Temporal analysis reveals diverse root system architecture and development differences among pennycress accessions to nitrate nutrition (Thlaspi arvense L.)

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Roots have a central role in plant resource capture and are the interface between the plant and the soil affecting multiple ecosystem processes. Field pennycress (*Thlaspi arvense* L.) is a diploid annual cover crop species that has potential utility for reducing soil erosion and nutrient losses; and has rich oil seeds amenable as a biofuel (30-35% oil) or high-protein animal feed. The objective of this research was to (1) precisely characterise root system architecture and development, (2) understand adaptive responses of pennycress roots to nitrate nutrition, (3) and determine genotypic variance available in root development and nitrate plasticity. Using a root imaging and analysis pipeline 4D pennycress root system architecture was characterised under four nitrate regimes (from zero to 5 mM nitrate concentration) across four time points (days 5, 9, 13 and 17 after sowing). Significant nitrate condition response and genotype interaction was identified for many root traits with a greater impact on lateral root traits. In trace nitrate conditions a greater lateral root count, length, interbranch density, and a steeper lateral root angle was observed compared to high nitrate conditions. Genotype by nitrate condition interaction were observed for root width, width depth ratio, mean lateral root length, and lateral root density. These results illustrate root trait variance available in pennycress accessions and useful targets for breeding of improved nitrate responsive cover crops for greater productivity, resilience, and ecosystem service.