Willow coppice and browse blocks: establishment and management

G..B. DOUGLAS[1], T.N. BARRY[2], N.A. FAULKNOR[3], P.D. KEMP[4], A.G. FOOTE[1], P.N. CAMERON[5] and D.W. PITTA[2]
[1]*AgResearch Grasslands, Private Bag 11008, Palmerston North*
[2]*Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Private Bag 11222, Palmerston North*
[3]*Hawke's Bay Regional Council, Takapau Road, P O Box 178, Waipukurau*
[4]*Institute of Natural Resources, Massey University, Private Bag 11222, Palmerston North*
[5]*Greater Wellington Regional Council, 34 Chapel Street, Masterton*
[1]grant.douglas@agresearch.co.nz

Abstract
Tree willow (*Salix matsudana* x *alba*) clone 'Tangoio' has potential as supplementary feed for livestock in summer/autumn drought. A trial was conducted in Hawke's Bay to determine the effect of planting stock (1.1 m stakes, 2 m poles) and cutting height (0.25, 0.5, 1.0, and 1.5 m) on edible (leaf + stem < 5 mm diameter) and total tree biomass in 2002 and 2003. Tangoio was also established progressively in high density (4,000–6,900 stems/ha) browse fodder blocks in Wairarapa using 0.75 m stakes, and the trees were browsed with sheep in summer 2003, when the blocks were aged 1–3 years. Total tree yield in all trials ranged from 0.12 to 2.29 t DM/ha/yr, of which 30-50% was edible. Trees cut to 0.5 m above ground often yielded more ($P < 0.05$) than those cut at 0.25 m. Tangoio established well in the browse blocks but its biomass was < 20% of that of the understorey pasture. Best management techniques for coppice and browse blocks are recommended.

Keywords: willow; supplementary feed; soil conservation; defoliation; tree-pasture systems

Introduction

Willows (*Salix* spp.) are receiving considerable interest in New Zealand as a useful supplement to pasture for feeding ruminant livestock (particularly sheep, cattle, and deer) in regions subject to drought in summer and autumn (Douglas *et al*. 1996; Moore *et al*. 2003). The foliage has good nutritional value (Kemp *et al*. 2001) which is similar to, but usually higher than that of pasture during drought, and livestock find a number of the commonly grown shrub and tree willows palatable. Willows are also potentially useful for controlling animal parasites (F. Gordon, personal communication) because of their height growth and perhaps chemical composition, which extends their applicability to non-drought regions.

Willow fodder can be supplied to livestock on farms by 1) cutting some or all of the foliage of existing, variously aged, widely spaced (usually 10–30 stems/ha) trees, planted mainly for soil conservation purposes; or 2) establishing and managing special-purpose fodder blocks, which may be coppiced or browsed. In coppice blocks the material is cut and carried to the livestock, or cut and left in the block for subsequent browsing. In browse blocks, livestock harvest the foliage directly, but some coppicing may be conducted in the block as part of the post-browsing clean-up programme. Both fodder block types invariably comprise trees at much higher densities (1,500–30,000 stems/ha) than those used in plantings for soil conservation.

Several species/clones of willow have been evaluated in trial fodder blocks (Douglas *et al*. 1996; Hathaway 1986; McCabe & Barry 1988), with the most promising being the tree willow hybrid *Salix matsudana* x *alba* clone ‘Tangoio’. This clone is palatable and productive, has good nutritive value, is one of the most drought-tolerant of the willows, and is readily available from a number of nurseries. Other species/clones which have some potential in fodder blocks include *S. kinuyanagi*, *S. matsudana* x *alba* ‘Wairakei’, and *S. viminalis* ‘Gigantea’. Recently, large blocks (1–4 ha) of Tangoio and *S. kinuyanagi* have been established on commercial farms.

Establishment of fodder blocks can be achieved by vertically planting cuttings, referred to as ‘wands’ or ‘stakes’, which are often 1.0–1.2 m long, with diameters of 15–25 mm and 20–40 mm, respectively (van Kraayenoord *et al*. 1986). However smaller cuttings (250 mm long, 10 mm diameter) have also been used in plantings in cultivated soil (Hathaway 1980). It is hypothesised that longer planting material e.g. 2 m ‘poles’, with more potential growing points and greater potential energy reserves for shoot growth, could enhance yield per tree, and per hectare. For most cutting lengths, farmer and land manager experience has shown that a quarter to one-third burial provides satisfactory plant survival and growth in a range of environments, but there are few quantitative data to support this.

Yield of willow fodder blocks ranges from 2.7 to 30.8 t dry matter (DM)/ha/yr depending on plant parts measured (variable stem sizes), plant age and stocking rate (stems/ha), site (e.g. soil type and fertility) and climatic conditions, and harvesting cycles (Hathaway 1980, 1986). Under a range of cutting heights and cutting frequencies at dry and moist sites, total biomass of Tangoio (2,700 stems/ha) above cutting height averaged 1.2–4.3 t DM/ha/yr, of which about 25% was edible (Douglas *et al*. 1996).

This paper describes recent research experience with establishment and management of Tangoio willow in coppice and browse fodder blocks on farms in the southern North Island. The reported coppice block trial aimed to determine the effect of different planting stocks and subsequent cutting height on tree biomass. Large browse blocks have been established for sheep grazing trials and relevant plant data from these trials are presented. Best establishment techniques and management practices for both types of fodder block are recommended.

Materials and methods

1. Coppice block

Site and experimental design

This trial was located on a private sheep and beef farm near Takapau in central Hawke's Bay, on a flat run-off adjacent to a stream. Resident vegetation comprised mainly perennial ryegrass (*Lolium perenne*), white clover (*Trifolium repens*), buttercup (*Ranunculus* spp.), and dock (*Rumex* spp.), and was hard-grazed before planting. Thereafter, livestock were excluded by fencing.

Treatments were:

1. Planting stock
   - 1.1 m stakes (mean diameter of 20 mm at one end and 28 mm at the other).
   - 2.0 m poles (19 mm and 33 mm diameter).

2. Cutting height
   - 1.1 m stakes cut horizontally at 0.25 and 0.5 m above ground.
   - 2.0 m poles cut horizontally at 0.25, 0.5, 1.0, and 1.5 m above ground.

The treatments were arranged in a split-plot design (main plots of planting stock; sub-plots of cutting height) in three randomised complete blocks. The experimental unit was the sub-plot which comprised one row of four poles/stakes at 2 m spacing. Distance between sub-plots was 3 m, and the 2 x 3 m spacing in the trial was equivalent to about 1,670 stems/ha. The 1.1 m stakes and 2 m poles were planted to a depth of 0.5 m on 5 September 2000. Planting depth was standardised so that the above-ground growth responses measured later could be attributed more directly to the cutting height treatments. Planting was conducted immediately after removal of pasture turves (50 x 200 x 200 mm) to reduce herbage (understorey vegetation) competition. Herbicide (glyphosate) application and manual removal of herbage were conducted as required during the trial.

Cutting height treatments were imposed on 1 August 2001, and comprised removal of all branches.

Plant measurements

Regrowth in the 2001/02 season was assessed for several attributes on 7 March 2002. The number of live trees was counted and the length of the longest regrowth shoot per tree, and the maximum canopy diameter (measured perpendicular to the original planting row), were measured. One tree per sub-plot was harvested to the original cutting height to determine the dry matter (g/tree) of edible fodder (leaf + stem < 5 mm diameter) (Douglas *et al*. 1996; Oppong *et al*. 2001), woody stem (at least 5 mm diameter), and total plant material, from which the percentage of edible fodder per tree was calculated. Remaining trees in each sub-plot were cut to their respective original heights. Tree regrowth in the 2002/03 season was assessed using the same methods on 24 March 2003.

Data were analysed using analysis of variance and mean separation across all treatments was achieved using the Least Significant Difference test at the 5% significance level. Orthogonal linear contrasts were used to test the significance of differences in response between treatment subsets such as 0.5 m vs 0.25 m cutting height.

2. Browse blocks

Site and planting details

Blocks were established in Wairarapa at Massey University's Riverside Farm, 15 km north of Masterton, and on a private sheep and beef farm, 'Fernglen', at Homewood on the east coast. The site at Riverside Farm was an undrained, rush-infested swamp, with negligible pasture production. The Fernglen site was similar except that it had few rushes and a thick cover of cutty grass (*Carex germinata*).

A total of 4 ha across three blocks was established at Riverside Farm in staggered plantings in winter 2000 (1 x 2 ha block) and winter 2001 (2 x 1 ha blocks), and 1.6 ha was planted in one block at Fernglen in winter 2002. Site preparation comprised killing or retarding growth of existing vegetation by spraying glyphosate by bike or by helicopter in March/April each year, sometimes burning, and ripping the land before planting in July/August. Planting stock comprised 0.75 m long stakes which were planted at 1.2 x 1.2 m spacings at Riverside Farm (6,900 stems/ha) and 1.2 x 2.0 m spacings at Fernglen (4,100 stems/ha), at a depth of 0.4 m. At Riverside Farm, the first block was planted in clone 'Moutere', another *Salix matsudana* x *alba* hybrid, but thereafter, all material was 'Tangoio'.

The blocks at Riverside Farm were prepared for the first sheep grazing trial during summer/autumn 2003 by grazing them in April 2002 with sheep and cattle to reduce the height of the trees and to control grass. Trees were then cut with a scrub saw in May to 0.2–0.4 m height. During winter 2002, back-planting was conducted in one block to ensure a consistent tree density. Sheep grazed the blocks during winter to control pasture cover and by early spring, there was a good cover of both grasses and legumes (white clover and lotus (*Lotus uliginosus*)).

At Fernglen and Riverside Farm, sheep were excluded from the blocks when willow bud break commenced in mid-August 2002. During the trial at Fernglen, two sawfly (*Nematus oligospilus*) invasions occurred in the block, which were controlled with Orthene insecticide (a.i. acephate).

Across the 4 ha at Riverside Farm and 1.6 ha at Fernglen, 100 ewes grazed ten (Riverside Farm) or five (Fernglen) breaks, each lasting 7 days (Riverside Farm) or 11 days (Fernglen). Herbage allowance was 2.1 kg DM/ewe/day at Riverside Farm and 2.5 kg DM/ewe/day at Fernglen. The Riverside Farm trial was conducted from 15 February to 30 April 2003, and the trial at Fernglen went from 20 February to 18 April 2003.

Plant measurements

Biomass of pasture and trees in the three blocks at Riverside Farm, and the single block at Fernglen, was determined. All foliage (leaf and stem) of four randomly selected willow trees per break was harvested before grazing, and another four trees were harvested after grazing. Pasture herbage, pre- and post-grazing, was sampled to ground level within eight quadrats (300 x 600 mm) per break, and washed. All tree and herbage samples were oven-dried (24 hrs at 80°C).

Mean biomass of the tree and pasture components in each browse block was calculated as kg DM/ha, and tree biomass was expressed as a percentage of total biomass (tree + pasture).

Results

1. Coppice block

Tree survival across all treatments averaged 93% in March 2002 and 90% in March 2003. The treatment comprising 1.1 m stakes cut 0.5 m above the ground had the lowest survival of 75% in both years, although it was not significantly different from survival in the other treatments. Poles cut 1.0 and 1.5 m above the ground were the only treatments with 100% survival.

The longest regrowth shoot in each season was produced by 2 m poles cut 0.5 m (2002) or 1.5 m (2003) above the ground (Table 1). Across both planting stocks, material cut to 0.5 m produced longer ($P < 0.001$) regrowth shoots than material cut at 0.25 m above the ground, and this was most pronounced for the 2 m poles. For example, in 2003, 2 m poles produced 1.1 m longer shoots at cutting height 0.5 m compared with 0.25 m, whereas 1.1 m stakes cut at 0.5 m height had shoots 0.3 m longer than at cutting height 0.25 m.

The widest canopies were almost 2.0 m in 2002 and about 1.0 m in 2003 (Table 1). For planting stock cut to 0.25 m and 0.5 m, in 2002, trees established from 2 m poles were about 0.3 m wider ($P < 0.001$) than those established from 1.1 m stakes. In 2003, diameter growth of both plant stocks was similar. In both seasons, trees from stakes and poles cut to 0.5 m above the ground produced wider canopies ($P < 0.05$) than those cut to 0.25 m.

Table 1. Longest shoot and canopy diameter of the regrowth of variously coppiced Tangoio willow trees near the end of the 2001/02 and 2002/03 growing seasons in central Hawke's Bay.

Stake/pole length (m)	Cutting height (m)	---------- 7 March 2002 ----------		---------- 24 March 2003 ----------	
		Longest shoot (m)	Canopy diameter (m)	Longest shoot (m)	Canopy diameter (m)
1.1	0.25	2.0	0.9	1.5	0.9
1.1	0.5	2.2	1.3	1.8	1.0
2	0.25	1.9	1.2	1.0	0.6
2	0.5	2.8	1.7	2.1	1.1
2	1.0	2.5	1.8	2.6	1.3
2	1.5	2.4	1.8	2.9	1.2
LSD (5%) for individual means		0.8	0.4	1.0	0.6
Prob. 1.1 vs 2.0m[1]		0.115	0.001	0.576	0.394
Prob. 0.25 vs 0.5m[2]		0.001	0.001	0.003	0.014

[1] Linear contrast across 0.25 and 0.5 m cutting heights
[2] Linear contrast across 1.1 and 2.0 m planting stocks

Total yield was highest for trees in 2002 established from 2 m poles cut 0.5, 1.0, and 1.5 m above the ground, and it averaged about 1,400 g DM/tree (Figure 1a). Across all cutting and plant stock treatments, average yield in 2002 (927 g DM/tree) was over twice ($P < 0.001$) that in 2003 (401 g DM/tree). In 2002, yield of both plant stocks was similar when cut to 0.25 m, but when cutting height increased to 0.5 m, the trees established from 2 m poles produced significantly more than those established from stakes. In 2003, total yield of stakes cut to 0.25 and 0.5 m was similar to that of the 2 m poles cut to the same height. Across both seasons and planting stocks, trees cut at 0.5 m height produced higher ($P < 0.05$) total yield than those cut at 0.25 m, except for the 1.1 m stakes in 2002, when yields from both cutting heights were similar.

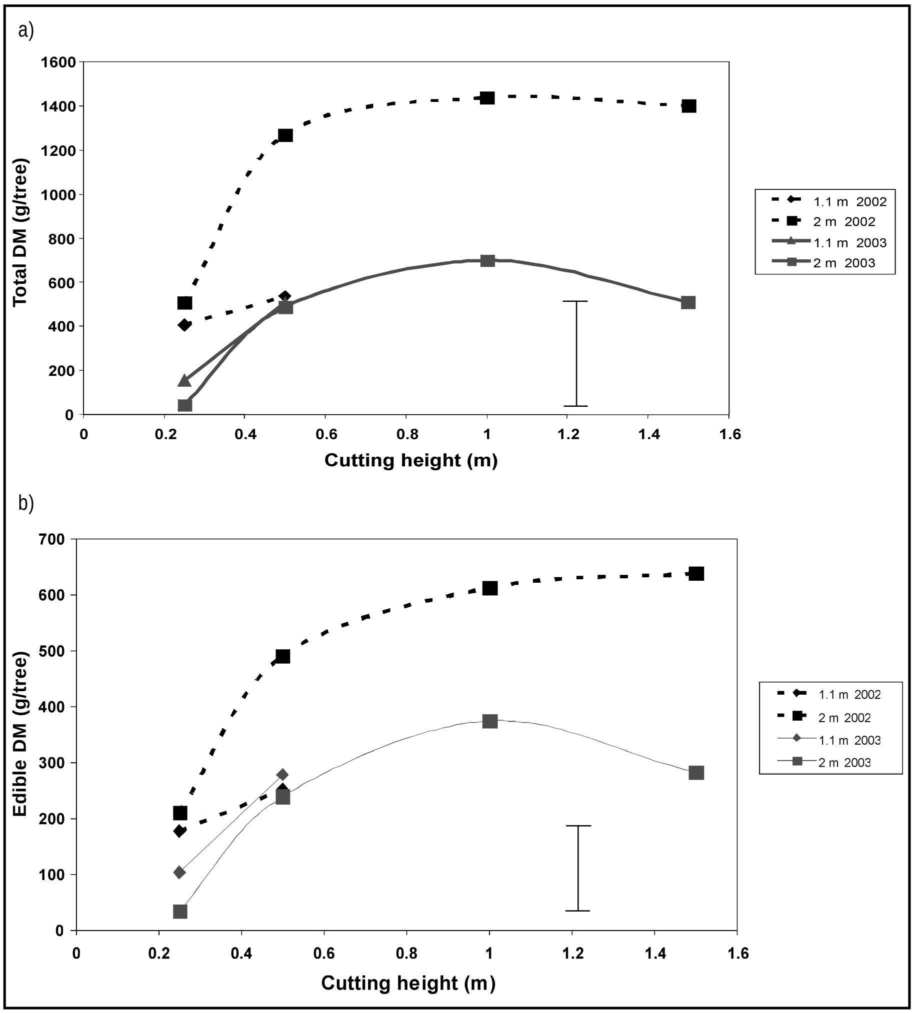
Edible yield per tree followed the same trends as total yield (Figure 1b). In 2003, the edible fraction averaged 61% of total yield, which was higher ($P < 0.05$) than the 44% in 2002.

2. Browse blocks

The biomass of trees in all blocks before grazing was less than 900 kg DM/ha, and it comprised 2 to 14% of the total biomass in the willow-pasture system (Table 2). Tree biomass and its contribution to total biomass in the system increased significantly with tree age, particularly between trees aged two and three years.

Grazing by sheep resulted in a utilisation of tree biomass of 32% (Block 1) and 33% (Blocks 2 and 3) at Riverside Farm, and 42% at Fernglen. By comparison, the pre-graze pasture mass of 5.0 to 7.3 t DM/ha at these sites was utilised 37–52% by grazing sheep.

Figure 1. Total (a) and edible (leaf + stem < 5 mm diameter) (b) regrowth biomass (g dry matter (DM)/tree/yr) of Tangoio willow in the 2001/02 (harvested 7 March 2002) and 2002/03 (24 March 2003) growing seasons in central Hawke's Bay. Bar is LSD (5%).



Discussion

This paper describes the potential value of 'Tangoio' willow in coppice and browse fodder blocks in the southern North Island, and provides guidelines on site selection, optimum planting stock, and block management. Different management (e.g. coppicing, browsing, harvest time, intensity of defoliation) may be practised

Table 2. Pre- and post- grazing herbage mass (kg DM/ha) of willow browse blocks in Wairarapa rotationally grazed with 100 ewes in summer/autumn 2003 (sample number = 4; standard deviation in brackets).

Site	Age of trees (yr)	Pre-graze			Post-graze		
		Pasture	Trees	% tree[1]	Pasture	Trees	% tree
Riverside Farm[2]							
Block 1	3	5570 (505)	886 (78)	14	2696 (161)	601 (49)	18
Blocks 2, 3	2	4964 (262)	324 (87)	6	3132 (126)	216 (37)	6
Fernglen[3]	1	7310 (565)	123 (15)	2	4239 (736)	71 (24)	2

[1] tree x 100/(tree + pasture); [2] trial conducted from 15/2 to 30/4/03; [3] trial conducted from 20/2 to 18/4/03

depending on tree fodder supply needs and reasons for its use. Management techniques adopted here were designed for tree feed utilisation during drought in late summer/early autumn, principally by sheep.

Sites selected for the fodder blocks in Hawke's Bay and Wairarapa were located in areas of the farm that were unproductive compared with adjacent resident grazed pasture. In Hawke's Bay, the coppice block was established on a run-off which had numerous herbaceous species, whereas in Wairarapa, browse blocks were established in swamps that were covered with thick stands of rushes/cutty grass. These areas were selected for willow planting because they had negligible productive and economic use, and therefore had potential for the greatest improvement. Other areas of farms which support good pasture growth could produce higher-yielding willow fodder blocks, but the economics and practicality of such an approach require close scrutiny.

Understorey herbage was controlled with herbicides and/or manual removal before planting in all blocks, but these methods were only continued in the coppice block in Hawke's Bay because the trial aimed to determine the potential growth of Tangoio willow in the various treatments. For the relatively few trees involved, this was a simple method which did not damage the trees, and it ensured that tree growth was not limited by understorey growth. In contrast, in the much larger blocks in Wairarapa, cattle and sheep were used to control subsequent herbage growth, which is a more practical option in this context because it is cheaper (no chemical and application costs), high plant densities hinder easy movement through the stands, and farmers generally find grazing more acceptable. However, in this system there was some damage to trees, particularly those in blocks planted earlier, because best livestock management was uncertain. As experience increased, herbage control improved and tree damage was reduced. Since complete herbage control was not achieved, potential yield of the trees was unable to be determined.

The browse blocks in Wairarapa were designed to supply drought feed for ewes during mating in late summer/early autumn. To achieve good control of the remaining, and subsequent tree and understorey vegetation, limited experience has found that follow-up grazing by cattle in autumn, followed by slight manual topping, and then sheep grazing during winter and early spring, has been satisfactory. These guidelines will be refined with further experience in Wairarapa and elsewhere. Achieving effective herbage control needs to be balanced with minimising damage to essential tree growing points/shoots.

Within one or two years of planting the blocks in Wairarapa, the sites had dried significantly compared visually with neighbouring similar areas without willow plantings. Furthermore, the planted sites had developed a cover of desirable forage species (grasses, white clover and lotus), which more than compensated for the low yield of the trees. Willows are renowned for their high water use (Grip *et al*. 1989; Ledin 1998) and it is suggested that their drying effect was responsible for the development of the forage species. A challenge is to achieve good long-term growth of the willow trees and better nutritive value in the herbaceous understorey.

Trees in Hawke's Bay were aged 1.5 years in March 2002 and 2.5 years in March 2003, compared with about 0.7 years (Fernglen) to 2.5 years (Riverside Farm, Block 1) in Wairarapa. The results in Wairarapa indicated an increase in willow DM with age, by a factor of about 2.6 per year, but the results were confounded with differences between sites, particularly weather (e.g. Fernglen warmer than Riverside Farm). At Riverside Farm, blocks of trees of two ages were adjacent to each other, and hence subject to the same weather, which provided stronger evidence for the effect of tree age on willow yield. In Hawke's Bay, the trend differed from that in Wairarapa, with (older) trees in 2003 yielding about 50% less than those in 2002 for most treatments. The 2002/03 season started later than the 2001/02 season, mainly because of a cold spring, and this was probably the predominant cause of the yield depression. An experiment comprising different tree ages is required to isolate the effects of tree age from those of weather.

Total yield of trees from winter to the following autumn varied from 0.12 t DM/ha at Fernglen, to 2.29 t DM/ha (assuming 1,670 stems/ha) for trees grown from 2 m poles in Hawke's Bay, in March 2002 (average of those cut to 0.5, 1.0, and 1.5 m above ground). The results indicated a significant advantage from using 2 m poles as planting stock where growing conditions were favourable (2001/02), and that yield from cutting them to 0.5 m was similar to that from cutting them at 1.0 and 1.5 m. Poles of 2 m length may be at least twice the cost of 1.1 m stakes, but the March 2002 results suggest that the yield benefits from their use may outweigh the extra start-up cost incurred in their use. Also, the discarded material from cutting the 2 m poles could be used for backup plantings. Studies to determine the effect of plant stock diameter on willow establishment and growth, in addition to cutting length investigated here, have commenced recently in Manawatu.

It is not possible to validly compare the results obtained in Wairarapa with those in Hawke's Bay because of the different planting stocks (at least length), planting depth and density, and management. The closest comparison that can be made is between the 0.75 m stakes used in Wairarapa, with 0.4 m above ground, and the 1.1 m stakes in Hawke's Bay, which were cut 0.25 m or 0.5 m above the ground. Across both seasons in Hawke's Bay, cutting stakes to 0.25 m gave total yield of 468 kg DM/ha, of which 235 kg DM/ha (50%) was edible, and stakes cut to 0.5 m had total yield of 873 kg DM/ha (edible 443 kg DM/ha; 51%). The total yield of trees in Block 1 at Riverside Farm was 886 kg DM/ha, which was very similar to the average yield of trees cut to 0.5 m in Hawke's Bay. Yields achieved in these trials were at the lower end of estimates from earlier studies (Douglas *et al*. 1996; Hathaway 1980, 1986), probably because of differences in a range of plant, management, and climatic variables.

Stem diameter in the edible biomass was constant in the Hawke's Bay coppice trial (< 5 mm diameter) but varied in the Wairarapa browsing trials. The utilisation of tree DM at Riverside Farm following grazing, for example 285 kg DM in Block 1, which was 32% of total yield, involved removal of similarly sized material by the sheep, but also some stem of larger diameter. Eating progressively larger willow stem, for example up to 8 mm diameter, can occur with cattle, due partly to the time taken to become accustomed to the fodder (Moore *et al*. 2003).

The information gathered in these trials will enable economic analyses to be conducted of coppice and browse systems. These will assist farmers to evaluate the suitability of fodder blocks in their livestock enterprises.

Recommendations

- Coppice and browse fodder blocks should be established on parts of the farm that have negligible pasture production in the undeveloped state.
- Swamps should be planted in willow to dry the site and encourage regeneration of desirable pasture species. This is providing water harvesting and supply are not issues.
- Stakes or poles should be managed to have an above-ground height of at least 0.5 m.
- Effective herbage control through grazing management and/or herbicides is recommended to encourage satisfactory tree growth.
- Following sheep grazing during late summer/early autumn, browse blocks should be grazed by cattle (dry cows preferred) in late autumn to further reduce stem height, followed by manual topping to the desired height, and then sheep grazing during winter and early spring to control the herbage.

Acknowledgements

Jeff Ravenwood (Homewood), Steve Wyn-Harris (Takapau), and Riverside Farm for land; Greater Wellington and Hawke's Bay Regional Councils for stakes/poles; Geoff Purchas, Colin Morgan and Nathan Crombie for technical assistance at Riverside Farm.

References

Douglas, G.B.; Bulloch, B.T.; Foote, A.G. 1996. Cutting management of willows (*Salix* spp.) and leguminous shrubs for forage during summer. *New Zealand Journal of Agricultural Research 39*: 175–184.

Grip, H.; Halldin, S.; Lindroth, A. 1989. Water use by intensively cultivated willow using estimated stomatal parameter values. *Hydrological Processes 3*: 51–63.

Hathaway, R.L. 1980. Effect of planting density and harvesting cycle on biomass production of willows. Internal report no. 16. National Plant Materials Centre, Aokautere Science Centre, Ministry of Works and Development, Palmerston North. 6 p.

Hathaway, R.L. 1986. Short-rotation coppiced willows. *Growing Today, August*, 18–19.

Kemp, P.D.; MacKay, A.D.; Matheson, L.A.; Timmins, M.E. 2001. The forage value of poplars and willows. *Proceedings of the New Zealand Grassland Association 63*: 115–119.

Ledin, S. 1998. Environmental consequences when growing short rotation forests in Sweden. *Biomass and Bioenergy 15*: 49–55.

McCabe, S.M.; Barry, T.N. 1988. Nutritive value of willow (*Salix* sp.) for sheep, goats and deer. *Journal of Agricultural Science (Cambridge) 111*: 1–9.

Moore, K.M.; Barry, T.N.; Cameron, P.N.; Lopez-Villalobos, N.; Cameron, D.J. 2003. Willow (*Salix* sp.) as a supplement for grazing cattle under drought conditions. *Animal Feed Science and Technology 104*: 1–11.

Oppong, S.K.; Kemp, P.D.; Douglas, G.B.; Foote, A.G. 2001. Browse yield and nutritive value of two *Salix* species and *Dorycnium rectum* in New Zealand. *Agroforestry Systems 51*: 11–21.

van Kraayenoord, C.W.S.; Wilkinson, A.G.; Hathaway, R.L. 1986. Nursery production of soil conservation plants. Pp. 149–160 *in*: Plant materials handbook for soil conservation vol 1: Principles and practices, Section 14, van Kraayenoord, C.W.S.; Hathaway, R.L. ed. Water and soil miscellaneous publication no. 93, National Water and Soil Conservation Authority, Wellington.

■