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Technical Update:

PRS™-probes aid development of sustainable agriculture in tropical regions

Tropical soils are more fragile than those of temperate regions. In many cases inappropriate management of these acidic, deeply weathered tropical soils has caused severe degradation of soil quality in tropical agro-ecosystems (Zhang, 2005). Understanding how the soil resource can be better managed through crop type and fertilization methods will greatly improve the quality and quantity of food farmed in these regions.

One new technology for monitoring the dynamics of soil nutrient supply in tropical ecosystems is the Plant Root Simulator (PRS)™-probe. The PRS™-probe consists of a 17.5 cm^2 ion exchange membrane encapsulated by a plastic stake for easy insertion and removal from the soil. The PRS™-probe adsorbs nutrient ions as they are released into the soil solution. The PRS™-probe can be buried *in situ* for days or weeks to accumulate the supply of nutrients accessible by the plant roots over time. This knowledge can be used to design sustainable cropping systems that balance nutrient removal and crop demand in tropical systems.

PRS™-probes are effective at measuring differences between soils in sun and shade coffee plantations

Coffee is a major commodity in international agriculture and its production has been increasing over several decades. There has been a trend toward sun grown coffee as farmers attempt to increase yield of this crop. This raises concerns for the long term sustainability of soils in sun grown coffee systems because of the intensive use of chemical fertilizers, fungicides, and insecticides. Shade plantations, on the other hand, are amended with composted manure and weeds are controlled manually. Comparisons need to be made between sun and shade grown coffee systems and the impacts these two methods have on the soil.

Washington State University M.Sc. student, Nicole Anderson analyzed the soil properties of sun and shade grown coffee during wet and dry seasons in Masatepe, Nicaragua. Sun and shade grown coffee plantations in close proximity were chosen for sampling. At each plantation, sampling plots (15m x 15m) were established and soil nutrient supply rates were evaluated with PRS™-probes for N, P, K, Ca, Mg, Al, NO_{3-}, NH_{4+}, Fe, Mn, Cu, B, S, and Pb. Seventy-two pairs of ion exchange PRS™-probes were placed in each sampling plot, using a grid format. PRS™-probes were left in soil for 4 weeks during the wet season and 6 weeks during the dry season. This long term burial period allows a dynamic measure of the soil nutrient flux over time.

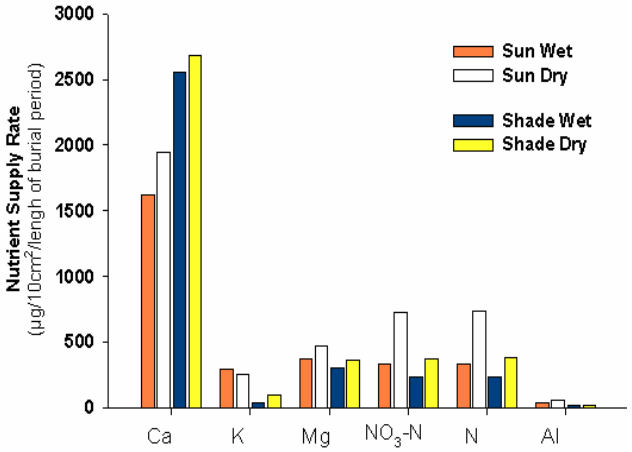

Figure1 Nutrient availability in sun and shade coffee plantations in Masatepe, Nicaragua during the wet and dry season (n=2).

Mean N, P, and K supply rates, measured using PRS™-probes, were higher in sun grown coffee plantations in both seasons relative to shade grown plantations. This was due to applications of chemical fertilizers in the sun grown coffee plantations. Shade plantations had variable supply rates of N, P, and K. Due to application of manure compost as fertilizer, calcium supply was larger in the shade system in both the wet and dry seasons. The presence of this basic cation decreased the supply rate of Al in the shade systems for both seasons as soil pH moved toward neutral.

PRS™-probes measure effects of long-term fertilization on soils for cassava production

Cassava is an important food crop in many tropical regions and represents the third largest source of carbohydrates for human food in the world. This crop is cultivated annually and is often cropped continuously. Soil degradation has been occurring in these long term

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cassava cropping systems. NPK fertilizers are now being used to increase cassava yield on these plots and PRS™-probes were used to determine the effect of these fertilizers on the soil properties.

Hung Nguyen et al., 2001, worked on cassava research plots established in 1990, that consisted of 12 treatments arranged in a randomized complete block design. Each treatment tested the long term effects of N, P, and K fertilizer and concomitant crop removal on soil nutrient supplies from the highly weathered Acrisols in Vietnam. These fertilizers were manually applied once a year from 1990 to 1998. Soil nutrient supply rates of NH_4-N, NO_3-N, P, SO_4-S, K, Ca, Mg, Al were measured using anion and cation PRS™-probes. Soil from the research plots was brought back to the laboratory and placed in 30-dram plastic vials. PRS™-probes were placed in the soil for 24 h to measure nutrient supply rates of each treatment fertilizer.

The long term application of NPK did not significantly increase the soil supply rates of nitrate and ammonium, as measured by the PRS™-probes, compared to long term PK application. However, significant increases in NH_4-N soil supply rate were observed when high rates of N, P, and K ($N_{80}P_{40}K_{80}$ and $N_{160}P_{80}K_{160}$) were used on the soil compared to control ($N_0P_0K_0$). This indicates an increase in soil N supplying power under these treatments. Soil P supply rates could not be determined by the PRS™-probes. The P concentrations in the eluent solutions from the PRS™-probe were below the detection limit of the automated colorimetry analyzer. This was caused by the nature of these tropical soils which have a low pH (4.4-4.5) making P less soluble as compared to temperate soils. New techniques are needed to apply ion exchange membranes effectively in high P fixing, low P content soils.

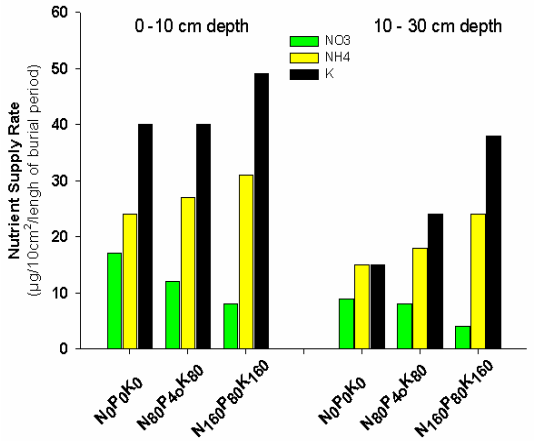

Figure 2 Effects of long-term fertilization on soil nutrient supply rates in cassava at two soil depths (n=12) over a 24 hour period.

Long term applications of K fertilizer had no effect on K nutrient supply rates. However, K applications significantly reduced the supply rates of nitrate in the soil and increased ammonium supply rates. This likely resulted from a preference of cassava for assimilating nitrate versus ammonium in order to maintain charge balance under large amounts of K in the soil.

Long term application of fertilizers in cassava cropping systems is effective at increasing availability of applied nutrients in the soil. A balanced application of primary plant nutrients is important to cassava production as nutrients not added in fertilizer were observed to become rapidly depleted in the system.

Literature Cited:

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2. **Nguyen, H., Schoenau, J.J., Van Rees, K., Nguyen, D., and Qian,** P. 2001. Can. J. Soil Sci. 81: 481-488. Long-term nitrogen, phosphorus and potassium fertilization of cassava influences soil chemical properties in North Vietnam.

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