SULPHUR AND ZINC IN RICE PRODUCTION

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Rice is a unique crop that can grow in dryland or wetland ecosystems. Rice can grow when the soil is flooded periodically during the growing season, or when soil is submerged for duration of growing season, or as upland rice with aerated soils (Bell, 2008). Rice yields have increased significantly over the last 15–20 years. Major contributing factors include higher yielding varieties and an intensely managed soil fertility program. A variety’s yield potential is proportional to plant available nutrients. Managing the primary, secondary, and micronutrients to maintain appropriate balance is essential to optimum crop response.

RICE ECOSYSTEMS

In a submerged soil environment rice has a shallow root system. Approximately 90% of rice roots are in top 8 inches of soil. The shallow root system and sulphur form limits availability of S and other plant nutrients. Several interactions occur under anaerobic (flooded) soil conditions including:

1) reduction of sulphate (SO₄) to sulphides (FeS, MnS, ZnS)
2) reduced oxygen supply to roots
3) reduced mineralization of organic sulphur
4) decreased sulphur oxidation (Doberman & Fairhurst, 2000)

These interactions negatively impact total plant available sulphur and some micronutrients.

Rice production in an upland management system has soil fertility conditions similar to other field crops. Sulphur deficiency generally occurs in presence of coarse textured soil, low soil pH, less than 2% organic matter, leaching conditions, and/or high levels of iron (Fe) and aluminum (Al) oxides (Doberman & Fairhurst, 2000). Organic matter is the primary source of sulphur and the factors controlling organic matter decomposition greatly influence plant available SO₄. Approximately 1–5% of soil organic matter is mineralized annually. However, S immobilization occurs simultaneously with mineralization and results in variable release of plant available S (Schoenau & Malhi, 2008). In most soil conditions supplemental S should be included in a planned nutrient management program to maximize rice production potential.
SULPHUR DEFICIENCIES

Plant nutrient sulphur (S) management is a function of its production environment.

Sulphur deficiencies generally occur in recently land formed fields (Walker & Street, 2003). Late season sulphur deficiency may occur, although no symptoms were present earlier in growing season. Sulphur deficiency symptoms include:

1) yellowing of flag leaf from tip (late season)
2) dark brown–black streaks between leaf veins (photo 1.0)
3) stunted plants
4) reduced tillering
5) yellowing of whole plant beginning with youngest leaves (early season).

Influencing factors of S deficiency include high cropping intensity and reduction of S mineralization in flooded soil environments. Sulphur deficiencies in rice production can be minimized when 25–30 pounds per acre of actual S (28–34 lbs/ac Tiger 90CR) are applied preplant incorporated (Doberman & Fairhurst, 2000).

ZINC DEFICIENCIES

Zinc is the most prevalent micronutrient to display deficiency symptoms in rice. Soils with high pH (> 7.5), medium and coarse textured soils are susceptible to Zn deficiency. When available soil phosphorus is above optimum levels with low organic matter there is greater possibility for reduced plant available Zn. Young rice seedlings displaying Zn deficiency may have one or more of following symptoms:

1) bronzed appearance with irregular rusty pattern (photo 1.1)
2) pale drooping leaves
3) pale green bottom leaves 2–4 days after flooding
4) chlorotic leaves die within 3–7 days after flooding (Doberman & Fairhurst, 2000).
A zinc deficiency typically manifests itself between 2 leaf and mid-tillering stages. Flood establishment tends to intensify zinc deficiency and accelerates the onset of symptoms (Harrell, 2013). If Zn deficiency symptoms are identified within 72 hours of flood establishment, a decision to drain the field must be determined. Application of Zn products to the flood water will not be effective. In severe cases draining the field will be the only option. After field drainage and soil dries new rice growth will begin in approximately seven days and then foliar zinc applications can occur. When foliar applications are complete, the field can be re-flooded. Although, rice can be salvaged from Zn deficiency, it is much more effective to prevent it utilizing soil tests analysis and applying a Zn product prior to planting (Cartwright, 2012). Zinc fertilization on rice in Louisiana varies by field and conditions. Figure 1.0 reveals optimum response to Zn at 15 lbs/ac. when soil had pH 7.7 and soil Zn concentration at 0.7 ppm. “The results of soil fertilization with Zn are generally more persistent than those obtained by foliar application of Zn salts or chelates” (Bergmann, 1992). If your soil sample analysis reveals a Zn deficiency, 7-15 pounds per acre of actual Zn (39-85 lbs/ac of Tiger Micronutrients Zn18%, or 40 – 90 lbs./ac Tiger Micronutrients Rice Mix) should be applied preplant incorporated.

Oftentimes it is difficult to distinguish between various nutrient deficiencies and a plant tissue analysis is recommended to confirm the deficient situation. Plant tissue analysis is a management tool that should be employed to monitor plant nutrient status. Table 1.0 provides concentrations of selected nutrients in plant tissue required for optimum growth.

**Table 1.0**

Guide for Interpreting Nutrient Concentrations from Plant Tissue Analysis

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Plant Part*</th>
<th>Growth Stage</th>
<th>Nutrient Concentration**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus (P)</td>
<td>Y-leaf</td>
<td>Mid-tiller</td>
<td>0.14 – 1.27 %</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>Y-leaf</td>
<td>Panicle Initiation</td>
<td>0.18 – 0.29 %</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>Y-leaf</td>
<td>Mid-tiller</td>
<td>1.5 – 2.7 %</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>Y-leaf</td>
<td>Panicle Initiation</td>
<td>1.2 – 2.5 %</td>
</tr>
<tr>
<td>Sulphur (S)</td>
<td>WS</td>
<td>Mid-tiller</td>
<td>0.17 %</td>
</tr>
<tr>
<td>Sulphur (S)</td>
<td>WS</td>
<td>Panicle Initiation</td>
<td>0.15 %</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>Y-leaf</td>
<td>Mid-tiller</td>
<td>22 – 161 ppm</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>Y-leaf</td>
<td>Panicle Initiation</td>
<td>33 – 160 ppm</td>
</tr>
</tbody>
</table>

*Y-leaf = youngest fully emerged leaf blade  
WS = whole shoot, entire plant  
**Nutrient concentrations required for adequate growth  

Adapted from Hardke, J.T. 2013 Arkansas Rice Production Handbook*
A 3 year sulphur research project at the University of Missouri confirmed that "preplant applications of elemental sulphur provided pound for pound equivalent results to ammonium sulphate. Trial summary:

Preplant S promoted tillering and canopy closure 3-4 days earlier than non-sulphur check.
Preflood S treatments provided 90% of yield potential of preplant treatments.
Postflood S treatments provided 50% or less of the yield potential of preplant treatments.
Application of 12 lbs S/ac preplant increased rice yields by 15 bu/ac.(Dunn, 2008).

Maximizing rice yield potential requires utilization of all decision aids available in your tool box. Some of those decision aids include soil sample analysis, plant tissue analysis, plant nutrient application timing, seed variety selection, planting methods, flooding process, soil texture, understanding soil chemistry interactions, and in-field diagnostics. Each production ecosystem has different set of management options that influence productivity. Sulphur and zinc are important plant nutrients that have demonstrated positive crop responses. Inclusion of Tiger 90CR, Tiger Micronutrients Zn 18% or Tiger Micronutrients Rice Mix in a planned rice nutrient management program will enhance optimum production opportunities. Sulphur oxidation is a gradual process; therefore, these Tiger Products will provide plant available sulphate and zinc throughout the growing season. Tiger 90CR contains 90% elemental sulphur; Tiger Micronutrients Zine 18% contains 18% zinc and 65% elemental sulphur, and Tiger Micronutrients Rice Mix contains 63% elemental sulphur, 17% zinc, and 5% iron. Visit TigerSul.com for additional information and recommendations.

References: