EDXRFS-BASED SENSING OF PHOSPHORUS AND OTHER MINERAL MACRONUTRIENT DISTRIBUTION IN FIELD SOILS

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ABSTRACT

With the advent of recent developments in X-ray fluorescence spectroscopy (XRFS), energy-dispersive XRFS methods can be extended beyond elemental characterization of heavy metals in oils, lubricants and additives, consolidated geologic materials, or eroded sediments. In agronomic applications, EDXRFS has been used to determine trace elements in plant materials, metal-contaminated soils, and macronutrients in nutrient-enriched field soils and animal manures. The principles of EDXRFS and its application to the sensing of low atomic number (Z) nutrients will be discussed. Elemental composition of geo-referenced soil samples from a manure-amended field was characterized and mapped to delineate the spatial distribution and zones of management of soil P or any other elements of $Z > 11$ that were simultaneously determined. Relationships to bioavailable P soil fractions were examined to derive predictors of nutrient availability, thus developing field-scale approaches to managing spatial variability and in-season P changes in soil and corn plants to enhance nutrient-use efficiency on the farm.

Keywords: Soil phosphorus, X-ray fluorescence spectroscopy, spatial distribution, predictor of nutrient availability, soil sensing, precision nutrient management

INTRODUCTION

Phosphorus (P) requirements for major crops are currently based on a pre-plant mass balance method. As it is a critical nutrient for early seedling growth, a portion of the required P is traditionally placed in the row, below the seeds at planting. However, spatial variability of soil P often observed within a field (Dao et al., 2008). The problem is more acute in fields amended with animal manure, which is highly heterogeneous in nutrient composition (Dao et al., 2006; Dao and Zhang, 2007). Therefore, this heterogeneity must be managed in addition to that of soil pH, hydrous oxides of Al, Fe, Mn, and organic C, which greatly influence

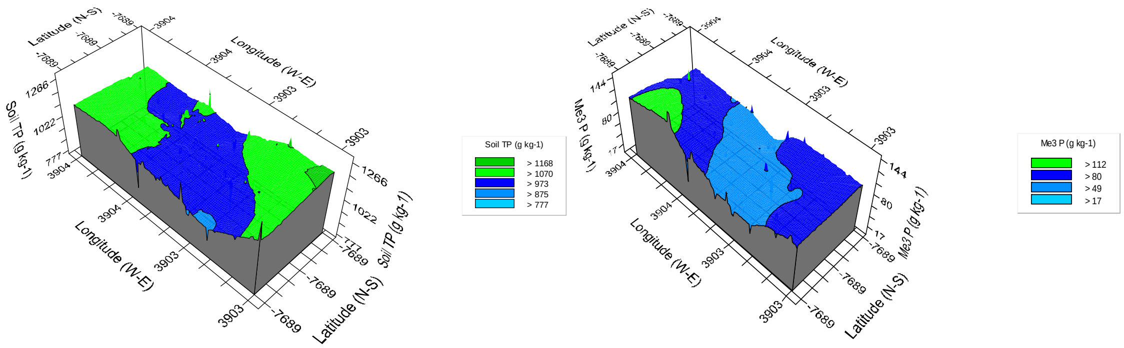

Fig. 1. Spatial distribution of total and Mehlich 3-extractable P concentrations.

soil P availability. The high analytical throughput of XRFS techniques can increase the spatial density of measurements. The more precise knowledge of field soil properties and site-specific nutrient distribution may result in improved nutrient-use efficiency in conjunction with variable-rate application technologies.

Recent advances in detector design, and polarization of incident radiation have made possible quantitative detection of light elements (11< Z <19). Energy-dispersive XRFS has found many more agronomic applications than solely being focused on heavy metal analysis (Ivanova et al., 1998). The multi-element capability of EDXRF has been applied to rapid analysis and source screening of poultry litter (Dao and Zhang, 2007). Elemental mineral composition of geo-referenced soil samples collected from a 30-ha manure-amended field was determined and mapped to delineate the spatial distribution and zones of P management (Fig. 1). Relationships to bioavailable P soil fractions were examined to derive predictors of nutrient availability, thus developing field-scale approaches to managing spatial variability and in-season P changes in soil and corn plants. The same methodologies are suitable for plant tissue analysis and for performing in-season crop monitoring to correct any potential nutrient deficiency and avoid potential yield reductions. Therefore, this direct spectroscopic approach can be crucial to the implementation of a balanced approach to natural resource management and mitigation of potential risks paused by fertilizers and organic bionutrient management practices.

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