Post-emergence treatment of iron-related rice-seedling chlorosis*

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Abstract

A number of nutritional problems have been reported for production of rice (Oryza sativa L.) on organic soils (Histosols). One of these, termed rice-seedling chlorosis, occurs when rice is drill-seeded into certain drained Histosols, and results in chlorotic, weakened seedlings that often die before or during imposition of the permanent flood. The condition can be predicted on the basis of soil testing and can be prevented by applying water-soluble Fe with the seed at planting. Greenhouse and field studies were conducted to determine the degree to which this problem can be corrected by the use of post-emergence foliarly applied Fe when the condition is not attended to at planting. It was determined that foliar application of Fe improved seedling growth, reduced seedling mortality, and increased rice grain production relative to no treatment. Nevertheless, prediction by the use of soil testing and prevention by application of Fe at seeding appears to be a more effective method for correcting seedling chlorosis than post-emergence foliar application of Fe.

Introduction

The approximately 32 million ha of largely undeveloped tropical peat soils comprise an important potential area for expansion of agricultural production in certain developing countries. Lowland rice (Oryza sativa L.) is an attractive crop for peat soils because flooding drastically reduces the oxidative loss of soil organic matter that occurs when Histosols are drained for cultivation of upland crops (Driessen, 1978). However, many nutritional problems have been encountered when rice is grown on Histosols (Driessen, 1978; Green, 1957; Snyder and Jones, 1988; Snyder et al., 1986). For example, when drill-seeded in certain drained Histosols in the Everglades Agricultural Area (EAA), rice may germinate normally but become chlorotic several weeks after emergence and die (Green, 1956; Snyder and Jones, 1988). Although more may be involved than simple Fe deficiency, Snyder and Jones (1988) demonstrated that the condition can be prevented by drilling water-soluble Fe compounds with the seed. Fortunately, soils in which the chlorosis occurs can be identified prior to seeding (Elliott and Snyder, 1987; Snyder and Jones, 1988). Nevertheless, the question remains as to what can be done to correct the chlorosis when a grower fails to take preventative measures. Several greenhouse and field studies were conducted to investigate post-emergence treatment of Fe-related rice-seedling chlorosis.

Materials and methods

Greenhouse study 1

Terra Ceia muck soil (Euic, hyperthermic Typic
Medisaprist) determined to be prone to seedling chlorosis (Snyder and Jones, 1988) was collected from the southern portion of the EAA and loosely packed into pots 120 mm diameter by 90 mm deep, providing approximately 420 g air-dried soil pot$^{-1}$. On 7 Feb. 1986, nine cv. Leah rice seeds were planted in each pot at a depth of approximately 1 cm. Using 5 replications and demineralized water, the following treatments were imposed: 1 mL per seed of a solution containing 28.8 g FeSO$_4$ 7H$_2$O (FeSO$_4$) L$^{-1}$ placed in the planting hole before seedling (termed 'Fe at planting'); FeSO$_4$ applied foliarly at the rate of 1, 5, or 20 kg Fe ha$^{-1}$; DTPA-Fe chelate (Sequestrene 330, Ciba-Geigy Corp., Agr. Div., Greensboro, NC) applied foliarly at the rate of 1 kg Fe ha$^{-1}$; and a check treatment receiving no Fe. The foliar applications were applied in a specially constructed spray chamber 20 and 28 d after planting using a liquid rate of 374 L ha$^{-1}$ and a nozzle pressure of 173 MPa. Each solution contained 1 mL L$^{-1}$ of wetting agent (Triton X-100, Rohm and Haas Co., Philadelphia, PA). Pots were irrigated with demineralized water to maintain adequate soil moisture. On 28 March, seedlings were harvested and separated into shoots and roots, dried at 70°C, and weighed. Data were statistically analyzed by SAS (1985) using the GLM procedure and CONTRAST option.

Greenhouse study 2

This study was conducted similarly to the first greenhouse study, using the same soil, rice cultivar, and cultural techniques. The pots were seeded on 7 March, 1986 and emerged 6 d later. The treatments, in addition to a check and FeSO$_4$ at planting, were: a one-time Fe chelate (1 kg Fe ha$^{-1}$) spray either 1, 2, or 3 weeks after seedling emergence; Fe chelate sprayed 3 times – 1, 2, and 3 weeks after seedling emergence; and Fe chelate sprayed twice – either 1 and 2 weeks after emergence or 2 and 3 weeks after emergence. The seedling shoots and roots were separated on 21 April, dried and weighed, except that only shoots were weighed for the two treatments involving just two foliar applications of Fe. Data were statistically analyzed by SAS (1985) using the GLM procedure and CONTRAST option.

Field study 1

The first field study was conducted on a seedling chlorosis-prone Pahokee muck soil (Euic, hyperthermic Lithic Medisaprist) in the southeastern EAA, using a randomized block design with 6 replications of the following treatments applied to the rice cultivars Leah and Lemont: foliarly-applied chelated Fe (1 kg Fe ha$^{-1}$) either 1, 2, or 3 weeks after seedling emergence; FeSO$_4$ at 20 kg Fe ha$^{-1}$ drilled with the seed at planting; and a check treatment that received no Fe. The rice was planted at the rate of 100 kg seed ha$^{-1}$ on 6 March, 1989, in plots 6 m long containing 6 rows spaced at 0.2 m. The rice emerged on 20 March, and the first foliar application of Fe was on 27 March. Foliar Fe was applied with a hand sprayer using demineralized water, a liquid rate of approximately 260 L ha$^{-1}$, and wetting agent (Triton X-100) at 1 mL L$^{-1}$. On 10 April, 3 weeks after seedling emergence, the completeness of the seedling stand was visually evaluated, using a 0 to 5 scale (5 indicating a perfect stand with no dead or missing seedlings, and 0 indicating no surviving seedlings). The plot area was flooded on 11 April. On 10 July, the center four rows of each plot were harvested using a small-plot combine (McCauley, 1979). The grain moisture was determined with a commercial grain moisture meter and yield was calculated at 120 g H$_2$O kg$^{-1}$ grain. Data were statistically analyzed by SAS (1985) using the ANOVA procedure and WALLER option.

Field study 2

The second field study was conducted very similarly to the first. The rice was planted on 11 April, 1989, in a commercial rice field on seedling chlorosis-prone Lauderhill muck soil (Euic, hyperthermic Lithic Medisaprist) in the southern EAA. Seedlings emerged on 18 April. The rice cultivars and treatments were the same as in the first study, except that there were eight replications of each treatment, and the treatment specifying foliar application of Fe 3 weeks after emergence was omitted because the commercial