Appendix 3: Additional sensitivity analysis

We ran the exact same set of simulations varying various parameters in order to see how robust our results are. Our expectation was that increased mobility of the nutrients and or increased uptake kinetics might increase root competition for nutrients and thereby shift the optimum branching frequency to lower numbers of branches per cm of major root axis. We also tested if aerenchyma formation, which we assumed would increase the metabolic efficiency of the roots (Postma and Lynch 2011a,b) had effects on the optimal LRBD. Finally we tested the effects of increased photosynthesis. This appendix includes all the figures of the sensitivity analysis.

In each figure we show on the left the default scenarios that were presented in the paper and on the right the scenarios with changed parameters. The lines in the figures are the growth responses to LRBD at a given nutrient availability. Comparing left and right figures we often see a vertical shift in the lines which corresponds to a change in growth to the parameters while horizontal shifts or shape changes correspond to interactions between the parameter and the LRBD.

Contents

1 Change in carbon fixation rate

We decreased and increased the carbon fixation rate in order to see how it effected the optimum LRBD. See paper for further discussion of the results.

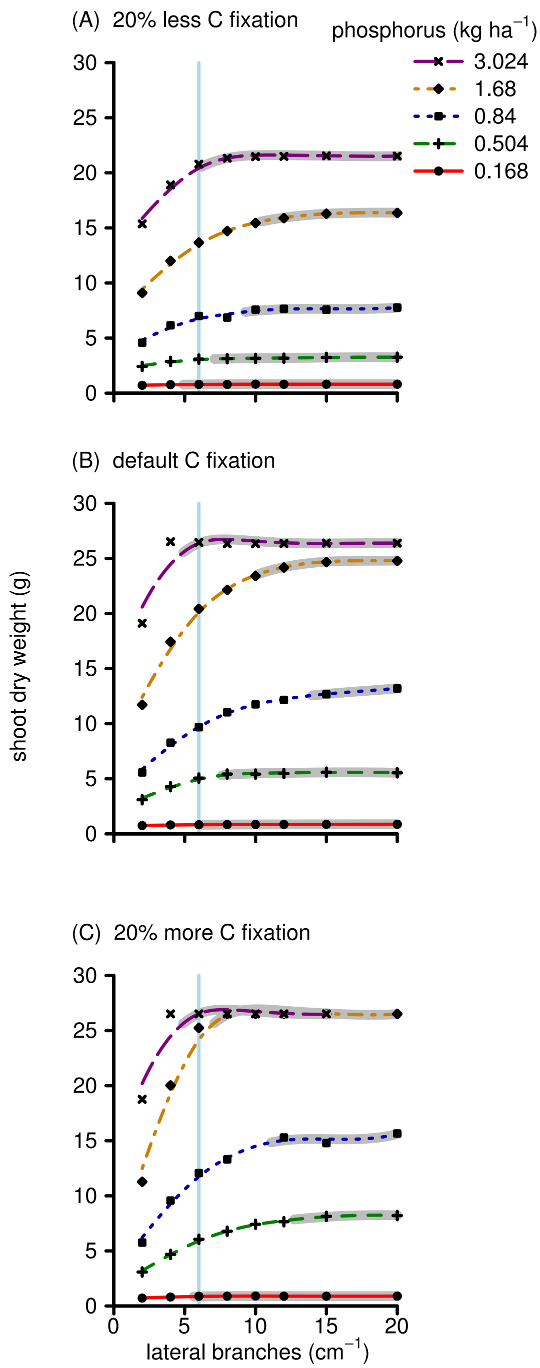

Figure S1: Same as figure 5 but for different levels of phosphorus availability.

2 Change in transpiration rate and consequently mass flow of nitrate in the soil

We de- and increased the transpiration rate by a factor 2. Mass flow can significantly increase nitrate transport in the soil towards the root. Our simulations of total nitrate uptake however were not sensitive to the transpiration rate, possibly because reduced uptake at one location in the root system is often compensated by increased uptake elsewhere.

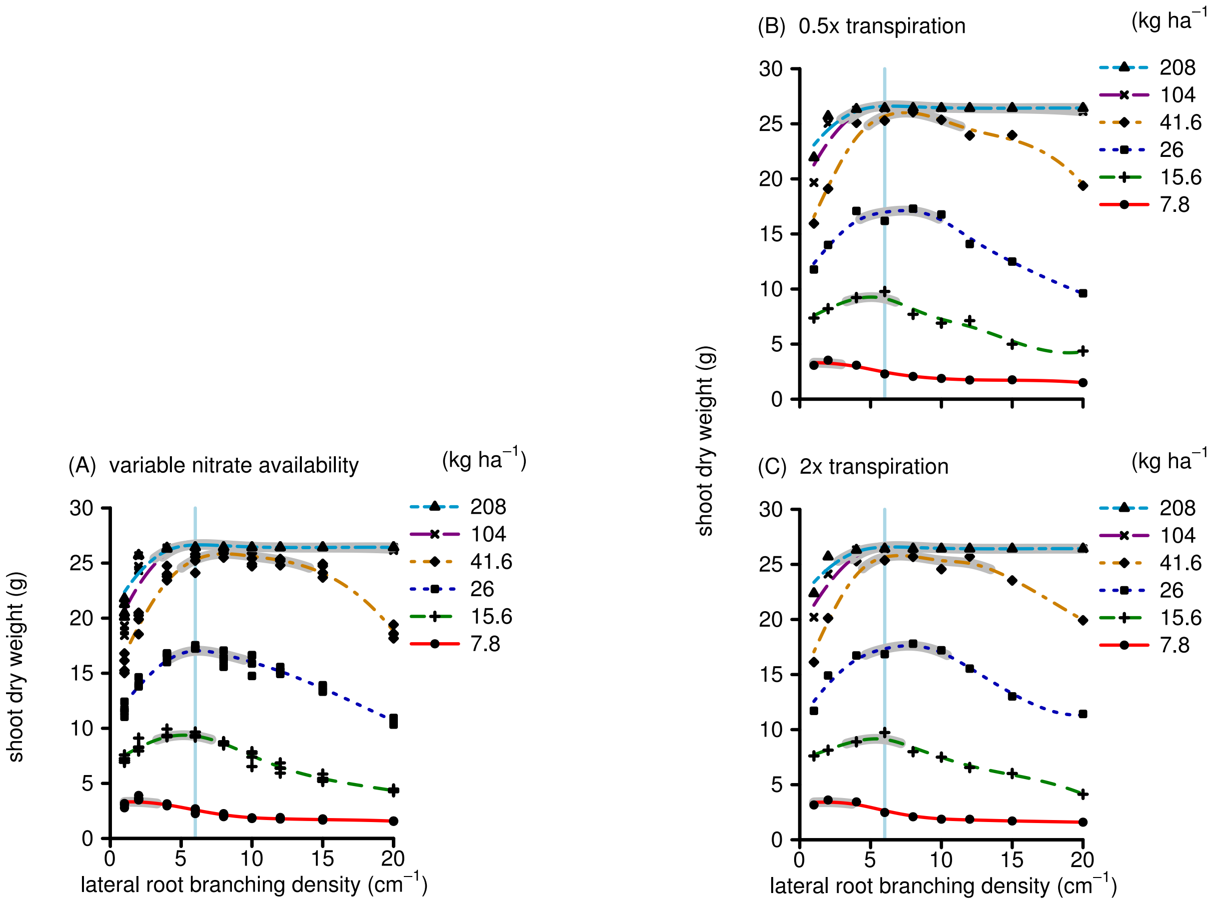

Figure S2: Comparison of simulation results between default (left), decreased (top right) and increased transpiration (bottom right). For further explanations see figure 2 in the paper.

3 Change in effective diffusion coefficient for phosphorus

We de- and increased the effective diffusion coefficient for phosphorus by a factor of 5. The effective diffusion coefficient depends on soil type and moisture content and can vary considerably. We see that the total phosphorus uptake and thereby the growth of maize on low P soils is strongly dependent on the diffusion coefficient (curves shift vertically). Greater diffusion coefficients will increase the phosphorus depletion zones and could potentially increase root competition. However, root competition remains low and the optimum LRBD for phosphorus remains in the higher ranges.

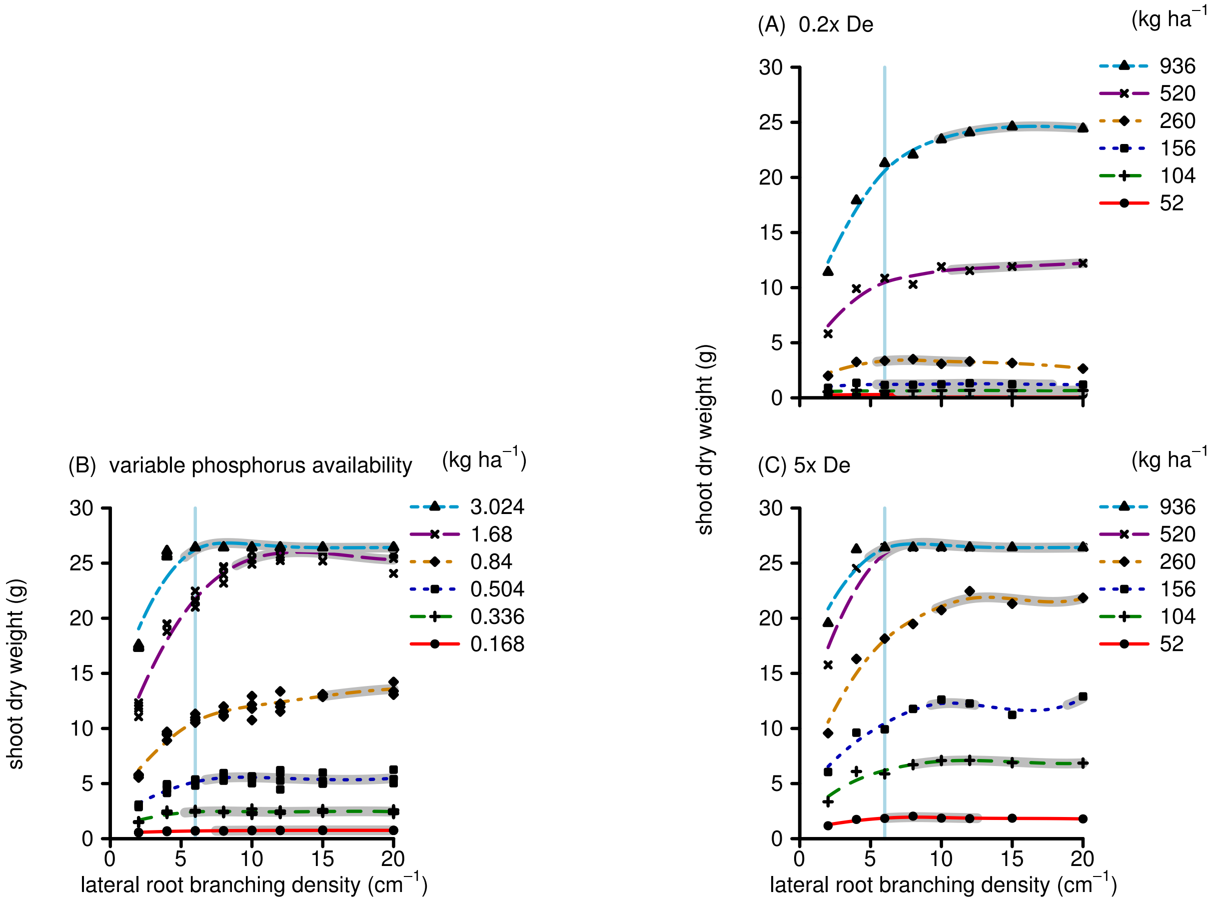

Figure S3: Comparison of simulation results between default (left) and de- or increased effective diffusion coefficient (De) (right). The De was decreased and increased by a factor of 5.

4 Increased uptake kinetics

We increased Km and Vmax by a factor of two, which would increase nutrient uptake by the individual root segments when the nutrient concentration at the root surface is relatively high (>~2*Km). This established the depletion zones faster and caused plants to be less stressed, especially in the medium nutrient treatments. The uptake kinetics had little effect on the optimum LRBD.

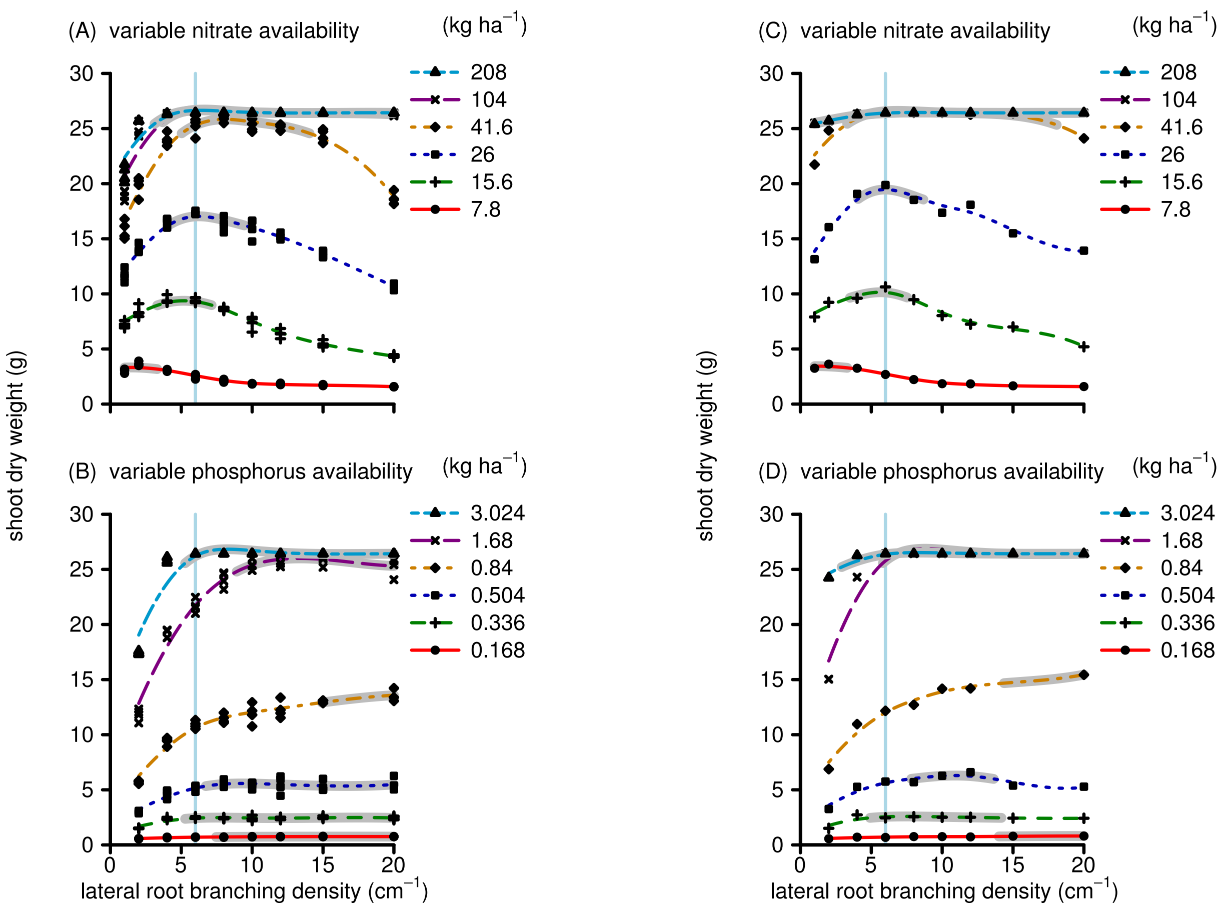

Figure S4: Comparison of simulation results between default (left) and increased uptake kinetics (right). For the right simulations, the uptake kinetics was increased by increasing both Km and Vmax by a factor of two. This does not affect the sensitivity (slope of the Micheal-menten type curve) but does increase the maximum achievable uptake rate.

5 Reduced root metabolic cost due to RCA formation

Our default scenario excludes the effects of aerenchyma formation. In previous publications (Postma and Lynch 2011a,b) we have shown that aerenchyma formation may significantly increase the growth of maize on low nutrient soils because it reduces the metabolic costs of the roots expressed in C, N and P requirements per unit root length. Here we simulated the nitrate and phosphorus scenarios for LRBD assuming a high level of RCA formation. We see a clear vertical shift, showing the RCA plants grow better on low fertility soils. In our previous publication we show that there was an interaction between lateral branching and RCA formation. The same interaction is clearly visible here as the effect of RCA is greater in the higher LRBD range. The synergism is very strong in for example the 41 kg.ha^{-1} nitrate scenario, but less visible in some of the other scenarios. We conclude that the strength of this trait synergism may depend on the nutrient availability.

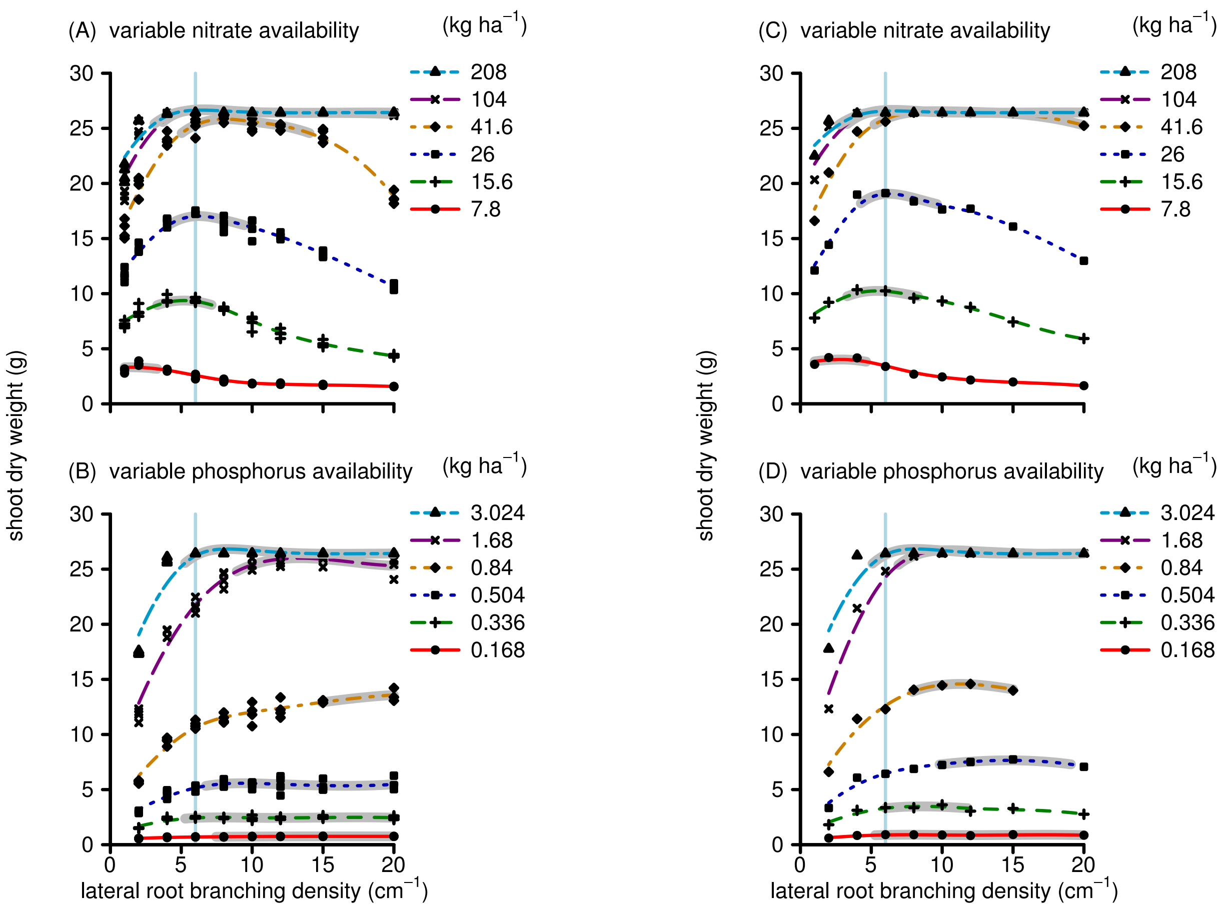

Figure S5: Comparison of simulation results between plant with RCA (default, left) and plants with RCA formation (right).