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SHORT COMMUNICATION

Effect of Magnesium on the Development of Sheath blight in Rice

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Abstract

This study investigated the effect of magnesium (Mg) on sheath blight, caused by *Rhizoctonia solani*, development on rice plants from cultivars BR-IRGA 409 and Labelle grown in nutrient solution containing 0.062, 0.125, 0.25 and 0.50 mM of Mg. Sheath blight progress on inoculated sheaths was evaluated by measuring lesions expansion (mm) at 24, 48, 72 and 96 h after inoculation. Data were used to calculate the area under lesion expansion progress curve (AULEPC). The relationship between the foliar Mg concentration and the Mg rates was quadratic. The Mg concentration on leaf sheaths tissue was highest at the Mg rates of 0.389 and 0.400 mM, respectively, for cultivars BR-IRGA 409 and Labelle. A linear model best described the relationship between the AULEPC and the Mg rates. The AULEPC decreased by 48.7 and 26.2% for plants of cultivars BR-IRGA 409 and Labelle, respectively, as the Mg rates in the nutrient solution increased. The results permitted to conclude that high foliar Mg concentration played a pivotal role to decrease sheath blight lesions expansion.

Introduction

Sheath blight, caused by *Rhizoctonia solani* Kühn [*Thanatephorus cucumeris* (AB Frank) Donk] (Hashiba and Kobayashi 1996), is one of the major diseases affecting rice yield (Ou 1985). Symptoms of sheath blight include lesions on the base of the leaf sheath near the waterline which are elliptical or oval-shaped and greenish-grey with yellow margins (Ou 1985; Rush and Lee 1992).

Control strategies for sheath blight have centred around the use of fungicides because resistant cultivars are not commercially available to growers (Lee and Rush 1983). Host resistance against infection by pathogens can be affected by nutrient deficiency or toxicity (Marschner 1995). Magnesium (Mg) has multiple functions in plant physiology for being the most abundant free divalent cation in the plants cytosol and the central atom of the chlorophyll molecule (Shaul 2002). Disease intensities can increase or decrease by supplying Mg to the plants (Jones and Huber 2007). Peanut plants grown under low levels of Mg were more susceptible to *Mycosphaerella arachidicola* than plants grown under high levels of this macronutrient (Bledsoe et al. 1946). The severity of bacterial spot, caused by *Xanthomonas campestris* pv. *vesicatoria* in pepper (Jones et al. 1983) and the incidence of leaf spot, caused by *Cochliobolus heterostrophus* in maize (Taylor 1952) increased as the foliar concentration of Mg increased. Panicle blast resistance in rice was positively correlated with the high foliar Mg concentration (Filippi and Prabhu 1998).

Information related to the effect of Mg on rice resistance or susceptibility to sheath blight is, for the best of our knowledge, lacking in the literature. Therefore, the objective of this study was to investigate the effect of Mg on sheath blight progress in rice to achieve better disease management.

Materials and Methods

Rice plants from cultivars BR-IRGA 409 and Labelle, susceptible to *R. solani*, were grown in Hoagland and Arnon's (1950) modified nutrient solution consisting of: 1.0 mM KNO_3, 0.25 mM $NH_4H_2PO_4$, 0.1 mM NH_4Cl, 1.0 mM $Ca(NO_3)_2$, 0.30 μM $CuSO_4 \cdot 5H_2O$, 0.33 μM $ZnSO_4 \cdot 7H_2O$, 11.5 μM H_3BO_3, 3.5 μM $MnCl_2 \cdot 4H_2O$, 0.1 μM $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$, 25 μM $FeSO_4 \cdot 7H_2O$ and 25 μM EDTA. The Mg rates used were 0.062, 0.125, 0.25 and 0.5 mM. Magnesium sulphate ($MgSO_4 \cdot 7H_2O$) was used as the Mg source. Sodium sulphate (Na_2SO_4) was used at the concentrations of 0.43, 0.375 and 0.25 mM to prepare the nutrient solution containing the Mg rates of 0.062, 0.125 and 0.25 mM. The Na_2SO_4 was used because it was necessary to provide sulphur to the plants without the presence of Mg. Rice seeds were washed in sodium hypochlorite solution (10%) for 1.5 min and then washed in deionized water for 3 min. The seeds were germinated in rolls of filter paper (15 × 15 cm) soaked with water and kept at 25°C. Six seedlings were maintained in each plastic pot (40 ×25 × 8 cm) (Ecovaso, Jaguariúna, SP, Brazil) containing 5 l of nutrient solution with the Mg rates. The nutrient solution was replaced every 4 days or when the electrical conductivity was 85% of the initial value. The pH of the nutrient solution was checked daily and maintained between 5.5 and 6.0 with the addition of 1 M solutions of HCl or NaOH.

Inoculum of *R. solani* (AG-1 IA) used to inoculate the plants was obtained according to Rodrigues et al. (2001). Plants (60 days old, maximum tillering stage) were inoculated by placing a 1-cm toothpick colonized by *R. solani* into the lowest inner sheath of the main tiller. Immediately after inoculation, all plants were transferred to a plastic mist chamber inside a greenhouse. Sheath blight lesions expansion, in mm, on the inoculated sheaths was measured at 24, 48, 72 and 96 h after inoculation (hai) with a digital calliper. Data from lesion expansion were used to calculate the area under lesion expansion progress curve (AULEPC) according to Shaner and Finney (1977).

For determination of Mg concentration on leaf sheaths tissue, samples from the main culm of each plant were collected, washed in distilled water, dried in an oven with forced ventilation (70°C) until constant weight and subsequently ground in a Thomas–Wiley mill type (Thomas Scientific, Swedesboro, NJ, USA) with 20-mesh sieve. The concentration of Mg on leaf sheaths tissue was determined by nitropercloric digestion according to Bataglia et al. (1983).

One 4 × 2 factorial experiment consisting of four Mg rates and two cultivars (BR-IRGA 409 and Labelle) was arranged in a completely randomized design with three replications. The experiment was repeated once. A total of 72 plants per each cultivar were used in each experiment. Cochran's test for homogeneity of variance (Gomez and Gomez 1994) indicated that the data from the two experiments could be pooled for data analysis. Data from Mg concentration on leaf sheaths tissue and AULEPC were verified to normality, homogeneity and independence of experimental error followed by analysis of variance. A regression analysis based on the Mg rates and two cultivars was performed. The cultivars BR-IRGA 409 and Labelle were coded as 0 and 1, respectively. The highest coefficients of the model used were tested by Student's *t*-test ($P < 0.05$) to the best-fit model with all significant terms as follows:

$$Y_i = \beta_0 + \beta_1 R_i + \beta_2 R_i^2 + \beta_3 C_i + \beta_4 R_i C_i + e_i;$$

where Y_i = observed value of the variable in the observation i (i = 1, 2, 3…, 48); R_i = Mg rate in the observation i (0.062, 0.125, 0.250 and 0.50 mM); C_i = cultivars for the observation I (0 = BR-IRGA 409 and 1 = Labelle); β_0 = constant regression; β_1, β_2, β_3 and β_4 = regression coefficients; and e_i = the regression error associated with the observed value y_i. Data from foliar Mg concentration were correlated with the AULEPC.

Results and Discussion

The relationship between the foliar Mg concentration and the Mg rates was quadratic (Fig. 1). The Mg concentration on leaf sheaths tissue was highest at the Mg rates of 0.389 and 0.400 mM, respectively, for cultivars BR-IRGA 409 and Labelle (Fig. 1). The expansion of sheath blight lesions increased from 24 to 96 hai, but in general, the greatest reduction was noticed on the sheaths of plants grown at the highest Mg rates regardless of cultivar (Fig. 2). A linear model best described the relationship between the AULEPC and the Mg rates. The AULEPC decreased by 48.7 and 26.2% for cultivars BR-IRGA 409 and Labelle, respectively, as the Mg rates in the nutrient solution increased (Fig. 3). The correlation between foliar Mg concentration and AULEPC was negative and significant for BR-IRGA 409 ($r = -0.802$, $P < 0.05$) and Labelle ($r = -0.632$, $P < 0.05$). The Mg is a macronutrient required for the aggregation of ribosomes and as a cofactor for RNA polymerases, ATPases, protein kinases, phosphatases, carboxylases and glutathione synthase and also important to reduce the intensity of several diseases (Huber and Jones 2013). Data from the present study showed that rice resistance to sheath blight increased when the Mg concentration on leaf sheaths tissue was increased. Brown spot severity was reduced on rice supplied with high rates

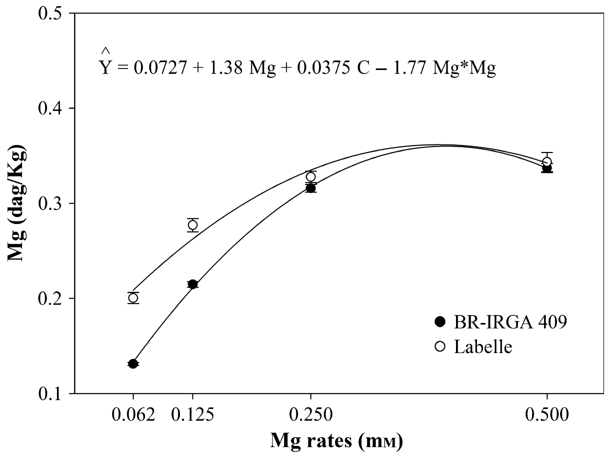

Fig. 1 Concentration of magnesium (Mg) in leaf sheaths of rice plants from cultivars BR-IRGA 409 and Labelle grown in nutrient solution containing different Mg rates and inoculated with *Rhizoctonia solani*. Data are from two pooled experiments. ($n = 6$).

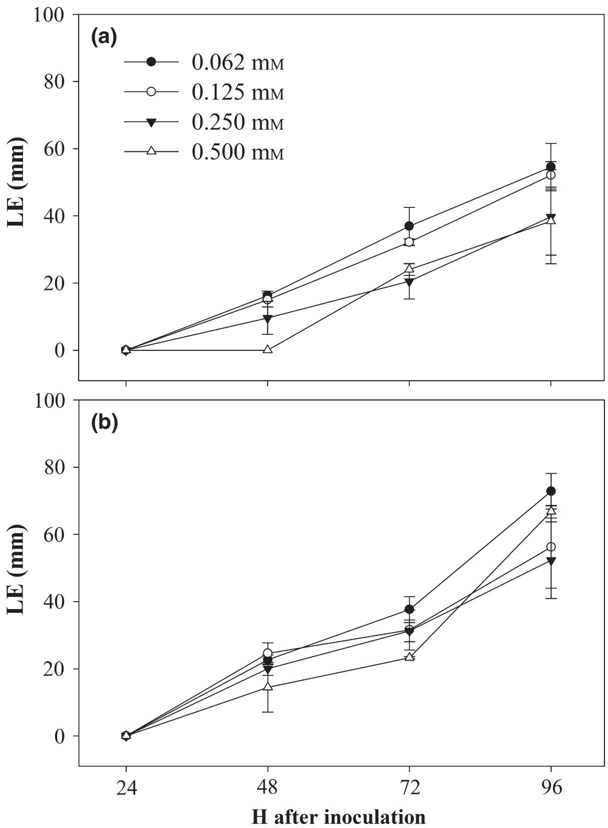

Fig. 2 Lesion expansion (LE) progress curves on rice plants from cultivars BR-IRGA 409 (a) and Labelle (b) grown in nutrient solution containing different magnesium rates. The error bars represent the standard error of the mean. Data are from two pooled experiments. ($n = 6$).

of Mg (Jones and Huber 2007). Cotton plants grown under low levels of Mg were more susceptible to *R. solani* than plants grown under high levels of Mg (Tsai and Bird 1975). Bean plants grown under low levels of Mg were more susceptible to *R. solani* than plants grown under high levels of Mg (Bateman 1965). Bledsoe et al. (1946) observed that peanut plants grown under low levels of Mg were more susceptible to *Mycosphaerella arachidicola* than plants grown under high levels of this macronutrient. Peanuts plants were also more resistant to *R. solani* when plants grown under high levels of Mg (Csinos and Bell 1989). By contrast, the highest foliar tissue concentration of Mg contributed to increase the intensity of flag smut and take-all on wheat, southern leaf blight on maize, stalk smut on rye and blast on rice (Jones and Huber 2007).

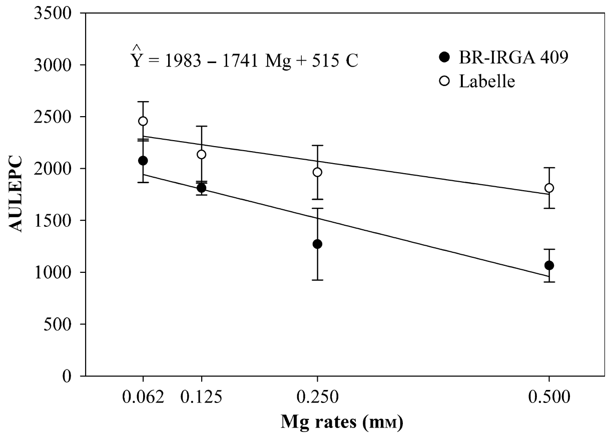

Fig. 3 Area under lesion expansion progress curve (AULEPC) on rice plants from cultivars BR-IRGA 409 (a) and Labelle (b) grown in nutrient solution containing different magnesium (Mg) rates. In the regression analysis, cultivar (c) will be equal to 0 and 1, respectively, for BR-IRGA 409 and Labelle. The error bars represent the standard error of the mean. Data are from two pooled experiments. ($n = 6$).

Overall, results from the present study showed that high foliar Mg concentration played a pivotal role in reducing sheath blight lesions expansion.

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