

IMPROVEMENT OF *LOTUS ULIGINOSUS*

By P. C. BARCLAY, Plant Breeder, Grasslands Division,
Department of Scientific and Industrial Research,
Palmerston North

Lotus uliginosus, commonly called *Lotus major*, is an important perennial legume in our grassland economy. It has proved valuable as a pioneer legume on peat, pumice, and hill country, where its rambling growth enables it to compete favourably with rushes, scrub, or fern, and as a permanent component of the wetter hill country where it is the important legume wherever the fertility and aspect are not optimum for white clover. It withstands heavy grazing and spreads both rhizomatously and stoloniferously. However, the material available is of great variability, the species in general establishes poorly from seed, and at Palmerston North is dormant in growth throughout May to August.

In any sexually reproducing cross-fertilised species, no two individuals are exactly alike and this variation, some heritable some not, is the basic material through which by selection plant improvement can be made. In the breeding of *Lotus uliginosus* at Grasslands Division improvement is being sought chiefly for increased yield, for extended seasonal production, for increased leafiness, and for seedling vigour. Naturally occurring *Lotus uliginosus* is a diploid with two sets of six chromosomes. Seed lots of the diploid were obtained throughout New Zealand and from overseas. Single plants were grown at Palmerston North to examine the range of the variation. In addition, new variation in the form of an autotetraploid (a particular type of polyploid) with four sets of six chromosomes has been induced by treatment of the diploids with colchicine. Three main selection programmes have begun as follows:

1. The selection of an improved strain from New Zealand diploid varieties.
2. The selection of an improved strain with winter growth based on intervarietal hybridisation between New Zealand diploid varieties and a diploid introduction from Portugal with winter growth.
3. The selection of an induced autotetraploid variety.

RESULTS

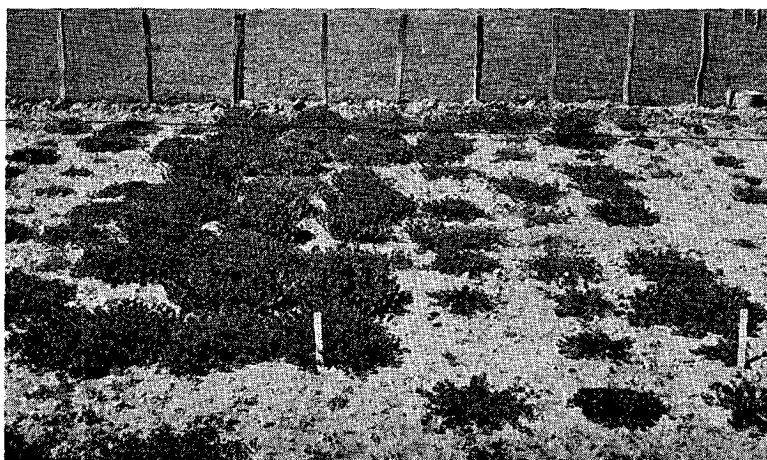
1. The Selection of an Improved Diploid Strain Based on New Zealand Adapted Varieties

Plant populations may become adapted to certain ecological or geographical conditions, and selection of individuals within such an adapted population is most likely to lead to an improved strain. For example, perennial ryegrass and cocksfoot were introduced into this country in the early days and by selection from material derived from these introductions, improved strains were produced that compared more than favourably with strains introduced in recent years from other countries. *Lotus uliginosus* was a regular constituent of seed mixtures during the initial establishment of New Zealand pastures and today is found scattered throughout the country. Over the past few years mass selections by the writer from such material have shown considerable improvement in general production and leafiness. Compara-

TABLE 1.
VARIETY TRIAL.
RELATIVE GREEN WEIGHTS of
Lotus uliginosus.

Trial \ Origin		Grasslands	Canterbury	Southland	France	S. E.
Single Plants	Cut 1 45 days	100	69	36	69	± 6
	Cut 2 64 days	100	70	36	42	± 10
Plots	Cut 2 64 days	100	57	14	34	± 7
	Cut 3 190 days	100	3 0	4	24	' 6

tive green weight yields from both single plant and plot trials between the selected Grasslands strain, two New Zealand commercial varieties, and one French variety are given in Table 1. Cut 1 is the growth from 30 November to 14 January, Cut 2 from 14 January to 19 March, and Cut 3 from 19 March to 25 September. It can be seen that at all cuts, for both single plants and plots, the Grasslands strain is superior to any commercial variety. In addition, the Grasslands strain withstands competition from volunteer white clover during the period the *Lotus* is dormant, whereas the commercial varieties do not. This improved Grasslands strain is now under test at our sub-stations and should it continue to prove superior to strains already in commerce, it will be released in the certification **scheme**.



Grassland strain of *Lotus uliginosus* with Southland strain on the left and French strain on the right.

2. The Selection of an Improved Diploid Strain with Winter Growth

A programme of intervarietal hybridisation in *Lotus uliginosus* became possible with the introduction from Portugal of a variety which grows during the winter at Palmerston North. Unfortunately this variety has much poorer summer growth than the New Zealand material. F_1 hybrids between New Zealand and Portuguese varieties have excellent winter growth. These hybrids are, however, still inferior to New Zealand adapted material during the summer. The programme now includes back-crossing to good New Zealand material and there is every hope of breeding a variety with a favourable balance between winter and summer growth.

3. The Selection of an Autotetraploid Variety

Even though polyploidy is one of the best known evolutionary processes, its use as a tool in plant breeding was not possible until a satisfactory method of producing polyploids on a large scale became available with the cytological study of colchicine effect by Dustin, Havas, and Lits (1937), and the practical application by Blakeslee and Avery (1937). However, newly induced polyploids are rarely of economic value; the plant breeder still has the job of appropriate selection to meet his requirements. In general, polyploids produced from diploids have shown the following desirable characteristics: (a) higher concentration of valuable substances such as vitamins; (b) larger seeds; (c) in some cases, as in red clover (Levan, 1945), an increased yield of dry matter. However? in addition to their favourable characteristics, they frequently also have unfavourable ones. Thus red clover tetraploids are usually susceptible to summer drought and have few leaves and thicker stems (Julén, 1956). Induced tetraploids also usually have low seed setting ability, about 60 per cent. of the diploid in hand pollinated red clover (Julén, 1956) and frequently less still in the field.

At Grasslands Division autotetraploids of *Lotus uliginosus* have been produced by colchicine treatment of very young seedlings. Mature plants have strong growth, possess thicker stems than the diploid, but have fewer but bigger leaves. Compared with red clover tetraploids they do not wilt markedly in the summer under drought conditions. Plot trials to examine the agronomic possibilities of this autotetraploid variety, in comparison with the selected diploid, have been sown this spring.

SEEDS of *Lotus corniculatus*, & of TETRAPLOID & DIPLOID *Lotus uliginosus*.

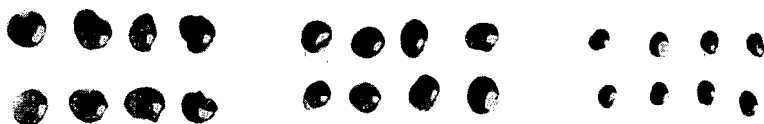


Fig. 1.

In one particular character, seed size, the tetraploid is most interesting. In Fig 1 are shown seeds of diploid and tetraploid *Lotus uliginosus* and of *Lotus corniculatus*, a natural tetraploid. The seed of the induced tetraploid is far bigger than that of the diploid, but a little smaller than that of *Lotus corniculatus*. The relationship of seed size to seedling vigour is being investigated and it can be reported that the diploid, with an average seed weight of 0.36 mg., gave seedlings one month old weighing 100 mg., whereas the tetraploid, with an average seed weight of 0.70 mg., gave seedlings one month old weighing 139 mg. This increased seedling vigour of the tetraploid may prove of great value in improving seedling vigour in the field.

The seed setting results based on a random sample of 9 diploid and 9 tetraploid plants are shown in Table 2 under the four headings: Seeds per Head, Seeds per Pod, Pods per Head, and Seed Weight per Head. Eight heads were sampled per plant. It can be seen that the tetraploid sets

Table 2.

SEED SETTING of DIPLOID & TETRAPLOID *Lotus uliginosus*.

DIPLOID

Seeds per head	Seeds per pod.	Pods per head.	Seed weight per head.
228 S.E. ± 24	22.1 ± 1.8	10.5 ± 0.6	101 ± 7
TETRAPLOID			
120 S.E. ± 21	11.2 ± 1.8	10.7 ± 0.5	97 ± 14
Mean level of top 5%.			
2 4 9	22.1	13.6	180
% improvement compared with DIPLOID means.			
+9%	0%	+29%	+79%

approximately 50 per cent. of the seeds per head set by the diploid. The seed weight per head comparison is a result of the tetraploid seeds being almost double the weight of those of the diploid. The character seeds per head is made up of two independent characters, seeds per pod and pods per head. The number of seeds per pod set by the tetraploid is only approximately 50 per cent. of that set by the diploid, whereas the number of pods per head does not differ significantly between diploid and tetraploid. In the table are also shown the calculated mean levels of the top 5 per cent. of the tetraploid data, together with the per cent. improvement of this top 5 per cent. compared with the diploid means. This potential of the tetraploid depends on the heritability of these characters being 100 per cent. Tetraploid plants selected on this basis will be compared for seed setting with the diploid this summer.

In order that winter vigour might be incorporated into the tetraploid variety, tetraploidy has also been induced from the Portuguese diploid and crosses are being made this summer between tetraploids from New Zealand and Portuguese material.

Summary

1. An improved diploid *Lotus uliginosus* selected from New Zealand material has been bred and is now being tested at Palmerston North and at the Grasslands sub-stations at Gore and Kaikohe.

2. Hybridisation between New Zealand and Portuguese *Lotus uliginosus* indicates that it should be possible to breed a further improved diploid with winter growth.

3. An autotetraploid *Lotus uliginosus* has been induced by colchicine treatment of New Zealand material. It has larger seeds and consequently greater seedling vigour, but its seed setting is 50 per cent. less than that of the diploid. It is hoped by selection to improve this seed setting.

4. An autotetraploid *Lotus uliginosus* has been induced from Portuguese winter growing material. Crosses are being made to incorporate this winter growth into the autotetraploids of New Zealand material.

Literature Cited

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DISCUSSION

- Q. I would like to question the desirability of selecting for improvement of what is essentially a hill country species at the Grasslands station at Palmerston North.
- A. I appreciate this question. The plant breeder in general realises he may be able to breed strains better adapted to certain regions by doing the selection work in these regions. However the plant breeding process requires extensive facilities and it would not be practical to duplicate these unless it was known just which of the many regions to select and just how much improvement would be gained thereby.
- Dr Corkill: It is the policy of the Grasslands Division to breed strains of pasture plants with wide regional adaptability. It is realised that regional strains bred in particular environments may be superior in these environments to a more general purpose strain. However, a multiplicity of regional strains in New Zealand would create difficulties in pure seed production and certification. In the production of these widely adaptable strains, progenies produced at our central station are tested under a wide range of conditions at our sub-stations located at Gore, Lincoln and Kaikohe, and in addition in regions adjacent to these stations. Progenies of Lotus will certainly be tested in regions in which it is likely to be used.