NORTH AMERICA

Phosphorus Management in a Dry-Seeded, Delayed-Flood Rice Production System

By David Dunn and Gene Stevens

"Hidden hunger" for P may exist in a number of Midsouth rice fields. Soil test P has not proven to be a reliable indicator of the need for P fertilization in dry-seeded, delayed-flood rice production systems. Tissue testing for P at pre-flood can identify possible P deficiencies in rice.

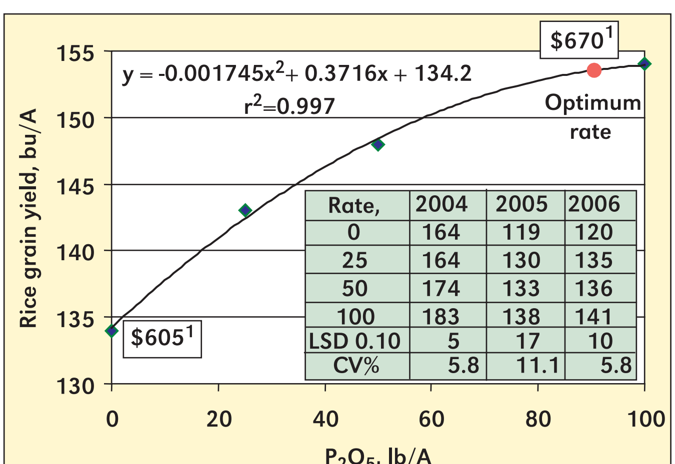
Proper P nutrition is critical for producing maximum rice grain yields. Phosphorus promotes vigorous early plant growth and development of a strong root system. Maximum tillering is also dependent on P. Often, P deficiency in rice is referred to as a "hidden hunger" because the symptoms are not apparent unless deficient plants are directly compared to sufficient plants (**See photo**). When compared to healthy rice of the same age, P deficient rice is characterized by an abnormal bluish green color of the foliage with poor tillering, slow leaf canopy expansion, and slowed maturity. When such plant comparisons are not available, plant tissue testing is the best tool for diagnosing P deficiency.

Beginning in 2004, a 3-year P evaluation was conducted at the Missouri Rice Research Farm located near Qulin in Dunklin County, on a Crowley silt loam (fine, montmorillonitic, thermic Typic Albaqualf). This location has been in a rice/soybean rotation for over 15 years. A dry-seeded, delayed-flood rice production system was employed, with plots in a new area each year. These areas had similar pH (6.8), ammonium acetate-extractable K (135 lb/A), organic matter (1.8%), and CEC (10.0 meq/100 grams) levels, but different Bray P-1 levels each year (2004, 38 lb/A; 2005, 8 lb/A; and 2006, 32 lb/A). In 2004 and 2006, a maintenance application of 25 lb P_2O_5/A was recommended, while in 2005 an 85 lb P_2O_5/A application was recommended. A randomized complete block experimental design with four replications was employed each year. The plot size was 25 ft. by 10 ft. All methods of water management and weed and insect control were the standard practices for cultivating dry-seeded, delayed-flood rice in Southeast Missouri.

Direct comparison of P sufficient (left) and P deficient (right) rice plots at pre-flood.

Three pre-plant rates of P_2O_5 (25, 50, and 100 lb/A) as triple superphosphate (TSP) were compared to an untreated check. These treatments were applied and incorporated with tillage immediately before rice was seeded. A 50 lb P_2O_5/A rate of TSP applied at one of three times (pre-flood, internode elongation, or early boot) was also evaluated. Soil and plant tissue samples were collected from each plot prior to flood establishment. Soil samples were collected by compositing 12 individual cores representing a 0 to 6 in. depth. Whole, above-ground tissue samples for P determination were collected from one row-foot in the second drill row from the outside edge of each plot. Rice tissue samples were dried at 100ºC, ground, and digested with sulfuric acid (H_2SO_4) and hydrogen peroxide (H_2O_2). Phosphorus concentration was determined colorimetrically using a spectrophotometer. At maturity, grain was harvested from the center 5 ft. of each plot. Moisture percentage of grain at harvest was measured in each plot and yields were adjusted to a 12.5% moisture basis.

Pre-plant P fertilization significantly increased yield in each year (**Figure 1**). However, visual identification of P deficient plots was possible only with a direct comparison with P-sufficient plots. The greatest yield each year was obtained with the 100 lb P_2O_5/A rate applied pre-plant. The greatest returns with P fertilization oc-



Rate,	2004	2005	2006
0	164	119	120
25	164	130	135
50	174	133	136
100	183	138	141
LSD 0.10	5	17	10
CV%	5.8	11.1	5.8

[1]Average annual net return/A (gross-fertcost); $0.25/lb P_2O_5; $4.50/bu rice

Figure 1. Average rice grain yields for pre-plant P treatments in 2004-2006, Missouri.

Abbreviations and notes for this article: P = phosphorus; K = potassium; CEC = cation exchange capacity; N = nitrogen.

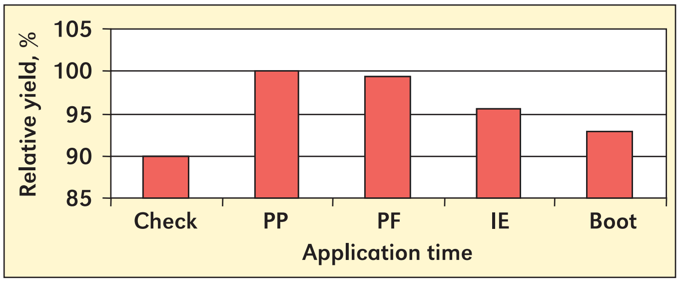


Figure 2. Average relative yields obtained by adding 50 lb P_2O_5/A at midseason timings, 2004-2006. (pp = pre-plant, pf = pre-flood (V5) growth stage, IE = internode elongation (R0) growth stage, boot = R2 growth stage)

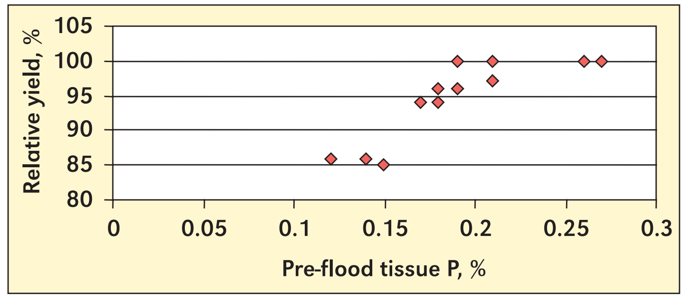


Figure 3. Relationship between whole-plant (aboveground), pre-flood tissue P concentration (%) and relative yield.

curred at 90 lb P_2O_5 /A, generating an average annual net return (gross-fertilizer cost) of $670/A compared to $605/A where no P was applied.

When the 50 lb P_2O_5/A pre-plant application was compared to 50 lb P_2O_5/A applied later in the growing season, an interesting relationship emerged (**Figure 2**). In terms of relative yields, the pre-flood application timing was able to capture 99% of the yield potential of the pre-plant timing, statistically equivalent. The subsequent application timings, internode elongation and boot, (averaged across all P rates) were able to capture progressively less of the yield potential (95 and 92%, respectively). The boot application was statistically equal to the untreated check (alpha = 0.10). This indicates that rice producers have a window of opportunity to correct a P deficiency, if it can be identified by pre-flood tissue sampling.

In the dry-seeded, delayed-flood rice production system commonly employed in the Midsouth U.S., rice is grown to the first tiller growth stage, N fertilizer (as urea) is applied to dry soil, and a permanent flood is then established. Supplemental N may be applied later in-season as needed. As the pre-flood urea-N is applied with ground-based equipment, a piggy-back P application would present a materials-only expense. Once a field is flooded, fertilizer applications must be made by airplane, which would raise costs an additional $5 to $10/A above materials. These factors combine to make a pre-flood P application the most cost-effective in-season timing.

Two methods of evaluating P fertility status (soil and tissue sampling) at pre-flood were compared. Tissue testing provided a better prediction of yield than soil testing (**Figure 3**). Whole-plant tissue P levels greater than 0.18% were consistently correlated with maximum rice yields (relative yields greater than 95%). Soil P testing at pre-flood was much less successful in yield prediction (relative yield or absolute yield). Consequently, tissue testing would be the preferred method for diagnosis and prediction of rice P status.

To properly collect a tissue sample at pre-flood, rice producers should select areas within each field that are relatively uniform (similar crop history, soil texture, fertilization history). These areas should represent management units (zones) which may be fertilized separately. The above-ground tissue should be collected from one foot of drill row at four or five randomly-selected locations within each unit. Care should be taken to prevent contamination with soil, since this will influence the results. The basal portion of the sample may be washed with distilled water if soil contamination is suspected. Samples should be placed in paper containers (not plastic) to allow drying during subsequent handling and transport to a qualified tissue testing lab for analysis. Proper labeling of samples ensures consistent identification later. When selecting a lab, close attention should be paid to turn-around time. Results not returned to producers in a timely manner may cause delays in flood establishment or an inability to capture the pre-flood application timing window.

Based on this 3-year study, producers have the opportunity to correct P deficiency in rice as late as pre-flood and still obtain maximum yield benefit. In 2004, the untreated check yielded 164 bu/A, which would be an acceptable yield for most producers. Our research documented a significant yield increase with P additions and points to a "hidden hunger" situation. The results of our work indicate that tissue testing for P at pre-flood could have indicated a possible P deficiency. Producers should consider tissue testing rice fields at pre-flood and apply P fertilizers if the tissue P level is 0.18% or below. BC

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