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Soybean root traits after a long-term corn-soybean rotation under different soil tillage and phosphorus fertilization

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Legume crops are widely implanted in conservation agricultural system because of nitrogen-fixing activity. However conservation agricultural, which associated minimum soil tillage, crop rotation and soil cover, could affect root growth and consequently crop yield of legumes with altered physico-chemical and biological soil properties and nutrient distribution compared to conventional agriculture. This study aimed to investigate how different tillage and P fertilization rate affect soybean (*Glycin max*, L.) root distribution and morphology with long-term experiments.

A 23-year rain-fed corn-soybean rotation field experiment was established in 1992 at L'Acadie, Quebec.. It is a split-plot design (four replicates) with main and sub-plot factors as tillage [moldboard plough (MP) and no-till (NT)] and P fertilization [0 (0P), 17.5 (0.5P) and 35 (1P) kg P ha⁻¹ every two years on corn phase]. Soybean roots and shoots were sampled in 2015 at flowering stage. Root samples were taken by collecting 5.25-cm diameter cores to a depth of 60 cm at 5 cm, 15 cm and 25 cm perpendicularly to the crop row. Soil cores were then cut at 0-5, 5-10, 10-20, 20-30, 30-40 and 40-60 cm. After root separating soil and roots by washing, root traits (biomass, length, surface and diameter, and proportion of primary, secondary and tertiary roots) were determined with WinRHIZO for the 18 individual samples per plot.

Tillage significantly affected vertical distribution of soybean roots. The average root length density (RLD) for a 60-cm soil profile was 1.95 cm cm⁻³ under NT and 1.55 cm cm⁻³ under MP. Roots mostly accumulated at 0-10 cm with 44% of the total root length under NT; whereas, the highest root length proportion was at 10-20 cm (36%) under MP. The RLD was also relatively ($P=0.45$) higher in the 0P (+16%) and 0.5P (+18%) treatments rather than 1P.

Soybean roots under NT had higher RLD and more roots accumulating in upper layers. It might be due to soybean root's response to heterogenous P distribution in NT with higher P concentration on soil surface. Besides, more roots, higher root/shoot and reduced soybean yield signified a growth pressure for soybean in NT. It could be related to the water availability or the higher crop residue rate on soil surface, which might constrain P and N nutrients in NT.