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Effects of Foliar Applied Copper and Boron on Fungal Diseases and Rice Yield on Cultivar MR219

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ABSTRACT

Long-term intensive cropping on the same piece of land with high-yielding varieties often exhausts the availability of soil micronutrients. Poor management of plant micronutrients has become a hurdle in the effort to increase rice production in Malaysia. The new rice variety, MR 219, was introduced to bring the yield potential up to 10 t ha^{-1}. However, to sustain the high yield, more N-fertilizer input is needed and this will increase incidences of disease. Moreover, nutrients imbalance due to limited micronutrients application may worsen the situation. In this study, two seasons of field experiments were conducted at Sawah Sempadan, Kampung Seri Tiram Jaya, Tanjong Karang (3° 28' 0" North, 101° 13' 0" East) in the off season of 2007 (July 2007 – November 2007) and the main season of 2008 (January 2008 – May 2008), using high yielding cultivar of MR219 to evaluate the effects of copper (Cu) and boron (B) foliar applications on the reduction of fungal diseases, and also to evaluate the effects of foliar Cu and B applications on rice production. Nine combinations of Cu and B treatment at varying levels of Cu (0 – 20 ppm) and B (0 – 20 ppm) were replicated 4 times and applied through foliar spray at three different times, namely, 30, 45 and 60 days after seeding (DAS). The foliar application of Cu and B was found to be able to reduce fungal disease infestation in MR219 rice cultivar and subsequently increase rice yield. Meanwhile, the foliar treatment of Cu and B applied in combination at level T7 (7.53 t ha-^{1}), T9 (7.33 t ha-^{1}), T8 (7.28 t ha-^{1}) and T6 (7.06 t ha-^{1}) produced significantly higher (P $\geq$0.05) rice yield as compared with the control, T1 (5.75 t ha-^{1}). A significant reduction in disease scoring was also recorded in the experiment where foliar treatment at level T9 (20 ppm Cu + 20 ppm B) cut down 5% of the disease incidence in MR219 rice plant. Rice yield components such as productive tiller m^{-2}, number of spikelets $panicle^{-1}$, percentage of filled grains and 1,000-grain weight have also shown remarkable increments as a result of the Cu and B foliar treatment.

Keywords: Rice, Micronutrients, Foliar Treatment, Copper, Boron, MR219

INTRODUCTION

Rice (*Oryza sativa* L.) is the main staple food for Malaysians. However, the self-sufficiency level of rice for Malaysia was only 72% in 2006 and the Malaysian government decided to increase its rice self-sufficiency level up to 86% by year 2010 (MARDI, 2006). Most of the granary areas in Malaysia are well-established with irrigation

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systems and farmers practicing double cropping with high-yielding varieties, such as MR219 or MR220 (Ho *et al.*, 2008). However, long-term intensive cropping on the same piece of land with high-yielding varieties has altered the availability of soil micronutrients (Wei *et al.*, 2006). Meanwhile, severe soil micronutrients deficiency has been reported to greatly affect rice production in the main granary areas in Malaysia (Zulkefli *et al.*, 2004).

Sumner (1997) reported that severity of fungal diseases increased in the recent years, with the introduction of high yielding cultivars that require higher fertilizer levels. Fungal diseases, such as brown spot (*Drechslera oryzae*), rice blast (*Pyricularia oryzae*) and sheath blight (*Rhizoctonia solani*), invade the new high yielding cultivar (MR219) and this maybe due to the large amount of N fertilizer application to achieve the targeted yield and also due to the imbalance of N fertilizer distribution between the vegetative and reproductive growth stage (Graham & Webb, 1991). According to Cassman *et al.* (1997), the need for increased nitrogen (N) fertilizer application to maintain high yield has often resulted in greater fungal disease infestation.

Balanced nutrition does not only help to achieve better yield in crop production but also allows plants to protect themselves from new infection (Agrios, 2005; Narayanasamy, 2002). In particular, copper (Cu) and boron (B) are two micronutrients which play great roles in securing rice production but these have been neglected by farmers. Dobermann and Fairhurst (2000) reported that Cu deficiency causing restricted emergence of new leaves in rice reduced tillering and promoted pollen sterility, while deficiency of B in rice also resulted in stunted growth and reduction in the number of panicles.

Copper compound had been developed into fungicides (Bordeaux mixture) in the early time. It has the ability to denature the spores and conidia of fungus and inhibit spores germination (Agrios, 2005). In addition, copper also helps in ligninification which produces primary defence for the plants to resist fungal diseases (Marschner, 1995; Evans *et al.*, 2007). Boron (B) is reported to be involved in keeping cell wall structure and maintaining membrane function (Marschner, 1995). It is believed to improve the strength of the membrane and cell wall with the cross-linked polymer and strengthen the plants vascular bundles which hold back the invasion of pathogens (Stangoulis & Graham, 2007).

Intensive cropping of high-yielding rice cultivars and mismanagement of fertilizer application have resulted in nutrients imbalance which further cause severe fungal infestation and greatly reduce rice production. Providing balanced nutrition in appropriate amount helps to increase rice production and develop resistance towards fungal diseases. Foliar applications of B and Cu serve as a good means, particularly in supplying rice plants with the nutrients that are crucially needed in time. It is believed that foliar applications of Cu and B will help in reducing the incidence of diseases and promoting rice production. Thus, two seasons of field experiments were conducted using high yielding rice cultivar of MR219 to evaluate the effects of the foliar applications of Cu and B in reducing fungal diseases and also to evaluate the effects of foliar applications of Cu and B on rice production.

MATERIALS AND METHODS

Two seasons of the field experiments were conducted at Sawah Sempadan, Kampung Seri Tiram Jaya, Tanjong Karang (3° 28' 0" North, 101° 13' 0" East) during the off season of 2007 (July 2007 – November 2007) and in the main season of 2008 (January 2008 – May 2008) using high yielding cultivar (MR219). The soil series in the field plots is Sedu which is classified as fine, mixed, isohyperthermic family of Typic Sulfaquent. This is an acid sulphate type of soil. This area has been cultivated with paddy for more than 25 years, where farmers widely use chemical fertilizers and pesticides. No additional micronutrients fertilizer is applied other than the subsidized fertilizers given by the Malaysian government. In addition, this area has been experiencing low rice yields with the average production of 4.5 tonnes per hectare, with severe infections of fungal diseases, such as brown spot (*Drechslera oryzae*) and sheath blight (*Rhizoctonia solani*). Soil sampling and analysis were carried out prior to the field experiment. The soil analysis showed that the experimental area were lower in Cu and B (Table 1), as compared with the critical nutrients range required by rice as reported by Dobermann and Fairhurst (2000) (Table 2).

Thirty six experimental plots consisting of 9 m^2 in area (3 meter wide by 3 meter long) with an additional of 1 meter width planted next to the adjacent plot as buffer zone against spray drift were lined out in the field and arranged in randomized complete block design (RCBD). Copper and B stock solutions were prepared from the laboratory grade of copper sulphate pentahydrate ($CuSO_4.5H_2O$) with 99% purity and sodium pentaborate ($Na_2B_{10}O_{16}.10H_2O$) with 99% purity. Nine combination of Cu and B treatment, namely control or T1 (0 ppm Cu + 0 ppm B), T2 (0 ppm Cu + 10 ppm B), T3 (0 ppm Cu + 20 ppm B), T4 (10 ppm Cu + 0 ppm B), T5 (10 ppm Cu + 10 ppm B), T6 (10 ppm Cu + 20 ppm B), T7 (20 ppm Cu + 0 ppm B), T8 (20 ppm Cu + 10 ppm B) and T9 (20 ppm Cu + 20 ppm B) were replicated 4 times and applied through foliar sprays at three different times (30, 45 and 60 DAS). Spray applications were made using backpack sprayer with nozzles oriented vertical spraying of 500 mL $plot^{-1}$. Nitrogen (N), phosphorous (P) and potassium (K) fertilizers were applied based on the standard recommended rate in all the treatments. Nitrogen fertilizer (150 kg ha^{-1}) as urea was divided into 3 applications; 25% was applied on 15 DAS, 30% on 35 DAS and 55% on 55 DAS, while phosphorous (90 kg P_2O_5 ha^{-1}) was applied as rock phosphate and potassium (150 kg K_2O ha^{-1}) as murate of potash applied as basal fertilizer at 15 DAS. Throughout the plants growth period, adequate plant protection measures were taken to avoid yield loss due to weeds and pests. However, there was no fungicide application throughout the experimental period and this was done to provide natural fungal disease infestation.

The physiological and yield component parameters measured included productive tillers m^{-1}, number of spikelets $panicle^{-1}$, percentage of

TABLE 1
Chemical properties of the soil samples in the experimental site

Chemical Properties	Values	Procedures
Soil pH	4.61	1:1 (soil weight / water volum), pH meter
EC (μScm^{-1})	141.57	1:1 (soil weight / water volum), EC meter
Total C (%)	12.01	Dry combustion
Total N (%)	0.30	Kjedahl method
Exch. P (mg kg^{-1})	37.23	Bray and Kurtz No. 2
Exch. K (mg kg^{-1})	72.36	Shaking (1*M*. NH4OAc, pH 7.0), AAS
Exch. Ca (mg kg^{-1})	293.36	Shaking (1*M*. NH4OAc, pH 7.0), AAS
Exch. Mg (mg kg^{-1})	119.64	Shaking (1*M*. NH4OAc, pH 7.0), AAS
Exch. Zn (mg kg^{-1})	1.11	Mehlich No. 1, ICP
Exch. Mn (mg kg^{-1})	5.27	Mehlich No. 1, ICP
Exch. Cu (mg kg^{-1})	0.12	Mehlich No. 1, ICP
Exch. Fe (mg kg^{-1})	91.50	Mehlich No. 1, ICP
Exch. B (mg kg^{-1})	0.15	Hot water, ICP

TABLE 2
Critical nutrients concentration for rice in soil

Nutrients	Exch. P (mg/kg)	Exch. K (mg/kg)	Exch. Ca (mg/kg)	Exch. Mg (mg/kg)	Exch. Zn (mg/kg)	Exch. Mn (mg/kg)	Exch. Cu (mg/kg)	Exch. Fe (mg/kg)	Exch.B (mg/kg)
Critical nutrients concentration in soil	12-20	15	20	36	1	3 – 30	0.2 – 0.3	4 - 5	0.5

Source: Dobermann & Fairhurst (2000)

TABLE 3
Rice yield (t ha^{-1}) produced as affected by Cu and B treatments at different levels in the two seasons of the field experiment

Treatments (ppm)	Rice Yield (t ha^{-1})	
	1st Season	2nd Season
T1 (0 Cu, 0 B)	5.75 c	5.06 a
T2 (0 Cu, 10 B)	6.83 ab	5.03 a
T3 (0 Cu, 20 B)	6.25 bc	5.15 a
T4 (10 Cu, 0 B)	6.83 ab	5.06 a
T5 (10 Cu, 10 B)	6.90 ab	5.13 a
T6 (10 Cu, 20 B)	7.06 a	5.18 a
T7 (20 Cu, 0 B)	7.53 a	4.95 a
T8 (20 Cu, 10 B)	7.28 a	5.15 a
T9 (20 Cu, 20 B)	7.33 a	5.24 a

In each row, values followed by the same letter (s) are not significantly different ($P \geq 0.05$) by LSD.

filled grain, 1000-grain weight and grain yield. Meanwhile, the productive tillers were measured in the experimental plot using quadrate with an area of 25 cm^2 at 60 DAS. Ten tillers were randomly sampled within the experimental plot at maturity to determine the yield components, such as the number of spikelets per panicle, the percentage of filled grain and 1,000-grain weight. The rice grain yields were obtained by harvesting all the plants in the experimental plot.

At 80 DAS, five spots in each of the experimental plot were randomly selected by using a quadrate. Twenty five leaves were selected randomly in the quadrate and inspected thoroughly; the leaves infected by fungus were marked. The leave areas infected by disease were monitored and the percentage of leaves area infected by fungus in the quadrate were also estimated and recorded as DS according to the method modified from International Rice Research Institute, IRRI (2002). Disease scoring (DS) for the genotype, which represents both disease incidences and symptom severities can be used as an indicator for virus and fungi resistance.

DS can be calculated as:

$$\frac{n(3) + n(5) + n(7) + n(9)}{tn}$$

where,

n(3), n(5), n(7) and n(9) = number of plants showing a reaction in a scale (3), (5) (7), (9) respectively
tn = total number of plants scored.

Data collected were subjected to the analyses of variance (ANOVA), performed using the SAS programme (SAS, 1998) to determine the statistical significance of the effect of the treatments. When the F-values were significant, the Fisher's Least Significant Difference, LSD test was performed for mean comparison. Meanwhile, the relationship and trend between grain yield, disease scoring and other parameters were analyzed by correlation and regression analyses.

RESULTS AND DISCUSSION

Rice Yield

Rice yields produced during the two seasons of the field experiment are shown in Table 3 where significant increase yield was recorded during the 1st season (off season 2007). Treatments with T7 (7.53 t ha^{-1}), T9 (7.33 t ha^{-1}), T8 (7.28 t ha^{-1}) and T6 (7.06 t ha^{-1}) produced significantly higher ($P \geq 0.05$) rice yield as compared with the control, T1 (5.75 t ha^{-1}). However, rice yield in the 2nd season of the field experiment showed no significant difference.

The application of Cu and B was aimed at supplying nutrients which are important in promoting plant growth and grain formation in rice (Dobermann & Fairhurst, 2000). The foliar treatments were found to be able to supply Cu and B timely to rice plant at the critical stage, as these elements were relatively immobile (Dobermann & Fairhurst, 2000; Tagliavini & Toselli, 2005). The additions of micronutrients, such as Cu and B (individually or in combination) were able to increase crop productions (Heitholt *et al.*, 2002; Zulkefli *et al.*, 2004; Dordas, 2006; Yang *et al.*, 2009).

The applications of Cu and B to the plant through foliar application were found to have enhanced photosynthesis and resulted in better plant growth and grain formation. Copper is needed in photosynthesis and respiration. It also plays a critical role in the formation of pollen and fertilization in rice (Dobermann & Fairhurst, 2000). Gupta *et al.* (2008) reported that high N supply to high yielding crop may accentuate Cu deficiency due to the lower availability of Cu in plants of high N nutritional status. On the other hand, B plays a key role in carbohydrate metabolism, sugar transport and pollen viability in rice (Dobermann & Fairhurst, 2000). Boron has long been identified as one of the major constraints for grain crop production in the world (Rerkasem & Jamjod, 2004; Rerkasem *et al.*, 2004). In the context of Malaysia, Zulkefli *et al.* (2004) have documented B deficiency as a limitation for achieving high yield in major rice planting areas. In particular, the application of B is able to enhance grain production significantly

(Rerkasem & Jamjod, 2004; Rerkasem *et al.*, 2004; Zulkefli *et al.*, 2004). The foliar application of B has been proven to be the most effective method for countering B deficiency in standing crop (Somani *et al.*, 2008).

Rice yield obtained in the 2nd season of the field experiment showed no difference in all the treatments, while rice yield in the 2nd season of the field experiment was also lower than that of the 1st season. This was due to the unfavourable field condition in that particular season (January 2008 – May 2008) where rice diseases infected the entire experimental area. Moreover, the lack of field maintenance by the neighbouring farmers resulted in severe disease infestation in the experimental plot (Pers. Comm. Encik Muhammad Jani Bin Rasimon). Plants in the experimental plot where no fungicide was applied were greatly affected. Copper and B treatments were not able to perform their role in reducing fungal infestation.

The ANOVA showed that the treatments applied in the 2nd season of the experiment resulted in no significant difference in terms of rice yield. Thus, other parameters that contributed to the yield components for the 2nd season of field experiment were not discussed.

Physiological and Yield Component Parameters

The results for the physiological and yield component parameters obtained from the field experiments showed a similar trend where the foliar treatment with 20 ppm Cu and 20 ppm B recorded a significantly better yield (Table 4).

The treatments with 20 ppm Cu and 20 ppm B produced significantly higher number of productive tillers m^{-2} (672.0)($P \geq 0.05$) during the 1st season of the field experiment as compared with the control plot (589.33) (0 ppm Cu and 0 ppm B). Tillers production is greatly affected by the availability of Cu. Copper deficient plant always shows a decrease in the numbers of tillers formed (Dobermann & Fairhurst, 2000). Foliar applications are able to timely supply adequate amount of Cu (Tagliavini & Toselli, 2005) during the critical period of tillering to panicle growth stage to correct Cu deficiency and enhance tillers formation (Dobermann & Fairhurst, 2000). Rerkasem and Jamjod (2004) reported that low B availability could reduce tiller numbers in wheat. Meanwhile, Boron plays an important role in accelerating the formation of panicles in rice plants. Dobermann and Fairhurst (2000) reported that B deficiency, particularly at the panicle formation stage, would greatly reduce the formation of panicles in rice plant.

Rice plants treated with T9 (20 ppm Cu and 20 ppm B) produced significantly higher numbers of spikelets $panicle^{-1}$ (130.43) ($P \geq 0.05$). This demonstrates the importance of Cu and B in enhancing grain formation in rice. Dobermann and Fairhurst (2000) also reported that both Cu and B affected pollen viability in rice plant. On the contrary, copper deficiency reduces seed production in wheat, and this is mainly due to male sterility rather than decrease in photosynthetic CO_2 fixation (Gupta *et al.*, 2008). Moreover, B is also associated with male sterility and grain set failure in grain crops, particularly in wheat (Rerkasem & Jamjod, 2004; Rerkasem *et al.*, 2004). Rerkasem and Jamjod (2004) found that B deficiency impaired the function of anthers and resulted in severe reduction in yield. Other than that, B deficiency also depresses pollen germination and the fertilization process (Cheng & Rerkasem, 1993).

Plants treated with T9 (74.73%) and T8 (73.70%) recorded higher percentages of filled grain as compared with the other treatments. This greatly affects the total grain yield because higher grain filling rates are required to secure maximum yield production. A combination of Cu and B successfully increased grain filling in rice. Both Cu and B play important roles in photosynthesis and respiration, carbohydrate metabolism and sugar transport in rice plant (Dobermann & Fairhurst, 2000). Khush and Peng (1996) stated that translocation and accumulation of photosynthate (carbohydrate) produced in leaves and stems into the grains are prerequisites for higher grain filling rates. Thus, the applications of Cu and B via foliar were able to increase grain filling by more than 5% in MR219.

TABLE 4
Physiological and yield component parameters as affected by different levels of Cu and B treatments in the two seasons of the field experiment

Treatment (ppm)	Productive Tillers m^{-2}		Number of Spikelets $Panicle^{-1}$		Filled Grain (%)		1,000-Grain Weight (g)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
T1 (0 Cu, 0 B)	589.33 b	405.33 a	113.50 b	130.40 a	69.46 e	66.33 a	25.09 cd	24.56 ab
T2 (0 Cu, 10 B)	618.67 ab	418.67 a	118.33 b	116.60 a	70.09 ed	64.66 abc	25.19 bcd	24.98 ab
T3 (0 Cu, 20 B)	629.33 ab	422.67 a	119.55 b	115.18 a	70.68 d	61.39 abcd	24.94 d	24.54 ab
T4 (10 Cu, 0 B)	584.00 b	389.34 a	115.70 b	122.70 a	69.68 e	56.99 d	24.71 d	23.50 b
T5 (10 Cu, 10 B)	630.67 ab	428.00 a	117.18 b	120.58 a	72.18 c	56.77 d	25.10 cd	25.13 a
T6 (10 Cu, 20 B)	633.33 ab	412.00 a	117.95 b	130.23 a	73.57 b	60.75 bcd	25.53 abc	24.91 ab
T7 (20 Cu, 0 B)	636.00 ab	418.67 a	115.23 b	115.35 a	72.55 c	66.05 ab	25.57 abc	24.95 ab
T8 (20 Cu, 10 B)	646.67 ab	421.33 a	113.13 b	125.28 a	73.70 ab	63.90 abc	25.65 ab	24.93 ab
T9 (20 Cu, 20 B)	672.00 a	400.00 a	130.43 a	123.60 a	74.73 a	60.19 dc	25.82 a	24.96 ab

In each row, values followed by the same letter (s) are not significantly different ($P \geq 0.05$) by LSD.

The response of rice cultivar MR219 to the Cu and B treatments with respect to 1000-grain weight was significantly higher in T9 (25.82 g) as compared to the other treatments (Table 4). High concentrations of Cu and B (T9, T8, T7 and T6) significantly influenced the 1000-grain weight of rice planted in the 1st season of the field experiment.

Disease Scoring

Disease scoring (%) showed a significant difference among the treatments in the 1st season of the field experiment (*Fig. 1*). Treatment T9 (24.30%) significantly reduced the number of diseased plants as compared to the others. Meanwhile, control T1 (29.65%) found to be the highest in the number of affected plants in the 1st season of the experiment.

The combined foliar treatments of Cu and B demonstrated a significantly suppressing effect on fungal infestation up to a certain limit. Rice plants with minute amount of Cu and B treatments could sustain and produce high yield even without fungicides treatments. During disease outbreak (2nd season of field experiment), the Cu and B treatments were not able to sustain the incidence of disease which remained high, and the rice yields were also badly affected.

The reduction of disease severity in rice was resulted from the biocidal effect of Cu and the combined effect of Cu and B as essential nutrients. Copper and B involved in the physiological and biochemical processes allow plants to response to pathogens invasion (Marschner, 1995; Dobermann & Fairhurst, 2000; Agrios, 2005; Evans *et al.*, 2007; Stangoulis & Graham, 2007). As an important component of fungicides, copper is able to denature the spores and conidia of fungus, which subsequently inhibit spores germination (Montag *et al.*, 2006).

Other than that, Cu helps in promoting lignification in plants to develop plants primary defence mechanism against fungal invasion (Marschner, 1995). Evans *et al.* (2007) stated the effect of Cu in promoting the formation of lignin and this resulted in reduced fungal diseases in different plant species. Similarly, Brown *et al.* (1995) also demonstrated the effect of Cu in enhancing the cross linking of cell wall

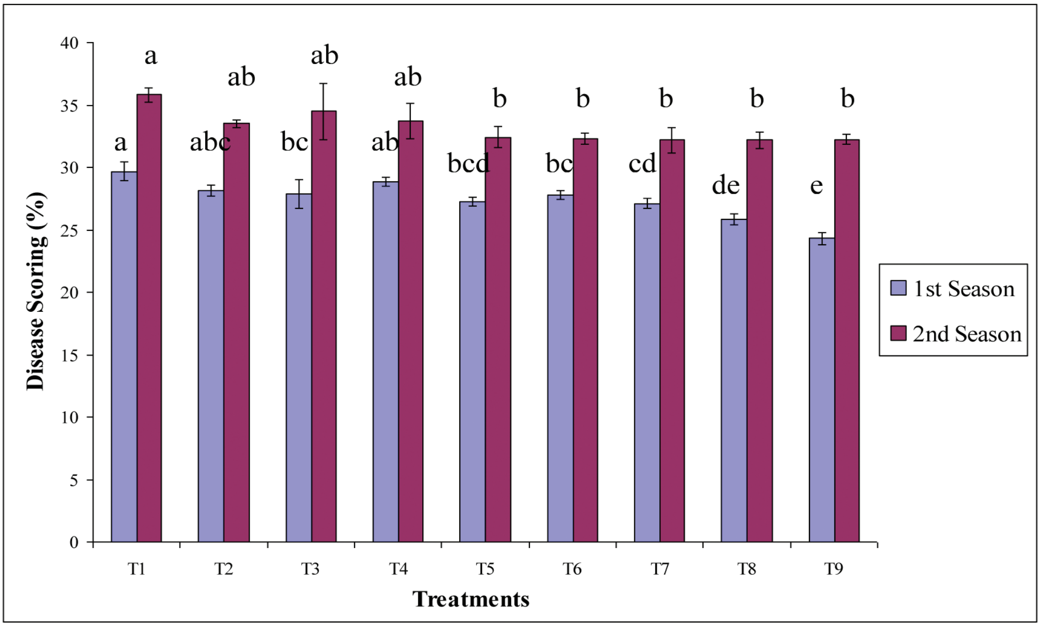

Fig. 1: Disease Scoring (%) as affected by Cu and B treatments at different levels in the two seasons of the field experiment

components and controlling fungal diseases. Modafar and Boustani (2001) revealed that the enhancement of cell wall bound phenolics compound and lignin content in plant tissues promoted host defence against fungus diseases.

Boron is responsible to maintain the cell wall structure, the membrane function and supporting metabolic activities (Bolaños *et al.*, 2004). In addition, Dobermann and Fairhurst (2000) also noted the function of B in enhancing lignin formation in rice. Stangoulis and Graham (2007) reported the importance of B in decreasing fungal diseases in various kinds of corps. The lack of B can cause distortion of cell wall structure and also inhibit biosynthesis of lignin in plants (Marschner, 1995). The foliar treatment of B has also been reported to cut down the number of lesions and reduce the severity of tan spot in wheat through its involvement in physiological and biochemical processes of the plants (Simoglou & Dordas, 2006).

Relationship between Plant Parameters

The coefficient of correlation analysis between rice yield, disease scoring and other yield parameters, such as productive tillers m^{-2}, number of spikelets $panicle^{-1}$, percentage of filled grain and 1000-grain weight, are shown in Table 5.

TABLE 5
Correlation coefficients (r value) between some rice parameters in the field experiment

Plant Parameters	Rice Yield
	Correlation Coefficients
Productive Tillers m^{-2}	0.3028 ns
Number of Spikelets $Panicle^{-1}$	0.0007 ns
Percentage of Filled Grain	0.5392 **
1,000-Grain Weight	0.4646 **
Disease Scoring (%)	- 0.4829 **

ns = Not Significant ** = Highly Significant

A significant correlation exists between rice yield and other parameters such as the percentage of filled grains, 1,000-grain weight and disease scoring (DS). However, disease scoring (DS) is negatively associated with the rice yield. Highly significant correlation exists between the percentage of filled grains and 1,000-grain weight with rice yield, and these indicate the importance of the parameters in promoting rice production. Meanwhile, a positive correlation between these parameters and rice yield is attributed to the improved grain filling of the treatments that contributed to these characteristics. Higher grain filling characteristics indicate better grain weight and density. The negative association between disease scoring (DS) with rice yield showed that rice production is greatly affected by disease incidence.

CONCLUSION

The findings of this study have shown that the foliar applications of Cu and B are able to enhance rice production by 27% under field condition. The yield increment was due to a higher percentage of grain filling and heavier 1,000-grain weight. Moreover, the foliar treatment has also been found to effectively reduce disease incidence by 5% and this is believed to be due to the biocidal effect of Cu and the enhancement of the physiological properties of the plants itself, such as better lignification and fortified cell membrane which is the primary defence mechanism to build up plants resistance. However, the foliar treatment of Cu and B should be applied together with proper plant protection measures, such as fungicide application, to ensure better plant growth and enhance rice production.

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