Soybean yield responses to rainfall reduction and tree root pruning in a tree-based intercropping system in Québec

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Objective and hypotheses

The objective of this study was to determine the effect of rainfall reduction and tree root pruning on soybean yield in a 7-year-old tree-based intercropping (TBI) system. We hypothesized that soybean yield tolerance to rainfall reduction will be higher overall in TBI system as compared to soybean monoculture. We also hypothesized that tree root pruning will increase soybean yield and tolerance to rainfall reduction at the tree crop interface as compared to unpruned TBI system.

Methodology

The TBI site included hybrid poplars and high-value hardwood species planted alternately every 5 m along each tree row. Spacing between tree rows was 40 m. The experimental design was a strip-split-plot replicated in four blocks. The TBI system was divided into ‘‘pruned tree roots’’ and ‘‘non-pruned tree roots’’ main plots. Root pruning was achieved with the passage of one tooth subsoiler at 2.5 meters (80 cm depth) from the tree row on both sides. Split-plot effects consisted of two randomly assigned treatments of full rainfall or partial rainfall exclusion. The rainfall exclusion treatment consisted in suspending PVC gutters at a height of 2–10 cm above the soil (covering 50% of the soil surface) at three different distances from de tree row (4, 12 and 20 m) and in a control without trees. Soybean yield was determined in 2018 in quadrats covering 1.52 m^2.

Results

We measured a significant interaction between tree root pruning and distance from the tree row (Fig. 1, $p < 0.0001$). Also, a significant interaction between root pruning and rainfall exclusion treatment was measured (Fig. 1, $p < 0.01$). Soybean yield at 4 m from the tree row for both rainfall treatments (full rainfall and water stress) were unaffected by root pruning according to Tukey’s tests ($p < 0.05$). At 12 m for both rainfall treatments, and at 20 m only for full rainfall treatment quadrats, yield in pruned tree root plots was lower than in non-pruned tree root plots (Tukey’s tests ($p < 0.05$). Soybean yield in the control plots was lower than at 20 m but higher than 4 m from the tree row regardless of the rainfall exclusion treatments (Fig. 2, $p < 0.0001$).

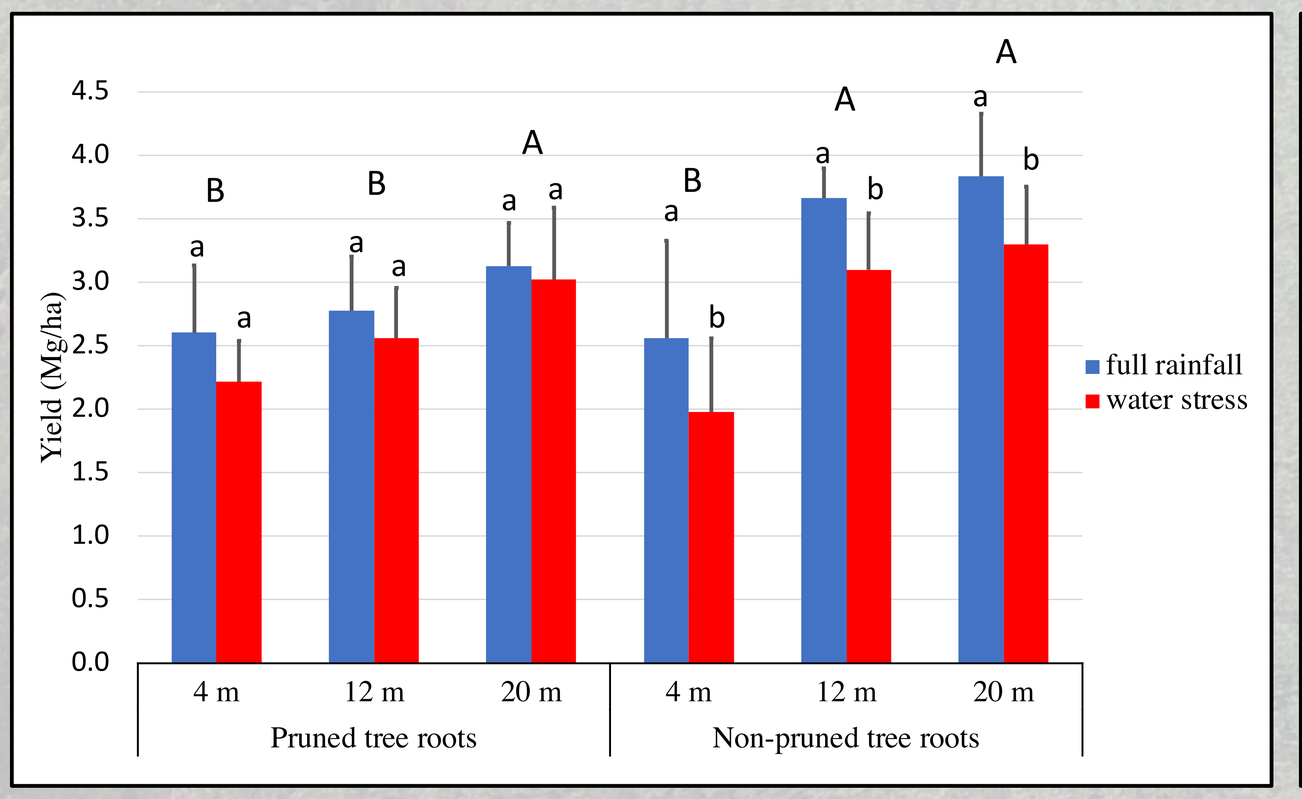

Figure 1. Soybean yield as influenced by tree root pruning, rainfall exclusion and distance from the tree row in a tree-based intercropping system in southern Quebec, Canada. Vertical lines indicate the standard deviations. Within each tree root pruning treatment, different lower case letters indicate significant differences between rainfall exclusion treatments according to Tukey’s tests ($p < 0.05$); different upper case letters indicate significant differences between distances.

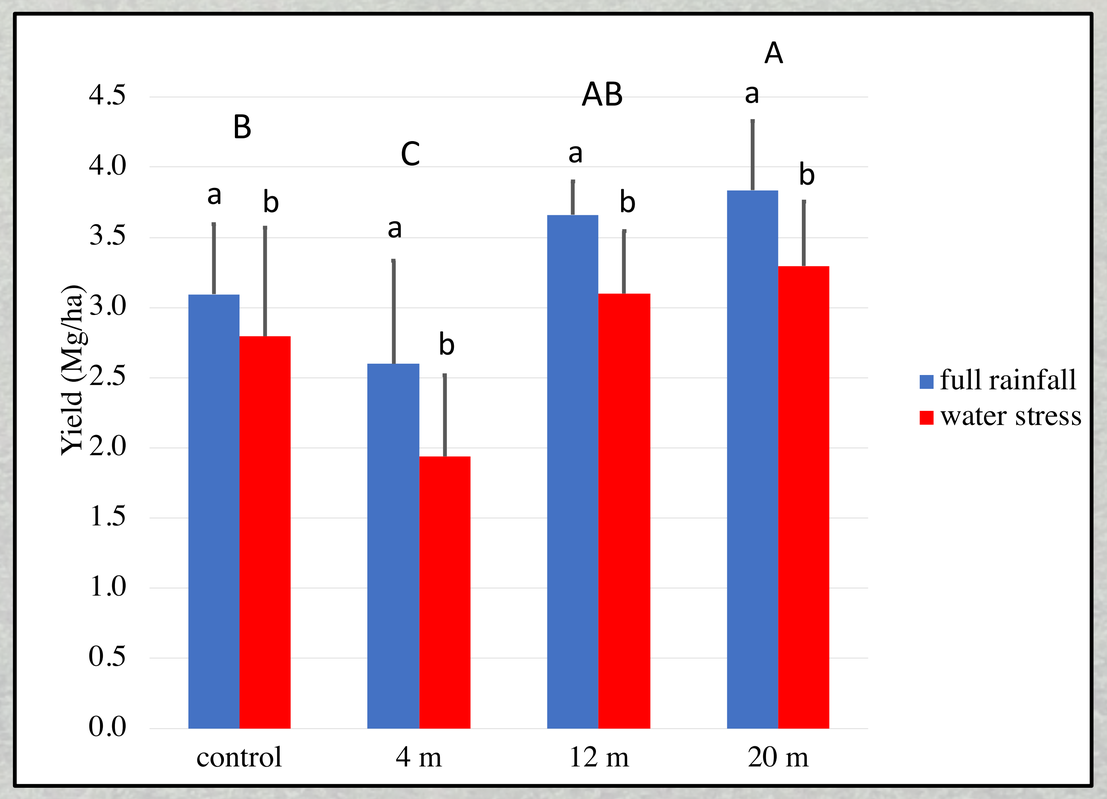

Figure 2. Soybean yield as influenced by rainfall exclusion at different distances from the tree row in a tree-based intercropping system and in a soybean mono-cropping system (control) in southern Quebec, Canada. Vertical lines indicate the standard deviations. Different lower case letters indicate significant differences between rainfall exclusion treatments; different upper case letters indicate significant differences between distances from the tree row and the control.

Conclusions

Contrary to expectations, tree root pruning did not increase soybean yield at the tree-crop interface (4 m) suggesting that competition for light was more important than that for water. Surprisingly, at 12 m (for both rainfall treatments) and 20 m (for full rainfall treatment only) soybean yield in the pruned tree roots plots were lower than that in non-pruned tree roots plots. These results suggest a presence of tree roots all over de TBI and this presence may enhance water absorption by several mechanisms like mycorrhizal symbiosis. However, root pruning eliminated the negative effect of the water stress treatment on soybean yield at all distances from the tree row. Both facilitation (20 m) and competition (4 m) were observed in the TBI system. Soybean sampling in 2019 will allow us to assess whether inter-annual variation in precipitation may mitigate the effect of rainfall exclusion and affect its spatial variation as a function of tree root pruning. Moreover, field study of 2019 , will enable us to provide a better understanding of the interactions between tree roots systems and crop water uptake.