Implications of tree management on poplar and willow pasture-tree systems

A thesis presented in partial fulfilment of the
requirements for the degree of

Doctor of Philosophy in Plant Science

Massey University, Palmerston North, New Zealand.

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2016

To Paty, Lily and Pau.

Abstract

Willow and poplar trees planted at wide spacing have proved their effectiveness as a biological method to control soil erosion in pastoral hill country. Due to lack of management, many trees aged 30^{+} years have grown very large (>60 cm diameter at breast height), resulting in excessive shading of understorey pasture. The large trees are also prone to breakage of branches and toppling during strong winds, potentially damaging farm infrastructure or injuring livestock.

Management of tree size can coincide with providing edible poplar and willow foliage as a source of supplementary fodder in summer droughts. Trees can be pollarded, involving total canopy removal, but the effects of pollarding on tree root dynamics are poorly understood.

This thesis evaluated the effect of the tree canopy removal on the root dynamics and root non-structural carbohydrate dynamics of pollarded mature willow and poplar trees and decapitated young willow and poplar trees grown from cuttings. Impacts of tree canopy removal when trees were at different phenological stages were also studied in pollarded mature willow trees and decapitated young willow and poplar trees. Finally, herbage accumulation under pollarded trees was contrasted with herbage accumulated under unpollarded (UP) trees and in open pasture sites (OP) away from direct tree influence.

Pollarding did not impose a unique impact on the root structure of mature willow and poplar trees. However some similarities were found in both species. For instance, pollarding had its main impact in the roots closest to the trunk and above 300 mm soil depth. In these root sections disrupted by pollarding, fine root length and mass of pollarded (P) trees were, one year after above-ground removal, from 2× to 4× less than equivalent unpollarded (UP) trees. However, one year after pollarding, pollarded trees recovered or maintained the initial fine root densities recorded in the same trees prior to pollarding.

The study conducted with young willow and poplar trees grown from cuttings showed that willow trees had a greater ability to recover from damage in the root structure after decapitation. Nine months after decapitation in early autumn, root mass of young willow decapitated trees was 57% greater than prior to decapitation and 64% less than non-decapitated (ND) trees. In contrast, within the same time frame, root mass of young poplar trees decapitated in early autumn was 80% less than ND trees and 52% less than the initial root mass recorded prior to decapitation. Greater resprouting ability of willow trees than poplar trees after decapitation was proposed as the cause for the greater resilience to decapitation observed in willow trees than in poplar ones.

Further evidence for a greater resilience to pollarding of willow trees was found in the root starch dynamics evaluated after tree canopy removal. Pollarded or decapitated willow trees (mature or grown from cuttings) were able to replenish their root starch concentrations similarly to UP or ND trees in the growing season following tree canopy removal. In contrast, both pollarded and

decapitated poplar trees (mature or grown from cuttings) had lesser root starch concentrations than intact trees one year after tree canopy removal.

Pollarding (P) or decapitation (D) at dormancy (DP or DD trees) showed no clear advantages in terms of the tree root structure maintenance or recovery after above-ground removal, over pollarding or decapitating the trees towards the end of the growing season in early autumn (AP or AD trees), when trees still had leaves. With mature willow trees, annual average fine root density (fRD) recovery of DP trees relative to pre-pollarding density was greater than annual average fRD recovery of AP trees. However, this difference was attributed to record moisture restrictions that disrupted the root growth of both AP and UP trees during the growing season following early autumn pollarding. Similarly, young DD and AD willow and poplar trees showed that four and a half months after decapitation, both treatment trees were able to recover or maintain initial root mass recorded prior to decapitation.

The study on herbage accumulation beneath pollarded trees, suggests that 4 years after being pollarded, P willow trees shaded pasture in a similar way to UP trees, as annual net herbage accumulation (NHA) attained in these two environments was statistically not different. Annual NHA under P and UP environments, were, respectively, 30 and 43% less than annual net herbage accumulation recorded in open pasture sites (4.9 t DM ha^{-1} yr^{-1}).

Ability of willow trees to recover, within the first year after pollarding or decapitation, initial root densities recorded prior to canopy removal, and to replenish root starch concentration similar to intact trees, suggests these trees could have pollarding cycles of 2 to 3 years. Short pollarding cycles could lessen herbage accumulation reductions on a pasture-tree stand level as more trees or more frequent repollarding is practised. However, results derived in this thesis from willow trees, need to be confirmed in at least two year lasting studies before recommending shorter pollarding cycles than currently advised of 3 or 4 years.

In contrast, poplar trees require longer pollarding cycles or higher tree stand densities if a pollarding program is instituted, as these trees were not able to recover within the first year after canopy removal, the root values recorded prior to pollarding and/or to replenish the root starch reserves

Acknowledgements

First and foremost I would like to express my sincere gratitude to my PhD supervisors. Dr Peter D. Kemp for his immense knowledge, endless kindness and patience during my studies and the most difficult times when writing this thesis, to Ian McIvor for his valuable knowledge and experience during the field works and experiments, and to Dr Grant Douglas for his analytical acuity, with an eye for detail that helped me to find the best way to analyse the data and information. Without their assistance and guidance this project would not have been possible.

I am also very grateful to the people who contributed in some many ways with the realization of this project. To Mark Osborne for logistics and field assistance. To Ian Furkert and Brian Best for gave me access to the laboratory and research facilities. Special thanks to Steve Ray, Lindsay Sylva and Lesley Taylor for their collaboration with the glasshouse study.

I want to thank very much to the Ennor Family, Rob, Jean, Trevor and Martin, for their invaluable assistance and access to their beautiful farm in the Central Hawke´s Bay.

My sincere thanks also goes to Denise Stewart, Denise Brunskill and Sheryll Curtis for their office support and kindness that made my PhD life easier during my stay in Massey University Campus.

I thank the Juarez Autonomous University of Tabasco (UJAT), the Programa de Mejoramiento del Profesorado (PROMEP-SEP), the Consejo Nacional de Ciencia y Tecnologia (CONACyT) and the Consejo de Ciencia y Tecnologia del Estado de Tabasco (CCYTET), for awarding me the scholarship grants and study leave to obtain the degree of Doctor of Philosophy.

Heartfelt gratitude goes to my Parents, my siblings and all my in-laws for all the support provided in every sense of the word, in all and the hardest moments of my studies.

There are not enough words to express all my gratitude and love to three very special people in my life, my wife Paty, and my two little daughters Lily and Pau, who enjoyed, but sometimes also withstood with me, this great adventure.

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Glossary and abbreviations

ANOVA: analysis of variance

Canopy: part of a tree above the trunk consisting of branches and foliage

Coarse roots (cR): roots with a diameter greater than 2 mm

Complete or total pruning: removal of all branches leaving intact the main stem single leader (mostly practiced in alley tree-crop systems)

Coppicing: cutting a mature tree at the base of the trunk at a height of 10-30 cm

DBH: tree diameter at breast height (1.40 m) over the bark

DM : dry matter

Fine roots (fR): roots with a diameter less than 2 mm

GLM: general lineal model

ha: hectare

Hill country: any land with slopes exceeding 15^0 and located below 1000 metres above sea level

kg: kilogram

LSD: least significant difference

m: metre

$\mathbf{m^{-3}}$:per cubic meter

Mass movement: erosion of soil or rock occurs when stresses (downslope component of gravity pulling soil down the slope, pore water pressure, loading by vegetation, seismic waves propagating through the soil) exceed resistances (in-slope component of gravity holding soil to the slope, friction and cohesion of soil particles, reinforcement by vegetation roots)

mm: millimetre

Mudstone: a sedimentary rock composed of silt and clay particles and weakly cemented together by a small quantity of lime.

N/A: not applicable

N/Av: not available

NHA: net herbage accumulation

NSC: non-structural carbohydrates

Open pasture (OP) hill country pastureland where trees were far away.

PAR: photosynthetically active radiation.

Partial Pruning: removal of branches at a particular height.

Pasture-tree system (PT): pastureland located on a steep slope in hill country where willow or poplar trees have been planted 10 to 15 m apart to each other as a way of biological control shallow landslides.

Pollarding: complete removal of tree canopy at a1.8 to 2.0 meter height above-ground

Pruning: removal of selected parts of the tree (as otherwise indicated, it was used for branches).

Root length density (RLD): length of the roots per unit volume of soil.

Root mass density (RMD): dry mass of the roots per unit volume of soil.

Sandstone: a sedimentary rock composed of sand grains, compacted and weakly cemented by a small quantity of lime.

SAS: statistical analysis system.

Thinning: the removal of some of the trees within a stand at some time after being planted with purposes of reducing tree stand density.

Wide-spaced tree planting: Trees that are planted 10 to 15 m spaced apart to each other.