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# Combined with GPR measurements in winter and summer helps to obtain complete root distribution information

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Roots play a key role in plant anchorage, absorption and storage of soil resources (water, nutrients, carbohydrates) and biogeochemical cycles in terrestrial ecosystems. Studying the configuration of the root system and its distribution in the underground space is critical to understanding these effects of the root. For nearly two decades, ground penetrating radar (GPR) has been used as a non-destructive geophysical method to describe the spatial distribution of coarse roots under controlled conditions and field conditions. The detection effect of the ground penetrating radar on the root system depends mainly on the frequency of the radar antenna used and the degree of difference in the relative dielectric constant ($\varepsilon$) between the root and the soil. Nevertheless, the relative permittivity of soil varies greatly between summer and winter due to the effects of seasonal frozen soil. Using this seasonal variation, we evaluated the use of GPR with 900 MHz and 400 MHz antennas to nondestructively delineate the spatial distribution of the roots system of the same shrubs both in summer (August) and winter (January of the second year) under field conditions in the Xilingler shrub grassland ecosystem in Inner Mongolia, China. In summer, the relative dielectric constant difference between root and soil is greater due to the high water content of the roots, and more root signals can be obtained. However, as the soil moisture content is also high, the electromagnetic wave decays faster, which limits the detection depth of the radar, and only the shallow root signals were obtained. In winter, because of the existence of shallow frozen soil, the relative dielectric constant of the soil is low, which is conducive to the penetration of electromagnetic wave into the deep soil, so deeper root information can be obtained. However, the water content of roots will decrease due to the influence of low temperature, which resulting in a smaller difference in the relative dielectric constant between roots and soil. Therefore, the recognition effect on the shallow root system is relatively poor compared with results obtained in summer. Combined with the detection results of the two antenna frequencies (900MHz and 400MHz) in summer and winter, wealth and complete information of shrub root system distribution can be obtained. An effective GPR-based root measurement strategy is proposed by making full use of the seasonal changes of soil environment, which can further enhance the application of GPR in plant root research.