Proceedings Agronomy Society
of New Zealand. 17 1987

PUNA CHICORY - A PERENNIAL HERB FOR NEW ZEALAND PASTURES

ABSTRACT

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'Grasslands Puna' chicory was bred as a pasture forage herb by Grasslands Division, DSIR, Palmerston North and approved for national listing, commercial release and certification in 1985. Chicory is a perennial herb of the family Asteraceae and is used as a leaf vegetable 'witloof' and a supplement in coffee in other countries and Puna is the first cutlivar bred for pasture in which the seed is commercially available.

Puna has very little winter growth but is most useful as a perennial summer forage; forage yields of up to 25,000 kg DM/ha have been produced from December through to May on well-drained soils of medium to high fertility in dry warm regions. Lambs grazing stands of pure chicory in Canterbury have gained over 300 g of liveweight per day. Friesian bull calves grazing pure chicory in the Manawatu gained 900 grams of liveweight per day. Opossums caged for fur also find Puna highly acceptable.

In pot trials soil pH over the range pH 4 – pH 6 had no effect on chicory growth. Chicory herbage has higher levels of many elements than normally occur in ryegrass.

Peak flowering of Puna chicory occurs in late December – early January and the optimum time to harvest is 20 days later. Stems are nearly two metres in height and must be cut and thoroughly dried before threshing. The plant growth regulator paclobutrazol (PP333) has been ineffective in reducing the height of stems. Chicory can be closed for seed production any time between August and October without losses in seed yield.

Seed yields have increased from 200 kg/ha in 1984 to over 500 kg/ha in 1987.

Additional Key Words: Breeding, agronomy, herbage and seed yield, liveweight gains.

INTRODUCTION

Chicory (*Cichorium intybus* L.) is a perennial herb of the family Asteraceae, native to Europe, large parts of Western and Central Asia, North Africa and South America. In European countries many cultivars of witloof chicory have been bred to produce a leafy winter vegetable (George, 1985). One year old dormant roots are dug up in the autumn and in the winter are forced under hydroponic conditions to produce chicons (etiolated terminal buds), which are used fresh in salads or as a cooked vegetable. The taproot can be roasted, ground and used as a coffee substitute or supplement, particularly in India and South Africa (Arya and Saini, 1984; Anon., 1983).

Roots of Witloof chicory have high concentrations of sugar and could be used as an energy crop to produce ethanol by direct fermentation (Douglas and Poll, 1986). In Russia the taproots are used for alcohol production (Davidovich and Davydova, 1947) and also for medicinal uses (Simon et al, 1984). As a pasture plant, chicory has never been widely used except on shallow chalky soils in England where it is drought resistant and its deep taproot breaks up the subsoil (Clapham *et al.*, 1962).

In New Zealand Cheeseman (1906) reported that chicory was commonly found in fields and waste areas of both islands. Cockayne (1915) concluded that chicory in New Zealand did not produce much herbage, soon ran to seed and was of no more value than catsear (*Hydochoeris radicata*) and should be classified in pastures as a weed. Several trials in New Zealand between 1948 and 1950 tested chicory in pure stands, pasture mixtures and herb mixtures (O'Brien, 1955). In these trials it established well but did not persist for any length of time and did not provide any great quantity of feed. O'Brien concluded that chicory was of little value except as a drought-resistant plant on low fertility land which dried out in summer.

Studies in 1973 in Palmerston North showed that there were large variations between plants (Rumball, 1986) and that it might be possible to select material with higher dry matter production than that of common lines of chicory. This material was seen as suitable for New Zealand dryland farming areas.

BREEDING

Rumball (1986) outlined the breeding of 'Grasslands Puna' chicory from 1975 to its commercial release and certification in 1985. Briefly one New Zealand line of unselected commercial seed was grown out in spaced plants and 64 parent plants were selected. Puna chicory is more densely leaved, vigorous and uniform than the base population from which it was selected, although variation remains in leaf shape and the colour of the midrib (Rumball, 1986). Grasslands Puna is the first of cultivar chicory in the world bred for use as a pasture species which has seed commercially available.

AGRONOMY

Soil fertility requirements

Crush and Evans (1988) found that in pot experiments the shoot yield of Puna chicory was insensitive to changes in soil pH from pH 4 – pH 6 and recommend growing chicory at moderate pH levels of 5.5 – 6.0 for optimum cycling of nutrients by soil microbial activity. To date there has been no research into the effects of fertilizer on dry matter production of the crop.

Sowing and establishment

Puna chicory should be sown in the spring at about 2 kg/ha. As it has little winter production, autumn sowings are not advised even though it will establish well from sowings made in early autumn. Seed should be sown in shallow drills (1-2 cm in depth). Very poor establishment has resulted from the deeper drillings used for ryegrass, but broadcasting seed has given good establishment (J. Hay, Grasslands Division pers. comm.).

Wherever chicory has been planted germination and establishment have usually been very good (Lancashire and Brock, 1983). Because it is virtually dormant in the winter the choice of companion speicies is difficult. Winter active species like 'Grasslands Matua' prairie grass and 'Grasslands Moata' tetraploid Italian ryegrass may not be suitable because the intensive grazings they are usually given in winter will probably damage the crowns of chicory and cause plants to die. Further agronomic studies are needed to determine what grasses and legumes can be used in chicory swards.

Seasonal production and persistence

In a pasture mix with four grasses and one clover, Puna chicory established very rapidly from a spring sowing and produced almost 70 percent of the pasture yield over the first summer and autumn (Figure 1); dry matter production in the second year following establishment was 4000 kg/ha or 32 percent of the total sward production. Lancashire and Brock (1983) reported that in mixed grass swards under set stocking all year Puna disappeared rapidly, but with rotational grazing Puna persisted.

Pure swards grown in 15 cm rows for seed production have yielded 25000 kg DM/ha in the Manawatu from early December to the middle of May (Table 1). In this trial Puna chicory was sown on 20 October 1985 and was first grazed in early December. From 17 December 1985 to 13 May 1986 four grazings were made. Before each grazing dry matter cuts were taken and the field heavily grazed for 1-2 days to 3-5 cm above the ground level. The interval between grazings allowed the plants to grow to over 30 cm in height. This system of rotational grazing with 4 to 5 week intervals appears to be the best management for Puna chicory. Similarly high yields of dry matter have been obtained in Canterbury (Fraser *et al.*, 1988).

TABLE 1: Dry matter production (kg DM/ha) of Puna chicory at different row spacings in the Manawatu in 1985/86.

Row spacing (sown Oct 20) 1985	Dec 17-Jan 6	Jan 6-Feb 14	Feb 14-Mar 25	Mar 25-May 13	Total
15 cm	2300	9630	7880	5260	25070
30 cm	1110	2000	4970	2780	8080
60 cm	780	3280	1820	2040	7920

TABLE 2: Coopworth lamb liveweight gain on grazed pure stands of Puna chicory, lucern and Rangi rape in Canterbury (mid -February to mid-April).

Crop	Daily allowance kg DM/head/day	Liveweight gain grams/head/day
Lucerne	3	246
Lucerne	1.5	166
Puna chicory	3	238
Puna chicory	1.5	168
Rangi rape	3	165

Animal performance

Lambs in Canterbury have grown very well on pure chicroy pastures (Fraser *et al.*, 1988). Eight-week-old ram lambs weaned on to Puna chicory with ad lib. feeding grew at a rate of 290 g/head/day from early November to mid-December (42-days).

TABLE 3: Chemical composition of Puna chicory herbage averaged over six different locations on nine different soil types (after Crush and Evans, 1988).

Element	% D.M. Puna chicory	Ryegrass*
N	3.00	4.5 - 5.00
P	0.32	0.35 - 0.40
K	6.9	2.0 - 2.5
Na	0.35	-
Ca	1.32	0.25 - 0.30
Mg	0.28	0.16 - 0.20
Zn	117 ppm	14 - 20 ppm
S	0.52	0.27 - 0.32
B	35 ppm	< 15 ppm
Mn	404 ppm	25 - 30 ppm

* Optimum range cited by Cornforth (1984).

TABLE 4: Effect of time of final defoliation (closing date) on Puna chicory seed yield (Hare and Rolston, 1987).

Final defoliation date (1st week of)	Seed yield (kg/ha) 1984/85	1985/86
May	236	228
August	252	153
September	282	171
October	237	158
November	194	128
December	37	102
LSD 5%	61	50

Lamb growth rates on pure stands of lucerne, white clover and Nui ryegrass over the same period were 310, 320, and 227 g/head/day respectively. Puna chicory grew at 275 kg DM/ha/day during this period (Fraser, unpub. data). Autumn lamb growth rates (mid February to mid April) were lower but were superior to that of Rangi rape, a commonly grown greenfeed (Table 2). Lambs fed a low allowance of Puna (1.5 kg DM/ha/day) grew as fast as those fed a high allowance of rape (3.0 kg DM/head/day). Puna chicory grew during this period at 120 kg DM/head/day (Fraser, unpub. data).

In the Manawatu 6 month old Friesian calves have also grown well on pure Puna chicory stands (Fraser *et al.*, 1988). With ad lib. feeding the calves grew at 0.9 kg/head/day from late February to mid March and from late April to early May the growth rate was similar (0.94 kg).

Caged oppossums grown for fur and meat production have found Puna chicory to be a very reliable palatable feed (S.C. Moloney, Grasslands Division, Palmerston North pers. comm.).

Chemical composition

Comparing Puna chicory with the standards for ryegrass and clover given by Cornforth (1984) and laboratory reference ryegrass, Crush and Evans (1988) found that potassium, sodium, calcium, sulphur, boron, manganese and zinc in chicory exceeded normal values for ryegrass and white clover. Nitrogen, phosphorus, mangasium, and copper were within the usual range and potassium levels were particularly high in chicory (Table 3).

Zinc is of interest as a prophylactic for facial eczema and Crush and Evans (1988) suggest that the high level of zinc in Puna may make it a valuable greenfeed in summer and autumn when facial eczema may occur in stock fed on pasture.

SEED PRODUCTION

Crops of nucleus seed (Rolston and Gomez, 1986) of Puna chicory have been harvested in the Manawatu by Grasslands Division, DSIR, since 1984. Seed yields have increased from 200 kg/ha to over 500 kg/ha in 1987.

Establishment and sowing rate

Puna chicory, like other cultivars of chicory, must undergo a period of vernalization in order to produce seed heads (George, 1985). In India the Kalpa Sel 1 cultivar requires a chilling temperature of -3 to -7^{0}C from October to March (Arya and Saini, 1984). No vernalization studies have been made on Puna, but in most parts of New Zealand winter temperatures are adequate for seed production.

Puna grown for seed production can be sown in either spring or autumn, but spring sown crops will not produce seed until the second summer, 15-18 months after sowing. Autumn sowings should be made before the end of March. Spring and autumn sowings have yielded 520 and 530 kg/ha of seed respectively (Hare and Rolston unpub. data).

In India chicory is sown at 3-5 kg of seed/ha in 30 cm rows (Arya and Saini, 1984); in California seed is sown at between 1 and 1.5 kg/ha in 75 cm rows and then plants are thinned to 20-25 cm apart in the row for seed production (Hawthorn and Pollard, 1954). There was no significant difference in seed yield between row spacings of 15, 30 and 60 cm and sowing rates of 2, 4 and 8 kg/ha (Hare and Rolston, unpub. data). Until further research is conducted on Puna chicory it is recommended that 2-3 kg/ha of Puna be sown in shallow drills (1-2 cm depth) 30 cm apart.

Highly fertile soils do not appear to be necessary for Puna seed production. Seed crops at Grasslands Division, DSIR, have received 60-80 kg N/ha in September but no research has been conducted to test responses to nitrogen fertilizer.

Weed control

No detailed studies on weed control in Puna chicory have been made, but at Grasslands Division weeds have been controlled in the seed fields through grazing, mowing and applying herbicide.

Propryzamide (0.5 kg a.i./ha), atrazine (0.5 - 1.0 kg a.i./ha) and paraquat (0.4 kg a.i./ha) have been used in mid-winter to control a range of grasses and broadleaf weeds without any harmful effects to spring or autumn sown chicory. Asulam (1.6 kg a.i./ha) gave good control of docks (*Rumex* spp.) in early spring, but caused some slight yellowing and checked the growth of Puna chicory plants, although these symptoms soon disappeared. Docks are a very serious weed as the seeds are very difficult to separate out during seed cleaning and docks must be controlled to meet Seed Certification standards.

In the Waikato in witloof chicory, Burney *et al.* (1982) got good control of weeds (*Solanum nigrum, Portulaca oleracea, Amaranthus powellii, Polygonum persicaria, Digitaria sanguinalis, Panicum dichotomiflorum* and *Eleusine indica*) through application of pre- and post-emergence herbicides. Four days after sowing in November propyzamide (3 kg a.i./ha) or chlorpropham (4.5 kg a.i./ha) were applied before emergence and then nitrofen (2 kg a.i./ha) was applied three weeks after sowing (post-emergence) when the plants were in the two true-leaf stage.

In Europe weeds are controlled in chicory crops using carbetamide, propryzamide and asulam all together at pre-planting or pre-emergence and chlorpham is applied at pre-emergence (Himme *et al.*, 1986, Stryckers, 1983).

Thistles are very difficult to spray in chicory fields and grubbing by hand is the most effective control measure.

Pests

In some seasons aphids and tomato fruit worms (*Heliothis armigera conferta*) infested Puna chicory seed crops particularly during flowering (November through to January). Whether these pests cause serious losses of seed is not known, as both pests have been controlled with a single application of dichlorvos (0.6 kg a.i./ha). No other pests have been reported in Puna chicory seed crops.

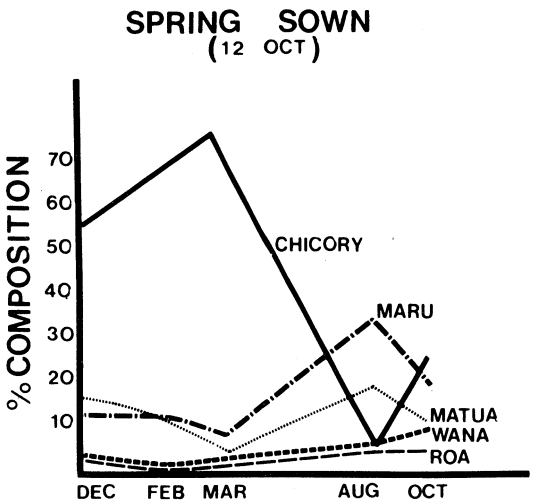

Figure 1. Percentage composition of a mixed pasture sward in first year after establishment (after Lancashire and Brock, 1983).

Defoliation and closing date

After grazing in May, Puna does not produce enough dry matter in the winter to warrant any defoliation until late August. Seed crops of Puna chicory can be grazed in the spring until the beginning of October without any decrease in seed yield (Hare and Rolston, 1987). Defoliating Puna chicory after October severely reduced seed yields (Table 4). The plant growth regulator paclobutrazol (PP333) had no effect on seed yields (applied at 1.0 and 2.0 kg a.i./ha) (Hare and Rolston, 1987).

Flowering, pollination and seed development

Flowering in Puna chicory commences in early December and continues over several weeks, peaking in late December-early January (Figure 2). The pale-blue ray flowers open in the early morning and are closed by mid-afternoon after cross-pollination by honey bees (Rumball, 1986; Hare, 1986). Puna seems to be largely cross pollinated, as are the cultivars grown to produce witloof (George, 1985), but some self-pollination may occur (McGregor, 1976). However, in trials using honey bees as pollinators, seed yields of witloof chicory were six times higher than yields from self pollinating crops (Davidovich and Davydova, 1947). Chicory is a good source of pollen and nectar for honey bees, and produces a yellowish-green honey (McGregor, 1976).

Studies of seed development showed in the Manawatu seed maturity of Puna occurred 20 days after pollination (Hare, 1986). This period may be up to 40 days longer in areas where night temperatures are cooler (Ayra and Saini, 1984). Seed colour is a good indication of seed maturity (Hare, 1986), turning from a light brown-fawn to a deep brown at maturity. Thousand seed weights for chicory are 1.2 to 1.5 g (Hare and Rolston, 1987), and when germinated at 20-25^{0}C seed sprouts within a day (Rumball 1986).

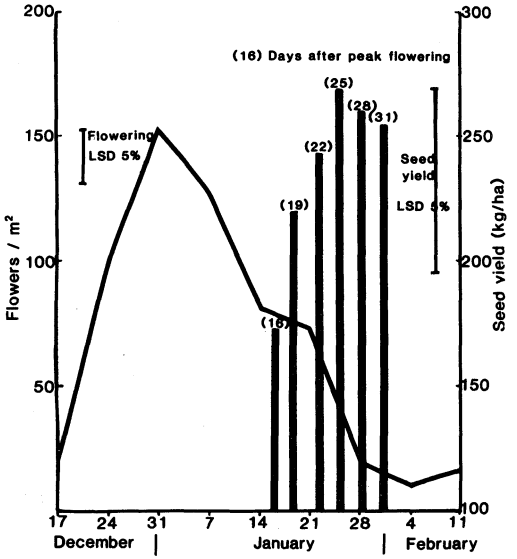

Figure 2. Flowering pattern of Puna chicory and seed yields from 16 to 31 days after peak flowering (Hare 1986).

Harvest time and harvesting

Puna chicory has an indeterminant flowering, so that plants bear ripe seed and blue flowers at the same time. This makes it hard to judge the optimum time for harvest.

In France witloof chicory seed is harvested approximately 40 days after the first flowers appear (J. Aletru, FNAMS, Montpellier pers. comms.). In the Manawatu the cooler summer temperatures extend this period to about 60 days after the first flowers appears in early December and in early February plants are mown for harvesting.

Sequential seed harvesting in the Manawatu showed that harvesting 19 to 30 days after the peak flowering (which is equivalent to 49 to 60 days after the appearance of the first flower) did not affect seed yield, but that earlier harvesting of the seed 16 days after peak flowering (46 days after first flower appeared), significantly reduced yields (Figure 2, Hare, 1986). Seed losses occur if birds feed on the seed and after strong winds and heavy rain.

After mowing, Puna chicory seed heads must be left lying in the field for up to two weeks. This curing process allows the marginally mature seed to mature and all seed to dry down from about 40% seed moisture at mowing to less than 15% seed moisture at threshing. The large hollow stems must also dry before threshing. In the Manawatu seed yields have increased from 200 to over 500 kg/ha in 1987 as knowledge of flowering patterns, closing dates, time of mowing and harvesting have increased.

After harvest the very fibrous crop residue should be burnt or removed from the field. This residue is too fibrous to be eaten by livestock or baled into straw. Two or three subsequent grazings of the crop are usually possible before winter.

MARKET POTENTIAL

Strong interest has been shown in Puna chicory in 1987 and the 1400 kg of seed produced by Grasslands Division in 1987 has been recently sold (R.D.J. Mather, General Manager Operations, Challenge Seeds Ltd pers. comm.). Farmers see the high dry matter production and drought tolerance of Puna in summer as important attributes.

Australian farmers have shown interest in chicory especially in areas where dry summers produce shortages of feed. Given chicory's natural growth in parts of Asia, North and South America and Mediterranean areas, Puna should have a place in pastoral livestock forage production systems in those regions. Puna is seen as having potential as a garden forage in those countries such as India, Taiwan, Thailand and Korea which have intensive cropping systems that allow for very little grazing land and rely on 'cut and carry' forage for livestock.

'Grassland Puna' will not only become an important perennial herb for New Zealand but it has the potential to play an important role in forage systems in temperate, mediterranean and tropical regions of the world.

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