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The inhibition of photosynthesis under water deficit conditions is more severe in flecked than uniform irradiance in rice (*Oryza sativa*) plants

Jiali Sun , Qiangqiang Zhang , Muhammad Adnan Tabassum , Miao Ye , Shaobing Peng and Yong Li

Abstract. fi fi fi fl ( ), - , 1 % (/) 20% (, 000) fi . - (*V*) (*J*) 20% (*IS*%, -) (*A*) (*g*) fi fi . fi fi 0 0% (*T* 0%, *T* 0%,) - , fi - fl (*A* -fl) - (*A*). *IS*% *A* *A* -fl *A* 2 fi fi fl .

Additional keywords: fl , - , fi .

1 201 , 22 201 , 3 201

Introduction

fl - fl - , - , , , , (*et al.* (*et al.* 1 0 *et al.* 2012). 2012 *et al.* 201). , fl fl 2 fl ( ) , , (*et al.* 1 0 *et al.* 2002 *et al.* (*et al.* 2002, 2003 *et al.* 200). 2012). I , . , , , . fl , , fi .

(A).

2 ,

. I

fi (2002 et al. 2002),

(. . , ,

)

- fi (et al. 2002 et al. 2014 - et al. 2014). fl

fi

fi ,

(IS%)

(g) -

fl .

fl , fi

,

(2012). ,

(g ,)

0

0% ($T_{0\%,A}$ $T_{0\%,A}$),

- - (et al. 1 2000 et al. 2012).

g fi

,

fi .

, g , $T_{0\%,A}$ ($T_{0\%,A}$) g , 0.1 $^{-2}$ $^{-1}$

(et al. 1 2000),

et al. (2012)

g , 0.4 $^{-2}$ $^{-1}$. fi ,

g 0.4 $^{-2}$ $^{-1}$ (

et al. 200).

g

fi $T_{0\%,A}$ $T_{0\%,A}$,

.

I ,

- , 1 % (/)

20% (, 000)

fi . -

(1) fi

- fl

(2) fl

fi .

fi

IS% -

- -

.

Materials and methods

Plant materials and water treatments

fi 21 201 ,

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( ),

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2. ,

11.0

. -

. ,

fi 10%

. ,

1 % 20%. , -

. I

(- , 1 20% fi

),

.

.

($^{-1}$) 40 ($_4$)$_2$ 4

($_3$)$_2$, 10 $_2$ $_4$, 40 $_2$ $_4$ $_2$ $_4$, 40

4 ($^{-1}$) 2.0 - , 0.

$_2$·4 $_2$, 0.0 ($_4$) 0.. 3 414-1 .0 .143. 3 3 (

$$\Phi_{\text{II}} = 1 - \frac{F}{F'}. \tag{1}$$

II (J) ′

$$J = \times \Phi_{\text{II}} \times \alpha \times \beta, \tag{2}$$

α β ′
II, . ′ α × β
Φ_{II}
′ ′ fi 2 ′ (Φ_2),
(II) .4 4 00 .411. .23 () / 1 1.04 30 (1) / 141( ) (4 -) / - 1 0 21

A g g_s × 3 1 00 µ $^{-2}$ $^{-1}$, 1 100 µ $^{-2}$ $^{-1}$. A g A_{-fl}, g_s A A_{-fl}. 0% 0% ($T_{0\%,A}$ $T_{0\%,A}$) 0 0% g ($T_{0\%gs}$ $T_{0\%gs}$)

A, 2). $_2$, A A $_2$ (2). et al. (2002).

Statistical analysis

Results

CO_2 response curve

A C_i 00 µ $^{-1}$ (1). $_2$

4 ± 0.3 µ $^{-1}$, ^{2} (4 .4 ± 0. µ $^{-1}$). A C_i (1). V g_s A, g_s, C_i, g_s C_i (1). $_2$ (1), A (1) $_2$ (1), A (1). g_s V J 20% g_s 42% 20% 20% 2 % 1 % V 42% g_s 20% 1 %

Induction states of photosynthesis and stomatal conductance

$IS\%$ A g (2).

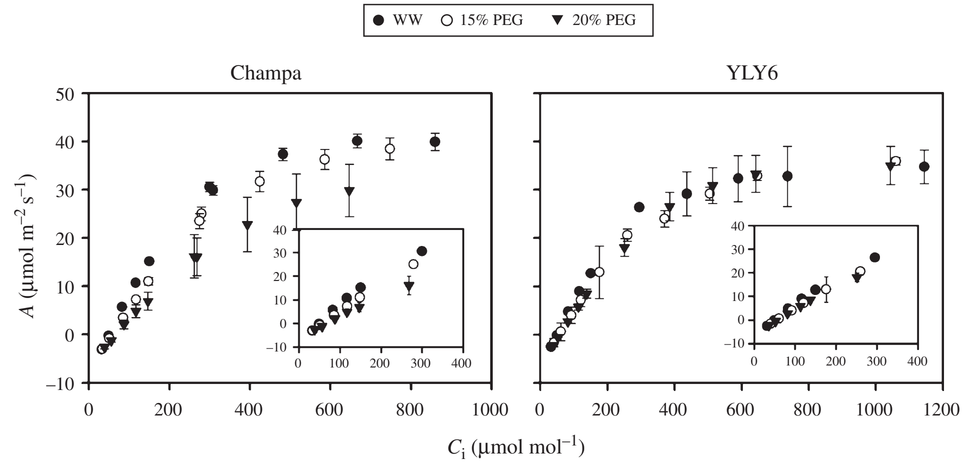

Fig. 1. $_2$ A, C_i, $_2$ 1 %, 1 % 20% , 20%

fi IS% A g 1 A IS% g ,
- , fi .
10 - . IS% A
- , IS% A g , - (. 4).
IS% g . IS% A 1 - , IS% A . 2. 3 (% 2
IS% g (. 3). IS%

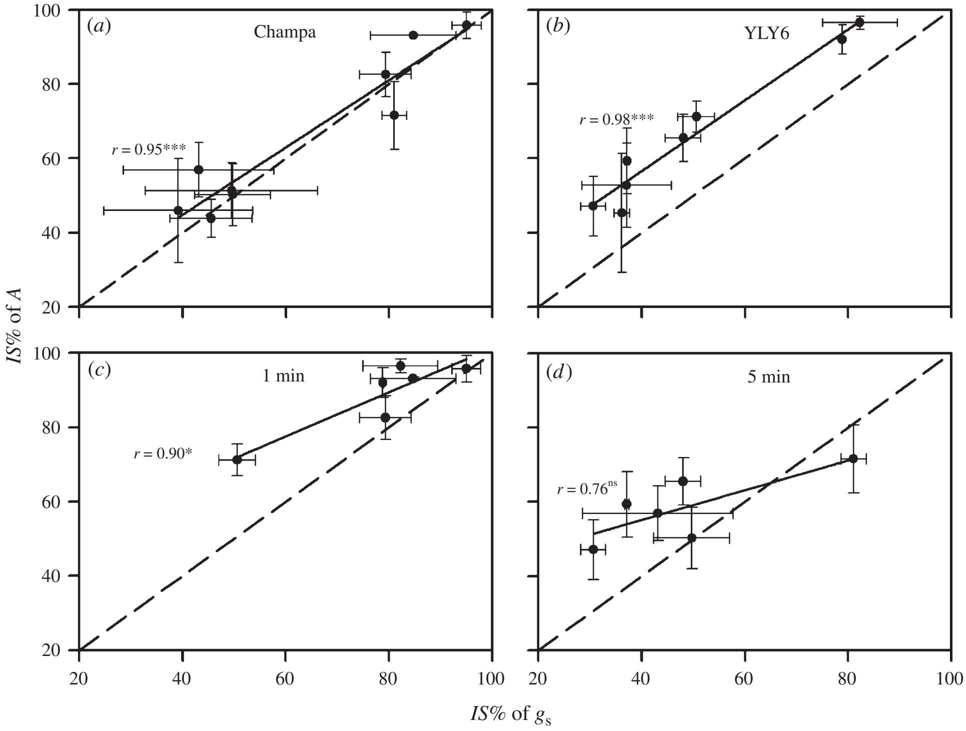

Fig. 3. *IS*% *A* *IS*% *g* - (*a*, *b*), - (*c*, *d*). *IS*%, *A*, *g*, . fi ***, $P < 0.001$.

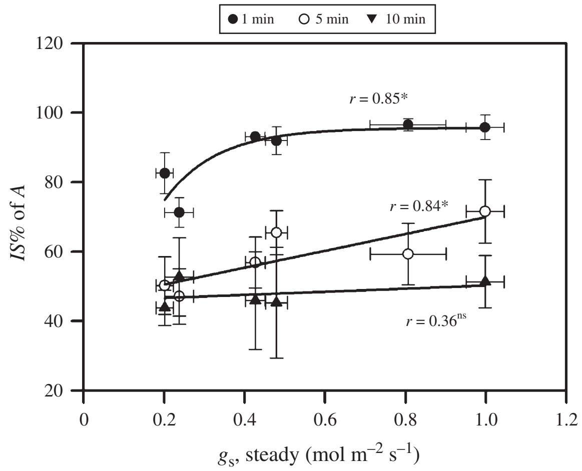

Fig. 4. *IS*% *A* *g*, - . *IS*%, *A*, *g*, , - . fi *, $P < 0.0$, fi $P < 0.0$.

% *g*, 0.4 $^{-2}$ $^{-1}$, *IS*% *g*, . - , *IS*% *A* *g*, . 10 - , *IS*%$_g$ *A* *g*, , *IS*% *A* 4 % .

Dynamic photosynthesis in the flecked irradiance

- , *A* -fl , *A* -fl *g*, fi fi *A* *g*, (2). fi fi $T_{0\%A}$ $T_{0\%A}$, , . fi fi $T_{0\%g}$, fi 20% fi fi $T_{0\%g}$, fi . fi 4 fi I I , . 4 0.1 %, , $_2$ fi .

Discussion

, fl , , , , (*et al.* 1 4 *et al.* 200 *et al.* 2012). fi fl , - , . *IS*%

Table 2. Effects of PEG-induced water deficit on steady-state photosynthesis under a low-light level ($A_{initial}$), maximum photosynthetic rate under flecks ($A_{max–fleck}$), minimum photosynthetic rate under flecks ($A_{min–fleck}$), steady-state stomatal conductance under a low-light level ($g_{s,initial}$), maximum stomatal conductance under flecks ($g_{s,max–fleck}$), times to 50 and 90% of $A_{max–fleck}$ ($T_{50\%A}$ and $T_{90\%A}$), times to 50 and 90% of $g_{s,max–fleck}$ ($T_{50\%gs}$ and $T_{90\%gs}$), post-irradiance CO₂ fixation (PIF), and CO₂ burst (PIB)

fi $P < 0.0$. , - 1 % , 1 % fi
20 % , 20% fi

		1 %	20%		1 %	20%
A (µ –2 –1)	.4 1.0	.1 0.4	3 0.4	3. 1.0	2.0 1.1	4.0 1.1
A -fl (µ –2 –1)	33.3 1.	2 . 1.	1 . 1.	2 .0 2.4	24. 2.	1 .2 2.
A -fl (µ –2 –1)	4.1 0. 0	1.42 0. 0	0.1 0. 0	2. 4 0. 3	2. 3 0.3	1. 0.3
g , (–2 –1)	0.31 0.02	0.22 0.0	0.1 0.0	0.12 0.03	0.0 0.03	0.13 0.03
g , (–2 –1)	1.1 0.23	0. 0.0	0.30 0.0	0. 2 0.10	0.42 0.14	0.33 0.14
T 0% ( )	1.1 0.1	1.4 0. 2	0. 0. 2	0. 2 0.1	1.31 0.	0.4 0.
T 0% ( )	. 2.1	11. 2.2	2.2	2. 1.1	3. 1.2	. 1.2
T 0% ( )	.04 0.	4.30 3.2	0.0 0.12	0. 0.20	1.2 0. 1	0.40 0.04
T 0% ( )	1. 0 .4	1 . 3.3	4.3 2.	1. 0.	2. 1.	.3 1.
I (%)	. 0.2	.2 0.	0.	.1 0.3	. 0.	. 0.
I (%)	0.13 0.11	0.0 0.0	0.32 0.0	0.30 0.10	0.4 0.0	0. 0 0.0

A, IS% A 2 (2000). IS% A - , - - (et al. 2002 et al. 2013). fi IS% A (et al. 2003), 2 (et al. 2002). fi IS% A g , 1 10 (. 2). IS% A IS% g (et al. 2002). I , IS% A IS% g - , IS% g (. 3a, b). , IS% - . , IS% A IS% g - (. 3c, d). I IS% A IS% g 1 - , fi $P < 0.0$ - (r 0. , P 0.0). IS% A IS% g 10 - ( ). , - (<) , - (>). IS% A g , (2000). I , IS% A g , 1 - (. 4). , IS% A g , 10 - , IS% g - fi . (et al. 2002, 2003 et al. 2012).

, , . , ($T_{0\%,A}$ $T_{0\%,A}$) ($T_{0\%,g}$ $T_{0\%,g}$) - 1 % , 20% (2). , , - 1 % , 20% (. . V J) (1). , , , , . . , - , (. 2). , I , , , (et al. 1 et al. 201). I 2 , 2- (et al. 1 et al. 201). et al. (2002) I I 1 .1 0. %, , 2 fi *Shorea leprosula* 2 , 2 14% % , , . I , .0 0.30% I I , fi fi . et al. (2003) A -fl A , 2 fi fi fl .

(2), fl fi . *et al.* (201) *A* -fl *A* - ( ). , . , - , (´ *et al.* 2012 2013). - , - fl - . . I , fi fi - , *IS*% *A* *g* 1 10 . fi fi - , fi *A* -fl *A* . *IS*% *A* *A* -fl *A* fi fl .

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(201 0300102), (31301 40), (2014), (2 201 031).

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