ARKANSAS

Phosphorus Fertilizer Recommendations for Rice

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Phosphorus was not recommended for rice production in Arkansas for several years prior to 1992. Dry matter responses to P fertilizer were common, but yield responses were seldom observed. Since 1992, yield responses to P fertilizer have been documented in numerous studies. Due to the variability of when and where responses occurred, several methods have been evaluated to determine P availability to rice. One method, the Mehlich 3 extraction, is used by many soil testing laboratories. While it has been shown effective for upland crops, it has received criticism for its estimation of P availability for paddy rice. This study was conducted to evaluate the effectiveness of Mehlich 3 extraction and soil pH in developing P availability indices.

Soil P availability under dryland conditions is influenced by several factors, not the least of which is soil pH. Optimum availability of P occurs in the pH range of 6.0 to 6.5. With acidic conditions, P is predominantly sorbed by iron (Fe) and aluminum (Al) oxides. The sorption of P by Fe and Al oxides decreases as soil pH increases, and more P is sorbed by calcium (Ca) and magnesium (Mg). At either extreme, P is not readily available.

Mehlich 3 extractable phosphorus (P) was not related to relative grain yields or P concentration in the rice tissue at the midtillering growth stage; however, soil pH was a reasonably good estimator of soil P fertilizer response.

It was believed in the southern U.S. for many years that rice growth was not limited due to insufficient P. This was because when a permanent flood is established, redox reactions result in reduction of trivalent Fe (Fe^{3+}) to divalent Fe (Fe^{2+}). As this occurs, the solubility of the Fe oxides increases. This leads to a subsequent increase in P availability to rice. On alkaline soils, however, more P is sorbed as Ca and Mg phosphates. Because Ca and Mg are not influenced by redox reactions associated with flood establishment, the solubility and subsequent availability of P are not necessarily increased sub-

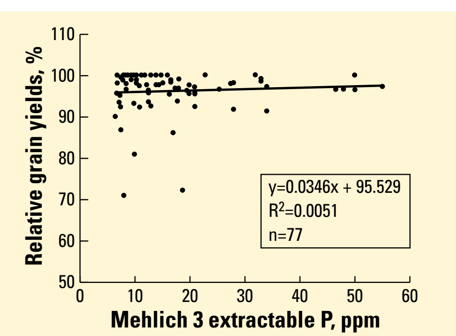

Figure 1. Relationship between relative grain yields and Mehlich 3 extractable P.

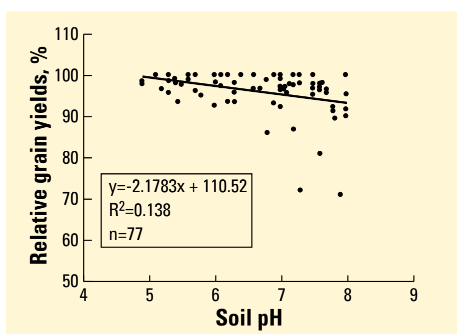

Figure 2. Relationship between relative grain yields and soil pH.

TABLE 1. Range of selected soil fertility properties from sites utilized in this study (n=99).

Soil property	High	Low	Average
pH	8.0	4.9	6.79
P ppm[1]	87	6	20.1
K ppm	255	41	101
Ca ppm	4,554	776	1,599
Mg ppm	821	85	232

[1]parts per million

TABLE 2. Phosphorus fertilizer recommendations for rice production in Arkansas, effective 1999.

Soil pH	lb/A P_2O_5 at soil test P, ppm		
	< 15	15 - 25	> 25
< 6.5	20	0	0
≥ 6.5	60	40	0

stantially after flooding. Therefore, soils that have limited available P prior to flooding will continue to have limited available P after flooding. The objective of the current study was to evaluate the ability of Mehlich 3 extractable P (M3P) and soil pH to predict P response by rice.

Experimental Approach

Eighty field studies were conducted between 1994 and 1998 in the rice-producing region of Arkansas evaluating various soil fertility problems. While the specific objectives varied, each study also evaluated response to P fertilizer. For studies located in production fields, the cultural practices utilized for the main fields were utilized in the plot area except for the fertilizer treatments in question. For studies located at the University of Arkansas Experiment Stations (Pine Tree Branch Experiment Station near Pine Tree; Rice Research and Extension Center near Stuttgart; Southeast Research and Extension Center near Rohwer), plots were managed for the specific experiment in question. Fertility levels of the soils used in this study are presented in **Table 1**. Plant samples were collected from some locations for analysis of P content in the rice tissue.

Because the studies utilized different cultivars, seeding dates, and other management practices, yield response was standardized across all studies by calculating relative grain yield as the ratio of yield from the plots that did not receive P fertilizer to the yield of those that received optimum P fertilizer. Regression analysis included modeling for curvilinear functions, which were not found to be better than linear regressions.

Prediction of Relative Grain Yields and P Uptake

Linear regression of relative grain yields versus M3P showed no significant relationship (**Figure 1**). This indicates that the Mehlich 3 extraction does not adequately predict P availability to rice grown in flooded soils. While M3P has been shown to be effective for upland

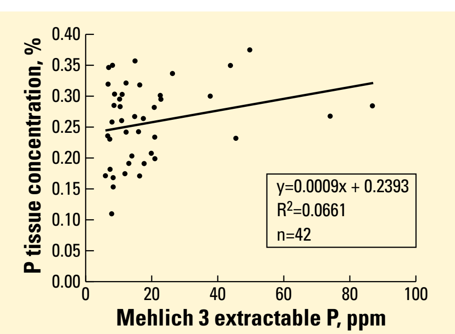

Figure 3. Relationship between rice P concentration at the midtillering growth stage and Mehlich 3 extractable P.

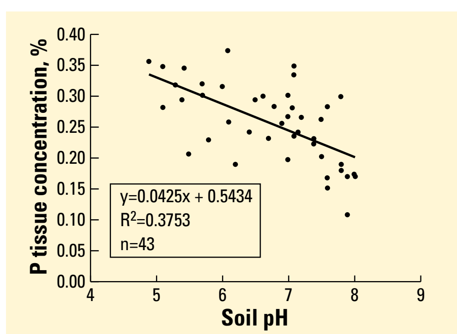

Figure 4. Relationship between rice P concentration at the midtillering growth stage and soil pH.

crops, it has been previously reported as an inadequate method for flooded rice.

Examination of the relationship between relative grain yields and soil pH indicates that soil pH is a better predictor of P fertilizer response by rice than is M3P (**Figure 2**). While predictability is still relatively low ($R^2 = 0.14$), the negative slope indicates that as soil pH increases, relative yield decreases, likely due to decreased P availability. This in turn increases dependence of rice on P fertilizer as soil pH increases and supports conclusions made in previous studies that suggest that rice response to P fertilizer is more likely on alkaline soils [*Better Crops with Plant Food*, 82(2):10-11, 1998].

Multiple regression analysis indicated that a model containing both M3P and soil pH provided the best prediction ($R^2 = 0.17$) of relative grain yields, but was only slightly better than soil pH alone.

The relationship between rice P concentration at mid-tillering (MT) and M3P indicates that Mehlich 3 does not predict P uptake by rice (**Figure 3**). The relationship between rice P concentration at MT and soil pH was highly significant ($R^2 = 0.38$, **Figure 4**). The P concentration in the plant declined significantly as soil pH increased. This decline with increased soil pH further strengthens the point that soil pH is a major factor affecting P availability to rice.

Summary

While these results suggest that soil pH is a better estimator of P fertilizer response by rice than M3P, a direct measurement of available P is more desirable. It is clear that the predictability is not high for either method, and development of a more effective method for estimating P availability to rice is sorely needed. In the interim, soil pH and M3P together provide a better indication of P fertilizer response than M3P alone.

As a result of this research, we have modified the P fertilizer recommendations for rice, effective in 1999 (**Table 2**), to consider both M3P and soil pH as contributing factors. This approach will also help to address removal of P in harvested rice (0.29 lb P_2O_5/bu) and limit soil P "mining." BC

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