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Establishment and management of Grasslands Puna chicory used as a specialist, high quality forage herb

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Abstract

Between 8000 and 10 000 ha of Grasslands Puna chicory are now sown annually in New Zealand, largely as a high quality forage herb capable of finishing a range of livestock types including deer, sheep, and cattle. This paper details the specific establishment requirements of Puna, including: weed control, renovation rotation methods, cultivation techniques and sowing methods. Management requirements are also discussed with particular emphasis on grazing management, including optimum rotation length and post-grazing residual height. Maintenance fertiliser and herbicide requirements, and stock health issues are also covered, with reference to the use of Puna in various livestock systems and its effect on profitability.

Keywords: *Cichorium intybus,* establishment, Grasslands Puna, leaf proportion, pre-grazing height, post-grazing residual height, 'rotational block grazing', stem development, stem control

Introduction

Chicory *(Cichorium intybus* L.) is a perennial herb originating from Central Europe, where it has been used in pastures for more than 300 years. Chicory is also grown as the leaf vegetable 'witloof' (George 1985). After selection and a breeding programme in the 1970s (Rumba11 1986), Grasslands Puna chicory was released in 1985 as the world's first forage cultivar of chicory.

Puna chicory is a perennial forage herb of high nutritional quality, with an 8- to 9-month growing season (early spring to late autumn). Puna has a slightly raised crown producing leafy top growth from a thick, deep tap-root with excellent drought tolerance and mineral extraction. Puna requires soils of medium to high fertility, with good to moderate drainage.

Despite virtual winter dormancy (Lancashire & Brock 1983), growth rates are high, most regions being capable of averaging 15-18 t DM/ha/year, and daily yields over summer in excess of 150 kg/ha (Lancashire 1978; Matthews et *al.* 1990). Herbage is of a high digestibility (DMD 86.8%), has a variable crude protein level (CP 15.0-26%) (Terrill *et al.* 1992) and has high metabolisable energy (ME) values of 12.2% (Stevens *et al.* 1993).

Chemical analysis by Crush & Evans (1990) showed Puna to have higher concentrations of potassium, sodium, calcium, sulphur, boron and zinc than ryegrass and white clover pastures. All other elements, including phosphate, were similar. The high concentrations of zinc and sodium offer potential advantages for animal health and growth rate.

Some farmers are consistently recording lamb liveweight (LW) gains of 300-350 glheadlday, compared with ryegrass/clover pasture at 120-200. Fraser et *al.* (1988) reported on several growth rate trials based on Puna. One experiment showed a 44% growth rate advantage to lambs fed on Puna compared with Rangi rape (*Brassica*). Cruickshank (1986) showed spring lamb growth rates on Puna, white clover and ryegrass of 290, 320 and 227 respectively. Fraser et *al.* (1988) reported Friesian weaner bull calf growth rates of 0.9 kg/head/day (some 0.2 kg/head higher than expected on ryegrass) on an optimum allowance of 100 g/kg of LW/day.

These results indicate the considerable potential of Puna in livestock systems.

Domestic seed sales are *now* about 40 #year, 60% into the South Island, with most of the North Island sales into the east coast (S. W. Ardagh, Challenge Seeds Ltd pers. comm.).

Puna chicory can be used either as a specialist perennial forage sown with clover, or as a summer-active component of a grass and clover mixture, e.g., ryegrass, cocksfoot and/or phalaris. Puna is particularly well suited to lamb and deer finishing, providing high quality summer forage when ryegrass/white clover pastures are low in quality.

This paper sets out the establishment and management requirements of Puna chicory as a specialist forage in animal finishing systems.

Establishment requirements

Paddock selection

Puna will tolerate a wide range of soil types including sand, peat and silt loams, Persistence on heavy clay loams tends to be poor because of potential crown damage and tap-root rots caused by *Sclerotina* spp. Soils

with significant pans, or seasonal underground aquifers, are generally not suitable. Medium (recent) silt loams with good summer water-holding capacity, moderate to good winter drainage and high natural soil fertility are most suitable. Crush & Evans (1990) suggested that Puna tolerates a wide range of pH, but was likely to perform best in the normal range of pH 5.6-6.0.

Paddocks should be easily accessible and subdividable (i.e., temporary electric), with daily access to water. Puna tap-roots can block tile drains, although once identified, these lines can be sprayed out soon after establishment using 2,4-D @ 3 l/ha.

Renovation rotation options

The objective of these rotations is to ensure a weed-free seedbed at sowing. This is important given the limited range of post-establishment herbicides available, particularly for difficult thistles, e.g., nodding and winged (*Carduus nutans* and *C. tenuifloris*).

Spring sowings should follow:

autumn-sown winter-active fodder crops (e.g., Italian ryegrass, oats)

an early-spring spray cultivation and condensed spring fallow (Milne *et. al 1993)*

an autumn spray cultivation and winter fallow.

Autumn sowings should follow:

spring/summer cash or fodder crop, e.g., barley, maize or Nutrifeed (Panicitum spp.)

spring/summer spray cultivation and fallow system (Hume & Lyons 1993).

To avoid problems with *Sclerotinia*, legume and brassica crops should not be used in the rotation before sowing Puna (Hare et al. 1990).

Sowing date

Puna establishes well from mid-spring (October) sowings, with the first grazing easily possible before Christmas. In cooler environments with good summer rainfall November sowings will be better. Early-autumn sowings are also possible, particularly in coastal districts which are autumn frost-free, and may be more reliable where early summer droughts can be expected.

Paddock preparation

From cultivation Roller and air drills are the most accurate. Variations include the use of crop or direct drill, with down tubes removed as a broadcasting unit. The Aitchison direct drill, with its sponge pick-up mechanism, is ideal.

Direct drilling This method is possible where paddock surfaces are level, soil structure is good, the drill type is very accurate in seeding depth and the resident pasture species are controlled adequately, i.e., spring/summer spray fallow (Milne *et al.* 1993).

Minimum surface tillage Where a tilth of 3-5 cm is created from a spraying and shallow cultivation (e.g., power harrow), sowing should be by roller or air drill.

Sowing depth

Maximum consolidation before and after sowing is important for accurate sowing depth and even and rapid germination. This is difficult on low bulk density soils (e.g., peat, pumice and sands) where rolling with a weighted Cambridge roller and moist soil conditions are important.

Sowing depth is important. The optimum depth of 1.0 cm is achieved with the roller or air drill sowing systems. Roller drills should be checked for accuracy and to ensure that Puna and clovers are not being segregated. A neutral bulking agent mixed with the seed, e.g., dry lime, or sand, will prevent this. Neither of these problems occur when either the air seeder or Aitchison drills are used as broadcasting units, onto the preCambridge rolled seedbed.

Herbicides and fertilisers

To assist with weed control, the pre-emergence herbicides ethalfluralin (Soralan) and trifluralin (Treflan up to 1.6 l/ha a.i.) (Hare *et al.* 1990 1993) should be soil incorporated soon after application (e.g., power harrows or tined cultivators set to 5-10 cm). Trifluralin will control fat hen, willow weed, docks, chickweed and summer grasses, etc, but not nightshade, thistles or shepherd's purse. EPTC can also be used in this way (Hare & Rolston unpub. data).

After establishment, few herbicides are safe on seedling chicory. Exceptions include bentazone (Basagran) and asulam (Asulox). As soon as young plants reach 12-15 cm in diameter, Basagran @ 1.44 l/ha a.i. should be applied for control of some broadleaf weeds. If thistles are still a problem despite all efforts before sowing, 2,4 DB at up to 1.6 l/ha a.i. can be applied in the first winter, after the selective grazing of chicory and clover leaf (Hare *et al. 1993)*. However, successive toppings, or the use of various wiping devices, are also effective in control of thistles.

In addition to any capital fertiliser required, a nitrogen-based compound fertiliser @ 30 kg N/ha (e.g., DAP @ 165 kg/ha) is recommended to be soil incorporated with the final chain harrowing just before sowing. For spring-sown pastures, a second application of N (@ 25 kg N/ha) can be made at, approximately 10-12 weeks from sowing. This will stimulate additional leaf canopy, further reducing potential weed competition.

Sowing mixtures and rates

The seed is small, light and rectangular with a 1000-seed weight of 1.4-l .7 g. As a minor component in a grass mixture, Puna is sown at 0.5-l .O kg/ha for spring sowings and l-l.5 kg/ha for autumn sowings (Puna is less competitive in autumn sowings than spring sowings). Specialist Puna mixtures (Table 1) can be sown at 4-5 kg/ha, with a large-leaved white clover cultivar always included, and in most regions red clover also. Clovers not only fix N but further enhance the nutritive value of the pasture and provide ground cover in winter.

Table 1 An example of a specialist, dryland Puna chicory pasture mixture

Cultivars	Seed Sown (kg/ha)
Grasslands Puna chicory	5.0
Grasslands Kopu white clover	4.0
Grasslands Colenso red clover	4.0
Total seed sown per hectare	13.0

Note: * Coating of Puna chicory with Betta-Start Pius was shown to improve percentage germination and seedling vigour (Hur and Hunt 1993). This coating process and 'Superstrike' include: fungicides, insecticide and a starter fertiliser.

Table 1 is an example of a specialist Puna chicory mixture, calculated for a 7.5 cm row spacing e.g. roller drill. For direct drilled sowings (15 cm row), reduce these rates by approximately 25%.

First grazing

The first grazing should be when plants have reached a height of 12-15 cm and pass the pull test (i.e., plants pulled with thumb and forefinger with only leaf and stem able to be removed). The grazing should be fast and non-selective with young stock strip grazed and back-fenced.

Management requirements

Fertiliser

Little or no research has been done to determine nutrient requirements. However, despite its ability to forage for soil nutrients it is assumed that as a high yielding forage plant (i.e. up to 25 t DM/ha/year), standard target soil nutrient values apply, i.e., Olsen P 20-30, K 8+ and S 10+. Nitrogen is also an important nutrient, particularly at seedling development.

Maintenance rates will depend on soil type, stocking rate and fertiliser history, for example, but as a general guide only, the following programme can be considered. The main maintenance application should be in August: an N,P,K and S fertiliser, supplying 35 kg N, 35 kg P and K, and 20-30 kg S/ha. By early December a second application of N (e.g., urea) should be applied, providing 20-25 kg N/ha. In regions where autumn growth is good, depending on the season and growth rates to date, a third application of N in late February early March may increase yield.

Clark et *al*. (1990a) showed that spring response to 1 kg of nitrogen was 10.6 kg DM/ha (@ rates up to 50 kg N/ha), similar to that of ryegrass and white clover pasture. However, 60% of the response was in stem production. At 200 kg N/ha they found plant densities were halved from 21.3 (@ 50 kg N) to 10.4 plants/m^2.

Herbicides (maintenance)

As already stated, to minimise the need for weed control, extra care is needed both before and at establishment. However, if thistles continue to be a problem and control through topping is not possible, herbicides and weed wipers (e.g., glyphosate and Versatill) are recommended for selected control. Where grass and broadleaf weeds infest pastures over time, a mixture of simazine (0.75 l/ha a.i.) and gramoxone (0.4 l/ha a.i.) (Hare et al. 1990) can be applied after a mid-winter selective grazing for available chicory and clover leaf. For sustained thistle invasion (e.g., nodding thistle) 2,4 DB up to 1.6 l/ha a.i., or MCPB @ 1.2 l/ha a.i., can be used if winter pre-grazing management is the same. Note: simazine, and atrazine even more so, can temporarily suppress white clover. Other products (also without chicory registrations) which could be applied in a similar way include: Gallant, Fusilade, Sencor, Karmex and Kerb.

Grazing management

To achieve the potential stand life (5-7 years), correct grazing technique is vital. Unsuitable management such as prolonged and heavy set stocking, or grazing at high stocking rates during periods of heavy rain, are likely to reduce persistence.

In order to achieve optimum utilisation and animal performance by non-selective grazing animals (e.g., lambs and ewes), 'rotational block grazing' for limited periods (3-5 days), with a back fence, is recommended. Similar levels of efficiency can be achieved by set stocking with selective grazing animals (e.g., deer and yearling cattle), which can maintain a constant herbage height (10-15 cm) and appropriate leaf to stem ratio (spring 3:1) (Clark et *al.* 1990a).

Leaf and stem management

It is important to distinguish between immature and mature stands. Immature stands result from spring

The authors and AgResearch take no responsibility for any outcome of any of the suggested herbicides used on chicory. However, the herbicides referred to in this paper have all shown promise experimentally. At the time of print there are no chemicals with registration for Puna chicory.

sowings and will not develop stem until the following spring. Autumn-sown Puna will develop stem in the first spring, as this is triggered by vernalisation during winter (George 1985). Hare *et* al. (1987), Clarke *et* al. (1990b) and Matthews et *al.* 1990 all stressed that the key grazing management objective is to maximise leaf yield and minimise stem development, even though this would reduce total annual yield. Mature stands produce a hollow primary stem in mid October (photoperiod triggered), which if left ungrazed will thicken and harden substantially from a height of approximately 60 cm and continue to grow over 2 m tall (Hare *et al.* 1987).

The easiest way to minimise stem development is through two quick, hard grazings to ground level, the first in mid spring (i.e., mid to late October) and the second in November, 20-26 days later. If stem development is already well advanced before the first grazing, breeding ewes or yearling steers can be used to remove stem. If the first grazing is missed, another option that farmers have found successful is to take an early-November silage cut at an approximate stem height of 50-80 cm. Mechanical topping can also be used, although successive toppings reduce plant numbers (i.e., for mature stands a target plant density is 18-24 plants/m*).

In spite of good spring control of primary stem, a finer more branched secondary stem may develop in early autumn. Often this is in response to an early or sudden drop in soil temperature, but the stem is not seen as a major problem limiting either quality or grazing control. Chicory, as a deep, tap-rooted plant, is very sensitive to fluctuations in soil temperature which will affect yield (Gianquinto & Pimpini 1989). East coast farmers in the North Island noticed reduced yields and secondary stem development during the cool summer and autumn of 1992.

Rotation length and grazing height

Clark *et al.* (1990a) predicted that over the spring and early summer, maximum leaf yield for mature Puna chicory occurred 34 days from grazing, and that the optimum pre-grazing height was O-5 cm. At a post-grazing residual height of 10 cm, more frequent grazings were required to maintain high leaf yields. These could be at 7-, 14- or 28-day intervals without penalty to yield. However, at a 0 cm grazing height (ground level), the minimum rotation length should be 20 days, with 28-34 the optimum. At 0 cm cutting height and rotation lengths of less than 14 days, plant persistence will be reduced through severe root carbohydrate drain and reduced photosynthesis (Clark *et al.* 1990a).

Table 2 combines published research, advisor and farmer experience into a guide on grazing management in a closed lamb finishing system. Clark *et al.* (1990a) also suggested that a better determinant of grazing frequency may be when a maximum of 30% stem occurs. The golden rule for Puna grazing management is to regularly check growth (l-2 times/week), particularly during stem development in spring.

Over winter, grazing should be kept to a minimum. One or two light grazings when soils are firm may be required to utilise accumulated growth from the two cool-season clover cultivars Grasslands Kopu white clover and Grasslands Colenso red clover.

When introducing freshly weaned lambs in spring, Puna should be at maximum pre-graze height of 10-12 cm. Heights greater than this can result in slow acceptance, with fence line trekking and feed wastage likely.

Table 2 A guide to the grazing management of mature Puna chicory in a specialist lamb finishing system.

Months	Rotation length (days)*	Target pre-grazing height (cm)	Target post-grazing residual height (cm)	Estimated growth rates (kg DM/ha/day)
Sept-October	30-35	12-16	5	40-60
Oct.-November	20-26	10-16	o-2	w-75
Nov-December	2 2 - 2 6	12-16	O-2	80-110
Dec-January	26-32	14-18	2-5	70-95
Jan-February	34-36	16-22	o-5	50-70
March-April	36-45	16-24	o-5	35-55
April-May	45-55	16-24	5	15-35

Note: . Rotation length (days) is an approximation only, asvariation in seasonal rainfall and soil temperature. mean that the farmer will have to modify these to suit actual growth rates. Pre-grazing heights provided and the aim of 70%+ leaf, may often be better guides to setting rotation length.

Conservation potential

G. Williamson (pers. comm.) recorded a DM yield (est. DM 30%) of 11.8 t/ha from a late-December silage crop wilted for 24 hours. However, because the high proportions of stem in this crop did affect silage quality, a cutting date no later than mid November is suggested. Stevens *et al.* (1993), in Southland indoor feeding trials, found the quality of Puna-based silage (fine chop, 40/60 Puna and Grasslands Manawa ryegrass) to be very high relative to timothy/red clover and ryegrass. Lambs on the Puna/Manawa silage had LWG of 125 g/head/day at 60% higher intake rates compared with ryegrass which gave LWG of 7 g/head/day. Feed analysis of the Puna silage was: DM% 25-30%, CP 12.6%, DMD 74%.

Animal health considerations

Stock water requirements

If plenty of fresh water is not available, LW gains will

be reduced (particularly lambs on closed rotations), probably because of the high sodium levels in Puna (Crush & Evans 1990). On the block rotational system, movable troughs, or a permanent circular trough in the centre of the paddock, break and back-fences radiating out, can be used.

Nitrate poisoning

As with most rapid growing forage types which are nitrogen responsive, nitrate poisoning can occur under certain environmental conditions (i.e., excess plant nitrate levels, sudden growth, or overcast conditions). Under these conditions, a simple herbage nitrate test should be performed.

Pulpy kidney

As with clover dominance in ryegrass pastures, the high energy value of Puna chicory can result in pulpy kidney in lambs. Lambs should be revaccinated before grazing Puna for any length of time (i.e., closed rotations).

Bloat

Only traces of tannin have been found in Puna (Terrill *et al.* 1992), insufficient to protect animals from bloat. Cattle have been found to have a degree of rumen expansion without clinical bloat when grazing pure Puna (D.A. Clark unpub. data).

Pests and diseases

Little research has been done on Puna's tolerance to common forage pests. However, field observations suggest good tolerance of diamond backed moth and aphids, but susceptibility to slugs and springtails. The fungi *Sclerotina minor* and S. *sclerotiorium can* reduce yield and persistence of Puna. S. *sclerotiorium* is the more widespread of the two and associated more with brassicas *than S. minor.* Both are soil borne and affect leaves, crowns and tap-roots, ultimately causing chronic degeneration and plant death (R. Skipp, AgResearch pers.comm.).

Uses for Puna chicory

Deer breeding and finishing systems

Puna's high summer forage quality and yield tit perfectly the growth requirements of the breeding hind and fawn, when traditional dryland ryegrass/white clover pastures are low in quality and high in endophyte. In Manawatu farmlet trials (D. Clark and W. Thomas unpub. 1991) which included 20% Puna/clover and 80% grass/clover, Red deer fawn weaning weights were 26% higher (39.9 kg LW), despite a 17% greater stocking rate (11.7 hinds/ha), and 101 kg/ha (47%) more LWG was achieved on the Puna/clover pastures than on the grass/clover only farmlets.

On-farm trials in South Auckland (Hunt 1993) have shown 15% greater fawn weaning weights on Puna/clover compared with ryegrass. Hunt (1993) found that autumn direct drilling Grasslands Tama into Puna for winter/early-spring grazing maintained this advantage through to slaughter. By November, weaners on Puna/Tama were 20% heavier (stags +24%, hinds +15%) than those on ryegrass. With these growth rate advantages, the target LW of 90 kg was easily met by November (normally December/January), with the average stag LW of 92 kg achieved by August (Hunt 1993).

Lamb and cattle finishing

Farmers and some researchers have shown Puna to have advantages in cattle finishing systems (Fraser *et al.* 1988; P. Muir, AgResearch pers. comm.), but Puna has provided the most consistent advantage in lamb finishing. Most farmers will finish their heaviest lambs on Puna for 2-3 weeks before slaughter and replace these with the next heaviest mob. This ensures a constant supply of lambs for grazing Puna for most of the summer. Using this system, farmers can supply lambs at much higher carcass weights (i.e., 18+ kg CW) earlier in the season and take advantage of the associated market premiums. Later in the season when lambs have all been sold, Puna can be utilised by replacement hoggets, or as flushing feed for breeding ewes.

Based on recorded pasture and animal growth rates with lambs, Puna chicory has the potential to produce $35/week/ha gross income, from October to March (i.e., 25 lambs/ha @ LWG 270 g/head/day, 41% DO and $1.80/kg CW). Some farmers have recorded lamb gross incomes of $1000/ha in one season (P. Andrews, Agriculture NZ, pers. comm.).

Table 2 provides a guide to approximate pasture growth rates and rotation lengths.

Summary

1. Puna has very good potential for finishing deer, sheep and cattle in both summer moist and dryland environments, with animal growth rates similar to that on pure legumes.

2. For successful establishment, special consideration needs to be given to paddock selection, pre-plant weed control and seeding methods and depth.

3. The major grazing management objective in spring is to ensure a high proportion of leaf relative to

stem (i.e., 3: 1, or 70% leaf), rotation length and post-grazing residual height being the two critical factors.

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REFERENCES

Clark, D.A.; Anderson, C.B.; Berquist, T. 1990a. Growth rates of 'Grasslands Puna' chicory (Cichorium *intybus* L.) at various cutting intervals and heights and rates of nitrogen. ***New Zealand journal of agricultural research 33:*** 213-217.

Clark, D.A.; Anderson, C.B.; Hongwen, Gao 1990b. Liveweight gain and intake of Friesian bulls grazing 'Grasslands Puna' chicory ***(Cichorium intybus*** L.) or pasture. ***New Zealand journal of agricultural research 33:*** 219-224.

Cruikshank, D.L. 1986. Nutritional constraints to lamb growth at pasture. PhD Thesis Lincoln University.

Crush, J.R.; Evans, J.P.M. 1990. Shoot growth and herbage element concentrations of 'Grasslands Puna' chicory ***(Cichorium intybus*** L.) under varying soil pH. ***Proceedings of the New Zealand Grassland Association 51:*** 163-166.

Fraser, T.L.; Cosgrove, G.P.; Thomas, W.J.; Stevens, D.R.; Hickey, M.J. 1988. Performance of 'Grasslands Puna' chicory. ***Proceedings of the New Zealand Grassland Association 49: 193-196.***

George, R.A.T. 1985. Vegetable seed production. London, Longmans.

Gianquinto, G.; Pimpini, F. 1989. The influence of temperature on growth, bolting and yield of chicory cv. Rossi di Chioggia ***(Cichorium intybus*** L.). ***Journal of horticultural science 64: 687-695.***

Hare, M.D.; Rolston, M.P.; Crush, J.R.; Fraser, T.J. 1987. Puna chicory – a perennial herb for New Zealand pastures. ***Proceedings of the Agronomy Society of New Zealand 17: 45-49.***

Hare, M.D.; Rowarth, J.S.; Archie, W.J.; Rolston, M.P.; Guy, B.R. 1990. Chicory seed production: research and practice. ***Proceedings of the New Zealand Grassland Association 52: 9*** l-94.

Hare, M.D.; Rolston, J.S.; Foote, A.G.; Archie, W.J.; Hagerty, G. 1993. Herbicide tolerance of Grasslands Puna chicory. ***Proceedings of NZ Plant Protection Conference 46:*** 282-287.

Hume, D.; Lyons, T.B. 1993. Methods of establishing tall fescue and ryegrass in a dryland environment. ***Proceedings of the New Zealand Grassland Association*** 55: (this volume).

Hunt, W.F. 1993. Maximising Red deer venison production through high quality pasture. ***Proceedings of the XVII International Grassland Congress:*** 1497-1498.

Hur, S.N.; Hunt, W.F. 1993. Improving germination and seedling establishment of chicory. ***Proceedings of the XVII International Grassland Congress:*** 135-136.

Lancashire, J.A.; Brock, J.L. 1983. Management of new cultivars for dryland. ***Proceedings of the New Zealand Grassland Association 44:*** 61-73.

Lancashire, J.A. 1978. Improved species and seasonal pasture production. ***Proceedings Agronomy Society of New Zealand 8:*** 123-127.

Matthews, P.N.P.; Kemp, P.D.; Austin G.M. 1990. The effect of grazing management on the growth and reproductive development of chicory. ***Proceedings Agronomy Society of New Zealand 20: 41-43.***

Milne, G.N.; Moloney, S.C.; Smith, D. 1993. Demonstration of dryland species on 90 east coast North Island farms. ***Proceedings of the NZ Grassland Association 55***: (this volume).

Rumball, W. 1986. 'Grasslands Puna' chicory ***(Cichorium intybus L.). New Zealand journal of experimental agriculture*** 14: 165171.

Stevens, D.R., Turner, J.D., Baxter, G.S., Casey, M.J., Miller, K.B. 1993. 'Grasslands Kahu' timothy: Quality pasture for animal performance. ***Proceedings of the New Zealand Grassland Association 55:*** in press.

Terrill, T.H., Rowan, A.M., Douglas, G.B., Barry, T.N. 1992. Determination of extractable and bound condensed tannin concentrations in forage plants, protein concentrate meals and cereal grains. ***Journal of Science Food and Agriculture 58: 321-329.***

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