SYMPOSIUM ON GRASSLANDS DIVISION'S NEW RYEGRASS

1. ARIKI, 'A NEW SELECTED PERENNIAL-TYPE RYEGRASS VARIETY

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Ariki (previously referred to as long-rotation ryegrass or new hybrid ryegrass) is a new variety bred from crosses between short-rotation ryegrass and N.Z. Perennial ryegrass. The success of Corkill[1] in breeding short-rotation from crosses between Italian ryegrass and perennial ryegrass led to this new improvement programme aimed at breeding a ryegrass with far more persistency than short-rotation but retaining its excellent seasonal growth and palatability. Corkill[2] was in charge of this programme from 1951 to 1957; since then it has been under the control of the author.

The following descriptions of characteristics and performance are based on spaced plants, mown swards, and grazing experiments carried out by a number of the officers at Grasslands Division, Palmerston North, and at the Kaikohe, Lincoln, and Gore sub-stations, as well as from results from a large number of farmers to whom seed was released for paddock-scale trials. In addition seed was released to the Department of Agriculture for wide-spread regional grazing trials, on which Mr Bascand is reporting as part of this symposium.

Awning

This characteristic has always been important in distinguishing between ryegrass species and varieties. In Table 1 Ariki, short-rotation and N.Z. Perennial ryegrasses are compared for percentage of awning. (Throughout this paper N.Z. Perennial refkrs to the latest Grasslands Division selection.)

TABLE 1—RYEGRASS VARIETIES: % AWNING

	No Awns or Tips	Short Awns	Long Awns
Ariki	97.9 ± 0.5	2.1 ± 0.5	0
Short-rotation	3.7 ± 2.6	68.5 ± 6.3	27.8 ± 6.1
N.Z. Perennial	100	0	0

Short awns in this classification are those less than half the length of the flowering glume. It should be noted, however, that in a large population (12,000 plants) a few long-awned but otherwise Ariki plants have been observed, It is clear that Ariki differs only slightly from N.Z. Perennial and greatly from short-rotation with regard to awning characteristics.

Flowering

Time of flowering is important in' the spring, mainly for seed production, and in the autumn for pasture management. In Table 2 Ariki, short-rotation, and N.Z. Perennial ryegrasses are compared for percentage of head emergence on 22 November 1962 at Palmerston North.

TABLE 2—RYEGRASS VARIETIES: % HEAD EMERGENCE, 22/11/62 PALMERSTON NORTH

Ariki	65.0 ± 4.0
Short-rotation	4.4 ± 1.5
N.Z. Perennial	93.9 ± 1.8

N.Z. Perennial is first to head in the spring, followed fairly closely by Ariki, with short-rotation very much later.

In Table 3 the same three varieties are compared for percentage of vegetative plants (those with no flowering heads) on 1 March 1962 at Palmerston North after several summer grazings.

TABLE 3—RYEGRASS VARIETIES: % VEGETATIVE PLANTS PALMERSTON. NORTH

Ariki	21.2 ± 3.0
Short-rotation	8.0 ± 1.8
N.Z. Perennial	72.7 ± 2.8

Ariki has only about one-third the percentage of vegetative plants of N.Z. Perennial. These figures are from spaced plants. In swards Ariki produces abundant leaf at this season and little sign is seen of seed heads unless the pasture is allowed to get too rank.

Fluorescent Seedlings

The presence of more than a certain percentage of fluorescent seedlings is at present used to distinguish N.Z. Perennial ryegrass from short-rotation or Italian ryegrass. In Table 4 a comparison is made of the percentage of fluorescent seedlings for Ariki, short-rotation and N.Z. Perennial, each variety being fourth generation from elite plants.

TABLE 4—RYEGRASS VARIETIES: % FLUORESCENT SEEDLINGS

Ariki	20.4 ± 0.5	7,200 seedlings
Short-rotation	74.2 ± 0.8	2,800 seedlings
N.Z. Perennial	1.0 max.	By regulation

It is quite clear that the three ryegrasses differ from one another for this characteristic. At the higher grades of certification percentage fluorescent seedlings should be a useful guide for distinguishing Ariki from both short-rotation and N.Z. Perennial.

Seasonal Growth

Results from many types of experiments and from many locations indicate that Ariki, especially during the first year, is intermediate in growth between short-rotation and N.Z. Perennial for all seasons except summer, when it is superior to both. In Table 5 are recorded the relative growths (N.Z. Perennial = 100 for each period) based on estimated green weight yields of spaced plants for up to eight ryegrass varieties grown at four locations. Of the overseas perennials, Tasmanian is a variety bred in Tasmania from N.Z. Certified Perennial, S23 and S24 are the well-known Aberystwyth varieties that are frequently used as international standards, and C.B. Pasture and R.v.P Pasture are the best by far of a large number of European perennial ryegrasses that we have had under test.

The three important comparisions are :

(a) *Ariki with Short-rotation*

Short-rotation is superior in the first winter at three locations. Ariki is superior in the first summer at all four locations, in two out of. three in the second winter, and in three out of three in the second summer.

(b) *Ariki with N.Z. Perennial*

Ariki has proved superior to N.Z. Perennial at three locations in all seasons. At Gore, Ariki was equal to N.Z. Perennial, though experiments in swards in later years indicate its superiority.

(c) Ariki with British or European Perennials

Ariki is vastly superior to all by the end of the second summer. Tasmanian is by far the best of the introductions but only shows to any advantage at Lincoln, where it is superior to N.Z. Perennial in the second summer, but inferior to Ariki.

Persistency

As the oldest swards of Ariki have only been down 43 years it is probably too early to give a final verdict on persistency. In Table 6 a comparison is made of the tillers per square foot from a hard grazing trial at Kaikohe by Lambert, and from hard grazing and lax grazing trials at Lincoln by O'Connor for Ariki, short-rotation, and N.Z. Perennial. The pastures are a little over three years old in each case.

TABLE 6—RYEGRASS GRAZING TRIALS (3 YEAR OLD 'PASTURES): TILLERS PER SQUARE FOOT

	LINCOLN		KAIKOHE
	Hard grazing	Lax grazing	Hard grazing
Ariki	722 ± 36	564 ± 36	538 ± 43
Short-rotation	·504 ± 36	396 ± 36	
N.Z. Perennial	608 ± 36	374 ± 36	538 ± 55

Whilst at Kaikohe under hard grazing Ariki and N.Z. Perennial do not differ in tiller numbers, at Lincoln Ariki is significantly higher than the other varieties under both hard and lax grazing. As would be expected, all tiller counts are greater under hard than under lax grazing. These results, from regions in which ryegrass is often under considerable. stress from temperature or drought, indicate that Ariki is likely to be truly perennial.

TABLE 5—RELATIVE GROWTH OF RYEGRASS VARIETIES (SPACED PLANTS)

	PALMERSTON NORTH				KAIKOHE				LINCOLN				GORE	
	1st W.	1st S.	2nd W.	2nd S.	1st W.	1st S.	2nd W.	2nd S.	1st W.	1st S.	2nd W.	2nd S.	1st W.	1st S.
Short-rotation	167	148	162	121	151	107	123	82	176	101	103	105	116	60
Ariki	138	178	162	1.52	111	125	136	135	141	140	141	130	112	96
Perennial, N.Z.	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Perennial, Tasmanian ...	9.5	98	79	42	95	91	104	86	120	110	108	115	91	66
Perennial, S.23	60	51	55	20	90	83	93	32					67	36
Perennial, S.24	83	83	53	8	97	96	98	43					83	45
Perennial, Dutch C.B. Pasture	62	54	63	35									71	57
Perennial, Belgian RvP Pasture	61	69	79	36									81	58
d.05	21	29	23	16	22	13	12	29	27	14	18	13	14	26

Adaptability to Cold

It became of interest when considering the amount of winter production from Ariki, to know its reaction to extremely severe winter conditions. O'Connor” has compared at Black Birch, Marlborough (4,000 ft altitude and over 70 days' frost lift per annum) and at Lincoln, a Swedish perennial known to be winter dormant, Ariki, and short-rotation. The results are shown in Table 7.

TABLE 7—RYEGRASS VARIETIES: WINTER PERFORMANCE, SOUTH ISLAND 1963

	Growth			% Heaved out by frost	
	LINCOLN		BLACK BIRCH		
	Mid June Score	Mid Sept. Score	Mid Sept. Fresh leaves (cm)	Low Fertility	High Fertility
Ariki	8.3	5.0	5.3	13	0
Short-rotation	8.3	6.0	3.0	40	0
Swedish Perennial	5.0	2.3	4.7	53	7

Whereas at Lincoln both Ariki and short-rotation grow away well after the winter, at Black Birch Ariki is superior in this respect, followed by Swedish perennial, with short-rotation well behind. At low fertility Ariki is remarkable for its low percentage of plants heaved out.

Leaf Rust

Associated with the strong summer growth of Ariki is a most decided freedom from rust when compared with N.Z. Perennial. This is evidenced by the data in Table 8 based on a large number of spaced plants grown under conditions of moderate N fertility.

TABLE 8—RYEGRASS VARIETIES: % RUST-INFECTED PLANTS, PALMERSTON NORTH 1/3/62

	Nil	Severe
N.Z. Perennial	17	39
Ariki	39	14

$P = <.001$

In addition, Barclay and Latch (Grasslands Division and Plant Diseases' Division) have shown that certain elite Ariki plants were twice as susceptible to rust infection under conditions of low N fertility as they were under conditions of high N fertility.

Argentine Stem Weevil ***(Hyperodes bonariensis)***

Extensive damage in both Islands to short-rotation and Italian ryegrasses has been reported by Kelsey [3] and Hoy[4]. Table 9 (O'Connor and Kelsey) compares Ariki, short-rotation, and N.Z. perennial for percentage of Argentine stem weevil infestation at Lincoln.

TABLE 9—RYEGRASS VARIETIES: ARGENTINE STEM WEEVIL % INFESTATION, LINCOLN 13/1/61

	Nil	Limited	Severe
Ariki	87	13	0
Short-rotation	0	79	21
N.Z. Perennial	81	17	2

Ariki, like N.Z. Perennial, is only slightly infested whereas short-rotation is far more severely infested.

Summer Debris

From previous sections it is already clear that Ariki has vigorous and clean summer growth compared with N.Z. Perennial. Lancashire at Grasslands Division made a study from late December 1962 to late February 1963 of the amounts of living leaf plus sheath and dead leaf plus sheath in grazed swards. Comparative results for Ariki and N.Z. Perennial are shown in Table 10. The figures are the sum of the totals of samplings to ground level on four occasions, the paddocks being lax grazed.

TABLE 10—RYEGRASS VARIETIES: SUMMER DEBRIS

	Leaf and Sheath Dry Matter (grams per square foot)	
	LIVING	DEAD
N.Z. Perennial	26.1	48.2
Ariki	49.2	32.2
S.E.	1.9	2.7

Ariki has almost twice the living material of N.Z. Perennial and only two-thirds the dead material. This is possibly an indication that the quicker growth of Ariki during the summer is also very acceptable to stock. In addition the lower amount of debris in the sward could be of importance in providing less substrate for ***Pithomyces chartarum,*** the organism causing facial eczema.

Quality for Stock

Grasslands Division have initiated various trials involving quality, and in addition have released seed to a number of other research groups for detailed quality studies. Few of the investigations have progressed far enough for report, except at Gore, where Harris has completed a series of lamb fattening trials. In one trial carried out in the spring of 1961 at 7 ewes to the acre with single lambs, the ewe weight increases were significantly higher on Ariki than on N.Z. Perennial, but lamb weights did not differ. The associated swards had similar clover production, but the grass content was significantly higher in Ariki.

In 1962 and 1963 Harris ran store lamb fattening trials comparing Ariki, short-rotation, and N.Z. Perennial and the results are reported in Table 11.

TABLE 11—RYEGRASS VARIETIES, GORE 1962/1963: STORE LAMB FATTENING

	Stocking Rate	Lamb Weights 9/2/62	Lamb Weights 14/4/62	Stocking Rate	Lamb Weights 31/1/63	Lamb Weights 3/4/63
Ariki	16	56.8	72.4	30	54.9	68.1
Short-rotation	16	56.8	67.9	25.5	54.9	67.5
N.Z. Perennial	16	56.8	70.6	30	54.9	66.1
			d.05 1.6			d.05 1.5

The lamb weights as at 14 April 1962 are significantly higher for Ariki than for N.Z. Perennial, and significantly higher for N.Z. Perennial than for short-rotation. The short-rotation result is associated with low grass production which was an effect of Argentine stem weevil and drought during establishment. The increased lamb weights on Ariki compared with N.Z. Perennial were produced on swards higher in ryegrass and lower in clover. The lamb weights at 3 April 1962 are significantly greater than on N.Z. Perennial but do not differ from short-rotation. This increased summer fattening ability of Ariki compared with N.Z. Perennial is again associated with higher ryegrass and lower clover content. In both these summer/autumn trials there was scouring, which was more serious on Ariki than on the other varieties and perhaps was associated with the higher grass content of the Ariki swards. However, all lambs were in acceptable condition for killing and there were no differences in the ratio of Prime : F.A.Q. gradings.

Acceptability to Animals

There is considerable evidence indicating stock preference for Ariki compared With N.Z. Perennial, not only for leaf growth but also for emerged flowering heads.

Grass-Clover Balance

In some early trials difficulty was experienced in establishing sufficient white clover with Ariki. Dr P. D. Sears in a series of establishment trials (Dr Brougham is presenting a summary of this information as part of this symposium) showed clearly that well-balanced swards can be established, provided the ryegrass seeding rate is appropriately low for the conditions, that frequent grazings are made during the establishment period, and that the N status of the soil is not too high. These experimental results have been well borne out by the ease with which a large number of our farm trials have been established.

Appraisal of Ariki

Ariki, which is proving to be as persistent as N.Z. Perennial, has a wide spread of seasonal production, ranking intermediate between short-rotation and N.Z. Perennial at most seasons of the year but superior to both in summer. It is relatively free from rust attack and is as resistant to Argentine stem weevil as N.Z. Perennial.

Lighter green than N.Z. Perennial, dense, leafy and palatable in both leaf and seed head, Ariki, used both in simple and complex mixtures, should be a valuable acquisition to both dairy and sheep farmers. Care should be taken after sowing to follow proper establishment practices. Best production will be obtained if sufficient fertiliser is applied and enough stock are carried.

Availability: Subject to decision by the Department of Scientific and Industrial Research and the Department of Agriculture, a release will be made of certified Government stock seed to selected seed growers in spring 1964. Certified pedigree seed should become available through commercial channels in spring 1966.

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2: FIELD PERFORMANCES OF GRASSLANDS DIVISION'S NEW SELECTED PERENNIAL-TYPE RYEGRASS, ARIKI

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In presenting this short paper on behalf of the Farm Advisory Division of the New Zealand Department of Agriculture, I wish to acknowledge widespread assistance from divisional advisory officers, cooperating farmers, and research station personnel. Our field-testing programme has been comprehensive, in association with that of Grasslands Division, embracing more than 130 established trials including new ryegrass selection. These ranged from simple primary testing to complex agronomic and livestock performance experiments.

Scope of Paper

I wish to limit this review to a consideration of some aspects of six research station and 60 farm grazing trials laid down before 31 May 1962 in three separate series, and I intend to discuss briefly the productivity, persistency, adaptability, palatability, and suitability of the new selection for livestock.

Objectives

The agronomic trials considered were laid down in two series, but design, management, and objectives have been essentially similar throughout, although trial scale and replication vary widely.

Basically the trials compare simple swards of ryegrass and clovers sown, in fields separately fenced for differential grazing management, under conditions of optimal seed bed preparation and soil fertility.

Basic seeding rates were arbitrarily fixed at 15 lb P.V.S. per acre for ryegrasses and 3 lb for clovers. The measure of standardisation achieved in the cooperative farm trials is considered satisfactory for comparisons between perennial ryegrass and its two hybrids of persistency, seasonal growth rhythms and to a lesser degree, of yield. Supplementary information on palatability, pest and disease resistance, nutritive value, and soil adaptability has been obtained from several trials. While this information has been less conclusive, it has prompted further work. ,

Distribution of Trials

Within limitations of seed supplies and availablity of personnel, attempts were made to establish trials in as many different climatic and pastorally important zones throughout New Zealand as practicable.

Almost all trials in the farm-scale series included a comparison between perennial ryegrass and Ariki ryegrass, while half the trials included a comparison between short-rotation and Ariki ryegrasses (see table 4).

Methods of establishment were equally divided between drilling and broadcasting. Three trials are being managed under dairy cattle to every two under sheep grazing. Pour of every five trials have treatments separately fenced, and though 18 trials are now under regular mowing for yields, **this series must be considered essentially observational for persistency differences under farm conditions.**

RESULTS OF TRIALS

1960 Series at Research Stations

These small-scale trials were established at Rukuhia, Manutuke, Marton, Winchmore, and Invermay according to randomised block layouts incorporating four replications of short-rotation, Ariki ryegrass, and perennial ryegrass. All treatments were separately fenced, and have been **managed similarly under sheep grazing on soils of medium to high fertility.** Generally the trials were mob stocked whenever pasture growth reached about 4 in. in height, but the grazing patterns varied slightly from station to station, depending on sward rates of growth.

Pasture yield assessments have been obtained by mowing, using a "rate of growth" technique], while measurements of sward heights and of ground cover by point analyses have been obtained periodically as management aids. These data have generally shown Ariki ryegrass swards to be taller and more open than perennial ryegrass pastures, but shorter and denser than short-rotation ryegrass swards.

Generally to date measurable sward differences in favour of Ariki ryegrass have been obtained annually and seasonally (except in spring) at all stations. The seasonal yields from the five stations have been averaged for the purpose of obtaining more reliable estimates of annual production over a period of three years. These have been in the ratios of 100 to 106 to'98 for perennial, Ariki, and short-rotation ryegrass pastures respectively, and in the ratios of 100 to 127 to 91 for the ryegrass component of each sward, as shown in table 1.

Pasture rates of growth have varied from. station to station and have revealed outstanding recovery growth by Ariki following drought conditions, and its superior summer and autumn growth relative to both parent types.

1961 Series on Farms

Despite the simple nature of these trials, they collectively endorse under varying systems of management the pattern of varietal performances recorded in the station series under more uniform conditions, and have the added value of being on a larger scale. Mean paddock areas for the station and farm series are 0.2 and 1.8 acres respectively.

Assessments of varietal performances have been based on observations of growth and recovery from grazing during the first two years of each trial. In 14 trials these assessments have been confirmed by herbage yields and in eight of 12 other trials grazing days have shown clear differences in sward carrying capacity under sheep or dairy cow management. The remaining trials of this series have been assessed observationally, according to the methods described by Lynch and Mountier.[2]

From the fourteen farm trials mown regularly during 1962-63 mean annual yield differences have been of the same order as those obtained from the five research station trials over longer periods, except for the ryegrass component of the short-rotation pastures, which has performed better in the farm series, possibly because of its exclusion from districts where its persistence is suspect, or because of a smaller sample of trials than for perennial or Ariki, or because the pastures are younger.

Total yields have been lower from the farm group than from the station group, which have been located mainly on better soils.

TABLE 1—MEAN HERBAGE YIELDS (lb dry matter/ac/an)

Variety	STATION SERIES 1960/63 Pasture	Relative	Ryegrass	Relative	FARM SERIES 1962/63 Pasture	Relative	Ryegrass	Relative
Pr.	10,120	100	5,860	100	8,480	100	4,840	100
Ar.	10,690	106	7,420	127	9,130	107	6,470	133
Sr.	9,860	98	5,350	91	8,270	97	5,630	116

A detailed consideration of relative sward growth rates will be published elsewhere, but the following tables extracted from the appendices summarise the agronomic assessments on present evidence:

TABLE 2—ARIKI RYEGRASS PASTURES COMPARED WITH PERENNIAL AND SHORT-ROTATION RYEGRASS PASTURES

Trials showing Ariki	To Perennial	To Short-rotation
Superior	33	23
Similar	20	8
Inferior	9	4
Totals	62*	35

*Four trials of the 66 did not include perennial ryegrass.

Using as a measure of pasture quality and production a scale of **"Fertility Index"** (or **F.I.**) ranging from 0 to 20 (where 0 is an extremely poor, unthrifty pasture and 20 a vigorous, high producing pasture[2]) the performances of perennial and Ariki ryegrass pastures relative to soils of different productive capacities were as follows:

TABLE 3—COMPARATIVE PERFORMANCES OF ARIKI AND PERENNIAL RYEGRASS PASTURES RELATIVE TO SOIL FERTILITY

Perennial ryegrass pastures	Ariki superior	Ariki similar	Ariki inferior
Fertility index above 14	10	4	1
Fertility index 14 or less	23	16	8
	33	20	9

Although some assessments cannot be- considered reliable, owing to palatability differences in unfenced trials, the overall position appears to be:

(1) Ariki ryegrass has performed as well as or better than its parent types in the majority of trials.

(2) Ariki ryegrass pastures have performed best on the best soils.

(3) The trials in which Ariki ryegrass' has so far been inferior to perennial ryegrass have generally been on infertile soils. As the majority of trials were deliberately located on soils of medium to high fertility to ensure good pasture establishment, supplementary investigations! have since been commenced on the poorer soils to determine the adaptability of the new selection.

Varietal Features Other than Yield

Observations on pest and disease resistance suggest that the new hybrid is intermediate between its parent types for *Puccinia* rust susceptibility and insect damage. To date the new hybrid has withstood damage in three trials by Argentine stem weevil (*Hyperodes bonariensis*) when neighbouring fields of short-rotation ryegrass have been denuded. The general application of DDT to all our trials may have restricted information on the resistance of Ariki ryegrass to this pest meantime, but the new selection appeared to be damaged more than perennial ryegrass in two South Island trials last spring.

Information on resistance to other insect pests has been less conclusive, but suggests that several insect pests consider the new selection more edible than perennial ryegrass.

Palatability

Observations on this quality have been limited, because of separate treatment and grazing requirements, and have been inconsistent. It has seldom been found practicable to dissociate the concept of higher palatability from that of higher yield under controlled grazing conditions, and where stock have had free grazing over both perennial and Ariki ryegrass swards, observers' opinions have varied periodically.

Again, different classes of stock have behaved differently on the same swards. For example, pregnant ewes at Manutuke devour all swards without prejudice during winter, but during spring dry ewes find the new hybrid selection least palatable, particularly round fence lines and gateways. At Marton topping has occasionally been necessary during periods of flush growth as an aid to consumption of Ariki, which produces grassier swards than do the parent ryegrasses.

The only inference possible at this stage appears to be that palatability is a factor associated with stage of growth or soil fertility, and more managerial experience will be needed before an assessment of the relative palatabilities of Ariki ryegrass and its parent types under varying conditions can be assessed. The new hybrid seems intermediate between perennial and short-rotation ryegrasses for this quality, but where it tends to suppress white clover, it may produce both less palatable and lower-quality swards than does perennial ryegrass.

LIVESTOCK PERFORMANCES

Sheep

Neither the 1960 nor the 1961 series of grazing trials was designed to determine the effects of swards of Ariki ryegrass on the animals, but reports from southern trials of a greater tendency for sheep of all ages to scour on Ariki pastures, and for sheep (particularly lambs and hoggets) to achieve lower weight gains on swards of the new selection, persuaded the Farm Advisory Division to commence elaborate stock thrift trials before releasing an otherwise promising selection through the certification scheme.[3,4]

Trials with sheep comparing a range of stocking rates on both perennial and Ariki ryegrass pastures have begun at Marton, Winchmore, and' Invermay, but are only in uniformity phases at present.

One lamb fattening trial conducted at Wakanui (Ashburton) last spring resulted in a 1.1 lb live-weight gain (significant at 5 per cent, level) over five weeks in favour of the mobs grazing perennial ryegrass. This may have been due to a paddock-variation effect, but similar. results were obtained at Winchmore on the agronomic trial already discussed, while in autumn 1963 heavy scouring on a “new” hybrid sward over two weeks occurred in sheep at Invermay, but did not occur in a later trial, though lambs lost weight on one plot.

All these effects may have been due to unbalanced sward composition, that is, a low percentage of clover, which probably assists lamb fattening. However, at Invermay, in pens, dry-matter intake over seven days was higher from the Ariki ryegrass swards than from perennial or short-rotation pasture. These results emphasise the need for sward-quality studies and more experience with this vigorous variety before specific grazing recommendations can be made.

Dairy Cows

The most satisfactory evidence of livestock performances on pastures of Ariki ryegrass has been obtained at the Ruakura Animal Research Station. Twelve sets of identical twins were allocated to the experiment: one'herd of 12 grazed 10 one-acre plots of perennial ryegrass, and their 12 twin mates grazed the same area of Ariki ryegrass

Results over the first year, have been included in the appendices, but briefly there has been a 10 lb or 4 per cent increase in butterfat per cow and an increase of 11 lb of butterfat per acre for the Ariki group, despite a reduction in lactation period compared with their mates on perennial ryegrass.

Pasture production has been measured in this trial (according to the electronic method developed by A. G. Campbell) and has shown net gains of 8,900 lb of dry matter per acre for perennial and 9,500 lb of dry matter for Ariki ryegrass, representing nearly 7 per cent difference in growth, which is reasonably consistent with the livestock figures. None of the differences was statistically significant. Herbage dissection data showed very low clover contents in spring but higher amounts in autumn (about 23 per cent in perennial, 12 per cent in Ariki) .

The season as a whole was notably free from metabolic disorders in the Waikato, only one case of milk fever occurring (on the perennial block).

No cases of milk fever or grass staggers have occurred in either group during the calving period just concluded (winter 1963).

CONCLUSIONS

1.. Persistency

Clear evidence has been obtained of the superiority of Ariki ryegrass over short-rotation ryegrass in northern districts or where Argentine stem weevil attacks occur. Over three years the new selection has been as persistent as perennial ryegrass, and it has shown quicker recovery after drought or grazing.

2. Productivity

Clear differences in annual and seasonal yields have been demonstrated under controlled conditions in favour of the new hybrid (for both total sward and ryegrass component relative to those of the parent types).

3. Adaptability

Under farm grazing conditions a relationship between adaptability of Ariki ryegrass and high soil fertility is apparent, but overall Ariki's growth and ability to compete with weeds are impressive.

4. Compatibility

Evidence of suppression of associated species by the new hybrid has been given. In the short term the dominance of Ariki over clovers may not matter unless livestock performances are adversely affected. In this event, solutions would seem to depend on improved sward management based on hard autumn grazing and the production of a more vigorous variety of white clover.

5. Suitability for Livestock

Although some instances of sheep scouring and lower weight gains by lambs on Ariki ryegrass have been recorded, no serious ill effects on animals grazing these swards have been recorded to date in the trials discussed.

6. Other Factors

The new selection appears to be intermediate between the parent ryegrasses in performance, for other factors.

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Trial 61/	Location	Soil Type	When Sown	Ryegrass Sown	Stock Class	F.I. P.r. Sward	Varietal performances Ar vs Pr	vs Sr
2081	Wairuhe (Dannevirke)	Manawatu s.l.	April	APS	C	12	O	+
2144	Oakura	New Plymouth 67 Brown loam	October	AP	C	15		
2217	Raetihi	65	November	AP	C	1.5		
2243	Kaitoke	78 provisionally	October November	APS Prairie	C	14	O	—
Y.29	*Stratford	68 Stratford sand	March	AP	C	13		
Y.30	*Stratford	68 Stratford sand	March	APS	C	14	—	—
62/								
1041	Te Puke	Paengaroa sand	April	A P Pm	C	15	0	O Pm
1047	*Te Teko	Tarawera gravel	April	A P Pm	C	13	0	O Pm
1066	Matakana	Warkworth clay	April	A Pm	C	13	0	O Pm
0.38	Wairakei	Atiamuri st-s	March	AP	S	10	0	
3030	*Nelson	Motupiko	February	AP	S	12	+	
3032	Motueka	Riwaka	March	APS	S	12	—	+
3033	Takaka	Karamea	March	APS	C	15	O	0
3037	*Broadfields	Paparua stony soil	March	AP	S	12	—	
3064	*Sefton	Mairaki s.l.	April	APS	S	13	+	O
3071	*Hallswell	Tai Tapu clay 1	April	AS1	C	15		+
3076	†Ashburton	Waimak-sandy loam	May	APS	S	13½	+	+
3090	Hook	Templeton shallow silt	April	A P Ps	S	11	+	
3103	Rotherham	Chertsey silt loam	March	AP	S	14	+	
3275	Kowhiterangi	Hokitika fsl	December	APS	C	14	—	+
4018	†Kurow	Otiake soil	March	APS	S	11	+	+
4020	†Omaru	Ngapara f.s.l.	February	APC	S	13½	0	0
4035	Ranfurly	Matarae schist loam	March	AP	S	133	—	
4184	*Dunedin	Koau	November	APSI	C	16	+	+
4186	Gore	Waimumu Y.G.E.	November	APS	C	13½	O	O
4190	Stirling	Cluthd f.s.l.	November	APS	S	15	0	O

TABLE 4—DETAILS OF TRIALS AND VARIETAL PERFORMANCES

Farm Trials: 1961 Series

Trial 61/	Location	Soil Type	When sown	Ryegrass Sown	Stock Class	F.I. P.r Sward	Varietal performances Ar vs Pr	vs Sr
1045	Parua Bay	Wharekohe s. loam	March	AP	C	12½	—	
1059	Maungatapere	Manu silt loam	March	AP	C	15	O	
1065	Auckland	34a Brookby clay loam and clay and gravelly sand	April	A P Pm	S	12	+	- P m
1070	Te Awamutu	Silt loam, 59 Ohaupo	March	AP	C	16	+	
1074	Hamilton	Horotiu sandy loam	March	AP	C	163	+	
1076	†*Edgecumbe	Set. I. Silet loam ash.	March	APS	C	13½	O	+
1077	†Katikati	54a	March	AP	C	17½	+	
1085	Dargaville	Kaipara clay	April	AP	C	15	+	
1099	Walton	57a	April	AP	S & C	12	O	
1101	*Arapuni	48a	March	AP	S	123	O	
1102	†Karaka	72 (clay) Karaka complex	April	AP	C	12	+	
1111	†Galatea	14b Galatea	March	AP	C	13	O	
1126	Waipapakauri	Kaitaia peaty clay loam	May	AP	C	14	—	
1134	Matakana	Warkworth clay	April	AP	C	13½	+	
1143	Te Kuiti	2, Clay + Pumice (river flat) sand	October	APS	S & C	11	+	—
11.52	Rangitoto, Te Kuiti	60f Mairoa Ash on mudstone	September	APS	S	10	+	+
1161	†Reporoa	18 Hatepe soils	October	APC	C	12½	+	
2026	†Havelock North	Paki Paki clay loam on sand	March	APS	S	14	O	O
2027	Levin	76a + 24 Kiwitea silt loam and Koputaroa sand	April	AS	C	17		+
2031	†Kauangaroa	12	March	AP	C	15	—	
2039	†Carterton	13d Kokatau silt loam	April	APS	S	14	+	O
2049	Palmerston North	Kairanga s.l.	April	APS	C	13	+	+
2057	Wairoa	Waihere s. loam (deep)	March	AP	C	14	O	
2073	†Manaia	66a	April	APS	C	13½	+	+
2080	†Okaiawa	66a Egmont 61 loam	April	APS	C	12	+	+

TABLE 5

Results of Stock Thrift Trial 62/AC203 Ruakura Animal Research Station 1962/63, on Horotiu Sandy Loam

Milk Production

	Ar	Pr	Std. Dev.	Sig.
Average butterfat per cow (lb)	259 (104)	249 (100)	25.3	N.S.
Average butterfat. per acre	310	299		
Average days in milk	259	268	15.6	N.S.

Cow Live Weight Gains Over One Year

	AR	PR	Std. Dev.	
Mean cow weight (lb) Calving-drying off	739	733	28.0	N.S.

Pasture Production (Estimated Electronically)

Season:	Ar	Pr	Std. Dev.	Sig.
Year 1962/63	9,500 (107)	8,900 (100)	867.6	N.S.
Winter 1962 (June-Aug.)	1,300	1,200	150.9	N.S.
Spring 1962 (Sept.-Nov.)	2,800	2,500	320.9	N.S.
Summer 1962 (Dec.-Nov.)	3,700	3,900	668.5	N.S.
Autumn 1963 (March-May)	1,700	1,300	913.6	N.S.

3. ESTABLISHMENT TRIALS ON RYEGRASS AND CLOVER MIXTURES

P. D. SEARS* and R. W. BROUGHAM, Grasslands Division, Department of Scientific and Industrial Research, Palmerston North.

* Now deceased.

This paper was to have been prepared and presented by the late Dr Peter Sears. It has been proceeded with for two reasons, First, because the results presented complement those presented in the first two papers of this symposium; second, because of the number of reports that have been received from farm instructors and advisers, and from farmers themselves, on the problems encountered with the establishment of clover in pastures containing the new hybrid as the dominant grass species. Peter Sears was strongly of the opinion that these problems were not new. In fact

Trial 61/	Location	Soil Type	When Sown	Ryegrass Sown	Stock Class	F.I. P.r. Sward	Varietal performances Ar vs Pr	Ar vs Sr
N.23	*Winton	Otapiri	October	A P S	S	1.5	+	+
4219	Bushey Palm.	Claremont	December	A P S	S	14	0	—
62/								
A.57	*Adair	Claremont s.l.	January	A P S	S	13	+	+
3104	†Wakanui	Omahau	April	A P	S	12	—	
3024	Albury	Opuha s.l.	February	A P S	S	13	0	0
3026	*Rangiora	Tai Tapu s.l.	February	A S	c	15	N.A.	+
3057	Weedons	Hatfield Shal. sl.	February	A P	S	11½	0	
3093	Seddon	Sedgemere s.l.	April	A P S	S	12½	0	+
4030	*Alexandra	Whanga	March	A P S	S	12	+	+

P.C. = N.Z. certified seed but not 1955 nuc. isolation.
* Mowing trials
† Grazing days
‡ Stock thrift trial

C = Cattle
S = Sheep
0 = Similar
+ = Superior
— = Inferior

Key
A = Ariki ryegrass
P = Perennial (1955 nuc. isolation)
Pm = Perennial-Mangere ecotype
Ps = Perennial Aberystwyth strain
S = Short-rotation hybrid
I = Italian

TABLE 4B—DETAILS OF RESEARCH STATION TRIALS

Trial 60/	Location	Soil Type	When Sown	F.I. P.r. Swards	Ar Vs Pr	Ar Vs Sr
R171	Rukuhia	Hamilton clay loam	March 60	12	+	+
Y27	Manutuke	Matawhero silt loam	April 60	15	+	+
M43	Marton	Marton clay loam	April 60	13	+	+
W274	Winchmore	Lismore (irrigated)	March 60	14	+	+
1545	Invermay	Recent alluvium	December 60	16/17	+	+

he held that by an observance of the principles of clover establishment from a large-amount of previous work, clover 'would be successfully established with the new hybrid.

These thoughts were the basis of the designs of the trials to be reported. Of necessity only a small amount of the data obtained will be presented, and opinions have been purposely left out. Conclusions from the significant features of the results, however, have been drawn.

The main trial reported was sown in the autumn of 1962. The new hybrid ryegrass and short-rotation ryegrass were sown in plots at seeding rates of 73, 15, and 30 lb per acre with red and white clovers sown at rates of 4 and 3 lb per acre respectively. In addition there were two cutting heights and two nitrogen treatments. The cutting heights were:

1. Cut when the herbage reached a height of 3 in. down to 1 in.
2. Cut when the herbage reached a height of 6 in. down to 1 in.

Half of the plots received urea at 2 cwt per acre at sowing and an additional dressing of 2 cwt per acre was applied to these plots on 15 July. The remainder of the plots did not receive'nitrogen.

The layout was therefore a 2 x 2 x 2 x 3 split plot design of three replications.

It should also be stressed that there was no return of nutrients to the plots after each cutting, so that experimental procedure on the plots that did not receive nitrogen simulated, in part, conditions where establishing pastures receive day grazings for short intervals.

Complete yield data are presented only for the series of plots that did not receive nitrogen. These have also been separated into two periods, the first from, sowing until 26 September 1962 and the second from 26 September 1962 to 20 November 1962.

Period 24/3/62 - 26/9/62:

Total production: Table 1 shows the total D.M. production obtained from the different treatments for this period.

Table 1-Total Production (lb D.M./acre) for Period 24/3/62 - 26/9/62

Cutting Treatment		3 in. - 1 in.		6 in. - 1 in.		
Species		Short-rotation	New Hybrid	Short-rotation	New Hybrid	
Seeding rate	73 lb	2,950	2,710	3,470	3,830	± 290
	15 lb	2,900	2,690	3,060	3,090	
	30 lb	2,710	2,420	3,640	2,750	
	Mean	2,850	2,610	3,390	3,220	± 170
Cutting treatment	mean	2.730		3.310 ± 120		

The significant features are:

1. The differences between the seeding rate or species comparisons did not reach significance level.

2. Total D.M. production was higher from the 6 in. cutting treatment.

Ryegrass Production: Total D.M. production from sown grass species are shown in Table 2.

Table 2—Ryegrass Production (lb D.M./acre) for Period 24/3/62 - 26/9/62

Cutting Treatment		3 in. - 1 in.		6 in. - 1 in.	
Species		Short-rotation	New Hybrid	Short-rotation	New Hybrid
Seeding rate	7½ lb	1,710	1,080	2,490	2,380 ± 240
	15 lb	1,890	1,430	2,420	1,920
	30 lb	1,990	1,450	3,180	2,180
	Mean	1,860	1,320	2,700	2,160 ± 140
Cutting treatment mean		1,590		1,430 ± 140	

The significant features are:

1. Grass yields were greater at the higher seeding rates.

2. Higher yields were obtained from short-rotation ryegrass than from plots of the new hybrid.

3. Higher yields were obtained at the 6 in. cutting level than at the 3 in. cutting level.

White Clover Production: Yields of white clover from the different treatments are shown in Table 3.

Table 3-White Clover Production (lb D.M./acre) for Period 24/3/62 - 26/9/62

Cutting Treatment		3 in. 1 in.		6 in. - 1 in.	
Species		Short-rotation	New Hybrid	Short-rotation	New Hybrid
Seeding rate	7½ lb	750	1,070	530	890 ± 80
	15 lb	670	930	410	680
	30 lb	500	760	320	430
	Mean	640	920	420	670 ± 50
Cutting treatment mean		780		540 ± 30	

Again the significant features are:

1. White clover yields were higher under the lower seeding rates.

2. White clover yields were higher in the new hybrid plots than in the short-rotation ryegrass plots.

3. White clover yields were higher at the low cutting heights.

Red Clover Production and Yields of Unsown Species

The red clover yields were small and are not presented for that reason, and the differences in yields of unsown species, which were approximately one-half of those of white clover yields, showed the same significant features as white clover yields.

For the series of plots' that received nitrogen at sowing and again four months later white clover yields only are presented. They are expressed both as pound/D.M. per acre for the period and as percentage composition of the total herbage yields from the different plots.

Table 4.-White Clover Production in the 'Added Nitrogen Series (as lb D.M./acre and % of Total Yield) for Period 24/3/62 - 26/9/62

Cutting Treatment		3 in. - 1 in.		6 in. - 1 in.	
Species		Short-rotation	New Hybrid	Short-rotation	New Hybrid
Seeding rate	7½ lb	187 (5.9)	350 (12.7)	140 (3.0)	400±83(8.9)
	15 lb	133 (4.2)	253 (8.3)	117 (2.4)	197 (4.1)
	30 lb	100 (3.0)	167 (5.7)	33 (0.6)	153 (3.1)
	Mean	140 (4.4)	257 (8.8)	97 (2.0)	250±48(5.1)
Cutting treatment mean		198 (6.5)		173 ± 33 (3.5)	

White clover (considered with the results presented in Table 3) is shown to yield, markedly higher where no nitrogen is added. For the other comparisons the significant features were much the same, but at a lower order of difference:

1. White clover yields were higher under the lower seeding rates.

2. White clover yields were higher in the new hybrid plots than in the short-rotation ryegrass plots.

Period 26/9/62 - 20/11/62

For this period again only white clover yields are shown both as D.M. yield per acre and as percentage of the total herbage. They are shown in Table 5 for the no nitrogen series and in Table 6 for the added nitrogen series.

Table 5—White Clover Production for the No-nitrogen Series (lb D.M./acre and % of Total Yield) for Period 26/9/62 - 20/11/62

Cutting Treatment		3 in. - 1 in.		6 in. - 1 in.	
Species		Short-rotation	New Hybrid	Short-rotation	New Hybrid
Seeding rate	7½ lb	1,690(54)	2,060(60)	1,720(59)	1,510± 140(56)
	15 lb	1,840(59)	2,110(61)	1,520(60)	1,640 (56)
	30 lb	1,790(61)	2,490(69)	1,370(54)	1,720 (57)
	Mean	1,770(58)	2,220(63)	1,540(58)	1,620± 80(56)
Cutting treatment mean		2,000 (61)		1,580±50 (57)	

The significant features of these results are:

1. Clover yields did not differ under the different sowing rates.
2. White clover yields were higher in the new hybrid plots than in the short-rotation ryegrass plots.
3. White clover yields were higher at the low cutting heights.

Table 6-White Clover Production for the Added-nitrogen Series (lb D.M./acre and % of Total Yield) for Period 29/9/62 - 20/11/62

Cutting Treatment		3 in. - 1 in.		6 in. - 1 in.	
Species		Short-rotation	New Hybrid	Short-rotation	New Hybrid
Seeding rate	7½ lb	1,160(46)	1,350(44)	800 (34)	890±90(35)
	15 lb	1,180(49)	1,390(50)	720 (30)	890 (38)
	30 lb	1,130(47)	1,150(42)	550 (30)	820 (35)
	Mean	1,160(48)	1,300(45)	690 (31)	870±50(32)
Cutting treatment mean		1,230 (46)		780 ± 30 (34)	

In addition to the above the results shown in Table 6, when compared with those presented in Table 5, show that for both species added nitrogen suppressed yields of white clover.

The results presented above are very similar to those obtained from a trial with the same layout carried out in the preceding year. They also conform to results obtained from a series of grazing trials carried out during this period. These are not presented, however, because of the time limit on this paper.

In summary, the results presented illustrate that if principles already established for other ryegrass mixtures are observed, both red and white clovers can be successfully established in pastures where the new hybrid ryegrass is the dominant grass species sown. In fact, because the new hybrid ryegrass is lower producing than short-rotation ryegrass in the first six months from sowing at comparable seeding rates and grazing heights, successful establishment of clover should be less of a problem. This is borne out by the results presented.

The three major principles highlighted by the results presented are:

1. More successful establishment of clover is obtained where early competition is reduced by reducing the seeding rate of the grass component in the mixture.

2. More successful establishment of clover is obtained when the establishing pasture is grazed frequently.

3. Clover is more successfully established where soil nitrogen levels are relatively low during the establishment period. In practice this can be achieved by cropping before re-grassing and by day grazing of young pastures.

Acknowledgements

The trials reported were carried out by the late Dr. P. D. Sears in collaboration with Mr V. C. Goodall of the Grasslands Division. who did most of the field work involved and all of the summarising of 'data. The results were analysed statistically by Mr A. C. Glenday, Applied Mathematics Laboratory, D.S.I.R., Palmerston North.

DISCUSSION

Dr. L. Corkill, in introducing the discussion, referred to the collaborative work required before a new variety could be introduced into commerce. Dr Barclay had reviewed the characteristics of the new variety, Mr Bascand had reported on the field performance from trials throughout New Zealand, and Dr Brougham had reported on research on establishment trials.

The concept for the new variety originated with Levy's work on ecotypes in New Zealand. He had shown that following hybridisation and ecotypic selection a wide range of types had evolved, many of which were undesirable. The plant breeder had shown the improvement that could be attained by controlled hybridisation and selection. This had resulted first in the breeding of short-rotation ryegrass (from crosses between perennial and Italian ryegrass), which was in effect an improved Italian ryegrass, and now Ariki (from crosses between perennial and short-rotation ryegrass), which was an improved perennial ryegrass. The objective in breeding this variety was that it should have the persistency, dense tillering habit, and ability to stand hard grazing of certified perennial ryegrass, associated with earlier spring growth, later flowering, improved palatability, and resistance. to leaf rust. Ariki had proved to have these characteristics and also, strangely enough, even better summer production than perennial ryegrass.

The impression might be gained that *the* Grasslands Division had worked only on the improvement of ryegrasses, in that four bred strains have been bred, but improved strains of cockstfoot, timothy, white clover, and red clover have also been produced. Ariki was bred as a general-purpose variety, but there was still scope for other hybrid varieties, for example, a later-flowering Ariki type for southern districts of New Zealand. But it should be borne in mind that the more varieties there were which intercrossed freely in the field the greater would be the problems in their certification.

"Short-rotation ryegrass has tended to replace Italian ryegrass; it is predicted that Ariki will tend to replace perennial ryegrass," Dr Corkill added. "There seems no doubt that the new variety will fill an important place in New Zealand grassland farming."

Mr D. Rider showed two slides of a ryegrass variety trial on his farm. Following a dry summer there was a much greater clover dominance in the area in short rotation ryegrass than in Ariki. He asked for comment on this difference.

A. (Dr Barclay): This grass will undoubtedly be used in Taranaki for that reason alone.

Q. (Mr C. Christie): On the Stratford Demonstration Farm, in two winters Ariki has shown bad tip burn. Would the panel care to comment7

A. (Dr Barclay): Tip burn may be associated with a fungus. Dr O'Connor has worked on this and I would like him to comment.

Comment (Dr O'Connor): In Ariki during winter we found that in non-urine patches 40 per cent of leaf length was damaged and in urine patches 6 · 7 per cent. Ariki is a high fertility demanding species and the higher the fertility the less the tip burn.

Q. (Mr J. Stitchbury): In the trials that Mr Bascand reported the total yields of dry matter seemed the same; apparently the proportion of Ariki was greater.

A. (Mr Bascand): The total yield of dry matter in the pasture sown with Ariki was 5½ per cent above the perennial pasture and 8 per cent above the short rotation ryegrass pasture. Ryegrass content of the Ariki pasture was 25 per cent more than the perennial and 35 per cent more than the short rotation ryegrass. Ariki is a very strong autumn grower and its weed suppression ability is remarkable.

Q. (Mr McKenzie): Would the panel say what they mean by palatability and does palatability really matter when under high stocking you make cows eat all that is in front of them?

A. (Dr Barclay): Stock readily ate the seed heads of Ariki and we could not get them to eat the seed heads of perennial.

A REVIEW OF ADVANCES IN TUSSOCK GRASSLAND

L. W. McCASKILL, Tussock Grasslands and Mountain Lands Institute, Lincoln

In September 1962 the Tussock Grasslands and Mountain Lands Institute produced a Directory of Research listing projects and personnel concerned with the tussock grasslands and mountain lands. The number of people involved was about 100 and the number of separate projects more than 150. It is obvious that, in trying to survey advances being made in the tussock grasslands, I cannot mention more than a few of these workers. Failure to mention them does not mean that I do not appreciate the value of their work; merely that a paper such as this should be more than just a catalogue.

Everyone has his own definition of tussock grassland and the area involved, but I am discussing some 11 ,000,000 acres, mainly in the South Island, carrying about two and a half million sheep and 40,000 cattle and having an importance to the New Zealand economy which cannot be. assessed in stock numbers alone. In sheep equivalents these lands could be claimed to carry about one to four acres but in places so much of the area is devoid of vegetation that stocking rates in the conventional sense mean little. Wool is the basic product, yielding at least 80 per cent of the gross return, and the flocks consist of over half Merinos, a little less than one-third half-breds, and one-sixth Corriedales.

I propose to review only some of the advances made since 1950.

In that year a statement was made at this Association's conference that "to New Zealand as a whole the tussock grasslands are of value for one purpose only, that is, the feeding of livestock". That statement went unchallenged. I think most people in New Zealand would now agree on the importance of the tussock grasslands from the point of view of soil and water conservation, of their value in regulating stream-flow for stock water on the plains, for the generation of hydro-electricity, and for irrigation.

Another statement made was not challenged either. I quote: "It is, however, necessary to consider carefully whether or not a legume should be introduced into unploughable tussock country.

That it is possible has been demonstrated on a number of occasions. It is, however, doubtful if it is advisable. It is unlikely to be profitable. . . .”

The year 1950 is also important because by then the trials on aerial sowing of seed and fertiliser organised and financed by the Soil Conservation and Rivers Control Council, urged on by D. A. Campbell, had culminated in the organisation of aerial farming on a large scale. Two early happenings in this respect were of significance to the tussock grasslands. In 3948 A. M. Prichard dropped grass seed from a plane on 100 acres of Te Akatarawa, Waitaki Valley, and in March 1949 C. Brazier of Airwork, Christchurch, completed a contract to sow from the air three tons of fertiliser on tussock country on Banks Peninsula.

Rabbits

It was the use of the aeroplane for rabbit poisoning rather than for seeding and topdressing which made possible what have been really dramatic changes in the tussock grasslands. Of the 40,000 tons of poisoned baits dropped since 1950 (including 5,197 tons in 1962), a very large portion was used on tussock country.

Without the “killer and devaluation” policy of the Rabbit Destruction Council, aided by the technique of aerial poisoning, advances in the tussock economy must inevitably have been slow and laborious.

Warner (1956) made a survey of the effect of rabbit destruction accelerated by the use of the new aerial tool. From 17 runs in Central Otago of an area of 264,000 acres he produced the following figures:

	Sheep wintered	Wool	Rabbits killed
1948	51,500	371,000	750,000
19.54	60,200	503,000	100,000

Some idea of the effects on the national scale is given by the export figures :

	Rabbit skins	Rabbit carcasses
1948	13,500,000	5,000,000
1955	760,000	420,000

While admiring the Rabbit Destruction Council for its remarkable achievements, we must regret that we have been unable to reduce our annual expenditure below £1¼ million and that we still have too many rabbits in too many places. We need an advance in rabbit destruction comparable with that of 1950.

Land Tenure

The period under review begins about the time when the Department of Lands and Survey, responsible for leasing the larger part of the land under tussock, proceeded to implement the provisions of the 1948 Land Act. This provided for security of tenure through the granting of "pastoral leases" of 33 years with perpetual right of renewal, subject to stock limitation, over the more stable land. It provided also for "pastoral occupation licences" for short terms, with no right of renewal, over such areas as we call Class VIII land today. In the light of present knowledge of catchment requirements, it is unfortunate that on reassessment the granting of new leases under the Act has been made almost entirely under pastoral lease. This can cause difficulties if and when we get down to planning rational land use. As against this, the granting of security of tenure gave new heart to Crown tenants and provided the basis for much of the improvement made over very large areas of tussock grasslands.

High-altitude Grasslands

The Tussock Grassland Research Committee were particularly concerned with the area which I suggest might preferably have been leased under pastoral occupation licence. In their report (1954) they summarised what was known at the time of the scientific aspects of the high-altitude snow-tussock. grassland. Because of the inherent instability and the advanced state of deterioration they urged that, pending the results of research aimed at rehabilitation, every effort should be made to reduce burning and grazing. Widely criticised at the time, the findings of the Committee have subsequently proved to be justified. Most of their suggestions for research have been implemented and some of the projects are mentioned in this review.

Nomenclature

It is a fundamental requirement for study and experiment that we should know what we are studying. Difficulties in the tussock grasslands in this respect have occurred mainly with the snow grasses. Some resolution of these difficulties has resulted from the intensive efforts which enabled Zotov to complete his work on *Danthonia* and *Arundo* in time for publication in the first issue of the New Zealand Journal of Botany (Zotov 1963). Far-reaching changes in nomenclature have been made in the 60-page revision and these will require considerable study by workers in the tussock grasslands: "The New Zealand species of *Arundo* are transferred to *Cortuderia,* which is placed in the new tribe *Corta-*

derieae, while those of ***Danthonia*** are grouped in the new genera ***Chionochloa, Notodanthonia, Erythranthera,*** and ***Pyrrhanthera*** and placed in the newly characterised tribe ***Danthonieae.*** All these, together with certain introduced species, are included in the sub-family ***Arundinoideae".***

Description of the Vegetation

Space permits mention of only two studies. In the first, Barker (1953) made a detailed ecological study of a 5,000-acre sheep run in South Canterbury. Floristic analysis showed that "after nearly a century of modification under pastoral use, two principal rather homogeneous plant communities are now present, each with its own characteristic combination of species". This study has exerted considerable influence, partly because it used the concepts and methods of the Zurich-Montpellier school of phytosociology, and partly because of what is 'now called the "Barker Line" in connection with the importance or otherwise of *Celmisia spectabilis* in the community.

Connor (1960) drew attention to the importance of ***Festuca matthewsii*** as a species characteristic of a type of snow tussock grassland not previously recognised as distinct. He showed that this tussock which is "palatable to sheep and is always grazed, often quite hard," can be a valuable indicator plant. He made it clear, too, that the complexity of snow grass associations, while posing a problem for botanists, provides an equally difficult problem for land users when it comes to management.

In another paper Connor (1961), using a method of sociological analysis, describes a snow tussock community in the Lindis Pass area where ***Festuca matthewsii*** is a characteristic species. In addition to showing the place of this tussock in the overall picture of the grassland, Connor has set a standard of description and analysis which must have great influence on future ecological investigations.

Climate

Until A. F. Mark, in connection with his long-term study of the autecology of snow grass, established 15 climatic stations on the Old Man Range in Central Otago (Mark 1962), and thus made a major advance in climatology in New Zealand, we had no detailed climatic records from any mountain areas. Mark recorded precipitation, air and soil temperatures, wind speed, evaporation, soil moisture, and general weather conditions in the major vegetation types. He has shown that "the present climatic pattern can be readily correlated with the zonation pattern of the vegetation". His climatic records there and on Coronet Peak and Maungatua have already proved a useful guide in the planning of further climatic studies by the Forest and Range Experiment Station, Rangiora, and the Plant Physiology Division of the Department of Scientific and Industrial Research.

Soil Biology

Our knowledge of the biology of at least three tussock grassland soils was greatly increased by the publication of a series of 18 papers in the New Zealand Journal of Agricultural Research between 1958 and 1960. Among these papers was one on earthworms by K. E. Lee, who in a major publication has since added vastly to our knowledge (Lee 1959). He stresses that under sparse cover, so common in the depleted areas, the earthworms are concentrated under individual plants and they are lacking where cover'is absent. Restoration of cover is basic to the restoration of the beneficial effects of a high population of earthworms, but we cannot hope for this until we can restore a full organic cycle.

The work of Stockdill (1959) indicates that where we develop tussock grassland into a highly improved condition, we should consider the cultivation of earthworms to aid such a cycle. We might even aim at the 400,000 earthworms per acre which W. W. Smith in 1887 recorded in one area of tussock grassland!

An outstanding contribution to our knowledge of the soil micro-flora has been made by Robinson (1962) as a result of his studies of a virgin tussock grassland Craigieburn soil in the Castle Hill basin, Canterbury. He found that in this typically infertile and unproductive soil "the nitrifying bacteria, usually considered nearly ubiquitous in soils, existed in this soil in extremely small numbers because of the limited amount of energy-yielding substrate available to them. The sulphur-oxidising autotrophs were also absent, presumably because of the small quantities of reduced sulphur compounds occurring in this soil".

Robinson comments on the fact that so much of the past work on the soil micro-flora has been concerned with soils receiving large applications of fertility-building materials.

Developing Robinson's thesis, O'Connor, Robinson, and Jackman (1962), dealing with the same soil, stress the fact that apparently negligible mineralisation effects obtained after cultivation of this unimproved grassland "are, agronomically at least, in striking contrast to the crop-growth conditions observed after cultivation of limed, topdressed, and legume-rich grasslands developed on the same soil".

From the practical point of view they suggest that primary cultivation of a grassland on such low-fertility, acid soil to initiate improvement may not be warranted if legume establishment and dominance can be more cheaply obtained by aerial oversowing or sod seeding. Cultivation, once the soil has been enriched by more decomposable residues, "could promote active mineralisation with resultant benefit to grasses or crops sown in prepared seedbeds".

This work must provide thought for those planning long-term improvement programmes in the tussock grasslands.

Insects

Kelsey (1957) listed 45 insects that feed on roots or aerial parts of tussock species. He considered, in general, that the leaf-eating insects helped in producing seedbeds in the centres of tussocks and that the major damage was caused by the root eaters. He recorded up to 47 larvae under a single tussock and showed how the movement of these through the soil made the top layer increasingly liable to the effects of frost action and wind erosion.

It is regrettable that Kelsey was unable to continue his experimental work, but, in a personal communication, he has summarised his views on the present situation. These are based on field observation over 15 years.

He says that ***Oxycanus*** can be responsible for the complete loss of inter-tussock growth and can entirely prevent the establishment of seedlings. Grass grubs have similar effects and in addition, because of their physical effects, contribute largely to the production of bare soil. "It is not generally recognised that a relatively few grass grubs or caterpillars can, without altering pasture composition, reduce available grazing to a very low level." . . . "While it is true that there are big gaps in our knowledge of entomological aspects of tussock grassland development, there is ample evidence that in DDT at 2 lb per acre there is available, at low cost, a solution for the control of the four main insect pests -grass grubs, ***Oxycanus, Persectania,*** and *Crambus*. It is felt that, now that rabbit control has been achieved, these insects constitute probably the most important single factor preventing establishment of continuous vegetative cover on much of our tussock grassland."

The only other advance in entomological knowledge is that due to E. G. White, who, financed partly by the Institute, has undertaken a comprehensive survey and investigation of the insect fauna of some areas of tussock. grassland. In one area of less than 10 square miles containing associations of snow grass and of silver, blue and hard tussocks, with the altitude ranging from 2,000 to 4,500 ft and an average rainfall from 40 to 50 in, he has collected approximately 1,000 species of insects. He has obtained information on the status of many individual species, an important step in the understanding of whether they are likely to be of economic importance. This project, the first intensive study in New Zealand of the insect fauna of a grassland area, should prove of further value in that the area includes both improved and unimproved tussock grassland.

Soil Classification

With the meeting in New Zealand in November 1962 of Commissions IV and V of the International Society of Soil Science such full publicity was given to soil classification and the work of the Soil Bureau of the Department of Scientific and Industrial Research that I can add nothing here of interest or value. I must, however, pay tribute to the tremendous help that the Soil Bureau and individual members of its staff have been to workers in the tussock grasslands in the period under review. I must refer also to a few publications which have been major advances as far as understanding tussock soils is concerned: Taylor and Cox (1956) placed the soils of the tussock grasslands into easily understood relationship with the remainder of the soil pattern; Taylor and Pohlen (1962) with a handbook for the field study of New Zealand soils have enabled all workers to use a uniform terminology and set of standards for describing, classifying and mapping our soils and incidentally given us a complete summary of the New Zealand Genetic Soil Classification; the printing of the provisional four-miles-to-the-inch soil map of the South Island and the tentative legend accompanying it provide a soil picture in broad terms of any area under study.

Soil-frost Action

Gradwell, in a series of papers (for example Gradwell 1962), has stressed the fundamental importance of vegetation in reducing and even preventing the effects of soil-frost action.

He has shown how a continuous ground cover of plants provides complete protection and how even a small amount of overhanging foliage reduces the growth of ice needles in the soil below.

Where the plant cover has been removed a layer of tussock litter from ½ to 2 in. deep can protect the soil below from severe frost action. He considers that complete protection can probably be obtained by a cover of plants or of litter much reduced in amount compared with the original closed cover of snow tussocks.

Gradwell's work is so illuminating as regards the importance of cover, he would be a bold man who, having read his papers, would light a tussock fire without being certain that by proper grazing management and spelling or by oversowing and fertilising he could ensure sufficient cover before the following winter to protect the soil against frost action. ,

Land Capability

The period under review saw the introduction by the Soil Conservation and Rivers Control Council of the American system of land capability classification. It has been widely applied by soil conservators of the Soil Conservation and Rivers Control Council (since 1955 of the Department of Agriculture) and of catchment authorities. Approximately half of the tussock grassland has been covered in more or less detail under this system and it is the basis for the preparation of conservation run plans under which improvement involving soil conservation is subsidised.

The system was developed in America largely for areas under a crop-land economy and is not ideally suited to a country mainly under pasture. O'Connor (1962) has pointed out weaknesses in the system as used in New Zealand, claiming that it is "by itself a poor guide to recommended use". While admitting that the weaknesses are largely overcome in practice by soil conservators, he considers we should aim at a more systematic understanding regarding the suitability of mountain soils "for different kinds of use and for different intensities of use of different kinds".

Analysing our experience in pastoral use and in experimentation over 100 years, he has produced a summary of typical South Island mountain soils, rated them for stabilisation and production, and classified them for pastoral suitability at five different levels of culture. He stresses the major importance of fertility in the maintenance or replacement of a mantle of vegetation and suggests "that perhaps a high level of cultural intensity may be necessary in the high-altitude zone, even for purely conservation objectives".

From the points of view of the long-term pastoral use of the tussock grasslands, coupled with soil and water conservation, O'Connor's views should be given the most careful attention by runholders, farm advisers, soil conservators, and administrators of land. He makes it clear that, to enable sound run plans to be formulated, the ratepayer and taxpayer may well be asked to help pay for the development of some soils at a high cultural intensity so that maximum off-site benefits be obtained at the same time as the pastoral industry continues.

In connection with any possible implementation and extension of O'Connor's suggestions, attenion is drawn to some ideas of Cutler (1962). Deploring the fact that of "many land development projects under way or proposed, it is unfortunately true that few are planned in terms of the national resources of soil. It is rare that technical advice is sought before development starts", Cutler has developed a system of soils according to their 'potential capability and limitations based on the Four-mile Reconnaissance Survey and the genetic classification. Cutler divides soils into five soil-capability classes and claims his system "provides a basis for the assessment of the most economic use of land". He found his system to work in well with land capability as practised by soil conservators.

Still on this theme: Leamy (1962) has demonstrated a method of correlating soil classification and soil capability in the Upper Clutha Valley. This method does not reveal any new information about soils, but soils can be arranged in groups about which generalisation on land use may be made and the edaphic potential of the soils of a given region may be compared.

It also offers objective means of assessing soil in the process of the valuation of land. The scheme in short "provides a useful tool for detailed land-use planning". In attempts to develop an overall land assessment, Leamy says, there is a place for both soil-capability and land-capability classification.

The most comprehensive maps of land-capability classes so far published in New Zealand are a 16-miles-to-the-inch map of Canterbury by Dunbar (1962) and 60-miles-to-the-inch provisional maps of North and South Islands in the report of the Soil Conservation and Rivers Control Council for the year ended 31 March 1963.

Whatever its minor deficiencies, the present system of land-capability mapping does provide us with a means whereby people working in a great variety of disciplines can look at land and its use with a common eye with a view to planning for use in perpetuity.

Condition and Trend

While assuming that the eventual proper use of tussock grasslands can be reached only after standards based on vegetative response to grazing are set to maintain a safe balance between soil stability, vegetative production, and animal use. Riney and Dunbar (1956) considered the most urgent need was to meet minimum requirements for conservation. Such requirements imply the maintenance of a soil-vegetation balance and the prevention of further depletion of existing soil and vegetation. In their publication a series of photographs with description provides evidence useful in recognising the status of an area in terms of its conservation requirements. A study of such evidence is vital to the development of management practices which will maintain stability and improve production where the soil-vegetation balance is satisfactory; and where it is unsatisfactory, will be such as to ensure a trend towards satisfactory condition. This idea that standards for land use must be based on and conform to conservation requirements was a marked advance in thinking on tussock grasslands. It is regrettable that up to the present it has not been used to a much greater extent.

In this connection it is perhaps worth reminding you of a statement on range condition by Kenneth W. Parker, an American, at the 6th lnternational Grassland Conference.

"Range condition is the health or status of the range, and a range in the most robust health or highest status is one which has been grazed by livestock on a sustained-yield basis and which is in an optimum state of soil stability and quality and has the highest possible development of vegetation under the prevailing climate,"

We should not aim at any lower status for our own tussock grasslands.

Sod-seeding or Overdrilling

The great success attached to the practice of aerial seeding and topdressing has tended somewhat to relegate to the background the problem of rehabilitating depleted areas in the semi-arid zones and in areas in the sub-humid zone where the rainfall is at the lower end of the scale. In these areas establishment of cover by aerial seeding is very difficult and we have had to rely largely on mechanical introduction. Over 6,000 acres have been seeded in this way in the Waitaki basin by the Catchment Commission's unit alone, and a similar area has been covered with Catchment Board equipment in Central Otago. The techniques learned in these areas will prove valuable for introducing high-quality grasses into areas improved by aerial introduction of clover in the moister regions,

Overdrilling of cereals into tussock grasslands to provide greenfeed has already passed the early experimental stage, and in areas with suitable rainfall it should help to alleviate one of the most critical stages in existing run management.

It should be stressed, too, that overdrilling is the only satisfactory method of introducing lucerne where it is not desired to prepare an orthodox seedbed by cultivation.

Plant Introduction

Particularly for the depleted areas, thoughts for improvement centred for a long time on the introduction and establishment of new or improved species and strains of plants.

At the nursery maintained by the Department of Agriculture for many years at Pisa Flat about 3.50 species or strains were tested and only five found to be adapted to that dry environment. Even they were not very successful when tried in the field. Similar disappointing results were obtained in other areas. One wonders now how much of the disappointment was due to the rabbit and to the lack of fertility. It is encouraging that K. F. O'Connor has commenced, and will gradually extend, plant testing with a wide range of material (some standard lines, some new strains) in a wide variety of environments and at altitudes up to 4,600 ft at least.

Fortunately we know so much about the performance of existing material (especially white clover and cocksfoot) that, provided we are prepared to supply the necessary fertility elements, there is no need to delay improvement while awaiting for specially-bred material for introduction,

There are large areas of tussock grassland in the low to medium altitude zones where effective soil moisture is low and tolerance of drought is a primary requirement of plant survival. For such areas indications are that lucerne can prove a more useful legume than' white clover. Lucernes such as Marlborough can be successfully established in pockets of better soil (some properties have up to 900 acres), but for large-scale sowing it is possible that better survival can be obtained by using creeping-rooted lucernes which have ability to colonise by spreading from the parent plant.

C. E. Iversen at Lincoln College, financed in part by the Tussock Grasslands and Mountain Lands Institute, has produced a strain which appears to have the ability to creep and to survive winter heaving and to have a season of growth considerably prolonged compared with that of Heinrich's Canadian strain. Testing of this strain is now being carried out under a wide variety of conditions at Molesworth, in the Mackenzie, and in Otago.

What do Sheep Eat?

In the tussock grasslands over 200 indigenous species and some 50 adventives have been recorded. Up to 50 species may occur on a face or on a valley floor.

Advances in basic knowledge as to what sheep eat are possible as a result of techniques developed by the Hercus family. With information obtained from use of these techniques it is possible to identify the species eaten by sheep at any time of the year. It should then be possible, by studying factors influencing growth and regeneration of these species, to develop a management system aimed at favouring them.

Barbara Hercus (1959) has applied to New Zealand conditions a method of cuticle analysis developed in Scotland. The method, based on the use of faecal samples and a set of references slides made from species growing in the area studied, gives qualitative results for any kind of animal feeding on any type of vegetation. It has the great advantage that there is no interference with the ordinary habits of the animals concerned.

J. M. Hercus (1963) uses a 12-inch ring dropped at pre-determined intervals along a series of traverses. The observer records all the species occurring within the ring, examines each closely, and, using a numerical scale, rates them according to the intensity of grazing.

Management

The landholder himself has been a major agent in developing improved systems of management. The increased attention given to the spelling of blocks to permit reseeding (aided by subsidies for conservation fencing), the use of cattle to control rank growth (aided by conservation subsidies for cattle-proofing fences), and the growing of alternative feed (aided by conservation subsidies) to permit spelling or destocking of eroded land, are all important advances, even though they may, in turn, have brought new problems.

Catchment boards have been vitally interested in the effects of management on cover. Some of them, concerned that little or no factual information was available as to what really was happening to the vegetation, have set up line transects and exclosure plots in a wide variety of situations. Most extensive of these investigations have been those of the North Canterbury Catchment Board. Their Chief Soil Conservator, R. D. Dick, in a personal communication, has stated that since work was begun in 1947, 60,000 points have been recorded each year as to bare ground and living or dead vegetation.

Results to 1962 show that on all line transects under grazing (and these run up to 4,550 ft) bare ground is increasing. On enclosed plots (the highest is at 3,250 ft) bare ground is gradually being covered by vegetation. Studies of this kind are basic to improvements in management.

Connor's work on the development and growth of flowering stems of plants of the tussock grasslands (Connor 1963) is an important advance on which improved techniques of management could be based. From the time when the flowering heads are formed (and they are then less than one-tenth of an inch long) to the time of full development of the seed head there is a long period when the seed heads are liable to damage by grazing, trampling, or burning. "The timing therefore of animal management is important for plant management" where spelling is necessary to ensure maximum seed fall for regeneration.

Also on the theme of management J. M. Hercus (1961) has shown on depleted land in Central Otago how a knowledge of what are the really useful species, and what they require for good growth and satisfactory seed production, can suggest alterations in management which will hasten improvement. Complete spelling at a critical stage of growth just three to five weeks earlier than *is* usual in run practice produced spectacular results as far as regeneration was concerned, both through re-seeding and the better growth of parent plants. He has offered a guiding principle in utilisation: -"Avoid grazing the same block at the same time in the growing season every year, and the most critical time is in late spring and early summer." Fortunately the improvement work going on with seeding and topdressing provides extra fodder which must be utilised at the very time native pastures should be spelled for regeneration.

Burning

To burn or not to burn has long been a difficult question facing many occupiers of tussock grassland, Opinions still differ -in fact they may vary as much as the tussock grassland itself varies. But most observers would agree that a major advance has been the reduction of burning in some areas and its complete cessation in others.

The rabbit stopped the practice over a wide area-he left nothing to burn. Observation by the runholder resulted in the practice being stopped or reduced elsewhere. New practices of grazing management, especially the increased use of cattle, showed that burning might profitably be dispensed with. By-laws of catchment authorities, sympathetically administered, have done their part as shown by Anderson (1962).

The provision of subsidy by the Soil Conservation and Rivers Control Council for the construction by catchment authorities of strategic firebreaks has helped considerably in the planning of burning control and in preventing accidental fires from becoming conflagrations.

Barbara Hercus (1962) over six years has evolved and tested a practical method of obtaining detailed effects of fire on the botanical composition of tussock grassland. Her results to date show that "the method does give a reasonably unbiased picture of the changes that occur after burning," but also stress how complicated the issue can be: "Every burn is' different; nine burns are under observation and on each site there are differences in the recovery pattern."

Where burning is considered necessary there would seem to be increasing application of the simple rule offered in 1958 by K. F. O'Connor to apply to all decisions on burning tussock grasslands: "NO burning without replacement." He explained this further as: "If vegetation recovered from fire to give a complete ground mantle before there was a chance of erosive forces like heavy rainstorms or frost, then burning could be justified on land' suited for pastoral use and not required for critical water storage. Likewise, if burning was to be followed by topdressing and oversowing, with the reliable expectation that an effective cover to the ground surface could be obtained within one growing season, burning could be justified."

O'Connor (1962a and 1963a) has subsequently justified his rule by research work in the Mackenzie Pass, "the first occasion on which burning has been compared with no-burning in a controlled and replicated experiment on snow tussock". The results published in these papers provide us with a firm basis for any further advance in the study and control of burning.

The Grazing Animal

It is surprising that so little attention has been paid by research workers to the breeding, feeding, management, and improvement of sheep in the tussock grasslands. This deficiency has been corrected recently in some measure by I. E. Coop and V. R. Clark of Lincoln College. Financed by the Tussock Grasslands and Mountain Lands Institute, they are studying the performance of several thousand individual sheep on two Merino and two half-bred runs in Canterbury. Investigations are still in the early stages, but indications are that lambing percentage and the percentage of dry ewes are related to the weight of the ewe at tupping. It is believed that the work will stress the importance of feeding young stock well and the possible need for changes in the management of ewes. It appears that the live weight of the ewe must be increased in early life and then maintained.

Animal research is particularly difficult without complete control of the livestock and their management. It is fortunate therefore that the Tara Hills property of the Soil Conservation and Rivers Control Council has, since 1961, changed its emphasis and is now primarily a research station. On this property of 8,250 acres investigations are being made by staff of the Department of Agriculture into such projects as planes of winter feeding, effect on lambing percentages of pre-tupping shearing of two-tooths, early weaning of lambs, and grazing habits and performance of different breeds of sheep.

Soil Fertility

As in recent years much attention has been paid at these conferences to soil fertility and as it was also widely discussed at the meeting of the International Society of Soil Science here last year, I propose to be brief out of all proportion to its importance.

The great advance in mechanical aid, the use of the aeroplane, has already been mentioned. From the point of view of nutrient deficiency, the discovery of the vital importance of sulphur in the establishment and maintenance of legumes in tussock grassland, from Marlborough to Southland, altered our thinking and changed our practices (for example, Lobb and Bennetts 1958).

Present advice by the Farm Advisory Division, Department of Agriculture, as summarised in the Tussock Grasslands and Mountain Lands Review No. 4, March 1963, is the result of some hundreds of plot trials with clovers treated with sulphur and phosphorus, separately and in combination, and with and without molybdenum. Where finance is available and suitable fertilisers are applied little difficulty is now experienced in the lower and mid-altitude tussock grasslands in establishing clovers either by aerial sowing or, in semi-arid areas, by overdrilling.

For the explanation of many of the factors involved we owe much to Walker and his co-workers at Lincoln College (e.g. Walker and Adams 1958, 1959, Walker 1960). Of particular value has been their study of sequences of tussock grassland soils based on the genetic classification of the Soil Bureau. Ludecke's paper at this conference last year (1962) illustrated the practical advice available from this type of study. Perhaps the next advance in this field will be the general planning of field trials on a basis of soil sequences.

Another contribution by Walker has been his provision, sponsored by the Institute, of "kit sets" of clover seed, inoculant, and fertilised materials to enable tussock farmers to establish their own indicator trials when a programme of improvement is proposed.

Mention only is possible of the work of O'Connor (1959, 1961, 1962, 1963b) in the field of soil fertility in difficult environments.

Success in the establishment of legumes by correction of soil deficiencies has been shown by increased wool weights, more and healthier stock carried, more surplus stock sold, increased lambing percentages, more vigorous grasses (both native and introduced), better cover, and reduced run-off and soil loss.

Space permits only one example, that of Te Akatarawa, a property of 32,000 acres in the Waitaki Valley. Sheep numbers have risen only from 6,500 in 1942 to 8,300 in 1962, but cattle have risen from none to 420 over the same period. The wool clip amounted to 10 1 bales in 1942 and 176 bales in 1952. This increase reflected the control of the rabbit. In 1952 seeding and topdressing commenced and by 1959 3,000 acres had received a total of 2 lb of clover seed and 5 cwt of fertiliser per acre. Top-dressing had to cease in 1959 to allow the cattle numbers to increase sufficiently to control the herbage. It will recommence in 1964. In 1962 252 bales of wool and 2,000 head of surplus stock were sold.

Conclusion

The advances mentioned (and others which I have not been able to touch on) have helped to meet the challenge of the lower tussock country and to a large extent of the mid-altitude steep-lands. They have resulted in our taking a new and more hopeful view of the problems facing the tussock grasslands, provided always that a reasonable margin between costs and returns can be maintained.

, Basically the answers to improvement of tussock grasslands at the low and middle altitudes remain the same as were given by K. F. O'Connor to the 1958 conference of this organisation:

"1. Build fertility by adequate topdressing of the right kind and quantity.

"2. Introduce plants that can utilise the higher fertility and can be used by animals.

"3. Maintain the plant population and the built-up fertility by turning round the pasturage through the organic cycle of the grazing animal."

As a follower of Kelsey I would add "and treat adequately with DDT".

The challenge of the high-altitude tussock grasslands is still before us.

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RESIDUAL EFFECT OF PHOSPHATE TOP-DRESSING ON A YELLOW-BROWN LOAM

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Annual phosphate topdressing has been needed on the yellow-brown loams of Taranaki to maintain vigorous productive pastures. There is, however, a wide range of opinion as to what is the optimum rate of topdressing and what is the optimum phosphorus status for pasture production.

The work on this problem by Soil Bureau, D.S.I.R., has been in two parts: First, a comparison of soils collected from fields which had been topdressed at different rates; second, a field trial to evaluate the residual effects of phosphate topdressing. The work was done on New Plymouth black loam, which is typical of the yellow-brown loams of North Taranaki.

The sites for the first part of the work had all been under pasture for at least 25 years. They were freely drained and had been used solely for grazing. The phosphate topdressing histories of the areas sampled were:

(a) One pair, no phosphate (No-P).

(b) One pair, 20-30 lb P/ac/year for 25 years (Mod-P) (2-3 cwt superphosphate).

(c) One pair, 60–80 lb P/ac/year for 8 years (High-P) (6-8 cwt superphosphate).

The results of this comparison have been published (Saunders, 1959) and some of these are shown in figs. 1 and 2.

There was an increase of total phosphorus content of the soils following topdressing, but only to a depth of 5 in. The increase at O-2 in. was much.greater than at 2-5 in. The increased phosphorus content roughly accounts for all the phosphate applied, taking into account the probable amounts removed as farm products. The phosphate added to the Mod-P soils roughly equals that added to the High-P soils (625 lb and 560 lb P/ac respectively), and greater loss as farm products accounts for the lower phosphorus content of the Mod-P soils.

The accumulation of phosphorus in the topdressed soils is mainly in inorganic forms of phosphorus; the amount present. as organic phosphorus has hardly increased. Burgess and Davies (1951) found a similar result in a yellow-brown loam near Stratford which had been under pasture for 25 years.

The concentration of the phosphate in a restricted amount of soil has the benefits of fertiliser placement, but it has the disadvantage that in dry spells it is no longer available, since the top inch of this soil can dry out to wilting point in one week without rain (Saunders *et al,* 1963).

A pot experiment showed that the level of available phosphate in these soils was well evaluated by the Truog test of the Department of Agriculture (fig. 2). Dry matter yield increased with the Truog value and the degree of response decreased. Although this was a pot trial and radish was used as the crop, the levels of response taken from it relate very closely to field experience.

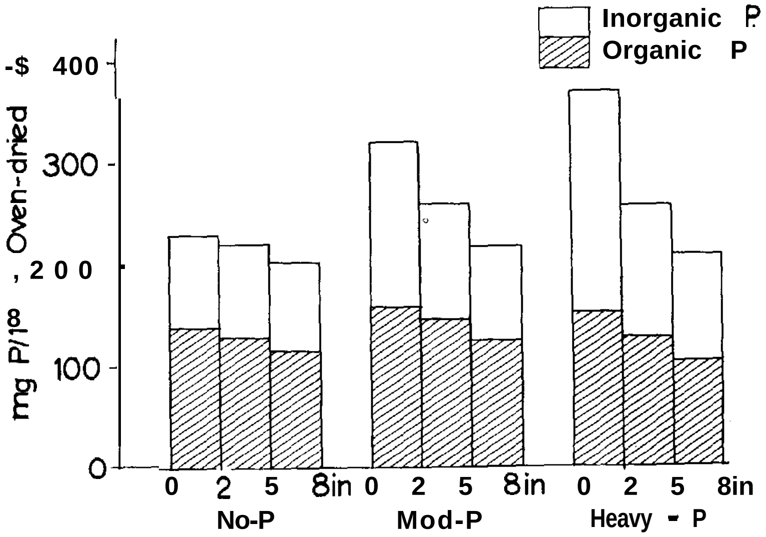

Figure 1.-Total, inorganic and organic phosphorus in New Plymouth black loam, which has had no phosphate, phosphate at moderate rates, and phosphate at high rates.

Degree of response	Truog values Pot trial	Truog values Field experience*
large	0 - 3	0 - 3
medium	4 - 7	3 - 7
small	8 -15	7 -13
none	16 -	13 -

*Pers. comm. A. C. Burgess and G. R. Moss.

The Truog values for No-P, Mod-P, and High-P soils are marked in fig. 2. The No-P soils fall into the top of the large-response category, the Mod-P into the medium-response, and the High-P soils are in the small-to-no-response group. Although the amount of phosphate applied to the Mod-P soils is of the same order as that to the High-P soils, the level of available phosphate has not built up proportionately. The high rate of application on the High-P soils has kept the level of available phosphate well ahead of the losses in farm products and by phosphate-fixation processes.

Since little or no response to phosphate can be expected from the High-P soils with a soil test of 15, the signs are that phosphate topdressing could be stopped or at least reduced. The question is for how long or to what level?

Some information on this question has come from the field trial which measured the residual effect of phosphate topdressing. The field trial was run in collaboration with the New Plymouth office of Department of Agriculture on the farm of the late Mr W. Hardwick-Smith. We gratefully acknowledge the willing help of all concerned, particularly Messrs A. C. Burgess and G. R. Moss.

The object of the trial was to compare the effectiveness of phosphate two and three years after application (the residual effect), with the effectiveness of phosphate in its first year of application. The trial was laid out in four blocks. These were topdressed with double superphosphate in four successive years

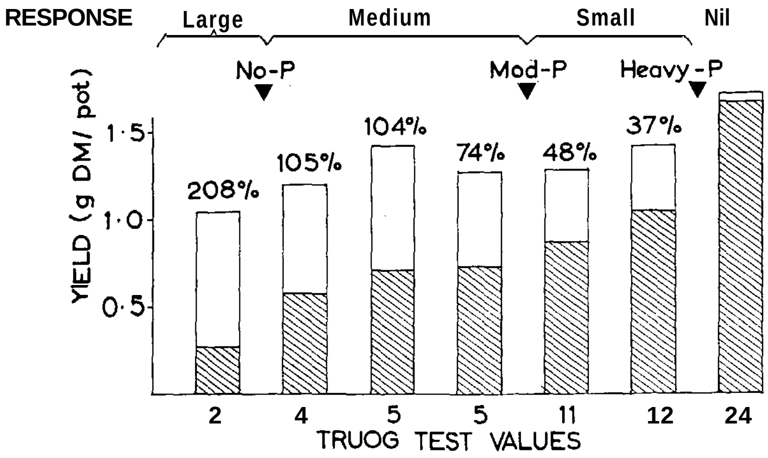

Figure 2.-Relation between Truog P test values and phosphate response on New Plymouth black loam.

as follows: Block 1, September 1954; Block 2, August 1955; Block 3, August 1956; and Block 4, August 1957.

The whole area received a basal dressing of KC1 and $MgSO_4$ each spring.

The rates of topdressing on each block were:

Block 1	0	20	40	80	160 lb P/ac.
Block 2	0	20	40	80	160 lb P/ac.
Block 3	0	20	40	80	lb P/ac.
Block 4	0	20	40	80	lb P/ac.

In 1955-56 a comparison was made between the response to first-year phosphate on Block 2 and the response to second-year phosphate on Block 1. In 1956-57 the comparison was made between first-, second-, and third-year phosphate and in 1957-58 the phosphate of four years was compared.

The results. of this field trial will be reported in detail shortly. (Saunders *et* al, 1963). In this paper, rather than give the results for the individual years of the experiment, we give mean values of three years of the trial to show the general trends. For example, the first-year phosphate response curve is calculated from three curves for phosphate applied in 1955, 1956 and 1957. The second-year response curve is the mean from three years, and the third-year response curve is the mean from two years.

The soil-pasture-phosphate relationships of the fast-growing spring and early summer pasture were very different from those of the slow-growing autumn and winter pasture. In accord with many other phosphate field trials the degree of response to added phosphate was least in spring and increased through summer to be greatest in autumn and winter. The phosphorus content of the pasture was highest in spring and fell to its lowest levels in summer and autumn. In winter it lay between the autumn and spring levels.

This trial showed that the residual effect of phosphate topdressing was subject to seasonal variation. In spring, when the degree of response to phosphate was low, the response curves for the second- and third-year phosphate were similar to that for the first-year phosphate (fig. 3). In summer this similarity was more striking, since the degree of response was greater. In this period of rapid growth the phosphate topdressing was showing a high residual effect in that there was no difference between the effectiveness of the first-, second- or third-year phosphate.

In contrast, in autumn the,response to first-year phosphate was much greater than to the residual second- and third-year phos-

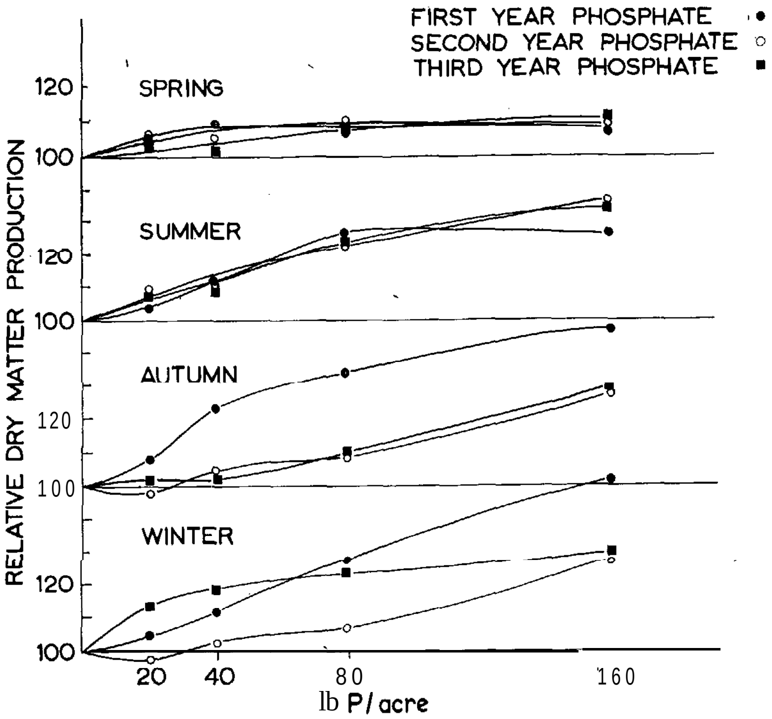

Figure 3.-Relative dry matter production to different rates of phosphate topdressing in its first, second and third year after application.

phate. For example, 80 lb P/acre as second- or third-year phosphate gave the same degree of response as 20 lb P/acre of Erst-year phosphate. The lower rates of 20 and 40 lb P/acre as second- and third-year phosphate gave no response.

In winter the second-year phosphate showed a small residual effect, but the third-year phosphate showed a good residual effect at the lower rates of topdressing, but not at the highest rate. Some of the difference between second- and third-year phosphate is not statistically significant, but there still remains an inexplicable difference.

Summarising: In the period of rapid pasture growth (spring and summer) the degree of response to phosphate was lower, the phosphorus content of the pasture was higher, and the effectiveness of residual phosphate was greater than in the period of slow pasture growth. These differences between the two periods of the year point to the soil and residual fertiliser phosphorus being more available to pasture in spring and early summer than in autumn and winter.

Discussion

The availability of soil phosphorus is determined by both soil and plant factors. The soil factors govern the concentration of phosphate in the soil solution and the rate at which it can be renewed. This rate of renewal is an important feature of phosphate nutrition of plants. The amount of phosphate in the available soil moisture of the High-P soils was 0.012 lb P/ac (2 oz superphosphate/ac). However, the demand of the rapidly-growing spring pasture was 0.14 lb P/ac/day (23 oz superphosphate/ac/day) . Hence the phosphate in the soil solution was renewed over-ten times a day.

Phosphate enters the soil solution by three major processes: dissolution of inorganic forms of soil and fertiliser phosphorus, mineralisation of soil organic phosphorus, and breakdown of plant and animal residues.

Though phosphate is being continually supplied to the soil solution, there is also a continual sorption of it from solution by the soil colloids which maintains the low concentration. Over short periods this sorption is reversible and as the plant withdraws phosphate the sorbed phosphate will re-enter the solution to maintain the phosphate concentration. Over a long period the sorbed phosphate will become fixed and is no longer able to reenter the soil solution. The extent and, rate of all these processes are governed first by the nature of the soil,, that is, its degree of weathering and leaching and its parent material. In addition these processes are influenced by the moisture content and temperature of the soil, and seasonal variations in these factors may well alter the concentration of phosphate in solution and its rate of renewal.

The phosphate in the soil solution is available to the plants only' when their roots can reach it and can absorb it. Therefore the density of roots in the soil and the soil moisture content could be important factors in phosphate availability, The work of W. A. Jacques and his colleagues at Massey College indicates that there is a greater density of roots under the grass-dominant spring pasture than under the clover-dominant autumn pasture and that lack of moisture in summer retards root renewal. These factors may contribute to the higher availability of soil phosphorus in spring than in autumn. These are just two of several plant factors.

The availability of the soil and fertiliser phosphorus at any time of the year involves the integration of soil and plant factors. The relative contributions of each factor are still largely unknown. Their evaluation is probably a good line of research toward improved utilisation of our phosphate 'resources.

In 'addition to giving information on the seasonal variation of soil-plant-phosphate relationships discussed above, this work provides some information which may improve the utilisation of phosphate on the yellow-brown loams of Taranaki.

After several years of high rates of topdressing. the High-P soils discussed were giving a Truog phosphorus test of 15, indicating little further response to phosphate fertiliser. When these yellow-brown loams reach this level it is probable that a lower rate of phosphate topdressing can be used. But in view of the lower effectiveness of residual phosphate fertiliser in autumn and winter it would not be advisable to stop topdressing altogether but to use a low rate in late summer or autumn.

It is common practice in Taranaki to split the annual phosphate topdressings (both maintenance and the heavier dressings used when establishing new pastures) and to make applications in autumn and spring. Since there appears to be a very high residual effect in spring and summer, it is probably better to use all the annual topdressing as a single application in early autumn to cope with the lower availability of the soil phosphate in autumn and winter: The residual effect would meet the need of the spring pasture.

A change to phosphate topdressing solely in autumn and to low rates on the high-phosphate-testing soils would have to be done without interfering with the potassium needs of the soils. Work at Soil Bureau (Saunders and Metson 1959) indicated that especially on low-potassium-testing soils, potassium is best applied as small frequent dressings rather than large infrequent dressings. Hence, even if phosphate topdressing in spring is stopped, it seems advisable that potassium topdressing should continue.

The residual effect of fertiliser phosphate in spring could well be of general occurrence, but there are two points to consider. In the yellow-brown loams of Taranaki the added phosphate accumulates mainly as forms of aluminium phosphate (Saunders 1959). This has been attributed to its high content of allophane and associated amorphous aluminium oxides. In soils in which iron plays a greater part in retaining the fertiliser phosphate the situation may not be quite the same: In soils in which organic matter levels are building up much of the fertiliser phosphate is converted to organic phosphorus (Jackman, 1960). It is probable that in this form it would not show a high residual effect.

References

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DISCUSSION

Q. (K. O'Connor): Was there good insect control in the trial, with reference to the possible part played by roots in seasonal availability of residual phosphate?

A. Yes. There was no sign of grass grubs themselves in soil samples. DDT was applied,

Q. (A. Pantall): How much phosphate was actually fixed in the soil?

A. To determine how much phosphate is fixed it is necessary to measure how much was used. Because the clippings were returned to the plots it is not possible to calculate the uptake of phosphorus and hence the amount fixed.

Q. (J. Stitchbury): What level of autumn topdressing could be recommended on paddocks with a high phosphate soil test?

A. The design of this trial was directed toward measuring residual effect and this other important question of maintenance rates could not be answered. Further trials along the lines of those used by Rukuhia Soil Research Station in the Waikato are needed. As a guestimate based on the results of the trials of Rukuhia and on the properties of the respective soils, I would think about 40 lb P/ac (4 cwt superphospate/ac.) would be required to maintain a high phosphate soil test.

Comment (J. Karlovsky): I agree with Dr Saunders that phosphate should be applied in one single autumn application if the aim is to increase pasture production during the critical late autumn and winter period.

Concerning potash, in Waikato single applications have proved to be as effective as split applications and best seasonal distribution of response has been obtained with autumn applications. Autumn application gave 40 per cent of annual response in autumn and winter but spring applications gave only 20 per cent of annual response in this period. Application of a single dressing in late spring - early-summer as suggested by Mr During gave 30 per cent of annual response for Waikato in autumn and winter.

Residual effect of phosphate topdressing appears to vary from soil to soil in Waikato.

Comment (Saunders): It is very probable that the residual effect should. vary from soil to soil and I have drawn attention at the end of my paper to two factors, the ratio of aluminium-bound to iron-bound phosphate and build-up of organic phosphorus, which may influence the residual effect.

Chairman's Comments (T. W. Walker): There is clearly a great deal more of this type of work to be done to rationalise our fertiliser usage.