The Effect of *Magnaporthe oryzae* Conidia on Photosystem in Rice

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Abstract—Investigation of the effect of *Magnaporthe oryzae* on rice to breed resistant varieties is important to environment protection to reduce the use of chemical pesticides. Investigation of the effects of *M. oryzae* conidia on the photosynthesis and photosynthetic pigment contents of rice which plantlets were watered were conducted. The results showed that photosynthesis of rice was inhibited by stomatal and non-stomatal factors in rice which treated by *M. oryzae* conidia. The different rice responded to various *M. oryzae* physiological races were found to be statistically different. The Pn, E, Gs, Ci and chl a/chl b of the rice restoring line R725 were decreased significantly by ZA5 and ZA17. The Pn, E, Gs, chl a/chl b and Car content of the rice restoring line R720 were decreased significantly by ZC8 and ZF2. The ZF2 also can change significantly the Pn, E, Gs, chl a/chl b and Car content of the rice restoring line R727.

Index Terms—Tillering stage, *Magnaporthe oryzae*, photosynthesis, photosynthetic pigment.

I. INTRODUCTION

Rice blast caused by *Magnaporthe oryzae* is one of the most serious diseases in paddy rice (*Oryza sativa*), which restricts the rice production seriously [1]. The use of chemical pesticides result in environmental destruction during controlling, therefore, to understand the relationship between *M. oryzae* and its host is very important to find more environmental prevention measure. Photosynthesis, as the basis of material accumulation in crops, is influenced by various factors, such as light and temperature [2], [3]. Adversity stress (cold, drought, salt) can reduce photosynthetic efficiency significantly and hinder the formation of photosynthetic pigments according to previous study [4], [5]. Some study showed that *M. oryzae* can change the ultrastructure of leaves in seedlings [6]. The question arising is whether *M. oryzae* conidia have effect on photosynthesis in rice. Now, more researchers use the *M. oryzae* toxins to water the seedlings of rice to research the impact of physiological characteristics, however, it is not better to imitate the process of *M. oryzae* infecting the rice [7]. Here, we study on the effects of *M. oryzae* conidia of five physiological races on the photosynthesis and photosynthetic pigment contents at the tillering stage to provide a theoretical basis for resistance mechanisms of rice blast.

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II. MATERIALS AND METHODS

Testing materials: three rice restoring lines (R725, R720 and R727) and five *M. oryzae* physiological races (ZA5, ZA17, ZC8, ZG1 and ZF2), were provided by rice research Institute of Southwest University of Science and Technology. Chemical components of soil consist of full nitrogen was 1.98 g/kg, available nitrogen was 80.3 mg/kg, available phosphorus was 43.3 mg/kg, and available potassium was 76.2 mg/kg.

Preparation of the fungus conidia: The activated strains of *M. oryzae* were inoculated in oat meal agar medium (oat 30g/L) at 28°C. Fungal conidia were harvested by scraping the biomass grown on oat meal agar plates with a sterile surgical blade, and resuspended in sterile water of 0.02% Tween-20. The sample was diluted for 10⁵ spores of *M. oryzae*.

Planting the seedlings and treatment by fungus conidia: Plants were grown in pot culture by direct seeding in experimental station of southwest university of science and technology. Three seedlings in 4 leaves stage were final singled to each pot. The seedling were sprayed 20ml solution with 10⁵ spores of *M. oryzae* for one of physiological race, respectively, with the control of sterile water of 0.02% Tween-20 at the tillering stage. After spraying, the seedlings would keep humidity for 24h.

Determination of indexes: Photosynthetic parameters of upper leaves were measured by GFS-3000 photosynthesis from 9:00-11:00 am in clear day at the tillering stage after 7d of spraying. Meanwhile, the content of photosynthetic pigments of the matched parts were determined referred the methods as previous described [8].

III. RESULTS AND ANALYSIS

A. The Effect of Conidia from Five *M. Oryzae* Physiological Races on the Photosynthesis

Net photosynthetic rate (Pn) is an important physiological index to evaluate the strength of photosynthesis and crop's prolificacy [9]. The results showed that the *M. oryzae* conidia changed considerably the photosynthetic indexes of leaves at tillering stage. Compared with the control, Pn of plants treated by ZA17, ZC8 and ZF2 conidia decreased by 26.89%, 19.56% and 18.43%. Especially, the ZF2 conidia reduced Pn of leaves in R725, R720 and R727 significantly, decreased by 16.61%, 19.09% and 18.43% (Fig. 1a).

Transpiration rate (E) reflects the strength of transpiration and water metabolism status in plants [10]. The conidia, with the exception of ZC8 to R720, reduced the transpiration rate significantly. The ZA5 conidia changed maximumly the Transpiration rate of R725, R720 and R727, decreasing by

43.91%, 36.56% and 55.68% compared with the control (Fig. 1b).

There are two reasons of net photosynthetic rate decreasing. One is stomatal factor, such as the number or size of stoma [11], and the other one is non-stomatal factor, like enzyme activity inside or Photosynthetic components [12]. So if the net photosynthetic rate is decreasing, we may inspect both the stomatal conductance (Gs) and intercellular CO₂ concentration (Ci). Compared with the control, Gs of plants treated by ZF2 conidia decreased by 45.05%, 45.03% and 45.68%, respectively (Fig. 1c). Effect of greatly on Ci of R725, R720 and R727, were ZC8, ZA17 and ZA5, and increased respectively by 14.67%, 4.96% and 15.75% (Fig. 1d).

Fig. 1. Variation of Pn, E, Gs and Ci in rice treated by *M. oryzae* conidia. Data are means of five biological replicates, with bars showing s.d. Different letters indicate significant difference at $P < 0.05$ by Dunnett's test, using DPS 7.05 software.

B. The Effect of *M. Oryzae* Conidia of Five Races on the Photosynthetic Pigment Contents

Photosynthetic pigment was the material basis of photosynthesis, whose content reflect the photosynthetic intensity in plants. *M. oryzae* conidia could affect photosynthetic pigment contents of leaves in rice in varying degrees. Chl a and Chl b content of R725 treated by ZA5 decreased by 34.47% and 18.18%, respectively, and Car content of R725 treated by ZC8 decreased by 25.68%.

TABLE I: VARIATION OF PHOTOSYNTHETIC PIGMENT CONTENTS IN RICE TREATED BY *M. ORYZAE* CONIDIA (MG/KG)

rice varieties	Index	ZA5	ZA17	ZC8	ZG1	ZF2	CK
R725	Chl a	2.89±0.07e	3.13±0.07e	3.51±0.27d	4.13±0.18b	3.80±0.11c	4.41±0.09a
	Chl b	1.44±0.03b	1.54±0.11ab	1.72±0.01a	1.64±0.07ab	1.53±0.01ab	1.76±0.02a
	Chl a+b	4.32±0.09e	4.67±0.18d	5.23±0.27c	5.78±0.25b	5.33±0.11c	6.17±0.10a
	chl a/chl b	2.00±0.03b	2.10±0.03ab	2.03±0.02b	2.52±0.02a	2.48±0.07a	2.51±0.07a
	Car	0.67±0.01ab	0.66±0.01ab	0.55±0.04c	0.63±0.01b	0.66±0.02ab	0.74±0.01a
R720	Chl a	3.93±0.01d	4.15±0.19c	3.74±0.03e	4.44±0.05b	4.27±0.02c	4.65±0.01a
	Chl b	1.83±0.04a	1.85±0.07a	1.75±0.10a	1.99±0.03a	1.86±0.03a	2.06±0.04a
	Chl a+b	5.76±0.05de	6.01±0.25cd	5.50±0.13e	6.43±0.08ab	6.13±0.05bc	6.72±0.05a
	chl a/chl b	2.20±0.08a	2.24±0.08a	2.15±0.03a	2.23±0.02a	2.30±0.02a	2.26±0.04a
	Car	0.71±0.02b	0.74±0.02b	0.75±0.01b	0.84±0.01a	0.73±0.04b	0.84±0.04a
R727	Chl a	3.43±0.03d	3.89±0.29bc	3.99±0.09b	3.47±0.21d	3.66±0.02cd	4.47±0.18a
	Chl b	1.56±0.02c	1.66±0.09bc	1.62±0.02bc	1.52±0.02c	1.73±0.01ab	1.83±0.02a
	Chl a+b	4.99±0.05c	5.55±0.37b	5.61±0.10b	4.99±0.22c	5.38±0.03bc	6.30±0.19a
	chl a/chl b	2.20±0.06bc	2.35±0.10ab	2.46±0.06a	2.29±0.06abc	2.12±0.01c	2.44±0.09a
	Car	0.58±0.03c	0.65±0.04b	0.68±0.01ab	0.56±0.04c	0.50±0.04d	0.74±0.04a

Note: Data in the table are mean ± SD of three biological replicates. Different letters indicate significant difference at $P < 0.05$ by Dunnett's test, using DPS 7.05 software. Chl a、Chl b、Car represent chlorophyll a, chlorophyll b and carotenoid, respectively.

M. oryzae conidia of five physiological races reduced Chl a content of R720, decreasing by 4.52%-19.57%, and the Chl b was similar or slightly lower than the control group. The conidia affected significantly to the Car content of R720 except for ZG1, all of them were decreasing by 15.48%, 11.90%, 10.71% and 13.10%, respectively.

Chl a content of R727 treated by ZF2 decreased, however, Chl b was similar to the control, so Chl a/b decreased the most greatly about 13.11%. Car content of leaves decreased by 61.62%, 12.16%, 24.32% and 32.43% treated by ZA5, ZA17, ZG1 and ZF2, respectively. The change of Chl a content is similar with the Pn. It shows the function of Chl a to photosynthesis is more important. As other result shows that in photosynthesis, the role of vast majority of chlorophyll is to absorb and transfer light energy, only a handful of Chl a transform the light energy [13].

IV. CONCLUSION

Photosynthesis of plants was inhibited by stomatal and non-stomatal factors under stress [12]. Our result showed that, the *M. oryzae* conidia of five physiological races reduced Pn and Gs of leaves to some extent, but the Ci of leaves were similar or slightly higher than the control, suggesting that the conidia would affect the stoma and harmed some photosynthetic components in some way. For example, the Pn of R725 was decreased significantly treated by *M. oryzae* conidia of ZA5 or ZA17. We inferred it caused not only the low Gs resulted in the deficiency of CO₂ supply but also the conidia had inhibited photochemical activity to hinder CO₂ utilization, which resulted in accumulation of intercellular CO₂. It was similar with previous study [14].

Photosynthetic pigment was the material basis of photosynthesis, whose content reflects the level under the stress in plants [15]. Chl a and Chl b were responsible for capture and transmission of light energy mainly, and a few Chl a molecule at special state converts light energy into electrical energy during the process of photosynthesis [16]. In our study, *M. oryzae* conidia could reduce Chl a, Chl b, chl a/chl b at the tillering stage, resulting in low efficiency of light absorption and transmission and inhibition of photosynthesis. Car, the important part of light absorption complex, was an important class of antioxidant and could reduce injury of photoinhibition and active oxygen in plants [17]. Our results indicated that Car in leaves were inhibited by conidia of five races in different degree, resulting in diminished capacity of light absorption and radical scavenging, decreased its protection to chlorophyll, and then affected the photosynthetic efficiency.

Photosynthesis and photosynthetic pigment content of one race in different cultivated rice and that of different races in the same cultivated rice were different significantly, which was consistent with the results relating to the study of activity of defense enzymes and virulence genes [18], [19], suggesting that the response of rice variety was statistically different for various physiological

races of *M. oryzae*. It was also consistent with the result of the study that there are different resistance genes of rice blast in different rice variety [20]. According to the association of the races and rice varieties, agronomist can change cultivation practices in a timely manner to improve the disease resistance of rice plants and reduce the use of chemical pesticides, which is of great importance for environmental protection.

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