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Understanding the Different Phosphorus Indices in Nutrient Management Planning

Abstract
Terminology in soil fertility and nutrient management Extension programming has evolved with increasing society emphasis on agriculture and environment interactions. Management of nutrient phosphorus (P) is important to agricultural environmental stewardship. Primarily, the term "Phosphorus Index" has two different meanings in nutrient management planning: the traditional use describes categories of plant response in soil test recommendations; the newer use describes a method of ascribing P movement risk in the landscape. Occasionally the term is used differently in soil science than these two examples. Extension personnel, agronomists, and technical personnel should use the appropriate terms to avoid confusing clientele.

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Introduction

Extension professionals perform many roles in agricultural environment stewardship education, often clarifying information provided by various agencies and technical providers, including their own universities. This article reviews soil fertility and nutrient management issues and terminology that have evolved that Extension personnel should utilize clearly in their programming.

The nutrient phosphorus (P) is integral to livestock and crop production. Nutrient management is managing the amount, source, placement, form, and timing of nutrient and soil amendment applications to ensure adequate soil fertility for plant production and to minimize detrimental environmental impacts. Nutrient Management Plans (NMPs) document the management decisions and serve as an operational action plan (NRCS, 1999). Extensive P research and outreach activity at the agriculture and environment interface introduced new nutrient management terminology. "Phosphorus Index" can be used in multiple ways in the NMP process.

Defining Phosphorus Indices

Environmental Risk Assessment Phosphorus Index

Off-target movement of P contributes to eutrophication in surface waters, a nutrient enriched situation exemplified through increased algae growth; adverse conditions associated with eutrophication include increased turbidity, oxygen depletion, loss of desirable species, and increased fish kills (Carpenter et al., 1998). Phosphorus moves from agricultural production systems via four mechanisms (Lemunyon & Daniel, 2002):

- Attached to sediment,
- In runoff water,
- Leached through the soil, and
- Removed via harvested plants.

Site-specific source and transport factors control the loss mechanisms other than through harvest: source issues include soil P levels and management of organic and inorganic fertilizers; transport factors include erosion rates and runoff properties (Hansen, Lemunyon, Sharpley, & Daniel, 2002). Recent research activity has targeted on how to best use these factors to evaluate the risk of P movement in the landscape. "Phosphorus Index" (NRCS, 1999) models are employed in 47n states in various forms to perform environmental risk assessment as all or part of the nutrient management planning strategy (Sharpley et al., 2003).

The models were developed in each state by researchers, Extension, and agency personnel to best fit regional or state conditions and vary accordingly. A recent review found 37 different factors utilized in the Phosphorus Indices of 12 southern states (Osmond et al., 2006). Four states, Arkansas, Iowa, Georgia, and North Carolina, adopted versions that predict quantities of P displaced under the various modeled scenarios. Other states assess the P loss risk via qualitative processes (Osmond et al., 2006; Sharpley et al., 2003).

Used during the nutrient planning process, the Phosphorus Index rates the propensity as low, medium, or high for P movement from a field under consideration for nutrient application. When the risk assessment is medium or high, either application rate may be lowered, alternative fields used, non-land application uses, or Best Management Practices implemented to reduce the environmental risk. Exploration of alternate management options is an excellent opportunity for teaching about the interface of agriculture and the environment between the NMP preparer and the client.

Soil Testing Phosphorus Index

Soil testing services (Peck & Soltanpour, 1990) are provided by many land grant universities to:

- Accurately determine the available nutrient status of soils,
- Clearly indicate whether nutrients are deficient or sufficient,
- Form the basis for any fertilizer recommendation, and
- Permit economic evaluation of fertilizer recommendations.

Soil test based recommendations rely on calibration and correlation research. Calibration is the determination of a particular crop nutrient requirement at different soil test values; correlation determines the relationship between nutrient uptake or yield, and how much nutrient is extracted by a particular soil test method (Beegle, 2005).

Soil test interpretations for P use crop response predictions often characterized by a curvilinear graph derived from the calibration process (Fixen & Grove, 1990). The soil test concentration of a particular nutrient is plotted along the abscissa; the ordinate data is a growth response variable, usually yield. The resulting curve may be separated into regions that correspond to the probable growth response in changing the soil test value through fertilization. These regions are referred to as "soil test categories," or in some states, "soil test index." Some states use terms such as "Below Optimum," "Optimum," or "Above Optimum" for these indices, others use terms more quantitative terms such as "Very Low," "Low," "Medium," "High," and "Very High."

In North Carolina, the soil testing usage is codified by state law, thus their state risk assessment is termed the more descriptive "Phosphorus Loss Assessment Tool" (D. Osmond, personal communication). Soil test P is a source factor in environmental risk Phosphorus Indices (NRCS, 1999), thus Phosphorus Indices are used within a Phosphorus Index. Using the soil testing information in the context of environmental risk assessment acknowledges that soil- and site-specific factors such as clay mineralogy, soil conservation practices, and landscape position also influence P loss (Osmond et al., 2006; Sharpley et al., 2003).

Other Phosphorus Indices

Soil P management and soil chemistry can be challenging to relate to the non-scientist. The dual usage of "Phosphorus Index" has potential for confusion. Nevertheless, the term appears occasionally in the literature describing yet other phenomena, such as soil-bound P sorption-desorption release to water (e.g., Hooda et al., 2000).

Summary

Phosphorus management has important implications for agriculture and environmental stewardship. The term "Phosphorus Index" has multiple uses, and Extension nutrient management programming must be specific. With widespread adoption of the environmental risk assessment Phosphorus Index, Extension soil testing programs should use the term "category" rather than index to quantify or describe soil test levels.

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