BREEDING FOR IMPROVED QUALITY AND QUANTITY OF FORAGE FOR THE GRAZING ANIMAL

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SUMMARY

An account is given of plant introduction studies; of descriptions of hybridization programmes including statements on 'Grasslands Ariki' ryegrass and the new white clover 'Grasslands 4700'; of programmes on induced tetraploidy; of an attempt to breed a variety of *Lotus pedunculatus* that will flower and set seed in Canterbury but which will remain largely vegetative in the region of use in Northland.

THE SUCCESS of a pasture plant breeding programme in part depends on clear objectives and in part on the plant variability available for selection. It also depends on the skill of pasture management under the influence of the grazing animal, a complicated process sensitive to change in climate, soil or technique.

The plant variability available for selection may be natural or induced. If natural, collections may be made within New Zealand, and this has always been an active process at Grasslands Division, in the hope of finding plants already adapted to our climate, soil or grazing systems. At present collections are being assessed of perennial ryegrass, prairie grass and *Phalaris tuberosa.*

Plants may also be introduced from overseas. In the first place these may be bred or natural varieties already recognized and certified nationally or internationally. In the second place they may be collections. Table 1 lists the introductions received and tested by Grasslands Division in a recent 6-year period.

Thus, 1,037 samples were received of 326 different species belonging to 21 different genera and were tested at one or more of Grasslands Division's main stations and often at subsidiary sites. The introductions came from 42 different countries, including 12 European, 4 Scandinavian, 4 Asian, 7 American, 6 African, 8 Mediterranean and Australia. Of all these, to date, only one introduction, a cocksfoot

TABLE 1: PLANT INTRODUCTIONS TESTED BY GRASSLANDS DIVISION, JANUARY 1961, TO DECEMBER 1966

Genera	No. of Species	No. of Samples
Agropyron	11	11
Agrostis	10	11
Bromus	79	175
Dactylis	2	111
Festuca	7	74
Hordeum	7	9
Lolium	8	84
Lotus	13	22
Ornithopus	4	7
Paspalum	28	44
Pennisetum	1	6
Phalaris	8	122
Phleum	5	21
Poa	6	6
Trifolium	103	265
Vicia	20	54
Miscellaneous (5)	14	15
Totals: 21	326	1,037

from the Manche district in France which has performed well in summer in Hawke's Bay, has given indication of being of likely direct benefit to New Zealand agriculture and will be submitted to exhaustive further tests. Many introductions, however, exhibit valuable individual traits while being poor in other characteristics. In *Trifolium*, for example, 18 of the 103 introductions were white clover and of these, four, an introduction from Morocco, and several Ladino introductions, are proving to be resistant to stem eelworm, a newly discovered disease of white clover in New Zealand.

At Grasslands Division new variation is being induced by hybridization within species, between species and between genera, and by the production of tetraploids by the use of the alkaloid colchicine.

'Grasslands Ariki' ryegrass, produced by selection within crosses between 'Grasslands Manawa' (short-rotation) ryegrass and perennial ryegrass, is now commercially available. Lynch (1966) has pointed out that Bascand (1963) has summarized the results of six research station trials and 60 farm grazing trials and has reported that Ariki ryegrass swards in these trials were about 6% higher-yielding than perennial ryegrass swards. Owing to poor

establishment of white clover in many of these trials, Grasslands Division recommended that such trials be closed down, and initiated research into satisfactory methods of establishing mixed swards of Ariki. These were ultimately published in the paper "Establishment trials of ryegrass and clover mixtures" (Sears and Brougham, 1963). It has also been implied that total annual production is the important thing, whereas Grasslands would claim that an improvement of a pasture variety for one or more seasons can be of vital concern to the New Zealand farmer. Thus Ariki ryegrass has much greater potential than indicated by Lynch, probably of the order published by Gould (1966) for Parua Bay and given in Table 2, although in his trial sown in 1961 Ariki did suppress white clover.

In Gould's trial the total yield of Ariki was 32.4% better than Ruanui, the ryegrass yield of Ariki was 57.5% better than Ruanui, and the associated white clover growth 34% less in Ariki than Ruanui for the period stated.

The fault of Ariki is not that it is not sufficiently superior to Ruanui, but rather that special methods, now adequately described, are needed for its establishment. Included among these methods is a low seed rate, and it is disappointing to find farmers often sowing much higher rates.

Nevertheless, a white clover that would associate satisfactorily with Ariki would be a great boon, and a programme was commenced in 1957 to breed a new white clover which it is hoped will fill this role. A winter-active, relatively summer-dormant introduction from Spain was crossed with summer-active, winter-dormant 'Grasslands Huia', and, following backcrossing to Grasslands Huia and further recurrent selection, a new variety tentatively called

TABLE 2: TOTAL YIELDS AND YIELDS (LB D.M. PER ACRE) OF RYEGRASS AND WHITE CLOVER, PARUA BAY, MAY 8, 1963 TO DECEMBER 18, 1963
(data from Gould, 1966)

	Total Yield	Ryegrass	White Clover	Other Species
N.Z. Perennial	2,930	2,000	820	110
Ariki	3,880	3,150	540	190

TABLE 3: PERCENTAGES OF D.M. PRODUCTION DUE TO CLOVER AND RYEGRASS. MOWING TRIAL, PALMERSTON NORTH, JULY 13, 1965 TO SEPTEMBER 2, 1965

Clover in combination with:	Grasslands Huia		Grasslands 4700	
	Clover	Ryegrass	Clover	Ryegrass
Grasslands Ruanui	58	40	81	17
Grasslands Ariki	41	59	76	23
Grasslands Manawa	38	60	62	36

'Grasslands 4700' is being multiplied for widespread region-grazing trials. Grasslands 4700 shows every promise of combining the summer activity of the New Zealand parent with the winter activity of the Spanish parent, while preserving the dense, strongly stoloniferous form of the New Zealand parent. Its performance in swards, compared with that of Grasslands Huia, has been studied in a mowing trial in association with three ryegrasses, Grasslands Ruanui perennial ryegrass, Grasslands Ariki ryegrass, and Grasslands Manawa ryegrass. The percentages of grass and clover for each of the six mixtures for a winter growth period are shown in Table 3.

It will be seen that the percentages of clover are high compared with those expected in grazing swards, but are typical of mowing trials without added nitrogen where clippings are removed. It can readily be seen that Grasslands 4700 associates much more strongly with all three ryegrasses than does Grasslands Huia. The increase in total D.M. production associated with Grasslands 4700 was 26% in the case of Ruanui, 14% in the case of Ariki, and 16% in the case of Manawa. In summer Grasslands 4700 has performed at least as well as Grasslands Huia, although dry country tests have not yet been done. It is hoped that Grasslands 4700 will maintain its promise in the forthcoming grazing trials.

In addition to the white clover from Spain, Mediterranean introductions are proving valuable in improving cool season production in a number of other species, including cocksfoot, tall fescue, red clover and *Lotus pedunculatus*.

Plant breeders are very conscious today of the importance of the nutritive value of the plants they select. Bailey (1964) has proposed a relationship between animal per-

formance and leaf cellulose content and Evans (1964) has shown an apparent association of cellulose with leaf strength. Wilson (1965) screened a population of Ariki ryegrass for both cellulose and leaf strength, and made two selections, one for high cellulose high leaf strength, and one for low cellulose low leaf strength. He found high overall heritabilities for both characters (approximately 0.8), and found the two F_1 populations were almost separated, and estimated that future advance for these characters was unlikely. Based on these results, it was decided to continue this work by a multiplication of the F_1's to produce an F_2 for high cellulose, high leaf strength, and an F_2 for low cellulose, low leaf strength, with a view to having these populations tested in animal weight gain experiments. Grasslands now has seed of these two F_2's, so that further quality trials can continue.

Since the classical work of Blakeslee (1937) and Nebel (1937) made possible the easy induction of polyploids with the drug colchicine, the effects of doubling the chromosome number have been examined in many plants and these effects have been recently reviewed by Mehta and Swaminathan (1957). At Grasslands Division early work was concentrated on *Lotus pedunculatus* and on *Trifolium pratense,* and improved varieties of these are either being multiplied for trial or are already under trial. More recently the Dutch have released tetraploid ryegrasses that have been reported to give increased yield (Wit and Speckmann, 1955; Wit, 1958), higher percentages of soluble sugars (Dent and Aldrich, 1963; Alder, 1964; Breese, 1964) and greater weight gain in animals (Alder, 1964). Stimulated by these reports, Grasslands Division have produced tetraploids of certain ryegrasses. Grasslands 4707 tetraploid Western Wolths (Barclay and Vartha, 1966) shows distinct promise and development of an induced tetraploid based on 'Grasslands Paroa' Italian ryegrass is well on the way. Another tetraploid ryegrass based on Grasslands Ariki is being developed and this looks promising as single-spaced plants. Leaf strength measurements comparing this tetraploid with Ariki and with Grasslands Manawa are shown in Table 4.

It can readily be seen that Ariki has a greater leaf strength than the induced tetraploid which itself is similar to Grasslands Manawa in this respect. It is hoped shortly

TABLE 4: COMPARISON OF MEASUREMENTS OF LEAF STRENGTH (G/MG) FOR RYEGRASSES

Variety	Vegetative Leaves Nov.21,1966		*n*	Flag Leaves Dec. 6, 1966		*n*
Grasslands Ariki	82.4 ± 7.0	**	32	71.7 ± 1.4		72
Induced tetraploid	70.3 ± 1.2	N.S.	160	59.0 ± 0.6	**	240
Grasslands Manawa	67.3 ± 2.9		32			

** = $P < 0.01$; N.S. = Not significant.

to have soluble carbohydrate and cellulose analyses done, and to take a seed crop this season so that comparative grazing trials can be carried out at an early stage in the programme.

Because seed-heads may not be acceptable to the animal, or that a plant in flower is at a sensitive stage in its development, plant breeders have been interested in the possibility of breeding varieties that would not flower in the region where they are to be used, but would flower and set seed under different conditions of day-length and temperature. Grasslands Division have such a programme in *Lotus pedunculatus,* a plant whose seed-heads are not eaten readily by animals and whose vegetative growth is largely terminated at the peak of flowering. The proposition is to breed a variety that will flower and set seed in Canterbury or further south, but which will remain largely vegetative in Northland. The programme is now in the final stages and has involved the use of an introduction from Germany of poor growth that does not flower at Kaikohe but flowers and sets at Lincoln. It has been crossed with vigorous Portuguese × New Zealand hybrids and selected F_2 plants are now being assessed at these places.

This paper has attempted, by way of examples, to outline some of the ways by which Grasslands Division are undertaking improvements in the quantity and quality of forage. Advances in knowledge of plant breeding techniques here and overseas proceed rapidly, and application of these, together with advanced practice in pasture and animal management should lead to continued progress. Basic genetics, too, with its expanding knowledge of the

biochemical nature of the gene and of gene action, raises the hope that in the not too distant future it may be possible to produce at will the type of plant variation required.

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