Spectral Assessment of Pasture Root Density in Soil Samples

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Introduction and objectives. Pasture fine root density responses to management are time-consuming to measure with conventional root coring and washing procedures. Results from laboratory-based near-infrared reflectance spectroscopy (NIRS) analysis may reflect the potential for field determinations of root density in soil samples via portable instrumentation (Kusumo et al., 2011). Our objective was to evaluate the accuracy of laboratory-based NIRS assessment of root density in soil core horizons scanned in intact/wet, coarsely-aggregated/wet, and pulverized/air-dry forms.

Methods. Silt loam soils supporting mixed cool-season perennial grass-legume-forb mixtures under differing defoliation treatments were sampled throughout growing seasons of 2012-2013. Cores to a depth of 15 cm were sectioned into horizons 2.5 cm thick x 7.6 cm in diameter. Spectra of core horizons were obtained over a range of 1200-2400 nm with a scanning monochromator (SpectraStar 2400 RTW, Unity Scientific, Brookfield, CT) with sample cups in rotating top window orientation. Scans were of a) ends of intact core horizons at field wetness; b) coarsely-aggregated samples at field wetness; and c) finely-pulverized samples following 24-30 hr of air-drying. Roots were separated by washing samples through a series of seives with a final hole diameter of 0.3 mm, dried to constant weight at 60° C, and expressed as weight proportions of dry samples.

Figure 1. Botanical composition of mixed cool-season grassland and sample presentation for intact and coarsely-aggregated forms.

Chemometrics software (Ucal 3.0, Unity Scientific) was used to develop NIRS prediction equations of root density as a function of spectral characteristics (modified partial least squares regression, math treatment 1,8,8 with standard normal variate/detrend). Spectra were analyzed over their full range and following removal of data in water regions (1420-1460, 1910-1950, and 2180-2400 nm).

Results. Root density ranged 0.01-1.03 g/100 g soil and averaged 0.14 g/100 g soil. The proportion of variation in root density that was explained by spectral variation was in decreasing order of intact cores, coarse aggregates, and air-dry pulverized samples, respectively (Table 1). Although water peaks in intact cores and coarse aggregates at field wetness could at least partially mask spectral information associated with roots (Fig. 3), intact cores appear to be an optimum form among those tested. This may be related to greater uniformity of particle size than in the coarsely-aggregated and pulverized forms (Fig. 2). Removal of data in water regions improved prediction accuracy. The relatively higher precision with which root density can be predicted in intact cores supports the feasibility of NIRS determination of root density with field spectrophotometers (Kusumo et al., 2011).

Figure 2. Particle size distribution in intact, coarsely-aggregated, and pulverized sample forms (crucible inside diameter 38 mm).

Figure 3. Absorbance spectra for A) intact; B) coarsely-aggregated; and C) pulverized samples at depths of 2.5-5 and 12.5-15 cm.

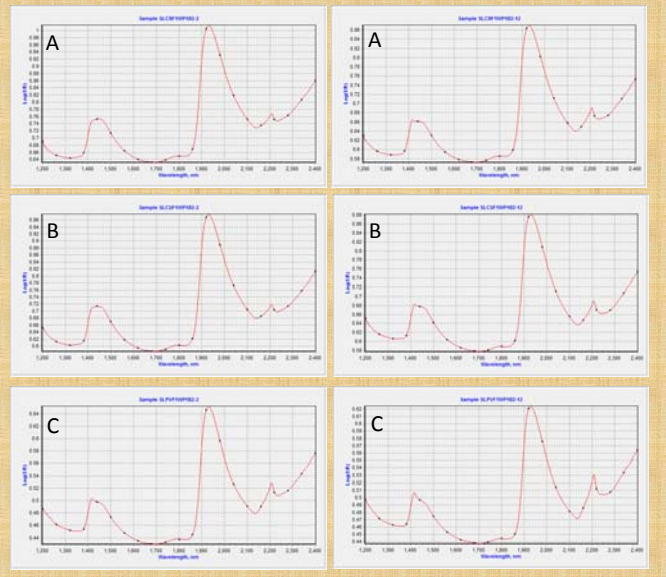

Table 1. Performance of root density equations for soil samples in intact/wet, coarsely-aggregated/wet, and pulverized/air-dry forms. SECV=standard error of cross-validation.

Treatments		Cross-validation		
Core horizon form	Spectral range, nm	n	SECV	r^2
			g/100 g DM	
Intact, field wet	Full, 1200-2400	174	0.07	0.46
Intact, "	Partial; exclude H_2O	183	0.07	0.51
Coarse aggregate, field wet	Full	176	0.08	0.33
Coarse aggregate, field wet	Partial	189	0.08	0.43
Pulverized, air-dry	Full	167	0.07	0.25
Pulverized, "	Partial	177	0.07	0.42

Reference.

Kusumo, B.H., M.J. Hedley, C.B. Hedley, and M.P. Tuohy. 2011. Measuring carbon dynamics in field soils using soil spectral reflectance: prediction of maize root density, soil organic carbon and nitrogen content. Plant Soil 338:233-245.