Plant & Food Research
Rangahau Ahumāra Kai

RESEARCH BRIEF 06

Willows affect pastoral soil properties

Summary

- Willow trees planted for soil conservation confer beneficial effects on the soil through canopy litter, roots and shade.
- **Soil water content** was higher closer to the tree – this may have been due to reduced transpiration from the grass, greater infiltration of rain closer to the tree, less runoff, and/or rain flowing down the tree trunk.
- **Soil bulk density** was lower closer to the tree – lower bulk density soil allows for greater water infiltration, greater water storage capacity, and easier root penetration by pasture plants.
- **Total soil nitrogen** decreased with distance from the tree – inputs to soil N may be from leaf litter, or from camping animals.
- Soil N is an important plant nutrient.
- **Total soil carbon** decreased with distance from the tree – higher carbon content improves soil fertility and water storage.
- **Total organic carbon and total organic N** show the same trends as total C and N – organic sources of C and N are contributed by leaf litter and root exudates from the tree.
- Tree roots generally run laterally and act as conduits for the infiltration and distribution of rainfall.
- Apparent tree effects on soil properties are observable down to 30 cm depth, in contrast to pasture effects.
- These effects are equally likely under poplar trees.
- These benefits are additional to those of soil stabilisation, shade, shelter and fodder.
- While there is need to support the results here from other New Zealand research findings, such soil benefits have been reported from the addition of trees to agroforestry arable systems in other regions of the world.

Soil properties

Soil organic carbon is important for soil quality because it helps retain soil moisture; gives good soil structure for water movement and root growth; is a food source for soil organisms; helps retain contaminants; degrade wastes; and is a source and store of plant nutrients. Soil carbon is also held in minerals such as carbonates, which together with organic carbon make up total soil carbon.

Nitrogen is generally the most important growth-limiting nutrient in pastoral production systems. The nitrogen taken up by pasture and trees is derived from a number of sources, particularly from fertilisers and the mineralisation of soil organic matter and manures. Total soil nitrogen includes mineral N forms such as nitrate and ammonium, and **nitrogen in organic matter** in the form of proteins and other compounds. Only about 5–15% of the N in organic matter is readily mineralisable as a plant nutrient.

Gravimetric water content (GWC) provides an insight into how water is being retained or where water is being lost from the soil at a point in time. Interpretation of GWC values is not easy, since rainfall, evapotranspiration, soil temperature, and other environmental conditions all have an impact on soil moisture in the short term. However, it is possible to hypothesise why there might be spatial trends in GWC.

Soil bulk density is a measure of the mass of soil per unit volume. About half the volume of a block of soil is voids filled by air and water. These voids are important for water storage, drainage characteristics, and to allow air to move into the soil for respiration of plant roots and soil organisms. When bulk density increases a soil is compacted, voids are crushed and drainage, water storage and aeration decline. This restricts root growth and nitrogen fixation, amongst other things.

Methods

Study location

The study was conducted in December, 2010, on a sheep and beef farm located approximately 10 km SSW of Waipukurau in Central Hawke's Bay (latitude S 40.15°, longitude E 176.4°, altitude 166 m.a.s.l.). The study site had an approximate 14° slope with a sandy loam soil. Willow trees were 13 years old, 36–39 cm diameter, and with a canopy radius of 4–6 m. Of the willow trees at the study site, some were pollarded and some were unpollarded (Figure 1). Only unpollarded trees were used for the study.

Transects from three willow trees were marked out, in a direction where no other trees were within 10 m of the transect. Intact soil samples taken at 1, 2, 3, 4, 5, 7 and 10 m from the trunk. Transects ran in a SW direction to reduce the impact of stock camping and shading. Three replicate soil samples were taken from 0–15cm depth and 15–30cm depth at each distance on each transect. The soil samples were analysed for bulk density, and GWC, total carbon, total nitrogen, total organic carbon, and total organic nitrogen. Differences in the various parameter means were compared using analysis of variance (ANOVA) for the effects of distance from tree and depth.

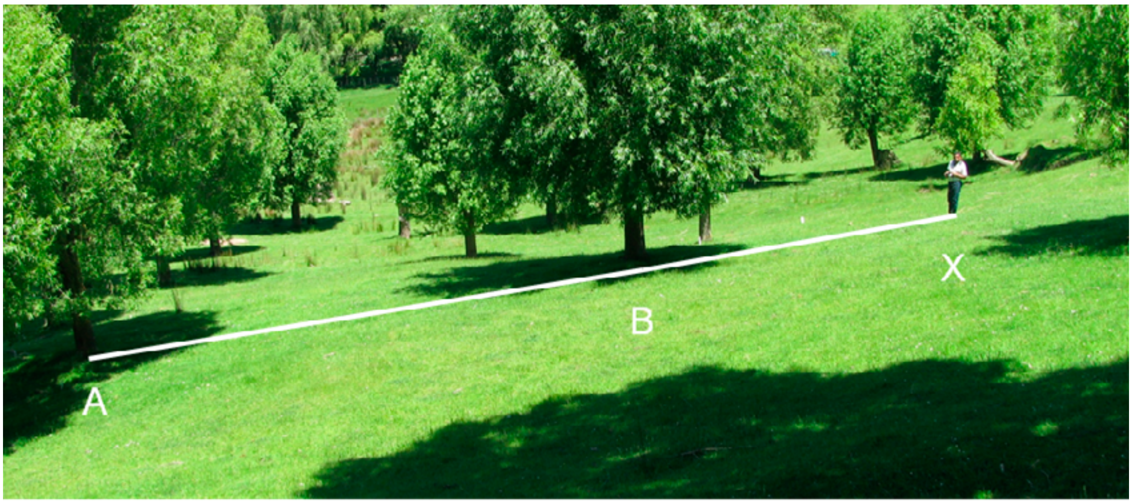


Figure 1. Pastoral hill country farm used, located approximately 10 km SSW of Waipukurau, Central Hawke's Bay

Results and discussion

Gravimetric Water Content

GWC declined moving out from the trunk until beyond the canopy (Figure 2, left). Differences were not statistically significant.

Bulk density

There was significant (SE=0.004) increase in bulk density (BD) with increasing distance from the base of the tree (Figure 2, right). Lateral willow roots lift the soil as they grow, which may explain BD being lowest where root density was highest. Another factor reducing BD may have been increased organic matter content close to the base of the tree, as indicated by the trends in nitrogen and carbon content (Figures 3 and 4). Soil BD decreases as organic matter content increases when variation in other factors such as structure and texture are minimal, and BD is often higher in areas visited more regularly by stock, such as feeding and camping areas (Mulholland & Fullen 1991).

Soil sampling – a dirty business

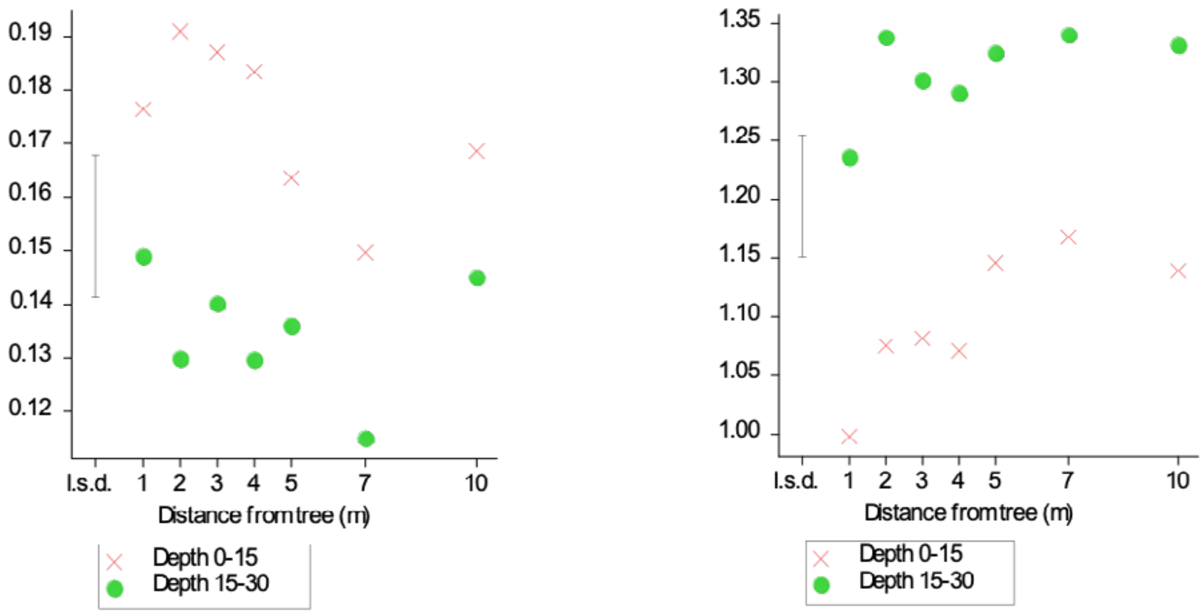
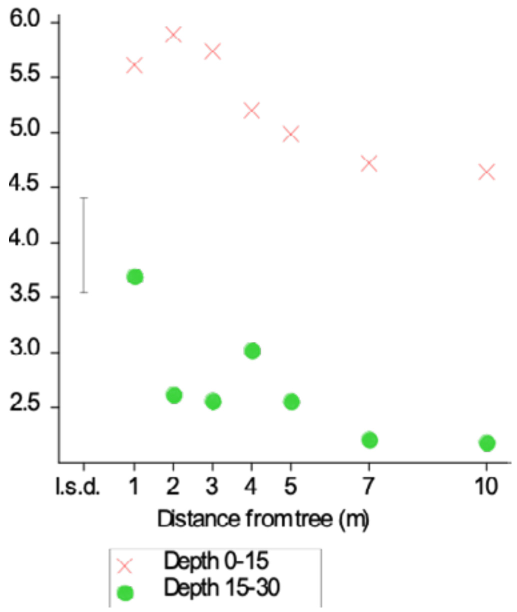


Figure 2. Soil gravimetric water content (GWC) (left) and soil bulk density (right), with distance from the base of willow at 0–15 and 15–30 cm depths.

Total carbon and total nitrogen

There was a significant decrease in total nitrogen (SE=0.027) and a decrease in total carbon (SE=0.37), with values falling 0.136 t/ha and 1.51 t/ha per metre, respectively (Figure 3), moving from the willow trunk. The higher soil organic matter closer to the base of trees is probably due to greater addition of leaf litter, and root residues from the trees. The influence of stock camping cannot be discounted, as it is likely to result in greater manure deposition. However, Wilson (2002) found consistently lower organic content under trees in stock paddocks than in non-stocked paddocks. Other studies (e.g. Young 1989) have indicated that soil organic matter is increased in pastoral situations by the presence of trees.

Soil cores tell a story



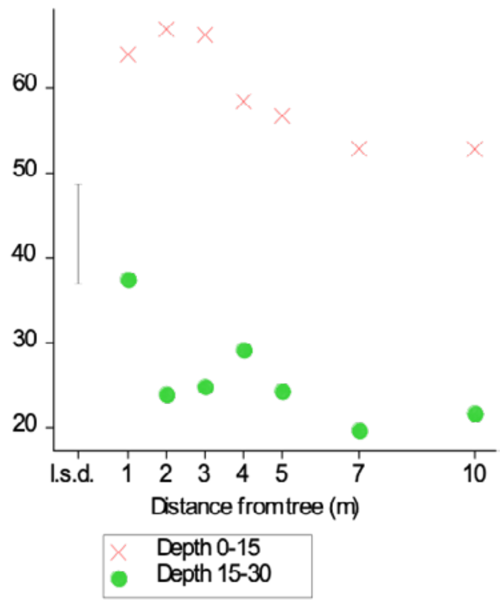


Figure 3. Soil total nitrogen content (total N) (Left) and soil total carbon content (total C) (Right), with distance from the base of willow at 0–15 and 15–30 cm depths.

Total organic nitrogen (TON) and total organic carbon (TOC)

Total organic nitrogen (Figure 4; left) at 0–15 cm showed a significant linear decline from the trunk by 0.026 kg/ha (SE=0.006) per metre. At 15–30 cm depth, the trend in TON was not significant, despite the mean values at 1 m to 4 m from the tree being higher than values for greater distances. High TOC and TON close to the tree may have been contributed by stock camping during the day. However, it is more likely that the major contribution was from activity of the trees, as stock are not always present in the paddocks. Total organic carbon (Figure 4; right) to 0–15 cm depth showed a significant linear trend, dropping by 0.026 kg/ha (SE=0.007) per metre. At 15–30 cm soil depth, there was no significant trend in TOC, despite the mean values at 1 m to 4 m from the tree being higher than values for greater distances.

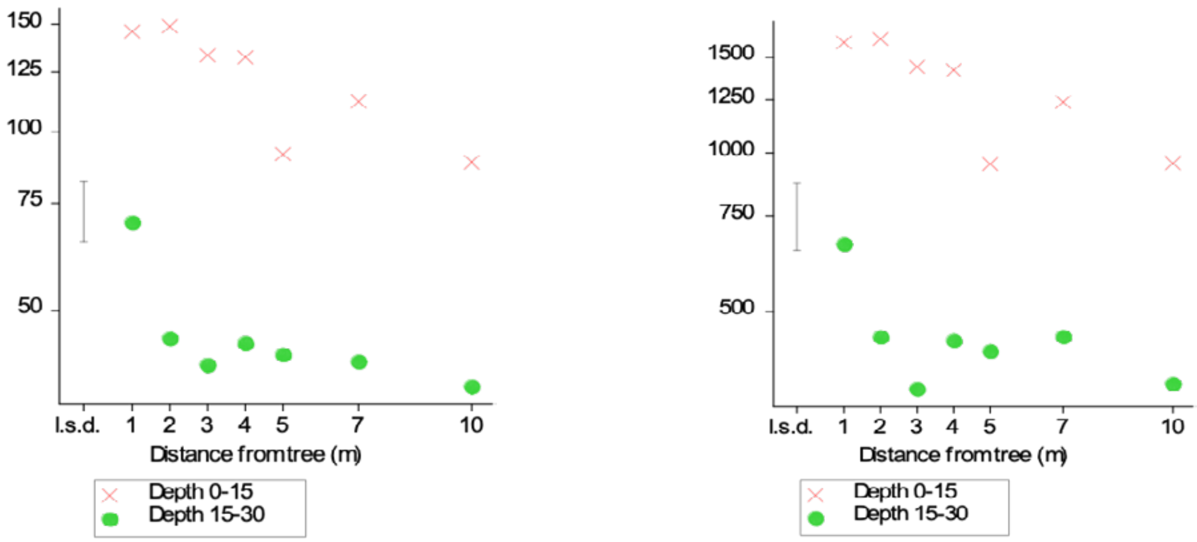


Figure 4. Soil total organic nitrogen (TON; left) and soil total organic carbon content (TOC; right) in kg/ha with varying distance from the base of willow, at 0–10 cm and 15–30 cm depths.

For more information

This is one in a series of research briefs about Poplars and Willows that can be found at poplarandwillow.org.nz

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