Northland Pastoral Extension Research Stocktake

Clover Growth and Management in Northland

Contents

1.0 Nitrogen Fixation in Pasture II Northland Warm Temperature, Kaikohe

P J Rumball
New Zealand Journal of Experimental Agriculture 7 (1979) page 7-9

Overview

Annual totals of N fixed by legumes in an intensively managed pasture on a podzol in Northland in 1974-75 and 1975-76 were 368 and 392 kg/ha. The pasture produced 11.4 – 14.1 t DM/ha, of which one third was white clover (Trifolium repens L.). Variation in rate of fixation was small within and between years, and seemed to be most influenced by soil moisture. The generally close correspondence between legume growth rate and N fixation rate, as well as periods of apparent N deficiency, suggest that rates of N mineralisation are very low at this site.

Method

Soil Type
- Wharekohe silt loam (podzol)
- Poor to very poor drainage in the winter and spring

Pasture
- 10 year old pasture
- Ex Manuka and sown autumn 1965 into Ariki perennial rye, Apanui cocksfoot, paspalum and Huia white clover
- 7 years pasture production (rate of growth technique) was 12.9 t DM/ha (range 11.8 – 14.2)
- Stocking rate of 19 ewes/hectare

Fertiliser
- Annual application of 500 kg/ha of 50% potassic in split dressings, 10 kg/ha of elemental sulphur each autumn and 6 kg/ha of copper sulphate every second year.
- Lime 1 tonne/ha every 3 years to maintain pH 5.6-5.8
- Soil nutrient input: kg/ha/year
    - P K S/S E/S
    - 23 125 30 10

Results

	Year 1974-75 (1)	Year 1975-76 (2)
Pasture Growth DM/ha/yr	14.2	11.5
Nitrogen Fixation kgN/ha/yr	368	392
Total Rainfall – mm	1797	1704

	Spring S-O-N	**Summer D-J-F**	**Autumn M-A-M**	**Winter J-J-A**	**Total**
Clover yield 1975-76 (kgDM/ha)	684	1029	1099	866	3678
Nitrogen Fixation kgN/ha/period: 1974-75 1975-76	 100 118	 80 122	 114 100	 74 52	 368 392
Rainfall mm per period 1974-75 1975-76	 316 339	 289 361	 724 370	 468 304	 1797 1704
Clover yield 1975-76 (clover yield per period as a percentage annual pasture production)	17	36	48	38	32
Nitrogen Fixation 1975-76 (N fixation per period as a % of the years N fixation)	27	22	31	21	

Comments: Results

- Peak pasture growth at 77 kgDM/ha/day in mid September.
- Slowest growth at 12 kg in winter.
- Negative pasture growth in mid March when heavy rain followed a long dry spell and decomposition exceeded growth.
- Maximum nitrogen fixation followed heavy summer rain, at 1.87 kgN/ha/day.
- All legume production was white clover.

Discussion

- For most of the year, soil water availability was more important than temperature variation in determining nitrogen fixation.
- There was a close relationship between clover growth, high clover content of the pasture and nitrogen fixation.
- These results (and other work, K Steele) suggest that mineralisation of nitrogen, on this soil type, is slow and/or distorted (does happen but at slow and/or at low rates).

Other Comments

- These nitrogen fixation results were the highest recorded through the country during the 1970s.
- Soil Nematode population unknown, but it was possibly zero!
- Very high clover population, e.g. 48% clover base in autumn.

2.0 Clover 300 – Northland Beef Producers

G Ussher, March 2000
Project Final Report to Foundation for Research, Science and Technology: a Research Development Project

Overall Summary

The results obtained on farm in year 3 continue to show that there is a major problem with very low nitrogen fixation levels on virtually all our Northland beef farms.

Results are indicating that the major factors depressing or inhibiting our nitrogen fixation levels are:

- Poor clover population, especially for the mid September to December period.
- The lack of well balanced soil fertility.
- Presence of soil pugging through the winter and spring.
- High to very high soil temperatures in summer.
- Low to very low soil moisture levels in the summer and autumn.
- Presence of soil nematodes in high to very high numbers.

See Appendix 1 for actual results of nitrogen fixation levels.

Trends Emerging

Clover Performance Indicators
Very low nitrogen fixation results for most farmers, compared to "old" research within Northland. High soil temperatures and low to very low soil moisture contents in the February sampling round proving to have a severe negative effect on clover population and clover nitrogen fixation, for each of the three years.

New Clover Cultivars
One project farm adopting the use of new grass and clover seed technology previously, showed major improvements in clover population and nitrogen fixation from this new grass and clover pasture. From June up to December 1998, the new pastures carried an 18% clover base compared to 7% for the balance of the farm, and the nitrogen fixation was 126 kg per hectare for this period compared to just 57 kg for the balance of the farm.

Balanced Fertiliser Programme
Herbage analysis indicating the difficulty of obtaining a very well balanced fertiliser input, especially under the severe financial stress with the then beef crisis.

Farms showing deficiencies based on clover analysis within the project period:

	1997	**1998**	**1999**
	No. of Farms		
Nitrogen	1	0	0
Phosphorus	2	1	2
Potassium	5	4	6
Sulphur	3	4	8
Copper	3	0	1
Molybdenum	2	3	3

Clover Pests and Diseases
Although five farms showed evidence of clover flea damage during the project period, damage was minimal, with only 10-20% of the clovers being affected at worst. Clover flea was not considered a major inhibitor of clover production in the spring of any of the three years.

Laboratory assessment of the nematode population showed that the presence of nematodes is a major problem. Seven farms had nematodes recorded in very high population, whereas the remaining seven farms although having "moderate" nematode population, had sufficient numbers under the dry soil conditions, that this nematode population could increase very quickly given suitable soil conditions.

Pugging damage and its severe negative effect on our clover performance was identified through the winter – spring of 1997. Adoption of pugging measurements was undertaken in the winter–spring of 1998 and 1999. These pugging measurements indicate that severe pugging does occur on Northland beef farms and is one of the reasons for our low to very low nitrogen fixation levels.

Grazing and Feeding
Herbage quality analysis undertaken in April 1999 showed high to very high pasture quality on all farms but one. This compares favourably with the results in February 1998 which showed 60% of farms having low to very low feed quality.

Pasture cover measurements indicate that pasture covers in late spring were at the "correct height" to ensure maximum clover production on all but one project farm. Although the theory is that "out of control" pasture in the spring is a major hindrance to high clover production, the measurements undertaken through all three springs, strongly suggests that for most farms this is not a problem.

Appendix 1

Clover 300

	Average of 3 years	Nitrogen Fixation (KgN/ha)			Soil Type
		1996/97	1997/98	1998/99	
Cookson	142	176	68	185	Podzol
Whitehills	128	118	94	175	Podzol
Upokorua	126		94	172	Podzol
Te Rangi	112	161	92	82	Podzol
Linssen	81	91	53	100	Clay
Beazley	77	57	49	124	Podzol
Brown	69	52	54	100	Clay
Appleton	69		44	94	Semi Volcanic
Owen	66	80	22	96	Clay
Dromgool	58		54	62	Sand
Burrill	55	65	36	65	Limestone
Hewlett	53	77	33	48	Podzol
Wagener	50	43	38	69	Peat/Sand
Snodgrass	46	62	29	47	Semi Volcanic
Group Mean	**81**	**90**	**54**	**102**	

Appendix 2

Clover 300 Data

Project Results – Clover (% Annual Pasture Production)

	For Sampling		
	1998/99	**1997/98**	**1996/97**
Te Rangi Station	10	13	21
Wagener, E	5	6	11
Brown, B	11	8	16
Linssen, B	12	11	20
Snodgrass, R	9	6	14
Beazley, A	16	10	9
Hewlett, B	6	4	15
Cookson, G	16	9	27
Whitehills Station	15	16	17
Owen, M	6	6	17.5
Burrill, R	12	8	20
Appleton, G	12	10	
Dromgool, J	6	5	
Upokorau	13	9	
Mean of all Farms	**11**	**9**	**17**

Drop from 1996/97 in Yearly Figure for all farms:

1997/98 @ 47%
1998/99 @ 35%

Overall average of all farms for the three years @ 12%

Appendix 4

Clover 300

1998/99

	Soil Type	Clover %	Pugging	
		Average Year	**September 98**	**September 99**
Te Rangi	Podzol	10	4.0	5.5
Cookson	Podzol	16	6.0	3.5
Whitehills Station	Podzol	15	4.0	5.7
Beazley	Podzol	16	3.0	3.3
Hewlett	Podzol	6	4.3	3.8
Upokorau	Podzol	13	3.8	5.0
Dromgol	Sand	6	2.0	1.0
Brown	Clay	11	3.5	4.7
Linssen	Clay	12	4.5	5.3
Owen	Clay	6	4.5	3.3
Wagener	Peat	5	4.6	4.3
Appleton	Semi Volcanic	12	2.0	1.5
Snodgrass	Semi Volcanic	9	1.5	1.0
Burrill	Limestone	12	6.5	6.0
Group Mean		**11**	**3.6**	**3.9**

3.0 Northland Clover Nematode Survey

G Ussher, August 2006
Project Final report to MAF Sustainable Farming Fund

Objectives - Overview

- To carry out an assessment of the parasitic nematode populations on Northland farms.
- To obtain on farm data covering factors that may mitigate the effect of these parasitic nematodes.
- To improve the awareness of our nematode problem amongst Northland farmers and servicing industry groups.

Approach

A field survey of 19 Northland farms located from Te Paki Station, in the Far North, to D. McKay, Maungaturoto in the South, during September to December 2006. Farms sampled:

- 17 were beef, sheep and beef enterprises
- 2 were dairy plus beef operations

Soil samples were collected on farm from representative paddocks based on:

- Pasture age and fertility
- Clover vigour and production

These soil samples were analysed at AgResearch laboratory, Ruakura, for nematode species and number. Results were given for nematode population by species, plus the percentage of parasitic nematodes to total nematode population.

- Farm information was collected covering factors that may potentially be mitigating the impact of parasitic nematodes.

Extension activities were undertaken.

Overview – What Are Nematodes?

Nematodes are very small worm like organisms found in our soils, ranging from less than 1mm in length up to 2mm in length. They are in all soils with total populations ranging between one million to 20 million per square metre.

Most of these nematodes are beneficial in that they assist in the breakdown of organic matter and the recycling of soil nutrients. But some are parasitic and feed on our clover and/or grasses. Because nematodes primarily affect root efficiency and abundance, their effects can add to those of drought and low soil fertility.

Results – Overview

Interpretation of the Results of the 19 Farms

Plant Parasitic Nematode Population as % of Total Nematode Population	Number of Farms	% of Farms	Classification: Likely Pasture Damage
Under 10%	4	21	No substantial damage
11 to 19%	8	42	Moderate
20 to 30%	5	26	High
30 plus %	2	1	Severe

For all farms sampled:

- Total nematode population average was 7294 per 250 cc of soil. This equates to 2.8 million / m2.
- Plant parasitic nematode population averaged 1417 per 250 cc of soil at 19.4% of the total nematode population.

A 10% level is taken as the separation point between minor damage by plant parasitic nematodes (levels under 10%) or substantially greater damage from levels above 10%; this for parasitic population as a percentage of total population.

Nematode Population by Soil Type

Soil Type	Number of Sites	Nematode Population per site Per 250 cc of soil	Mean Plant Parasitic Nematode %
Peaty sand	3	3277	21
Volcanic	5	6153	14
Limestone	2	8560	28
Sand (free draining)	9	8350	19
Podzol (Gumland)	16	8019	19
Clay	31	5634	16

The above results need to be treated with caution, e.g. the limestone site shows a high nematode population and the highest parasitic percentage, but this data is from just two sites. But this data is suggesting that podzol (commonly called gumland) soils have a higher nematode population than the clay soils, by 40%, while they also have a higher plant parasitic nematode population as a % of total population than the clay, but by just 20%.

Clover Content and Vigour

Subjective assessment from experienced technicians was taken of the clover content of the pasture and how “growthy” this clover was, on each site sampled for nematodes.

Legume rating for all farms - as a percentage of the pasture:

	Farm Average	Range Between Farms
Legume Population %	13.5	4.0 – 27.0
Clover Vigour	5.5	2.8 – 8.0

The clover vigour is a 0 to 10 scale with 0 being extremely poor clover compared to superb at 10.

Of interest and probably to be expected, the farm with the lowest legume population at 4% also had the lowest vigour rating at just 2.8, and at the same time the farm with the highest legume population at 27% also had the most growthy clover, with a rating of 8.

Legume content and vigour by nematode population:

Farm	Total Nematode Population	Plant Parasitic Nematode Number	PPN as % of Total	Legume %	Clover Vigour
Gunson	9728	3541	36.4	4	2.8
Dromgool	7463	821	11.0	7	3.0
Beazley	9345	1400	14.5	27	8.0
Kennett	7657	1463	19.1	28	7.3

While the Gunson farm had the poorest legume content and vigour and had the highest plant parasitic nematode population, the rest of the results were not as “clear cut”.

While Dromgool had the next lowest legume performance, this farm had a relatively low and safe population of parasitic nematodes.

In contrast the Beazley and Kennett farms with high legume performance had moderate population of parasitic nematodes, rather than the low to very low populations that might have been expected from such a strong clover base.

From this work and trial work elsewhere, a firm conclusion is that while the presence of plant parasitic nematodes is important and does have an effect on our legume performance, other factors are important. On many farms these other factors may well have a far larger impact on legume performance than the presence of plant parasitic nematodes.

Pugging Damage

Pugging rating is a subjective estimate with the scale being 0 at no pugging damage through to 10 being exceptionally severe pugging damage.

With a dry to very dry winter period prior to sampling in 2006, pugging rating was low to very low across the majority of farms at just 2.3 as farm average.

Pugging damage had no direct impact on whether the parasitic nematode populations were high or low. Soil type was the main driver of the pugging damage: nine free draining sand sites rated at zero damage, whereas the worst two affected farms at 4.6 and 6.0 were clay or podzol soils.

Ongoing pugging damage needs to be avoided to reduce physical stress on the legume base.

Other Insects
Half the farms (53%) had no insect damage showing on leaves of the legume plants, whether it be white clover or at some sites, lotus.
Clover root weevil damage was seen on four farms (at 21%) of the total number of farms. Percentage of plants showing clover root weevil damage was low (under 15%) on all farms except Brown's which had one site with 30% damage to clover leaves.

Clover flea and slug damage was identified on five farms each at 26% of surveyed farms. Of these farms 90% of them had a range of insect damage showing; e.g. clover root weevil and slug damage occurring together.

Soil Fertility

<u>Nematode Species</u>
The nematode species found on farm:

	This species as % of Plant Parasitic Nematode	Percentage of farms that this species was present
Meloidogyne (root knot)	18.2	100%
Heterodera (clover cyst)	16.0	100%
Pratylenchus (root lesion)	24.7	90%
Heicotylenchus (spiral)	8.2	100%
Paratylenchus (pin)	24.6	95%

Of the nematode species found:

- Root knot, clover cyst and spinal species effect only clover and made up 42% of all the plant parasitic nematodes.
- Root lesion affects clover and grasses. Adding this population to the clover only nematodes, gives 67% of the parasitic nematodes that are a major parasite of our clovers.
- Paratylenchus (pin nematode) affects grasses more than it does clovers. This nematode requires high/higher numbers to cause significant plant damage.

Results – Comparison Over Time
Of the farms surveyed in this project, six had a nematode assessment undertaken in February 2002 as part of the Clover 300 Project.

Comparison of Results by Time

	Total nematode Population per 250 cc of Soil		Plant parasitic Population per 250 cc of soil		Plant parasitic Population as % of Total N Population	
Year	2002	2005	2002	2005	2002	2005
Group Average	1342	8071	277	1653	21	20

While there appears to be a very large increase in both total population and plant parasitic populations between 2002 and 2005, it is difficult to make a valid comparison because of the different time of year plus different paddocks sampled.

The February 2002 sampling was probably too late into a dry period to obtain accurate seasonal nematode counts.

It is interesting to note that the plant parasitic population figure as a percentage of the total population is almost exactly the same at 21% in 2002 and 20% in 2006.

What to do on Farm in the Face of Plant Parasitic Nematodes
It is not a practical possibility to eliminate plant parasitic nematodes from our soils. Firstly, the cost of potential chemical control is extremely high and secondly, the chemical used would also eliminate the beneficial nematodes, and other micro-organisms, which are needed for maintaining good soil health, e.g. through their role in the breakdown of organic matter and nutrient recycling. But it is a possible to sharply reduce the nematode population on part of the farm for a one to three year period, e.g. trial work has shown the reduction in the nematode population following the growing of a brassica crop during the summer.

One potential option is to operate a legume free pasture for one to three years before re-establishing a perennial pasture which will have a white clover component. By having no clover present for this one to three year period, there is no feed source for these parasitic nematodes and their numbers will decrease to lower levels.

Using species such as chicory or plantain for summer and autumn production, plus adding short rotation ryegrass for the winter, spring period, can provide a highly productive feed system with a nil legume base, for a short–medium period.

When white clover is re-established, in virtually a nil nematode environment, it has the chance to produce to its maximum ability. Over time, the nematode population will increase, which may be two to three years, but in the mean time there will be high to very quality feed being produced from the high to very high legume base.

An example of this is Omapere Station, the Meat and Wool New Zealand Monitor Farm for the Far North during the early 2000s. An area of gumland, low fertility soil with a very poor pasture base and very high rush population, was cultivated and grew a maize silage crop over summer of 2000/01. It was not possible to establish a perennial pasture in the autumn of 2001, so the area was left fallow until establishing grass and clover in the autumn of 2002.

Overall pasture yield and clover yield is shown below.

Omapere Station new pasture following maize and a fallow - tall fescue and clover:

	Pasture Yield kgDM/ha/yr	Clover Yield kgDM/ha/r	Clover Percentage – October	Clover Percentage Year Average
02/03	15,980	6,220	34	39
03/04	10,028	1,169	15	12
04/05	?	?	5	?

A very successful establishment of the new pasture, coupled with very good fertiliser inputs during the 2002/03 year, saw very high pasture production and a very impressive clover yield at 6,220 kgDM/ha during that first year.

Although no nematode population assessments were undertaken prior to or during the 2002/03 year, based on the pasture history and the superb clover yield it is assumed that the nematode population during this 2002/03 year was either nil or very low.

The clover yield in the second year was just 20% of the yield in the first year. With the clover population decreasing still further in the third year, the nematode population was assessed in October 2004. The parasitic nematodes were a very high 39% of the total nematode population. These results highlighted the impact that parasitic nematodes can have on clover yield.

But at Omapere, as will be the case on any farm, other factors were contributing to the poor clover yield. In this situation at Omapere, a severe soil fertility problem was also seriously impacting on or hindering the white clover. This fertility problem is shown by the clover result below:

Non Cropping Areas – Focus on Management:
For the majority of farms, and most areas on those farms that cannot undertake forage cropping programmes, the major focus needs to be on reducing the management induced stress that impacts on the clovers in our pastures.

Management features that are important are:

- A balanced fertiliser input to ensure that the best and most balanced soil fertility possible is present for the clovers.
- Grazing management needs to be designed to avoid major stress periods:
    - Avoiding shading of clover by ryegrass in the late spring or by kikuyu in the autumn period.
    - Avoiding overgrazing or even just hard grazing during the hot, dry summers. Clovers need to have some "shelter or protection" from the sun during the summer period.
    - Avoiding, or sharply reducing the pugging damage during the winter, early spring. The August to October period is very important for holding or improving the clover population. This is the time of year when white clover spreads through its stolon growth. Pugging damage will severely restrict this stolon growth.
    - When new clover seed is introduced via a regrassing programme, there has to be an absolute focus on successfully establishing the clovers.

Activities important for successful clover establishment include:

- Sowing clovers to a shallow depth.
- Not using a too higher rate of ryegrass seed, e.g. using as a maximum 15 kg/ha of a diploid ryegrass.
- Restricting nitrogen to a minimum, e.g. a maximum of 50 kg/ha in that first 12 months.
- Selecting white clover cultivars that have some selection and breeding background for tolerance to some of the various species of parasitic nematodes.

Breeding Advances
New clover seedlings selected at Ruakura have demonstrated superior production to others in field trials conducted in northern regions. They were screened against high field nematode populations which were enhanced by cultivating the clover through black plastic. Thus the clover may have tolerance to high soil temperatures as well as nematodes.

Clover nematode survey – farm mean results:

Name	Total Nematode Population per 250cc of soil	Number of Plant Parasitic Nematodes per 250cc of soil	% of Plant Parasitic Nematode	Legume %	Clover Vigour 0-10
TP	5154	428	8.3	14	5.8
IS	6365	1470	23.1	23	6.5
GU	7638	1818	21.4	15	6.3
TW	4567	434	9.5	12	5.3
EP	8207	1150	14.0	9	5.0
DO	3696	721	19.5	11	4.4
BB	7210	2322	32.2	6	6.7
LC	3410	194	5.7	7	4.8
JP	5983	335	5.6	9	5.3
AB	9645	1400	14.5	27	8.0
OS	10170	1932	19.0	9	4.0
GC	11220	2570	22.9	23	6.3
GA	6270	915	14.6	10	5.8
JD	7463	821	11.0	7	3.0
MO	6617	1892	28.6	21	6.0
CB	10008	1892	18.9	13	5.0
CK	7657	1463	19.1	28	7.3
DG	9728	3541	36.4	4	2.8
DM	7573	1630	23.0	10	5.7
Farm Group Results	7294	1417	19.4	13.5	5.5

Clover Vigour: subjective assessment as to how "growthy" the clover plant was: 0 being extremely poor and 10 being superb.
Legume %: subjective assessment of what component of the pasture the legume component of the pasture the legume was making up.
Total nematode and plant parasitic nematode numbers are these in the 0-10 cm depth sample.

4.0 Clover Performance in Northland Pastures

B Cooper, C Mercer, B Willougby
Massey University Dairy Farming Annual 1999, Pages 41-47

Overview

The performance of white clover is important to animal production from Northland pastures due to its high forage quality and its nitrogen contribution for associated grass growth. However, white clover does not always grow reliably in the region. In recognition of this, there has been a white clover research programme based at the Kaikohe AgResearch site until 1996 when it was relocated at the Research Station near Kerikeri. For northern New Zealand the improvement of cool season productivity, and the selection for greater tolerance to pasture pests and disease associated with the mild wet climate were considered two important breeding objectives. Northland evaluations of overseas clover introductions and ecotypes from local sheep, beef and dairy farms have resulted in improved cultivars with good seasonal growth being available to farmers when renovating old pastures or when following crops.

Many factors can reduce clover growth including the interaction of farm management with climatic conditions and disease. AgResearch trials have identified clovers highly resistant to leaf diseases and the stem nematode (Ditylenchus dipsaci) such as Grassland Prestige, Grasslands Kopu, Grasslands Challenge and Grasslands Sustain. However, there are still a number of pests which affect clover in Northland and currently form the basis of local research programmes.

Some Significant Pests of Northland Clover

1. Clover Flea (Sminthurus viridis)

   Clover of Lucerne flea is a serious pest in areas of Northland. This greenish/yellow coloured springtail is 3-4mm in length, and characteristically leaps when clover pasture is disturbed. Damage to clover leaves is caused by the juvenile and adult fleas removing green leaf tissue. Feeding occurs from autumn through to spring when damage reaches a peak with populations of one to six thousand clover fleas per square metre causing pasture losses of up to 30%. The attack starts as small leaf spots building to complete leaf cover removal in suitable conditions of moisture and temperature. There can be up to six generations in a year. Current farmer control of clover flea is by the application of insecticides but these have no residual control of later hatching eggs and may put at risk New Zealand's "clean green image".

   In response to local farmers' concerns over clover flea damage, a trial was established on Bruce Killen's property at Kaikohe. Twenty-two lines of white clover and two red clovers were tested. Trial results showed the two red clovers, G Pawera and G Colenson, were less affected by clover flea damage. The clover flea affected two of the white clover lines less than the other white clover lines. The next step was to identify the source of the tolerance. These two lines, both originated from within the G Prestige breeding pool.

   In 1998 the Northland clover Pest Interest Group was set up. The group has received AGMARDT funding for a range of research project on the management of clover flea. These experiments are designed to provide farmers with improved information on insecticide control until a biological control can be introduced such as predatory mites (e.g. Neomologus capillatus)

(Ireson et al., 0998), or until a tolerant white clover cultivar becomes commercially available.

2. Root-knot and clover nematodes (Meloidogyne trifoiophila and hesterodera trifolii) (root attacking nematodes). A survey of five Northland farms in 1998 showed these nematodes to be widespread, confirming early surveys.

Table 1: Numbers of root-knot nematode galls (two species) and of clover cyst nematode cysts per 100mm diameter pot of field collected soil mixed 50:50 with sterile sand and sown with white clover seed. Counts were made seven weeks after sowing. Sites are in Northland.

Site	**Meloidogyne trifoliophila galls**	**Meloidogyne hapla galls**	**Heterodera trifolii cysts**
Steele's farm, Waiharara, Kaitaia	400	3	12
Umawera, Te Tio Road	150	0	20
Awanui Street, Kaitaia	700	4	0
Waihou Valley	600	0	30
Signals Road, Okaihau	5	0	15

The nematodes suppress white clover growth but chemical control methods are not economically or ecologically acceptable. Pasture management options are limited although Watson (1193) showed that the recovery of nematode infected white clover from summer drought was enhanced by controlling summer grazing to allow shading of white clover stolon.

Clover cyst nematode affects white clover by stunting growth, causing a proliferation of lateral root growth and a yellowing of the clover leaves associated with nitrogen deficiency. Root-knot nematode infection results in swollen and severely stunted roots and vastly reduced root numbers. Root penetration by the nematodes and to some extent the hatching of eggs are though to be stimulated by root diffusates. Nematode numbers increase with improving plant growth thereby depressing the potential of clover yield in favourable seasons. In warmer regions such as Northland, more generations may occur per year than in cooler areas of the country. The damage inflicted by both nematodes should not be confused with the rhizobium nodule, which develops outside the root is tubular in shape and pink in colour when healthy. The cysts of the clover cyst nematode are also outside the root, but are smaller at about 1 mm long, white at first then round and brown when matures. The galls from the root-knot nematode are swollen roots, not attachments like rhizobium modules. They are up to 10 mm long and white.

3. <u>Clover root weevil (Sitona lepidus)</u>

Clover root weevil (CRW) is a new pest in Northland and was first identified in New Zealand in early 1996 (Barratt et al. 1996). New Zealand researchers are starting from scratch as they work to understand this pest. Populations of CRW in New Zealand are ten times greater than recorded overseas, and because of our reliance on white clover, CRW is of major concern. To understand the problem and attempt to develop practical solutions for control, research has been undertaken on a number of fronts involving both scientists and farmers. These groups are examining it on farm impact, lifecycle and distribution, climatic limitations, feeding preferences, biological control and pest management.

The adult CRW is around 5mm in length, brown to grey in colour and feeds on clover foliage. The larvae are 1-6mm in size, legless, with a brown head and creamy white body. The smaller larvae feed on the clover nodules whilst the larger larvae feed on clover roots. In New Zealand both the adults and their larvae are present throughout the year.

In 1998 trials were established to test the tolerance of a range of pasture legumes to CRW on several Waikato farms and a dairy farm near Warkworth. The Warkworth site at Thompson Road was planted with 118 white clover lines, seven red clover, five lotus corniulatus, six lotus pedunculatus, five lucerne, and seven caucasian clover. The white clover selections were made from commercial and experimental lines having characteristics that may make them less vulnerable to CRW. The deep rooting, rhizome like nature of Caucasian clover may offer an advantage to this pasture legume in the presence of CRW.

Preliminary data suggests that adult CRW feeding on white and caucasian clover is greater than that on red clover, lotus or lucerne. Within the white clover lines there is variation in clover growth and levels of weevil damage. If this is consistent at other sites, then it may be possible to breed more tolerant white clover lines in the future.

Weevil damage in 1998 compared to 1997 was relatively low, as a result of the dry, hot conditions in Jan–Feb 1998. A similar situation occurred in 1999.

Summary

Pests such as clover flea, nematodes and the clover root weevil can all have a major effect on clover performance in Northland. Further plant breeding and testing of selections may identify tolerant or resistant material. White clover is sensitive to competition from grasses, and is particularly vulnerable to mismanagement and environmental stresses during spring. Farmers need to be aware that their grazing management can severely inhibit clover performance in future seasons. High rates of nitrogen (200 kg/ha/year plus), will favour grass growth to the detriment of clover growth and clover recovery from stress. To obtain the maximum response from our clovers we need to keep them healthy and vigorous. Fertiliser levels can be checked by regular leaf analysis and deficiencies corrected. Grazing management is related to feed demands but farmers will benefit from improved feed quality if pastures can be managed to enhance clover survival.

For farmers considering renovating old pastures or following crops there is a wide range of clover cultivars with a spread of seasonal growth and leaf size to suit most environments. Current research programmes will further improve the range and attributes of white clover for Northland farmers.

5.0 Clover Root Weevil (Sitona lepidus) in New Zealand – An overview

H Eerens, S Hardwick, P Gerald, B Willoughby
Northland Pastural Extension Project 2006 Seminar Proceedings

Overview

The clover root weevil (Sitona lepidus) (CRW) entered New Zealand probably in the early 1990s but was not detected until 1996, by which time it had spread over 200,000 ha and containment was impossible. When CRW arrived in New Zealand, it found an environment free of diseases and predators, rich in its preferred food source (white clover) and which was benign to an initially unlimited population growth. An initial population explosion resulted in near complete elimination of white clover after which the CRW population crashes. A small residual population allows clover to recover. The CRW and clover populations go through typical prey predator cycles until equilibrium is reached. The result is that pastures end up with permanently lower clover densities compared to pre-CRW levels. For pastoral farmers this has major consequences especially where reliance on clover-fixed nitrogen is high. The loss of clover reduces the level of nitrogen fixation by clover, and also reduces forage quality. The ultimate consequence is lower production at a higher cost as mineral nitrogen will have to substitute losses in fixed nitrogen.

Trial Work

Life Cycle Assessments

Research studied the relationship between temperature and rate of egg and larvae development. The lower limit for egg hatching is 7.5 ^{o}C at which temperature hatching takes more than 60 days, while at 27 ^{o}C it only takes 10 days. The proportion of eggs that hatch is around 80% over the aforementioned temperature range but drops to 20% when temperatures exceed 30 ^{o}C. This means that three generations per year can be expected in Northland. Temperature, moisture and the availability of clover determine whether an adult female CRW will lay eggs or whether she develops flight muscles. In cool moist conditions (good clover growing conditions) around 90% of CRW females are fully reproductive and only 4% have flight muscles. These numbers change to 32% and 35% respectively in hot dry conditions (poor clover growing conditions), indicating that CRW responds to unfavourable conditions by migrating to more suitable environments. Female CRW either have fully productive reproductive organs or flight muscles but not both, although they can switch between the two stages.

Under favourable conditions CRW females can lay up to 2000 eggs/m^2 (measured in the Waikato). The number of larvae in the soil is determined by environmental conditions and the availability and accessibility of clover nodules. Nodules are essential for early larval stages and larval survival is directly related to the number of nodules that are available per larvae. At 2000 eggs/m^2 the number of clover nodules is likely to limit CRW larval development, while more than 85% of the nodules will suffer some damage. This will have major consequences for the nitrogen fixation ability of white clover plants.

CRW tolerant species: these were evaluated 275 legume lines at six different sites and did not find any evidence of resistance to CRW amongst white clover lines. Lines with strong agronomic performance were least affected by CRW. Of the species evaluated, white clover (caucasian clover) was most susceptible to CRW adult feeding, followed by red clover while minimal foliar damage was observed on lotus species and lucerne. The initial evaluation was based on leaf damage but later evaluations also assessed soil fauna around the roots. The agronomic performance of white clover was far superior to that of the other species although caucasian clover requires a few years establishment before its true potential is revealed. As two root primordial are formed at every stolon node in white clover (Thomas 1987) it tends to suggest that genotypes with a higher number of nodes tend to be more tolerant of CRW damage. The number of nodes is positively correlated to stolon length per plant which allows plants to quickly grow beyond its original size and in turn is an indication of plant vigour.

Pasture Management:
Pasture management practices in New Zealand have in recent years become increasingly unfavourable for clover as nitrogen application rates increase, more vigorous new ryegrass cultivars are used and spring and summer grazing patterns are changed. Clover levels were already declining and CRW is one more unfavourable stress factor. By removing one or more stress factors, e.g. irrigation in summer dry areas, clover productivity improves even when CRW densities are also higher.

When renovating pastures breaking the grass to grass cycle by incorporating a crop benefits clover establishment. More seedlings were counted 55 days after sowing and the clover proportion was higher when pastures were sown following either a Brassica or maize crop compared to sowing grass to grass. The removal of the resident clover population before sowing clover reduces the CRW and nematode populations. This benefits clover establishment even though the pests will gradually re-invade the newly sown pasture.

Once CRW has completely re-infested a whole paddock, pasture management needs to promote white clover without reducing total productivity. Frequent grazing in spring minimises competition from grasses, while higher residuals in summer minimises UV damage to stolons. The loss of a high proportion of nitrogen fixing nodules has an impact on available nitrogen. Frequent applications of small amounts of nitrogen, immediately after grazing, assists in maintaining production levels.

Biological Control Options
Two potential biological control options are currently being investigated. A British based search for natural enemies of CRW identified a Microctonum aethiopoides strain from Ireland as a potential candidate. This parasitoid has been released in Northland in 2006.

Economic Impact of CRW
The financial impact of CRW is dependent on the level of clover production and nitrogen fixation that was achieved before CRW came on the scene. An accurate assessment of the size of this impact is difficult as it varies depending on environmental conditions, but a simple model was developed to calculate the economic impact of the loss of nitrogen (Table 1). As either the level of damage to nodules increases or at higher pre-CRW nitrogen fixation rates, the impact of CRW will be higher. The cost of losing white clover as an animal feed was also modeled and the costs are presented in Table 2. Once again the impact of CRW is higher when pre-CRW clover production levels were higher. Clover's contribution to total DM production varies over years and tends to follow a cyclic pattern over several years, which makes it virtually impossible to accurately allocate a damage figure to the presence of CRW. Even if CRW is responsible for an only 10% reduction in the

white clover population nationwide, the annual damage would amount to $300 million based on an estimated value of white clover of $3 billion to the New Zealand economy Cardus et al. (1995).

Discussion/Conclusion

The clover root weevil is likely to be a nationwide pest of New Zealand which will severely stress the white clover based pastoral industry, increase production cost, and have the potential to negatively impact on the environment. In the absence of CRW resistance, farmers will have to adjust their pasture management practices to be more clover friendly and select clover strains that have a higher tolerance to CRW. Biological control options have become available but will take some time before they have an impact on CRW population densities, and even in the most optimistic scenario, some damage to clover is likely to occur. The economic impact will be different for each region depending on the damage CRW causes to clover densities and nitrogen fixation, but production costs are likely to increase while productivity is likely to decrease.

Table 1: The financial impact (in NZ$/ha) of the damage to nodules caused by the clover root weevil (CRW) on a New Zealand farm in relation to the amount of clover fixed nitrogen before CRW arrive in the country, assuming Urea (46%N) is used at a cost of NZ $550/tonne with cartage and spreading costing NZ $90/tonne.

% clover nodules damaged by CRW	**Amount of clover fixed nitrogen (kg/ha/yr) before CRW**						
	40	80	120	160	200	240	280
10	5.57	11.13	16.70	22.26	27.83	33.39	38.96
20	11.13	22.26	33.39	44.52	55.65	66.78	77.91
40	22.26	44.52	66.78	89.04	111.30	133.57	155.82
60	33.39	6678	100.17	133.56	166.95	200.34	233.73
80	44.52	89.04	133.57	178.08	222.61	267.14	211.65

Table 2: The financial impact (in NZ$/ha) of clover leaf removal by the clover root weevil (CRW) on a New Zealand dairy farm in relation to total dry matter (DM) production and clover contribution to the total DM before CRW arrived in the country and based on a milk solid payout of $4.30/kg.

% of clover leaf removed by CRW	**Total DM Production 10 t/ha Clover contribution to total DM before CRW arrived**				
	5%	10%	15%	20%	25%
10	4.93	9.87	14.80	19.74	24.67
20	9.87	19.74	29.61	39.47	44.34
40	19.74	39.47	59.21	78.95	98.68
60	29.61	59.21	88.82	118.42	148.03
80	39.47	78.95	118.42	157.90	197.37

% of clover leaf removed by CRW	**Total DM Production 12 t/ha Clover contribution to total DM before CRW arrived**				
	5%	10%	15%	20%	25%
10	5.92	11.84	17.76	23.68	29.61
20	11.84	23.68	35.53	47.37	59.21
40	23.68	47.37	71.05	94.74	118.42
60	35.53	71.05	106.58	142.11	177.63
80	47.37	94.74	142.11	189.48	236.84

% of clover leaf removed by CRW	Total DM Production 14 t/ha Clover contribution to total DM before CRW arrived				
	5%	10%	15%	20%	25%
10	6.91	13.82	20.72	27.63	34.54
20	13.82	27.63	41.45	55.26	69.08
40	27.63	55.26	82.90	110.53	138.16
60	41.45	82.90	124.34	165.79	207.24
80	55.26	110.53	165.79	221.05	276.32

6.0 Re-establishing Clover in the Presence of Clover Root Weevil (sitoma lepidus)

B Willougby, T Eden, D Wilson and D Hackell
Report prepared for The Northland Clover Pest Interest Group, June 2005

Overview/Background

In the light of the difficulties farmers are experiencing in establishing and maintaining clover in pasture in the presence of clover root weevil, the Clover Re-establishment Field Trials have been established in the Northland and Waikato regions to answer the farmer questions:

1. Which is the best practice (crop to grass or grass to grass) for the re-establishment of pasture and in particular the clover component?
2. When re-sowing a pasture does the endophyte type, diploidy vs tetraploidy or sowing rate of perennial ryegrass have an effect on clover establishment and persistence?
3. Are there benefits in the form of better white clover establishment in sowing white clover with red clover as observed in Northland?

Trial Establishment

The Waikato field trial was established on 21 April 2004. Three paddocks were chosen that were planned for renovation. Trial paddocks were all flat to gently rolling with a N/NW aspect. Pre-sowing conditions were ex-brassica, ex-maize and a grass-to-grass treatment following ammonium phosphate (Buster) herbicide at 51/ha. The ex-crop paddocks were rotary cultivated and rolled prior to the grass seed being drilled.

The five sowing treatments (Table 1) included perennial ryegrass with either a wild type endophyte or the now commercially available "animal friendly" AR1. The seeding rate was varied to compensate for the larger seed size of the tetraploid and ensure a similar number of seeds were sown per ha.

Table 1: Sowing treatments for Henderson trial sown April 2004

Variety	Type	Endophyte	Sowing rate (kg/ha)
Perennial ryegrass			
Bronsyn He	Diploid	Wild type	16
Bronsyn AR1	Diploid	AR1	16
Auartet HE	Tetraploid	Wild type	20
Quartet AR1	Tetraploid	AR1	20
Bronsyn HE	Diploid	Wild type	8
Clover			
Kopu 2	White		4
Sustain	White		4
Collenso	Red		4
Sensation	Red		4

Clover seed was broadcast at the prescribed weight per plot with a manually operated seed spreader, and the plots rolled with a Cambridge roller after seeding. Soil moistures and temperatures were adequate. Light rain followed three days after the trial was sown ensuring ideal conditions for seedling establishment. Cricket control was undertaken, slug populations checked and none found.

Seedling counts in the field were made, along the drill row to determine germination at two weeks post sowing and further counts made at eight weeks post sowing to measure clover seedling survival.

Results and Discussion

There were no issues of seed quality with germination established in the range 95-99% for all lines (Table 3).

Table 3: Results of grass seed germination test

Perennial ryegrass	Seed line	% germination
Tetraploid with AR1	Quartet	97
Tetraploid with wild type endophyte HE	Quartet	99
Diploid with AR1	Bronson	99
Diploid with wild type endophtye HE	Bronson	95

The technology available on the John Deere 750A drill played a significant role in the high standard of establishment of the trial. The air pneumatics delivered the seed to the coulter with the operator able to monitor individual coulters for seed flow/blockage. Coulter depth was managed electronically with an outcome that the seed was sown to the prescribed depth and at a uniform spacing confirmed by measurement and at the prescribed rate with negligible error confirmed by weighing the seed into the seed drill reservoir and weighing the remainder after sowing.

From the soil tests the soils from each paddock were ash derived with pH ranging from 6.1 to 6.2 and good overall soil fertility.

The results of the field assessment of seed germination are contained in Figure 1 and clearly illustrate the superior clover seedling establishment in the ex-brassica and ex-maize paddocks compared to the grass-to-grass sowing with the difference 158% and 80% respectively.

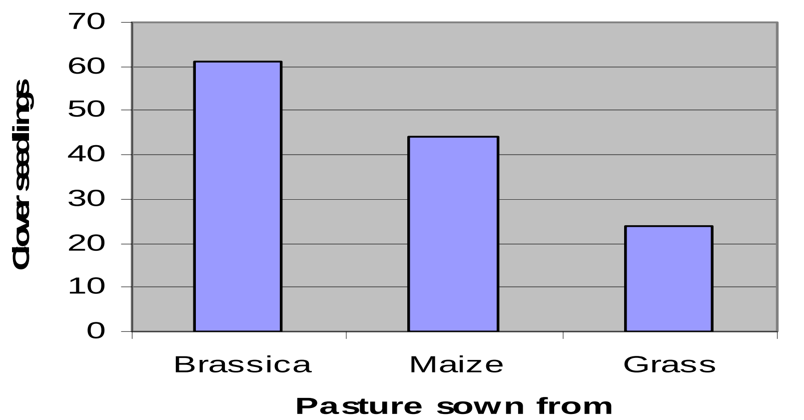

Fig. 1: Average clover seedling counts 8 weeks post sowing, June 2004

The first production measurements were made 8 weeks post sowing and just prior to first grazing.

There were no significant differences between ryegrass varieties for total production.

Overall production from the grass and maize paddocks was not significantly different; but the production from the brassica paddocks was 135% greater than either ex maize or ex grass. The production from the half (8 kg/ha) seeding rate was not significantly different to the full rate (16-20 kg) at either the June or October measurement date.

A significantly greater proportion of clover was produced from the ex brassica (11%) and maize (8%) in spring.

Table 4: Composition as a percent of the production (kgDM/ha) in spring 2004

	Rye	**White clover**	**Weeds**	**Other Grasses**
Brassica	75	11	1	13
Grass	85	4	5	6
Maize	72	8	5	14

By January 2005 soil temperatures had begun to rise and with soil moisture adequate, strong growth was measured in the brassica and maize paddocks. On average the brassica paddock grew 4.2 times and the maize paddock grew 1.2 times more dry matter than the grass paddock.

Average daily growth rates from October 2004 up to January 2005:

Ex brassica at	50 kg DM/ha/day
Ex grass at	15 kg DM/ha/day
Ex maize at	33 kg DM/ha/day

Pasture composition reflected the quality of pasture in the brassica and maize paddocks with 30% and 29% respectively of the dry matter produced from clover (white and red). Ryegrass in the grass paddock had become reproductive earlier, reflected in the balance of composition of 6% being dead (senescent) material compared to 3-4% in the brassica and maize paddocks. Red clover at this stage is not making a significant contribution to production in any for the paddocks and does not appear to be contributing to any differences in the white clover establishment and growth.

Table 5: Composition as a percent of the production (kgDM/ha) in summer 2005

	Rye	**White clover**	**Red clover**	**Weeds**	**Other Grasses**
Brassica	62	30	4	0	0
Grass	76	9	1	6	2
Maize	65	29	2	1	0

The white clover component of the pastures (Figure 5) did not vary significantly between the ryegrass varieties or at the half sowing rate in summer 2005.

Only production from the high endophte diploid ryegrass was significantly different from any of the other grass treatments with no significant variations across the three paddocks (brassica, grass, maize). Growth rates declined from the highs of 60 kgDM/ha/day recorded of the brassica paddock in early summer to a range of 3 to 12 kgDM/ha/day across all treatments.

Because of the short nature of the pasture and large areas of bare ground particularly in the brassica and maize paddocks a decision was made that point analysis would give a more accurate representation of the pasture composition. The results of this assessment show that the percent bare ground in the grass paddock (6%) is approximately half that in both maize and brassica paddocks (10%). Clover levels in the grass paddocks (12%) are half of either the brassica or maize paddocks (24% and 17% respectively) with weeds (10%) being the main substitute. Grass cover was not significantly different being 65%, 72% and 59% respectively for the brassica, grass and maize paddocks.

Earthworms: Assuming that the grass paddock has retained its earthworm population as it was not cultivated, there was little difference between that and the brassica 14 months post sowing. However, the earthworm population in the maize paddock was significantly less (77%) than the other two paddocks, and probably attributable to the extra cultivation and fertiliser the maize paddock received. There were no significant differences in earthworm populations across the ryegrass varieties. From observations the earthworm species were predominantly Aporectoda calignosa and Lumbricus terrastus, both being suitable species to provide best benefit to soils supporting pasture.

A wide range of soil fauna was encountered in the soil sampling from the grass paddock. Eight pest and beneficial species were identified. None of the potential pest species such as clover root weevil, Irenimus, white fringed weevil, grass grub, and black beetle reached pest population levels.

Earthworms were the most abundant invertebrate followed by clover root weevil. Clover root weevil numbers in the brassica and maize paddocks were similar at 29.2 and 30.8 per m^2 respectively (Table 6). The lesser population of clover root weevil (18.5/m^2) in the grass paddock most likely reflects fewer host plants (clover).

Table 6: Soil fauna (numbers/m^2 sampled from the grass, maize and brassica paddocks in June 2005

	Brassica	**Grass**	**Maize**
Clover root weevil	29.2	18.5	30.8
Earthworms	235.6	258.6	141.0
Irenimus weevil		1.6	0.4
White fringed weevil		17.7	0.8
Wire worm		1.6	0.8
Stink beetle		0.4	0.4
Grass grub larvae		20.6	
Black beetle adults		2.5	

Discussion and Recommendations

The following key points are made from data and observations on the clover re-establishment trial in the Waikato in year one.

- Renovating from brassica or maize clearly results in a better quality pasture as measured by the greater proportion of clover. This resulted from better clover establishment at the outset and continued through all seasons in year one. This can be attributed to reduced pest impact (clover root weevil and nematode in particular) and vigorous seedlings better able to withstand pest attack.

- The role of the drilling equipment (John Deere 750A) in grass seed placement is acknowledged in the success of the trial establishment.

- While the grass to grass re-establishment at times demonstrated growth rates equal to the pastures developed from crops, particularly in autumn, the pasture quality (clover content) was generally inferior.

- Differences in the effect of ryegrass variety (diploid or tetraploid) or endophyte type in terms of clover survival or production is yet to be detected in measurements to date.

- While the red clover failed to make any significant contribution to pasture production it was interesting that the white clover sown at 2 kg/ha with the red clover seed at the same rate produced the same as the clover stolons sown at 4 kg/ha.

- Worms play an important role in maintaining soil structure and recycling nutrients. Although there were less worms in the maize paddock, the brassica and grass paddocks had similar numbers, and all paddocks had adequate worm populations.

7.0 Plant Introduction Trials

Performance of some forage legumes in Northland.

P J Rumball and J P Lambert.
New Zealand Journal of Experimental Agriculture 8. 1980 – pages 179-183

Overview

Legume species from various countries were evaluated at Kaikohe Research Station in 1959 – 62 and at Kaikohe, Purerua and Karikari Peninsular in 1974-78.

Method

Seedlings were germinated after inoculation with appropriate rhizoba, and transplanted in spring. They were compared for vigour (0-10 scale) with two controls being Turoa red clover and Huia white clover.

Five different species were evaluation – these species are named in the paper.

Results and Discussion

1. 1959-62
   Performances in the first growing season are summarised as follows:
   a. Accessions performing better or as well as the controls: Desmodium uncinatum (CPI 8890), Desmodim intorim, Trifolium vesiculosum, and Vigna parvifloar.
   b. Accessions performing poorer than controls but better than the overall average: Desomdium uncinatum (all other lines), Desmodium canum, Lespedeza stiplaca, Pueraria triboba, Glycine javancia, Trifolium neglectum.

   A number of lines did not survive the winter, and best performance in the second growing season were recorded by D unicnatum (CPI 8990) D intorium, P triloba, V ameona, and other lines of D uncinatum, D batocuaulon, I pseudo-tinctoria and D canum.

2. 1974-78
   The following notes summarise performance over the three sites for four years.

   Cajanus cajan (pigeon pea)
   Plants 10-15 cm high in spring, averaged 34/48, and 93cm on the three sites at the end of the first season. Heights increased to 75, 79 and 219cm respectively for the end of the following season. Subsequently, light grazing eliminated all plants within a year.

   Cajanus was subject to heavy caterpillar attack and on one site suffered severe wind damage.

   Cornilla varia (crown vetch cv "Penggift")
   First season performance at all sites was considerably better than the controls and similar to Desmodium species. Growth was slow or nil between May and early October but plants were undamaged by frosts (to -7°C). In the second

season, plant spread by rhizomes was up to 1.6m but foliage growth was less than the previous year.

Subsequently, spring and summer performance of crown vetch was much reduced by competition from white clover and on two sites by annual Lotus spp. Most growth occurred in autumn. Remmants persisted at the end of four years but performance was low.

Crown vetch had a long flowering season and although much seed was produced and found to be viable, no seedlings were seen. Plants appeared healthy at all times and foliage was less subject to insect attack than other legumes.

D smodim intortum, D sansicnese, D unicinatum
Seedling vigour and first season growth of all three were very good and ahead of controls. Second season growth and subsequent persistence at all sites was in the order: D uncinatum, D intorium, D sandwicense. After 4 growth seasons, few plants of D uncinatum remained and none of the other 2 species. Growth began in early and mid late October for D unicintum and D intorium respectively and in early November for D sandsicense. All species were sensitive to drought and when this was severe reacted by shedding most of their leaves. As a result most growth occurred in autumn. D sandwicense and D uncinatum yielded viable seed catch season but the later flowering and seed ripening of D intortum was sometimes curtailed by early winter frosts. In the absence of frost all species maintained a few yellow, late season leaves through winter.

Symptoms of disease were not observed on the Desmodium spp, but the accumulation of large amounts of foliage in late summer-autumn was attacked by a wide range of caterpillars.

D intorium and D unciantum rooted from nodes along the stolon when conditions were warm and moist. D sandwicense was far more erect and far more variable in form.

Leucaena leucocephaia
Growth rate of leucaena was slow. On the best site, plant height average 44cm at the end of the first season. During winter, leaves were shed and at the more frost prone site upper parts of stems were killed.

At all sites many smaller plants died. Survivors made some net growth in succeeding years in the absence of grazing but productivity was low.

Lotomonis bainesii
Establishment and growth over the first season were considerably faster than for white clover. Leaves were retained over winter except at the coolest site and growth recommenced in early October. Second summer performance was as good as the first but its advantage over white clover was less. Under competition, Lotonois grew poorly during the third season, and only remnants were present at the end of the following summer.

Most growth occurred near mid summer because of the plants' ability to respond quickly to showers. Drought halted growth, but there were no other effects. The flowering season was late and although viable seed was produced, no seedlings were seen. Growth was very prostrate with rapid growth occurring at the edges and plant centres dying away fairly quickly.

Trifolium burchellianum and T semipilosum (Kenya white clover)
Both Kenya clovers established more slowly than the controls and in no subsequent season was either as productive as Huia white clover. Flowering in Kenya white clover was practically continuous but, as with T burchellianum, it peaked in September–October when Huia was strongly vegetative. The best growth of the Kenya clover occurred in autumn. In summer they were affected by drought equally as much as the controls and in winter, although leaves were retained, growth was negligible. After weed control ceased they persisted reasonably well for two years but production was low.

Vicia villosa (hairy vetch cv. "Madison")
From planting (spring), growth of Vicia was very vigorous at the Kaikohe site but was limited by dryness on the other two sites. Autumn recovery was good. Few plants of this annual died at the end of the first season even though most produced some flowers and seed.

From May to August there was little growth but there was no apparent damage from frost. By early October plants were growing very vigorously, by early November flowering began, and by late January seed ripening was completed and plants were dead. Summer rain from then on resulted in the appearance of seedlings which grew only slowly until the following spring.

Conclusions

Many species outgrew the red and white clover controls over the first and sometimes the second summer. After this, competition from volunteer weeds and occasional grazing caused all to become minor components or die out, in contrast to the control plants which generally continued to thrive.

Invading species delayed and reduced early summer growth of the subtropical species such that little feed was carried forward and response to summer rain was relatively poor. Most growth occurred in autumn, coinciding with the rapid recovery of local species. Good performance of the better adapted perennial subtropical legumes such as Desmodium uncinatum would necessitate severe reduction of spring competition from cool season species. Therefore, perennials may not offer any practical advantage over summer annuals. This would apply particularly on the poorer, summer dry soils.

Goold (1978) measured the performance of Desmodium intortum cc. "Greenlead" and D unicatum cv. "siverlead" on two favourable soils in Northland, finding them capable of high growth rates in summer. However, they were sown pure and no information was available as to the nature of dry matter contribution of volunteer species.

8.0 A Greenfeed Sorghum and Subclover System for Dairy Production

I J Jurlina
Proceeding of Agronomy Society of NZ, 1978, pages 157-158

Overview

Measurements of a supplementary feeding system based on greenfeed sorgham and sub clover.

Soils – Waipu Clay.

Method

Greenfeed sorgham drilled at 22 kg/ha between 15 November and 15 December: soil temperatures high enough to give rapid establishment.

Fertiliser at 750 kg/ha of 30% potassic super and 250 kg/ha of ammonium sulphate. Full cultivation.

Results

Three grazings on some areas and two grazings on other.

Total average yield at 10,000 kgDM/ha. Cows received 6.5 kgDM/day of sorghum.

Used sub clover (cultivar woogenullup) on area that had grown sorghum in previous summer. Seed sown in May. Very little production up to mid September. By mid October pregraze of 3300 kgDM/ha for first grazing. Second grazing in mid November of 1800 kgDM/ha pregraze.

9.0 The potential Role of Legumes in Maize Grain and Forage Cropping Systems

A O Taylor and K A Hughes.
Proceedings Agronomy Society of NZ: 6, 1976, pages 49-52

Overview

A discussion paper covering theoretical systems for the use of legumes in maize grain and/or other forage cropping systems such as songhum forage crops. Theoretical yields, advantages and disadvantages of various systems as discussed.

The use of the legumes is driven by their nitrogen supplying ability to the soil, during or after a maize or forage crop, and so decreasing the need for using bagged nitrogen.

10.0 Why Use Legumes in Intensive Forage Crop Production Systems

A O Taylor
Proceedings Agronomy Society of New Zealand, 10, 1980, pages 49-52

Overview

A discussion paper covering theoretical systems for the use of legumes in intensive forage crop, maize cropping production systems.

Results

- Legume ley systems being tested in Northland and Waikato are discussed.

- Linear programme modeling predicted optimal dairy production being a system containing 20% to 40% of the farm area in a crop with substantial use of legumes in these cropping systems.
    - Good quality grazable feed during September/October, being cool season annuals, or
    - Feed during summer, being red clover.

Discussion

- Both red clover and cool season active annual legumes are likely to fix the bulk of their own nitrogen when used as short term leys between periods of cereal or maize cropping. This biological nitrogen fixation could be between 200 and 600 kg N/ha/year.

- The use of legumes in place of cool season cereals (or ryegrass) should at least remove the need to apply 60-120 kg N/ha as fertiliser, but may require higher phosphate inputs.

11.0 The Suitability of Subterranean Clover Cultivars for a Double Forage Cropping System

A O Taylor and B J Hunt
Proceedings Agronomy Society of New Zealand, 11, 1981, pages 57-60

Overview

Dry matter yields, reseeding characteristics of various cool season annual sub clover are shown. The forage system uses sub clover to grow in alternation with greenfed sorghums: this cool season crop supplying feed in September to early October period when the sorghums are then planted.

Method

Located on Waipu clay soil close to Kaitaia.

In autumn the area was cultivated out of a closely grazed sorghum: discing and rotary hoe.

Seed sown 20 kg/ha on 1 April and raked into soil.

Sub clover cultivars used:
- Dalick being a very early maturity cultivar
- Trikkala being a moderately early cultivar
- Woogenullup being an early-mid season cultivar
- Mt Barker being a mid-late season cultivar
- Tallcrook being a late season cultivar

Results

Dry Matter Production
All cultivars established and nodulated effectively.

A considerable amount of Poa annua also germinated in autumn and provided serious competition for the rather prostate, early maturing cultivar Daliak which never became dominant. The other sub clover cultivars dominated poa in late winter/early spring.

The forage yield of all cultivars was low at first cut in late July, but the better ones had produced yields of 2500 kg DM/ha by early September.

Table: Total Forage (kgDM/ha) and percentage of Trifolium subterranean produced on first year plots of five cultivars under two cutting treatments. Poa sp. made up the bulk of the other forage produced

	Dailak	Trikkala	Woogenellup	Mt Barker	Tallarook
2 cut system					
Sept 1	2568	2869	2735	3109	2685
Nov 9	1175	3776	3311	3414	4141
Total	3743	6645	6046	6523	7006
% clover	20.1	89.1	80.0	89.9	83.0
4 cut system					
July 27	766	1140	927	1369	1170
Sep 1	740	1436	1040	1020	1144
Oct 2	510	1230	1012	1060	862
Nov 9	561	1827	2462	2274	2673
Total	2577	5633	5441	5723	5849
% clover	24.3	77.7	75.2	80.3	79.3
Daily Growth Rate - sowing to last harvest	12	25	25	26	26

Seed Production
A strong effect of cultivar was seen, with Trikkala producing 30 times the number of seeds of Tallarook.

Seeds collected from the later maturing lines was much less mature, e.g. very few of the Tallarook seeds were viable.

Table: Reseeding characteristics

	Trikkala	Woogenellup	Mt Barker	Tallarook
Seed number/m2 (27/11/78)	6458	4337	1721	212
Hard seed at harvest as % (27/11/78)	40	9	2	0
Germinated seedlings (5/3/79) /m2 (last Sudax Grazing)	194	316	22	10
Young plants and seedlings (8/5/79) /m2 (before last Sudax Grazing)	90	41	4	2

The net result of these differences in reseeding characteristics became clear when the pattern and extent of subsequent seedling germination was measured. In early March, greenfeed sorghum over the trial area was around 0.6m in height after having been grazed in February. Seedlings of subterranean clover had germinated under this developing canopy aided by higher than average February rainfall (147mm compared to a 40 year mean of 99mm). More seedlings were counted of Woogenellup than of Trikkala in small 35 x 35 cm quadrates (Table 2) but this was not statistically significant because the seedling cover was very variable. Substantially fewer seedlings were present on the Mt Barker and Talarook plots as would be expected from the lower seed production and generally smaller seed size of these later maturing cultivars.

Two further grazings were obtained from the sorghum, with one full grazing in mid-March and a final grazing of scattered regrowth in early April. Effective growth of the sorghum ceased after this final grazing. Subterranean clover seedlings on the trial plots were counted after the final grazing and a reduction in seedling numbers was found compared to those present in early march. Plants of Woogenellup, Mt Barker and Tallarook appeared to be survivors of those already germinated in March. The greatest number of seedlings were present on the Trikkala plots and some of these appeared to have germinated recently. Rainfall during March was higher (183mm) than the 40 year mean of 74mm and would have been sufficient to allow some continued germination of viable seed.

Discussion

In this trial, natural regeneration of cv. Trikkala was best, followed by Woogenellup, Mt Barker and lastly Tallarook. Seed production and seed quality from the previous spring was clearly responsible. Trikkala produced over one hundred times the weight of seed of Tallarook and almost half this was hard, while none of the Tallarook seed was hard. The other two cultivars were intermediate. Seeding characteristics were related to maturity.

Only early flowering cultivars appear capable of producing sufficient seed of adequate hard seediness to re-establish successfully following cultivation in late November to establish a greenfeed sorghum.

In the present trial the forage yield of cv. Trikkala was not significantly different from that of two relatively late maturing cultivars and was actually higher than that of Woogenellup. Trikkala known to favour wet sites, so the wet Waipu clay soil of this site may have affected the yield rankings.

In a previous trial on a drier peat soil cv. Trikkala yielded significantly less than either Mt Barker or Woogenellup. If subterranean clover is to be used to any significant degree in this type of double cropping system, more work will be needed to define the soil preferences of Trikkala and to screen other early flowering cultivars for yield and persistence.

Conclusion

- Trikkala and Woogenullup cultivars are the most successful subterranean clovers to produce good levels of dry matter and also to produce the number of seeds and then seedlings in the second season.

- A major problem with this forage system is the poor to very poor dry matter production in the first winter, mid spring with growth rates of 25-26 kgDM/ha/day measured.

This from sowing on 1 April up to last harvest on 9 November.

12.0 Annual Cool – Season Legumes for Forage 1. A Survey of Lines for Yield and Disease Resistance at Kaitaia and Palmerston North

A O Taylor, K A Huges, B J Hunt
New Zealand Journal of Experimental Agriculture 7, 1978, Pages 141-147

Overview

Various annual winter growing legumes were trialled near Kaitaia and also Palmerston North. Fungal disease were identified, yield measured.

Method

Sites were Kaitaia on Houhora sand and Ruakaka peaty sandy loam, plus Palmerston North on silt loam.

Results

Forage yields of up to 40 species and cultivars are recorded in this paper.

Table: Example Forage yield (t DM.ha) of medicago lines planted early April and harvested as a single cut in mid-late October: trials were at Sweetwater (SW) and Waipapakauri (WP), Kaitaia, and at Palmerston North (PN) in 1976 and 1977

	Forage yield (t DM/ha)			
Species	**SW 76**	**WP 76**	**WP 77**	**PN 77**
Medicago aculeate	8.48	10.53		
intertexta	10.29	10.61	8.27	3.25
intertexta			6.76	2.64
littoralis	8.23	9.28		
orbicularis	9.92			
rugosa	11.17	8.08		
scutellata			8.93	1.93
scutellata			9.98	1.91
scutellata			10.11	2.54
scutellata			5.77	1.12
tornata	11.08	9.68	9.30	

More yield data shown in paper.

Sowing Methods
Legume seed spread by hand and raked into surface of seedbed.

	Sowing Rates – kg/ha	
	1976	**1977**
Trifolium species	20	15
Medicago species	30	20
Ornithopus species	30	20
Vicia species	60	30
Lotus species		5

Sowing Date
SW in 1976 on 7 April
WP in 1976 on 7 April
WP in 1977 on 13 April
PN in 1977 on 1 October

Harvested
SW in 1976 on 27 October
WP in 1976 on 18 October
WP in 1977 on 28 October
PN in 1977 on 25 October

Table: Example Forage yields (t DM/ha) of Trifolium lines planted in early April and harvested as a single cut in mid-late October

	Forage yield (t DM/ha)			
Species	**SW 76**	**WP 76**	**WP 77**	**PN 77**
Trifolium alexandrinum	1.52	0.78		
Trifoilum balansae			9.32	7.66
Lietum	3.79	3.86		
incarnatum	9.42	5.04		
incarnatum	8.85	9.16		
purpureum				
subtertaneum Daliak	7.07	3.79		
subterranean Clare	1.86			
subterranean Mt Barker			4.19	
subterranean Trikkala			2.97	1.23
subterranean Woogenullup	4.93	6.30	4.68	
subterranean SA1573			2.81	2.75
vesiculosum	7.94	7.56	8.78	

More yield shown in this paper.

Daily growth rates – kg DM/ha/day:

Species	SW 76	WP 76	WP 77
Trifolium			
balansae			47
Sub – Trikkala			15
Sub – Mt Baker			21
Sub – Woogenellup	24	32	24
vesiculosum -			
Yuchi	39	40	44

Table: Forage yield (tDM/ha) of Vicia, Ornithopus and Lotus lines planted early April and harvested as a single cut in mid-late October

	Forage yield (t DM/ha)			
Species	**SW 76**	**WP 76**	**WP 77**	**PN 77**
Vicia:				
atropupurea	5.84	3.97		
alasycarpo	6.60	7.43	9.23	7.29
Satlva	3.19	6.78		
Sativa	8.64	6.42		
Ornithopus:				
compressus		7.07		
sativus	12.37	8.18	10.85	6.42
Lotus:				
angustissimus			4.71	

Discussion

- The difference in growth/yield at Palmerston North compared to Kaitaia was a reduction of 30 to 70% at the cooler site, this for a range of annual legumes (20 cultivars grown).
- The better species produced a reasonable amount of forage, approximately 4.0 t/ha, by the end of August.
- There were differences between the two sites and between years, at Kaitaia.
- Medicago species yielded consistently well at Kaitaia, 80% of them producing 9.0 – 11.0 t DM/ha.
- Cultivars of T subterranean varied widely in growth habit and competitive ability.
- The larger leaved and larger seeded cultivars, Woogenullup and Clare established rapidly, were weed competitive and regrew well after cutting.
- T Balansae produced good late winter/early spring growth at Kaitaia. This annual legume also had high production at Palmerston North.

13.0 Annual cool – Season Legume for Forage II. Seasonal Growth Patterns and Effects of Cutting Frequency and Cutting Height on Yield

A O Taylor, K A Hughes and B J Hunt
New Zealand Journal of Experimental Agriculture 7, 1979, pages 149-52

Overview

Species of annual legumes that had shown promise the preceding year, were sown April 1977 in small plots close to Kaitaia.

Most of the forage was produced in a eight week period beginning in early August for Medicago species and Ornithopus, and in early September for T vesiculosum and T subterranean.

Forage yield of legumes was maximised by taking a single late cut. Forage yield was decreased with increasing cutting frequency and decreased cutting height.

Ornithopus stativus was least affected by cutting frequency and height. It showed similar regrowth as Tama annual ryegrass.

Conclusion was that those legumes would be best used as wilted and preservative treated silage, cut in late October, or by break grazing in the late September to late October period.

Method

Site was ex maize silage crop, Waipapakauri near Kaitaia on Kaitaia peaty clay. High soil fertility site.

Results

Table 1: Date of harvest in the four cutting frequency systems

Treatment	Cut Number			
	1st	2nd	3rd	4th
4 cut	29.6.77	10.8.77	13.9.77	25.10.77
3 cut	28.7.77	13.9.77	25.10.77	
2 cut	16.8.77	25.10.77		
1 cut	25.10.77			

Table 2: Forage yield (t DM/ha) of five legumes and Tama ryegrass under 4 cutting frequencies and 2 cutting heights. Cutting heights were 9cm and 3cm. Dry matter % of forage at the final harvest (1 cut system) are also given

	M Scut	M Tom	O Sat	T Vesic	T Sub	Tama Ryegrass
4 cuts						
9cm	4.97	5.04	6.75	6.35	3.45	3.15
3cm	1.09	4.42	4.85	3.12	2.41	2.84
3 cuts						
9cm	4.71	5.93	8.11	5.72	3.42	4.95
3cm	1.67	3.31	5.71	3.36	2.83	5.23
2 cuts						
9cm	7.63	9.18	9.15	9.83	4.25	6.15
3cm	4.08	5.65	6.54	6.73	4.73	5.46
1 cut						
3cm	9.23	10.61	10.75	9.44	4.67	6.14
DM %	16%	18.6%	10.3%	12.0%	15.0%	20.0%

Results and Discussion

Rates of forage production for all species was highest in early to mid spring.

The system used was that these annual legume were harvested in late October in readiness for the normal period for maize planting. Harvesting could be delayed where greenfeed sorghums are the following crop because these are normally planted in mid-late November.

Any additional production by these legumes by delaying spring harvest is uncertain, e.g. in mid October, both Medicago species were setting seed and not producing any further forage, within this system. Compared with Woogenellup sub clover producing 2.0 tDM/ha in mid October to mid November period.

Tama ryegrass was also in full flower in late October. This Tama production was considered to be low.

Winter production from these legumes is poor, even in the mild winter temperatures of Kaitaia. Any management system must make effective use of the potential rapid growth of the crops in the eight weeks starting in mid August.

The cutting height and frequency data indicates that these annual legumes require careful grazing management to maximize production.

Methods of Use

Some cool – season annual legumes will yield well in mild winter climates and can be considered as possible components of double cropping systems. When planted in early April, production even by late winter, is low so they cannot replace cereal greenfeeds for winter grazing.

These legumes grow rapidly in early to mid spring and although dry matter production is generally maximized by taking a single late cut, no documented attempts have been made in New Zealand to conserve pure stands of these legumes as hay or silage.

Conservation as silage is more practicable than hay, but the low soluble sugar level of most legumes requires that they are extensively wilted and possibly treated with acid preservative. Rapid wilting to 35% or 40% DM is not easy with dense stands of crops with dry matters in the 10 to 20% range when freshly cut. Good drying conditions, crop conditioning and tedding may be necessary. If suitable farm systems can be devised, the legumes may be best grazed and not conserved as silage or hay. On dairy farms where significant areas of ryegrass clover pasture are shut early for silage, a feed deficit can arise in early October at a time when these legume forages would be ideal for grazing. If used in this way, maximum animal production would be desired and high nutritive quality would be important.

14.0 Effects of Winter Application of Phenoxy Herbicides on White Clover and Pasture Production in Lower Northland

E N Honore, A Rahman and C B Dyson
Proceedings 33rd New Zealand Weed and Pest Conference pages 56-58

Overview

An investigation into the effects of three phenoxy herbicides on pasture production in Northland, with its mild winter, where true clover dormancy does not occur.

Method

Trials undertaken 1976 to 1978. Herbicides applied to short, white clover based pastures.

Pasture and Forage Crop Weeds
The rates of application and herbicides used were ethyl ester of 2,4-D and potassium salt of MCPA were applied at 1 kg/ha and sodium salt of MCPB was used at 2 kg/ha. These rates were rather low with regard to label recommendations for pasture weeds but would be expected to be quite sufficient under good conditions. The details of trial sites and application dates of herbicides are shown below.

Table 1: details of trial sites and herbicide application dates

Trial No.	Trial Location	Year	Pasture type	Clover %	Application dates	
					Early	Late
1	Silverdale	1976	Cattle	25-30	24 June	N/A
2	Waimauku	1977	Cattle	20-25	31 May	1 August
3	Otakanini	1978	Sheep	8-10	21 June	7 August

Results and Discussion

With early application MCPB had little effect on clover production until late spring when there appeared to emerge some residual effects in Trials 1 and 2 which had higher clover levels than Trial 3. By contrast MCPA and 2, 4-D showed a substantial early effect in all trials, reducing clover growth by about 70%. A residual effect was also shown in the same two trials as for MCPB.

The effects of late application were much more pronounced for MCPA and 2, 4-D (Fig. 2). Treatments were applied part way through an active growth period and the two chemicals not only restricted the clover production but also killed some of the clover forage present at the time of application. Both trials (2 and 3) showed residual effects from all treatments.

The total DM production data (including weeds, where present) are given in Table 2. The analysis of the treatment effect over the trial showed that the reductions in the total dry matter production from MCPA and 2, 4-D were significant at least at the 5% level for each time of application and that even the late application of MCPB caused a significant depression in dry matter production.

Table 2: Total pasture production (kg/ha DM) from the time of application until the following January

Treatment Trial	Early sprayed				Late sprayed		
	1	2	3	Mean	2	3	Mean
Control	7700	6340	5240	6490	5840	4590	5210
2,4-D	7070	5470	4890	5810*	4230	3840	4030 **
MCPA	7070	5530	5070	5890*	5090	3720	4400*
MCPB	7520	5760	5540	6060	5120	1970	4540*

*, ** *Significantly lower than the control at 5% and 1% respectively.*

There is a suggested relationship between the extent of initial weed infestation and the replacement by grasses of the eliminated weeds. In Trial 3 with weeds comprising only 3% of DM produced in the controls, grass production averaged over chemical treatments was reduced by 2% from early application and by 10% from late application compared with control. On the other hand, in Trial 2 with about 30% weed infestation grass production was increased by about 30% from early application and 20% from the late application, compared with the control. Trial 2, early application, showed a 12% increase associated with 8% weed DM presence. In weedy pastures, therefore, the effect of spraying may be to remove most weed growth, reduce the clover growth and to increase the grass growth by removal of the competing species, Nevertheless the total DM yields compared with the control were reduced by 250 -400 kg/ha more than the loss in clover production per se in these trials.

Conclusion

In the relatively mild winters of Northland there is apparently no “safe” time for applying phenoxy herbicides. Early to mid winter applications caused less damage to clover than the late winter sprayings. Total pasture dry matter losses from MCPA and 2, 4-D ranged from 400–900 kg/ha in the seven months following early application, while with the MCPB in the same period the losses were insignificant. All three chemicals caused significant reductions ranging from 600 -1600 kg/ha from the late application.

The risk of pasture production losses in early spring when feed is at a premium, would dictate that the application of phenoxy herbicides should be restricted to the early winter. Management practices which will strengthen the pasture and encourage the smothering of annual weeds during the winter could well be considered as an alternative to the overall application of hormone type herbicides.

15.0 G18 White Clover – A New Cultivar for Lowland Pastures

J Van Den Bosch, J A Lancashire, B M Cooper, T B Lyons, W M Williams.
Proceedings of the New Zealand Grassland Association. 14, 1986, Pages 173-177

Note: G18 was renamed as Kopu white clover, and is called Kopu within this research stocktake.

Overview

Kopu white clover is a larger legume, more upright growing clover than Huia or Pitau, has been bred for intensive low land farming. It originated from crosses between Pitau and Ladino plants, selected in soils infested with stem nematode.

Kopu has produced more than Pitau or Huia. Total pasture production has often been similar but clover dry matter has increased 26% over 4 years cf to a Huia pasture in Northland, greatest superiority being under lax rotational grazing.

Method

A sheep grazing trial ran for four years with Kopu, Pitau and Huia mixes with Nui ryegrass, on podzol and volcanic soils at Kaikohe.

Grazing management: winter and spring grazing was the same but summer and autumn grazing treatments were:

1. hard grazing every 2 weeks.
2. 8 cm grazing down to 3cm
3. 15 cm grazing down to 3 cm
4. 20 cm grazing down to 3 cm

Results

Northland

1. In the grazing trial Kopu produced more clover dry matter than both Pitau and Huia on both soils, its superiority being greatest under the laxer grazings (Table 1). The increases compared with Huia varied from 25-84%. Total pasture yields of the 3 mixtures, meaned over the four years, did not differ.

2. In the spaced plants, growth of the Kopu lines was similar to that of Pitau over late spring/summer, but its yield was 20-50% higher over late autumn/winter. The number of plants showing disease symptoms, particularly rust and stem nematode, was much lower in Kopu than in both Pitau and Huia (a mean of 17% of Kopu plants infected, compared to 34% for Pitau and 36% for Huia).

Persistence
Leaf size measurements taken more than five years after the trial's establishment indicated that Kopu had persisted, even after more than three years of continuous sheep grazing in Palmerston North.

Table 1: Dry matter yield (kg/ha, clover only and total) over four years on two soils with four grazing treatments at Kaikohe. (% clover in brackets).

Grazing treatment				
	Every 2 weeks	**8 to 3 cm**	**15 to 3 cm**	**20 to 3 cm**
	Clover only yield (mean of 4 years Podzol soil			
Huia	4942	4524	4525	4794
Pitau	5099	5068	4830	5098
Kopu	6157	6006	6456	7121
	Basalt soil			
Huia	2164	2164	1564	1867
Pitau	2352	2567	2035	2231
Kopu	2870	2700	2829	3441
	Total DM yield (mean of 4 years) Podzol soil			
Huia	12843 (38)	12052 (38)	11752 (39)	12088 (40)
Pitau	13376 (38)	12196 (42)	12003 (40)	12057 (42)
Kopu	12898 (48)	12181 (49)	12233 (53)	12548 (57)
	Basalt soil			
Huia	9754 (22)	9453 (29)	8004 (20)	8543 (22)
Pitau	9970 (24)	9675 (27)	7811 (26)	8809 (25)
Kopu	9582 (30)	9959 (20)	8704 (33)	8688 (40)

Discussion

Kopu persisted as well as the other cultivars under grazing in all trials, including the Manawatu trials which were continuously grazed with sheep for three to four years. Large leaved white clovers are usually less tolerant of heavy grazing pressure, but Kopu still out produced the other cultivars under the two weekly grazing in the Northland trial.

Rotational grazing, particularly with cattle, would greatly assist Kopu's establishment and growth by allowing greater stolon spread and development.