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**GROWTH, MANAGEMENT AND NUTRITIVE VALUE OF
WILLOWS (*SALIX* SPP.) AND OTHER BROWSE SPECIES IN
MANAWATU, NEW ZEALAND.**

**A THESIS PRESENTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF DOCTOR OF
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ABSTRACT

Pastoral farming in New Zealand depends mainly on the grazing of ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*). These pastures yield less during dry summers and farmers are then faced with feed shortages. This study revealed the potential of deciduous willows, *Salix matsudana* x *alba* and *Salix kinuyanagi* as useful supplementary fodder during dry summers. The species can be managed under cut and carry or *in situ* browsing systems. The use of the *Salix* spp. as drought fodder is a viable option for pastoral farmers to assist them to overcome pasture feed shortages while maintaining their role in conserving soil.

Three experiments were conducted to determine (1) the effects of cutting height and frequency on browse yield and quality of deciduous *Salix* spp., compared with *Dorycnium rectum*, a small leguminous shrub and (2) the effects of planting stocks and fertiliser use on the yield and quality of the *Salix* species. Experiment 1, conducted at HortResearch, Aokautere (10 km from Palmerston North) demonstrated that edible dry matter (DM) yield of the *Salix* spp. and *D. rectum* was uninfluenced by stump height and frequency of harvest. *S. matsudana* x *alba* outyielded *S. kinuyanagi* and *D. rectum*. The *in vitro* organic matter digestibility (OMD) and nitrogen (N) concentration of the three species were: *S. matsudana* x *alba* (670 g kgDM⁻¹ and 21 g kgDM⁻¹), *S. kinuyanagi* (613 g kgDM⁻¹ and 18 g kgDM⁻¹) and *D. rectum* (665 g kgDM⁻¹ and 22 g kgDM⁻¹). Experiments 2 and 3 were conducted at AgResearch Grasslands, Ballantrae (25 km from Palmerston North). Experiment 2 showed that unrooted stem cuttings produced as much foliage as rooted stem cuttings, and the former are recommended due to their cheaper establishment. *S. matsudana* x *alba* consistently outyielded *S. kinuyanagi* even though DM yields were lower than at Aokautere. Experiment 3 revealed that DM yields of the *Salix* species were unaffected by fertiliser application. The low DM yield at Ballantrae may be due to the effects of strong winds and low temperatures. At both Aokautere and Ballantrae, *S. kinuyanagi* (255 vs. 289 g kgDM⁻¹) had higher total condensed tannin concentrations than *S. matsudana* x *alba* (60 vs. 154 g kgDM⁻¹).

Two experiments were conducted at AgResearch Grasslands, Palmerston North to determine (1) the leaf lifespan and effect of leaf maturation on leaf quality of the *Salix* spp. and the legume *Chamaecytisus palmensis*, (2) the appropriate time to cut the *Salix* spp. to optimise regrowth and browse quality for summer use, and (3) the changes in non-structural carbohydrate reserves associated with defoliation. The long leaf lifespan of the *Salix* spp. (6.5 months) and *Chamaecytisus palmensis* (5.5 months) indicated that the green standing biomass could be retained until needed in summer. The leaves of the *Salix* species and *Chamaecytisus palmensis* declined in N concentration and other nutrients at 3 months, which was longer than for those of most herbaceous species (1-2 months) during most times of the year. Leaf N concentration in all three species at each harvest met the recommended level (17 g kgDM^{-1}) for a diet adequate for a lactating ewe rearing a lamb. *S. matsudana* x *alba* yielded 70% more DM than *S. kinuyanagi* when cut in mid-spring. Sucrose comprised over 90% of the total soluble carbohydrate concentration in the roots of *S. matsudana* x *alba* defoliated once and three times in the growing season.

Two experiments were also conducted at Massey University to determine (1) the effect of browsing intensity and frequency on the regrowth of the *Salix* spp. and *C. palmensis*, and (2) sheep preference for these browse species at different times of the growing season. Regrowth of *S. matsudana* x *alba* and *C. palmensis* was similar under heavy or light browsing whereas heavy browsing in *S. kinuyanagi* increased regrowth in woody stem and total DM yields. *S. matsudana* x *alba* was the preferred species. Sheep biting rate, percent time spent browsing species and preference rating of species were higher in summer than autumn for *S. matsudana* x *alba* and similar for *C. palmensis* in both seasons. For *S. kinuyanagi*, these variables were higher for autumn and almost zero for summer browsing.

The two *Salix* spp. will complement *C. palmensis*, when grown in moist sites, where *Chamaecytisus* trees have low survival. The *Salix* species under proper management will provide useful supplementary feed for livestock during summer.

GLOSSARY OF TERMS AND ABBREVIATIONS USED

Browse - leaves, soft stems and fruits or pods of woody plants that serve as animal feed.

Coppice-managed - woody plants cut low to encourage regrowth from remaining stem.

Leader - dominant shoot of regrowth after cutting or undefoliated growing plant.

Lopping - cutting one or more branches of a woody plant.

Monopodial growth - shoot growth that results from the expansion of terminal buds on the main axes and its branches.

Pollard - cut back the crown (canopy) of a tree for wood or browse so that regrowth is beyond browsing height, and to reduce shade cast by the crown.

Regrowth - shoots produced from the remaining stem (s) after defoliation.

Stump - woody stem remaining after cutting trees and shrubs.

Sympodial growth - shoot growth that results from secondary axes, rather than from the expansion of true terminal buds.

AOAC - Association of Official Agricultural Chemist

CAB - Commonwealth Agricultural bureaux

CT - Condensed tannin

DM - Dry matter

DMD - Digestible dry matter

ME - Metabolisable energy

N - Nitrogen

NDF - Neutral detergent fibre

NRC - National Research Council

NWASCO - National Water and Soil Conservation Organisation

OMD - Organic matter digestibility

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