In the Lolium species the euploids showed a higher seed set as compared with the hypoploids whereas the fertility of the hyperploids was nearly the same as the euploids. The same relations were obtained with regard to thousand grain weight (Tab. 4) eventhough the differences were of smaller magnitude.

When reporting above about the changes in aneuploid frequencies under field condition no consideration were taken to eventual differences in plant density. Miss Karin Klinga is investigating this in St 839, the 4x Festuca population used above. She is working with 4 densities - 50, 100, 200 and 400 germinated plants per meter. So far she has taken four samplings and will make the last one this month. Fig. 2 shows the data hitherto analysed. As expected the more dense the original stand was, the more drastic the elimination of plants has been. In June -81

FIG. 2. DENSITY CHANGES WITH AGE OF LEY



the two most dense of the original stands are on the same level. Only two samplings are analysed with regard to number of euploids and aneuploids. There is an evident tendency that the euploids are eliminated at least in the same extent as the aneuploids in the most dense stand whereas in the other densities there are only minor changes of number of euploids, at least in June -80. Karin Klinga will be ready to tell you the final results from this part of her thesis work in about a year. The total data so far obtained indicate that even though there are great differences in plant density at sowing the natural selection give rise to about the same number of plants in later stages of the ley and at that time the aneuploids are eliminated to a very great extent.

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SEED YIELD AND SOME FACTORS INFLUENCING SEED SETTING ON VARIETY LEVEL IN LUCERNE.

I. Bócsa - J. Buglos
G.A.T.E. Agricultural Research Institute, Kompolt, Hungary

In ranking lucerne varieties seed yielding ability has never constituted an important criterium, thus lucerne breeders have given but scarce account of activities aiming at improving seed yield of lucerne. Even in our days seed yielding ability is not listed among the factors regarded as determinant of the value of lucerne, and in many countries breeders are still not truly aware of the significance of this trait.

Seed yield of lucerne, in fact, is a very important issue particularly in countries which can be termed as "sub-optimal for seed production"; on areas like that seed yield of lucerne is very uncertain and closely dependent on the weather. Countries of the "sub-optimal zone" are not able to sufficiently multiply well adapted varieties of their own and very often are forced to import foreign varieties of uncertain origin and insufficient adaptation.

Variety testing bodies are now on the way to appreciate the seed yielding ability of the varieties, but they still fail to investigate it according to its merits. Even their scarce data are not publicized for fear of infringement of commercial or breeder interests. Farmers would, namely, prefer varieties of good seed yielding ability.

The first rather solitary approach to improve seed yield of lucerne by means of selection is linked with Fryer (1939). Then Stevenson and Bolton (1947) direct attention to the possibilities in self-tripping. It was Wilsie (1951, 1958) who first reported that no correlation exists between seed and fodder yield. Melton (1969) on the other hand found a positive relationship between these traits ($r = 0.54$). Pedersen (1953) confirms these results and reports an impressive success by means of recurrent selection : an increase of 38.8 per cent compared to the standard. These findings all serve to prove that seed yield of lucerne can be improved and that efforts needed take a relatively short time to realize the breeding objective.

Lesins (1961) while giving a comprehensive summary of the whole problem points out the possibility of developing a self-compatible form of lucerne for zones of adverse conditions for seed production. More detailed investigations were carried out by Busbice and Wilsie (1966) but so far only Pedersen-McAllister (1961) and Lesins (1973) reported results of practical significance. The former ones selected variety Uinta giving a 67 per cent higher seed yield than cultivar Ranger, the latter breeder developed Ellerslie a self-compatible variety registered in Canada.

Material and methods

Eleven Hungarian and foreign media and sativa cultivars have been investigated for fodder yield in more than one cycles of different duration. Trials were arranged in randomized block design in 4-5 repetitions, with plots of 5.7, 11.4 or 22.8 sq meters. Cuts were taken mostly at early flowering stage to record fodder yield only. Sampling for dry matter and protein content also took place but now we disregard these details.

The 11 cultivars mentioned together with cultivar Bucany have been also tested for seed yield in the same design on plots of 35 sq meters with 4 rows 70 cm apart. Rate of seed was 2.8-3 kg/ha to allow about 100 seeds/meter. Seed was harvested always from the second growth.

Self-compatibility of the varieties was investigated by bagging and selfing 1500-2000 florets per plot. Individual plants were not identified, but care was taken to involve at least 20 different plants per plot to obtain representative values on variety level. Over 4 years about 6000 florets per variety have been bagged and hand opened.

In 5 varieties 4000 florets per cultivar have been bagged without hand opening following the same sampling pattern as above. In this trial Tapioszelei-1 a Hungarian variety was also included without being subjected to trials for seed and fodder yield.

Self-compatibility was expressed partly by number of seed per pod, partly by number of pods per 100 florets. The same indices were applied to characterize self-tripping. Correlations between seed yield and some of its determinants were also computed.

Results

Table 1 shows that the difference between extremes in the fodder and seed trial 10.1 and 54.7 per cent respectively, indicating a far more promising prospect in selection for increased seed yield. This conclusion corroborate Pedersen's and other worker's findings.

TABLE 1

Fodder and seed yield of varieties tested

Variety	Fodder yield (relative)	Seed yield (relative)
Nagyszénási*	100.0	100.0
Bánkuti	99.7	113.2
Szarvasi	99.6	98.8
Mv Synalfa	96.0	95.9
Kosyn	97.1	103.6
Békésszentadrási	100.9	103.6
Óvári	96.8	98.7
Flamand	103.7	86.3
Du Puits	101.8	90.7
Isis	93.6	141.0
Hodoninska	99.5	86.3
Bucany	-	96.1
LSD 5%	7.1	14.0

* Yield of standard : 36.7 t/ha/year

On investigating the self-fertility/self-compatibility of the varieties we have found that under certain conditions self-fertility might rise to a very high level, a fact confirmed by Lorenzetti and Veronesi (1980), and that varieties show marked differences in this respect. (Table 2)

TABLE 2

Self-fertility and self-sterility of varieties

Variety	Self-fertility %	Self-sterility %	Opened florets
Isis	31.1	6.7	7.150
Nagyszénási	29.8	7.2	4.786
Békésszentandrási	29.5	6.9	6.610
Szarvasi	29.2	6.9	6.818
Bánkuti	27.4	5.5	6.375
Flamand	25.0	24.2	5.871
Du Puits	24.2	16.1	5.789
Kosyn	23.9	2.8	6.893
Hodoninska	23.3	18.5	6.418
Óvári	22.4	9.4	7.127
Bucany	21.7	14.8	6.419
Mv Synalfa	18.8	20.8	6.379
			76.675

Extremes might differ by more than 50 per cent. In self-sterility we have found even greater amplitude : with 2.8 and 24.2 extreme values a 9 fold difference can be demonstrated. It was also striking that the lowest seed yields were obtained from those 3 varieties which ranked high in self-sterility. (Flamand, Du Puits, Hodoninska). It is also worth mentioning that cultivar Isis is characterized by a relatively high self-compatibility and a good seed yield.

These differences suggested us to have a closer look at the relationship between seed yield on one hand and self-compatibility and self-sterility on the other : the r values obtained were 0.58 and -0.62 respectively; they are statistically significant and the investigations have been carried out on varietal level.

By studying self-tripping in case of 5 cultivars marked differences and a sizeable range (7.2-23.1 per cent) have been obtained. Results are summarized in Table 3.

TABLE 3

Self-tripping of varieties tested

Variety	Bagged florets	Pod set %	Seed/pod
Isis	6000	18.5	1.80
T-1	4000	8.5	2.30
Mv Synalfa	4000	4.3	1.81
Kosyn	4000	11.9	1.98
Nagyszénási	4000	11.2	2.50

Correlation between self-tripping and seed yield appeared to be close with an r value of 0.80.

At last we studied self-tripping of inbred generations of cultivar Isis. We have found that in S_2 self-tripping succumbs to a minimum as does self-fertility. In S_3 on the other hand self-tripping equals or surpasses S_1. This tendency is well indicated by the seed/pod values too. (Table 4)

TABLE 4

Some components of seed yield in Isis inbred generations in case of self-tripping

Inbred generation	Bagged florets db	Set pod db	Self-tripping %	Obtained seed	Seed/pod
S_0	7800	1316	16.9	2355	1.78
S_1	5900	556	9.4	775	1.38
S_2	3000	101	3.3	109	1.07
S_3	8200	875	10.6	1058	1.21

From the data presented follows that cultivar Isis with its outstanding out-cross seed yield, together with its marked self-compatibility and self-tripping could have served for a promising initial material for selecting cultivars of high seed and medium fodder yielding ability. It is very likely that first of all its seed/pod index should be increased since, as it is shown in Table 3, in this respect there is ample room for improvement.

Presented data seem to suggest high self-compatibility and self-tripping together with good seed/pod index as being the most important criteria of a good seed yielding variety. Such varieties in countries with unfavourable conditions for seed production are badly needed and their development would satisfy an old but ever up-to-date demand.

Summary

Twelve varieties have been tested for seed production over 4 years. Extreme yielders show a difference of about 50 per cent. Fodder yield of 11 entries of twelve is known. The greatest difference between the extreme yielders was 10 per cent only.

Marked differences occurred between entries with respect to self-compatibility. The average of about 70 000 flowers values of self-compatibility ranged between 18 and 31 per cent.

We have established significant positive correlation between seed yield and self-compatibility (r = 0.58).
When comparing self-tripping between 5 varieties and 3 inbred generations within the same variety, following results were obtained : extreme values ranged between 7 and 23 per cent, S_1 to S_2 generations showed a marked decrease, while S_3 reached the level of S_1 again. We have found a significant positive correlation between self-tripping and seed yield (r = 0,80).

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REPRODUCTION MECHANISMS AND SEEDS YIELD IN DIPLOID *Hedysarum coronarium L.*

EL GAZZAH-M., LANDOLSI-S and CHAIBI-N.
Laboratoire de Génétique et Biométrie,
Faculté des Sciences de Tunis

INTRODUCTION

We are interested in this study in the examination of the reproduction mechanisms in relation with the seeds yield in natural diploïd *Hedysarum coronarium L.* called Cock's head (2n = 16). It is a leguminous papilionaceous plant with a fodder vocation, enough accepted in the north of Tunisia and pratically all the mediterranean countries.

A-REPRODUCTION MECHANISMS AND FERTILITY INDEXES

The flower, red to violet and rarely white, is characteristic of leguminous papilionaceous plants. The pods are straight and jointed (1 to 5 joints). Before the pollinization, each flower presents an ovary with 1 to 5 ovules. The number of joints composing one pod can be determined only after the fecundation. Indeed, one distinguishes the two following cases :

- Ovule fecundation and a joint formation in the pod,
- Unfertilized ovule and absence of joint formation (zone without joint at the pod-level).

The formed embryos lead to mature seeds. Meanwhile, some do not continue their development, degenerate and are considered "abortive embryos". The ovule becoming is not dependent on its position in the ovary.

After these ascertainments, we have tried to establish a method for valuation of the seeds yield in this plant in relation to the breeding system applied in the experience.

Various methods were already presented at the time of breeding systems studies in plants (DATTEE, 1976 ; EL GAZZAH, 1978 , EL GAZZAH and CHALBI, 1978, 1981 ; ....).

We present here the following parameters for studing the seeds yield of this plant at individuals or populations levels when variability is concerned :

a) $F_g = \frac{n}{N}$, frequency of "pods formation" ($o \leq F_g \leq 1$), where N is the number of pollinized flowers and n the number of formed pods ,

b) $F_r = \frac{\sigma}{O_f}$, the rate of "Successful fecundations" ($o \leq F_r \leq 1$), where O_f is the number of fertilized ovules (number of formed joints) and σ the number of mature seeds obtained. These two indexes are generally independant and are characteristic of two successive stages of reproduction.

c) $R_G = F_g . F_r$ ($o \leq R_G \leq 1$), the estimation of the real seeds yield, from the two indexes quoted above,

d) $E_a = \frac{O_f - \sigma}{O_f} = 1 - F_r$ ($o \leq E_a \leq 1$), the abortive embryos rate.

All these parameters have been used for studing reproduction in different populations.

B-STUDY OF SEEDS YIELD AFTER PROVOKED SELF-FECUNDATIONS :

From studies conducted recently on reproduction systems with different spontaneous populations, we summarize in this paper the main results :

- The formed pods present a variable number of joints; the most frequent situation is when we have three joints and two seeds by pod.

- When flowers buds are sacked, selffecundations give no results. Effectively, we have observed that the stigma is situated about 0,5 mm upper the stamens. So, only provoked selffecundations lead to mature seeds.

- The populations studied show a great tendancy to crossfertilization.

- The indexes F_g , F_r and R_G described after provoked selffecundations, have normal distributions. Normality of observed distributions from 280 individuals has been tested and χ^2 values obtained are not significant at 5% for corresponding values of degrees of freedom (see fig 1, fig 2 and fig 3) :

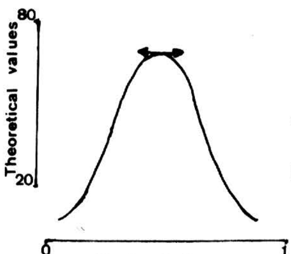

Fig 1. $F_g = \frac{n}{N}$

$\mathcal{N}(0{,}42 ; 0{,}16)$

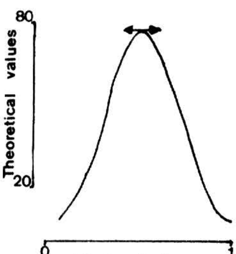

Fig 2. $F_r = \frac{o}{O_f}$

$\mathcal{N}(0{,}67 ; 0{,}14)$

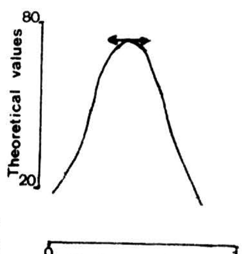

Fig 3. $R_G = \frac{n \cdot o}{N \cdot O_f}$

$\mathcal{N}(0{,}28 ; 0{,}14)$

DISCUSSION AND CONCLUSIONS

We think that the study of the seeds yield in cock's head must be relied on fertility indexes depending on the frequency of pods formation and the successful fecundations rate.

In the nature, this plant springs up again by crosspollinization ; and so, maintains a good adaptative value related to heterozygoty. In controlled conditions, the provoked selffecundations lead to selffertility indexes with a large variability between the individuals and this, in spite of their diploïd structure. Meanwhile, the presence, although rare, of selfincompatible individuals (2/280) on the one hand and some unfertilized ovules on the other hand, leads to suppose the existence of a selfincompatible system trails. The majority of plants is selfcompatible. In this case , selffertility(measured by one of the three indexes) seems to be controlled as a polygenic inheritance. The improvement of the seeds yield depends on the successful fecundations rate and the frequency of pods formation after the pollinization.

The presence of unfertilized ovules on the one hand and some abortive embryos on the other hand , leads to suppose the existence of various incompatible genic combinations during and after the fecundations. The diversity of pollen types during the pollinization allow to decrease these genic forms and increase the seeds yield in this plant.

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LIST OF PARTICIPANTS.

Denmark

ANDERSEN, S.
DENNIS, B.
PEDERSEN, CH.

Finland

JOY, P.

France

CHOSSON, J.F.
DEBRAND, M.
GENIER, G.
JADAS-HECART, J.
PICARD, J.
POISSON, C.

Germany (W)

BERNER, P.
BUGGE, G.
KOBABE, G.
LEON, J.
LÜTKE ENTRUP, E.
PAUL, CH.
SCHELLER, H.
SIMON, U.

Hungary

BÓCSA, I.
BÓJTÓS, Z.

Italy

CECARELLI, S.
LORENZETTI, F.
VERONESI, F.

Netherlands

BAERENDS, B.
BALTJES, H.J.
BOONMAN, J.G.
DUYVENDAK, R.
KLEINHOUT, A.
VIJN, R.
VAN CRUCHTEN, C.J.M.
VAN DEN BOGAERT, C.W.
VAN DIJK, G.E.
VAN WIJK, A.J.P.

Norway

BERG, T.
LARSEN, A.

Poland

LIPINSKI, J.

Sweden

ANDERSSON, B.
HALLING, S.
SJÖDIN, J.

Switzerland

BADOUX, S.

NÜESCH, B.

Tunis

EL GAZZAH, M.

United Kingdom

ELLIS DAVIES, W.

HAMPTON, J.G.

HAYWARD, M.D.

HEBBLETHWAITE, P.D.

Belgium

AERTS, J.

ANDRIES, A.

CARLIER, L.

DE BAETS, A.

DE GROOTE, R.

DE ROO, R.

D'HOOGH, R.

HEURSEL, J.

MEKERS, O.

ROUSSEAU, M.

VAN BOCKSTAELE, E.

VAN BOGAERT, G.

VAN HEE, L.

VAN SLYCKEN, A.

VYNCKE, A.

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