ALTERNATIVE FORAGE SPECIES FOR HAWKES BAY

G.J. Rys, N. Smith and M.W. Slay
Ministry of Agriculture and Fisheries, Hawkes Bay Agricultural Research Centre,
P.O. Box 85, Hastings

ABSTRACT

Productivity and persistence of *Sanguisorba minor* (sheeps burnet), *Dorycnium pentaphyllum* (prostrate canary clover), *Dorycnium hirsutum* (hairy canary clover), *Astragalus cicer* (cicer milkvetch), *Melilotus alba* (sweet clover), *Hedysarum coronarium* (sulla), *Medicago sativa* (lucerne), and *Lotus corniculatus* (birdsfoot trefoil) were evaluated as spaced plants in both flat land and hill country. Lucerne was the most productive and persistent species under flat land, high fertility conditions. Sweetclover did not persist after the first year at either site. The remaining species were intermediate in persistence and productivity.

The response of sulla and sheeps burnet to defoliation treatments was assessed in separate small plot trials. In the first year, sulla was most productive under frequent low defoliation management producing 18,600 kg DM/ha. Herbage yields of sulla were markedly reduced in the second year with the highest yielding infrequent defoliation treatments producing 6,100 kg DM/ha. Sheeps burnet was most productive in spring under a 12 week cutting interval. In the first year production totalled 15,700 kg DM/ha. However, in the second year, an 8 week cutting interval in spring gave the highest annual yield of 11,600 kg DM/ha.

Lamb growth rate was evaluated for 4 weeks on sulla, lucerne and improved pasture. Lamb growth rates on sulla and lucerne were over 3 fold greater than from pasture.

The potential of these species for pastoral farming in Hawke's Bay is discussed.

Additional Key Words: persistence, drought tolerance.

INTRODUCTION

Summer moisture deficits are a major limitation to pastoral agriculture in Hawkes Bay. The Heretaunga Plains are one of the driest areas in the North Island (Griffiths, 1982). They have a mean annual rainfall of 800 mm with growing season (Sep-Feb) moisture deficits (rainfall — evaporation) of up to 200 mm. South of the Heretaunga Plains, much of central Hawkes Bay also receives less than 1000 mm rainfall annually.

Annual dry matter yields from permanent pastures at Maraekakaho, a central site in the low rainfall zone of Hawke's Bay had a mean production of 6,740 kg/ha, with a seasonal distribution of 15% in the summer, 24% in the autumn, 17% in winter and 44% in the spring (Radcliffe, 1975). Both the magnitude of permanent pasture production and its uneven seasonal growth pattern necessitate appropriate animal production systems. The potential exists to minimise the summer feed deficit and ensure more reliable production patterns using alternative species.

These regular summer moisture deficits have prompted research into alternative forage species which could more closely match animal feed requirements with feed supply. Stock management policies such as early lambing, enabling the sale of a high proportion of stock before drought onset, are not always possible because of winter-wet soils and associated poor winter and early spring pasture growth. An alternative approach is to utilise permanent fodder species which are more productive under drought stress and/or which can accumulate a living bank of feed to be utilised *in situ* later during periods of feed shortage.

In recent years there has been an upsurge in interest in evaluating the potential of numerous alternative plant species. Much of the research has concentrated on the soil conservation potential of alternative species in revegetation of tussock grasslands (Wills, 1983). However, many of the species evaluated may have potential under more intensive pastoral systems.

Characteristics that will influence the adoption of alternative species have been outlined by Wills (1983), and include factors such as growth habit, adaption to grazing, speed of establishment, alternative end uses and forage characteristics. However, the widespread use of alternative forage species in pastoral agriculture ultimately depends upon achieving a high, sustainable yield and annual acceptability and performance.

Sanguisorba minor spp. *muricata* (sheeps burnet) is a long lived, low growing herb of Mediterranean origin. It has good resistance to drought and frost and is highly palatable to stock. It is slow to establish in semi-arid environments. When established, spring/summer yields of up to 4,500 kg DM/ha have been recorded (Sheppard and Wills, 1982).

Melilotus alba (yellow sweet clover) is a fast growing, drought and frost tolerant legume. It is adapted to a wide range of soil and climatic conditions but does not tolerate acid soils. Yields of 6000 kg DM/ha annum have been

recorded in the South Island high country. Although normally a biennial, autumn oversowing can induce an annual growth cycle (Wills, 1983).

Dorycnium spp. (canary clovers) are low-growing, shrubby perennial legumes of Mediterranean origin. They are extremely drought and frost tolerant. Two species have been evaluated (Wills and Douglas, 1984). *D. pentaphyllum* has a prostrate spreading habit and poor natural reseeding. *D. hirsutum* is less palatable to stock having more hairs. Prolific flowering provides adequate seedlings for natural regeneration. It grows best on light soils over a pH range of 5.5 to 8.9 (Wills, 1983).

Hedysarum coronarium (sulla) is a short lived biennial, herbaceous legume 30-150 cm tall with a strong branched taproot. It is adapted to neutral/alkaline, well drained soils and to summer drought with certain lines exhibiting cold tolerance. It persists by reseeding. It is palatable to stock (Watson, 1982).

Astragalus cicer (cicer milkvetch) is a long lived perennial legume that spreads by rhizomes. It has ascending or prostrate hollow stems that reach up to 130 cm in length. Forage quality appears similar to lucerne. It does not cause bloat or contain toxic compounds. It is winter hardy and is adapted to a wide range of soil types, tolerating slight acidity to moderate alkalinity (Hoveland and Townsend, 1985).

These species have been compared in Hawkes Bay with the traditional species for dry environments, *Medicago sativa* and *Lotus corniculatus.*

METHODS

A series of four studies were carried out over the period 1985 to 1988.

Trial 1. Spaced Plant Evaluation of Eight Species.

Eight species; sulla (cv Aokau), cicer milkvetch, hairy canary clover, prostrate canary clover, sweetclover, sheeps burnet, birdsfoot trefoil (cv Granger), and lucerne (cv Rere) were laid down in a randomised block design of 4 replicates and 10 individual plants per plot at two sites.

Site 1 was at the Hawkes Bay Agricultural Research Centre (HBARC), a highly fertile flat site, of Mangateretere silt loam soil type. Individual seedlings 90 days old were transplanted at spacing of 1.5 m between rows, 0.25 m within rows, into cultivated soil on 17/9/85. Inter-row areas remained cultivated to between 2.5 cm and 5 cm height at regular intervals over the following 3 years. Green weights were taken from all plants and dry matter content determined on a representative sample from each species. Soil tests to 75 mm depth (MAF Quick Test) were pH 6.7, Ca 18, K 18, P (Olsen) 30, Mg 48, Na 9.

Site 2 was located at Fernhill, Taradale on a easterly sloping (15°) hill side of Matapiro sandy loam soil type. Individual plants were transplanted on 26/8/85 into 30-40 cm wide strips that had been sprayed 5 weeks earlier with glyphosphate (2.2 l/ha ai). Plants were spaced at 2.0 m between and 1.0 m within row plots. Soil tests 75 mm, (MAF Quick Test) were pH 5.8, Ca 6, K 11, P (Olsen) 15, Mg 35. Records were taken of plant survival over a 3 year period i.e. the plants were not defoliated. The species at this site were subjected to more competition from resident species than at site one.

Trial 2. Defoliation Management of Sulla

This study compared 5 defoliation managements of sulla: (1) Frequent, low cut. (2) Frequent, high cut. (3) Infrequent, low cut. (4) Infrequent, high cut. (5) Left to seed in first year and harvested in second year at an infrequent, high cut. The frequent cut sought to harvest at 5-10% flowering with the infrequent at 70-80% flowering. The 'low-cut' treatment was defoliated at 3-5 cm height and the high at 10-12 cm height above ground level.

The trial was established in autumn (9/4/86). Two hundred kg/ha unhulled inoculated sulla seed was broadcast onto cultivated soil, rolled and harrowed. Two hundred and fifty six seedlings/m^2 had established by 1/5/86.

Soil tests at the site (MAF Quick Test) were pH 6.5, Ca 17, K 14, P (Olsen) 27, Mg 41, phosphate retention 15%.

The trial consisted of a randomised block design with 3 replicates. Harvests were taken from 2.8 m x 3.8 m plots using a sickle bar mower. Sub samples were taken for dry matter content and species (sulla and others) separation. All material was discarded. Weed control was achieved using fluazifop - butyl (2 l/ha ai) and hand weeding as required in the first year. In the second year no weed control measures were taken. No fertilisers were applied during the two year trial period.

Trial 3. Defoliation Intervals and Nitrogen Rates on Sheeps Burnet.

Four defoliation intervals in spring of 4, 8, 12 and 16 weeks at 50 kg/ha/annum nitrogen and 3 nitrogen rates 50, 150 and 350 kg/ha/annum at a spring defoliation interval of 8 weeks were evaluated in the same trial.

The trial was established in autumn (9/4/86) with 60 kg/ha of seed broadcast onto cultivated soil, which was then rolled and harrowed. Five hundred and three seedlings/m^2 had established by 1/5/86. The trial was conducted on adjacent plots to the site which had similar soil tests.

The trial consisted of a randomised block design with 3 replicates. Main effects of nitrogen rate and defoliation interval treatments were analysed separately. Harvests were taken from 2.3 m x 3.6 m plots using a rotary mower cutting to 3 cm. All material was discarded. Weed control was achieved using chloroxuron at 3 kg/ha ai and simazine at 2 l/ha ai.

Nitrogen was applied as urea in split applications on four occasions throughout the year, with two applications during rapid spring growth.

Trial 4. Lamb Growth Rates on Sulla

This trial compared lamb growth rates in early summer on sulla, lucerne and resident pasture following establishment of 0.4 ha block of sulla at the Takapau Research Station, Central Hawkes Bay, in autumn 1987 on a Takapau silt loam soil type.

Fourteen lambs per treatment (7 ewe and 7 ram lambs) were randomly allocated according to weight and placed on each treatment at an allowance of 3 kg DM/head/day.

TABLE 1: Individual Total Plant Dry Matter Yields (kg/plant) of Forage Species at the Hawkes Bay Agricultural Research Centre.

Species	1985/86 (3 harvests)	1986/87 (4 harvests)	1987/88 (3 harvests)	3 year Total
Sulla	0.34	0.39	0.73	1.46
Cicer Milkvetch	0.14	0.33	0.40	0.87
Hairy Canary Clover	0.14	0.20	0.32	0.66
Prostrate Canary Clover	0.06	0.22	0.40	0.68
Sweet Clover	0.11	0.03	0	0.14
Sheeps Burnet	0.18	0.37	0.30	0.85
Birdsfoot Trefoil	0.22	0.38	0.34	0.94
Lucerne	0.39	0.82	0.91	2.05
LSD ($P<0.05$)	0.05	0.13	0.35	0.34
CV%	18	28	52	25

Areas were adjusted to achieve this allowance and an estimated pasture growth rate of 30 kg DM/ha/day was allowed during the grazing period duration of the trial. Animals were introduced on 4/12/87 and removed on 30/12/87.

Measurements were taken of fasted (12 hr) liveweights, pre and post grazing dry matter yield and species composition, over the grazing period. Harvests were taken from 3, 0.5m² quadrats for lucerne and sulla and from 0.2 m² quadrats in pasture.

RESULTS

Trial 1

In the first year sulla and lucerne were the most productive, with prostrate canary clover the lowest yielding (Table 1). By year two lucerne was substantially higher yielding (0.82 kg DM/plant) than all other species with sweetclover extremely poor yielding (0.03 kg DM/plant). In year three, sulla and lucerne were highest yielding, with sweetclover not persisting. The remaining species had similar intermediate yields.

Lucerne had the highest total yield over the three year period (2.05 kg DM/plant) followed by sulla (1.46 kg DM/plant). Sweetclover was the lowest yielding (0.14 kg DM/plant). No significant yield differences existed between the remaining species.

Individual plant survival was recorded at both sites (Table 2). Plants at the Taradale hill site were not defoliated. Twenty percent of the plants at the Taradale site, and 45% at the HBARC site survived into the second year. Cicer milkvetch was extremely persistent at HBARC. Both canary clovers proved to have similar persistency under continuous defoliation with over 30% surviving after 2 1/2 years. Hairy canary clover was more persistent at Taradale. Sweetclover did not persist, with numbers declining to 20% when defoliated and 63% when not defoliated after the first year. Virtually no plants persisted after the second year. Sheeps burnet, birdsfoot trefoil and lucerne all persisted at the flat land site under the dry Taradale hill site. Birdsfoot trefoil plant survival was similar at both sites.

Trial 2

In the first year, maximum annual yield of sulla (18,580 kg DM/ha) was achieved in the 'frequent low-cut' treatment (Table 3) which was significantly more than from the 'infrequent high' cut treatment. There were no

TABLE 2: Percentage of Forage Species Evaluated at Two Sites in Hawkes Bay.

Species	Hawkes Bay Agricultural Research Centre 13/12/85	31/10/86	19/11/87	20/4/88	Taradale 14/11/85	13/11/86	10/2/88
Sulla	87	45	15	5	51	20	20
Cicer Milkvetch	100	100	100	100	—	—	—
Hairy Canary Clover	100	80	48	33	88	87	87
Prostrate Canary Clover	65	65	42	36	80	33	33
Sweet Clover	85	20	0	0	95	63	3
Sheeps Burnet	98	98	85	80	96	66	43
Birdsfoot Trefoil	100	95	83	60	89	79	65
Lucerne	97	95	95	95	66	51	35
LSD ($P<0.05$)	25	20	22	19	13	21	22
CV%	17	18	23	23	18	41	56

*transplanted : HBARC 17/9/85
Taradale 26/8/85

TABLE 3: Effect of Defoliation Management on Sulla Dry Matter Yields (kg/ha).

Treatment	1986/87 Sulla	1987/88 Sulla	1987/88 Weeds	Total
Frequent, low	18580	2300	2300	4600
Frequent, high	15790	3190	1290	4480
Infrequent, low	15210	6130	1140	7270
Infrequent, high	13520	5670	770	6440
Infrequent, high (seed)	—	11100	980	12080
LSD (P<0.05)	4520	2690	490	2730
CV%	14	25	20	21

*Low = 3 cm and high = 10 cm cutting height.

differences between 'frequent high' and 'infrequent low' defoliation treatments. In the second year, the infrequent high and low cuts had similar sulla yields as did the frequent high and low cuts. The infrequently defoliated treatments had over twice the yield of the frequently defoliated treatments. Sulla yields for the 'infrequent high' cut left for seed in the first year was 11,100 kg/ha; twice that of the frequent cut treatments, but 2420 kg/ha lower than the same treatment yielded in the first year. Weed yield in the second year, when no control measures were taken, was significantly higher on the 'frequent low' cut treatment.

Trial 3

Spring defoliation interval had no significant ($P<0.05$) effect on annual production of sheeps burnet in the first year (Table 4). In the second year, the 8 week defoliation interval increased annual yields above the 4 or 12 week intervals. Absolute mean annual yield of all treatments declined 38% in the second year.

Response to increasing nitrogen rates just failed to reach 5% significance (Table 4), although trends for marked responses were evident in both years.

Trial 4

Pre-grazing yields of pasture and lucerne were similar with sulla yielding 65% higher production (Table 5). The removal of growing points in sulla and lucerne resulted in a marked decrease in yield by the end of the grazing period whereas continued growth maintained standing dry matter in the pasture treatment at a similar level. Lamb liveweight gain was similar from lucerne and sulla at 178 and 183 grams/animal/day respectively, both being significantly higher ($P<0.001$) than from pasture, at 52 g/animal/day.

TABLE 4: Effect of Nitrogen Rates and Spring Defoliation Intervals on Annual Dry Matter Yields of Sheeps Burnet.

Treatment		Year	
Nitrogen Level (kg/ha/annum)	Defoliation Interval (weeks)	1986/87 (14/8 to 30/4)	1987/88 (1/5 to 15/5)
150	4	13930	8410
150	8	13920	11620
150	12	15760	7570
150	16	15220	9160
LSD (P<0.05)		5210	9890
CV%		11	11
50	8	10880	9890
150	8	13920	11620
350	8	15210	13000
LSD (P<0.05)		4860	3650
CV%		9	14

Prior to grazing, sulla was predominantly stalk (50%) with 35% leaf material. The composition after grazing indicated a heavy selection for sulla leaf, with sulla flowers/seed also being consumed. Weeds and dead material was actively selected against during grazing.

The lucerne treatment total dry matter consisted of 87% lucerne prior to grazing. Active selection against weeds and dead matter resulted in a marked relative increase of these to 43% in the post-grazing residuals.

Active grazing selection for white clover in the pasture treatment changed the composition from 13% pre- to 4% post-grazing. Weeds and dead matter content similarly changed from 5% pre to 19% post-grazing.

DISCUSSION

This research assessed the potential of longer lived (longer than annual) species. Annual species have the associated risks of continual annual regeneration to ensure species survival.

Cicer milkvetch proved to be extremely persistent at the HBARC site. Although relatively low yielding (0.14 kg/plant) in the first year, 3 year total yields were similar to sheeps burnet and birdsfoot trefoil. A major feature of this

TABLE 5: Pre and Post Grazing Dry Matter Yields (kg/ha) and Lamb Liveweight Gain on Sulla, Lucerne an Pasture.

Species	Pre-grazing Yield	Post-grazing Yield	Initial Liveweight	Liveweight Gain (grams/animal/day)
Sulla	5260 ± 420	2510 ± 180	27.2	178
Lucerne	2920 ± 330	1690 ± 200	25.6	183
Pasture	3440 ± 580	3380 ± 110	25.8	52
LSD (P<0.05)			1.1	40
CV%			5	39

*Pasture allowance 3 kg DM/head/day. ±Standard Error

TABLE 6: Alternative Species Composition (%) Pre and Post Grazing.

Species		Component	Pre-grazing	Post-grazing
Sulla	—	Flower/Seed	10 ± 1	11 ± 3
	—	Leaf	35 ± 4	7 ± 1
	—	Stalk	50 ± 5	70 ± 3
	—	Other	5 ± 1	12 ± 2
Lucerne	—	Lucerne	87 ± 6	57 ± 22
	—	Other	13 ± 6	43 ± 22
Pasture	—	Grass	82 ± 11	77 ± 7
	—	Clover	13 ± 7	4 ± 2
	—	Other	5 + 6	19 ± 13

±Standard Error.

species was its virtual disappearance during the winter, leaving exposed ground, which may limit its use as a sole species. Forage quality is similar to lucerne (Townsend *et al.*, 1978). No major insect pests or diseases have been recorded (Hoveland and Townsend, 1983). *Astragalus cicer* apparently contains no toxic compounds even though aliphatic nitro compounds have been widely reported in the genus *Astragalus* and are highly toxic to monogastrics and ruminants (Burns, 1985). The persistence and yield in this trial suggests the species warrants further investigation in New Zealand.

The two *Dorycnium* species showed differential persistence at the two evaluation sites. Prostrate canary clover did not establish as successfully as hairy canary clover at the HBARC site although after 2½ years, survival of both species was similar at 33-36%. Plants were harvested 10 times over a 3 year period, to a height of 3-5 cm, giving an indication of this species' persistence to regular defoliation under a high fertility, non competitive situation. Although the first year yields of prostrate canary clover were half (0.06 kg) those of hairy canary clover, total yields over 3 years were similar. However, this was the second lowest yielding species (Table 1). Prostrate canary clover may be less persistent under greater competition from other species, as shown by the marked decline in plant numbers after the first year at the Taradale site. Hairy canary clover was particularly persistent at the Taradale site, although neither species was defoliated. Prostrate canary clover is very palatable to stock with hairy canary clover less palatable (Wills, 1983). Reduced palatibility may prove an advantage under extreme drought conditions, limiting over-grazing. The open growth habit of hairy canary clover allows grasses and herbs to grow within the canopy. It also has good seeding ability (Wills, 1983). The lack of competitive ability, high palatibility and poorer seeding ability may limit the usefulness of prostrate canary clover.

Sheeps burnet was persistent at the high fertility site under defoliation, but had only half the persistence under lower fertility and increased competition. Individual plant yields were similar to birdsfoot trefoil. Mean yields of 14,000 kg DM/ha in the first year at the high fertility site indicates the potential of this species. However, the decline to 10,000 kg/ha in the second year indicates that long term production may be more limited. The species performs best under a long defoliation interval and long term yield was highest under a spring defoliation of 8 weeks giving annual yields of 13,000 and 11,600 kg/ha respectively. The 16 week spring defoliation interval was incorporated to allow seeding, and to assess the impact of carrying spring produced feed over into early summer, although feed quality still required assessment. The long term productivity of sheeps burnet will be dependent upon a suitable legume component to provide nitrogen, as indicated by the nitrogen responses achieved in these trials. Red clover may be an appropriate species as it requires similar management practices to achieve optimum production. Sheeps burnet may prove to be an appropriate companion species to reduce intake of oestrogen by animals grazing red clover. Its slow establishment (Sheppard and Wills, 1985) and limited competitive ability may, however reduce the potential of this species in Hawkes Bay.

Sulla populations declined markedly within the first year at both sites suggesting the species behaves more like an annual than biennial. Individual surviving plants indicated a good yield potential, although still below that of lucerne. These results were confirmed by a maximum yield of 18,600 kg/ha achieved on the plot mowing trial in the first year at the frequent, intensive defoliation and compares favourably with yields of 14,000 to 16,000 kg/ha/annum obtained at Palmerston North (Foote, 1988).

Defoliation management affected productivity in the second year, with frequent, low cuts giving the lowest sulla yield. Less frequent defoliation, allowing plants to achieve 80 to 90% flowering in spring before defoliation, improved yields in the second year. The taking of sulla for seed production in the first year, harvesting in mid January resulted in a DM yield of 11,000 kg/ha in the second year. Some of this yield was due to establishment of seed, although no counts were taken of seedling populations. Foote (1988) found substantially lower yields from a 2 year stand cut at 3 monthly intervals to 5 cm compared to a stand cut to 15 cm confirming the importance of defoliation intensity on yield.

Grazing management must aim at maximising regrowth through maximising the number of axillary buds. Sheep are the preferred animal species as cattle are likely to damage plant crowns increasing the incidence of fungal disease. At HBARC, *Botrytis, Alternaria* and *Stemphylium* spp. were isolated from dying plants and are likely to be a problem on poorly drained soils. The nutritive value of sulla is similar to red clover (Maymone *et al.*, 1951) and in this trial gave equivalent liveweight gain in lambs to lucerne (180 g/head/day) in early summer. This was 3½ times that obtained from pasture reflecting the poor pasture quality at this time of the year. In comparison sulla has the ability to carry a large quantity of feed into the summer, without rapid deterioration of quality. Yields of 6,000 to 7,000 kg DM/ha could be carried forward as far as late February. This species has potential for deer farming where

summer calving of hinds leads to high feed requirements in summer, times when feed quantity and quality is a problem on traditional Hawkes Bay pastures.

Limitations of sulla include its slow establishment and relative sensitivity to weed competition. The use of dehulled seed, appropriate inoculation and a planned weed control programme will minimise these limitations (Foote, 1988).

Sweetclover was the least productive and least persistent species at both sites. On the heavier soil type at the HBARC site, persistence was shorter than at the Taradale site. Root rot caused by *Phytophthora* spp may have contributed to this differential persistence, being a recognised important disease of this species (Hoveland and Townsend, 1983). Lack of persistence has also been recorded in central Otago by Wills *et al.* (1987).

Several other factors may reduce the widespread use of sweetclover in New Zealand. Because new growth comes from stem buds, lax defoliation must be employed, limiting the use of set stocking practices. Sweetclover is sensitive to herbicides and its lack of adaption to acid soils will limit its potential range in New Zealand. Sweetclover also contains coumarin, an aromatic compound which affects palatability, although all newly released cultivars contain low contents (Hoveland and Townsend, 1983).

Despite the potential of these alternative species, lucerne still proved to be the most productive and persistent at the high fertility HBARC site. At the Taradale site in response to competition, drought, lower fertility and insect attack, particularly Sitona weevil, lucerne persistence was markedly reduced. However, lucerne in higher fertility flat land sites where it is able to be adequately managed will be difficult to surpass as a dryland species. Yields of 12,600 kg/ha/annum have been recorded in 3 year old lucerne stands, within 10 km of these trial sites. Sulla may have a place in specific circumstances i.e. deer enterprise. In dry, low fertility hill areas of Hawkes Bay, the performance of the other species evaluated here suggested they will contribute little to improved performance of these pastures.

ACKNOWLEDGEMENTS

The authors wish to thank Mr D. Adams and Mr T. Phung for their technical assistance. Mr G. Douglas and Mr L. Foote, Soil Conservation Centre, Aokautere, are gratefully acknowledged for discussions on appropriate species and provision of transplants and seed.

REFERENCES

Burns, J.C. 1985. Antiquality factors in temperate forage legumes in the United States. In "Forage Legumes for energy efficient animal production". Proceedings of a Trilateral Workshop held in Palmerston North, New Zealand April 30-May 3 1984. Eds. R.F. Barnes, P.R. Ball, R.W. Raymond, W. Brougham, G.C. Marten, D.J. Minson. US Department of Agriculture, Agricultural Research Service. pp. 260-267.

Foote, A.S. 1988. Local cultivar adaptation for Mediterranean's sulla. *N.Z. Journal of Agriculture, Feb/March:* 25-27.

Griffiths, E. 1982. Soil pattern and environment in Hawkes Bay. *Proceedings N.Z. Soil Society Conference, Hastings, Hawkes Bay 1982:* 54-64.

Hoveland, C.S., Townsend, C.E. 1985. Other Legumes. *In* "Forages. The science of grassland agriculture". Eds. M.E. Heath, R.F. Barnes, and D.S. Metcalfe, Iowa State University Press. pp 147-148.

Maymone, B., Tibero, M. Mazzotti, P. 1951. Chemical composition and feed value of *Hedysarum coronarium* L. *"Proceedings of the Conference on Improvement of Pasture and Fodder Production in the Mediterranean Area"*, Rome, pp 3-19.

Radcliffe, J.E. 1975. Seasonal distribution of pasture production in New Zealand. VII Masterton (Wairarapa) and Maraekakaho (Hawkes Bay). *N.Z. Journal of Experimental Agriculture, 3:* 259-265.

Sheppard, J.S., Wills, B.J. 1985. Sheeps burnet — a forage herb for soil conservation in New Zealand. *N.Z. Agricultural Science 19(3):* 115-119.

Townsend, C.E., Christensen, D.K., Dotzenko, A.D. 1978. Yield and quality of cicer milkvetch forage as influenced by wilting frequency. *Agronomy Journal 70:* 109-113.

Watson, M.J. 1982. *Hedysarum coronarium* — a legume with potential for soil conservation and forage. *N.Z. Agricultural Science 16(4):* 189-194.

Wills, B.J. 1983. Forage plants for the semi- and high country and rangelands of New Zealand. *In* "Proceedings of the 1983 Hill and High Country Seminar", Lincoln College, Centre for Resource Management, Special Publication 26. pp 59-65.

Wills, B.J., Douglas, G.B. 1984. Canary clovers, Streamland 32, National Water and Soil Conservation Authority Publication. 4 pp.

Wills, B.J., Sheppard, J.S., Begg, J.S.C. 1987. Evaluation of alternative dryland pasture plants and browse shrubs for soil conservation and drought-prone Otago grasslands. *Proceedings of the N.Z. Grassland Association 48:* 115-118.