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// . . . /10.10 1/ 1 3 3

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

(*et al.* (*et al.* 1 0 *et al.* 2012). 2012 *et al.* 201).
fl 2
(*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 . - fi

(1) fi

- fl

(2) fl

fi .

fi

IS% - -

.

Materials and methods

Plant materials and water treatments

fi 21 , 201 ,

, ( ), .

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)

$$\Phi_{II} = 1 - \frac{F}{F'}. \quad (1)$$

II (J)

$$J = \times \Phi_{II} \times \alpha \times \beta, \quad (2)$$

α β

II, . α × β

Φ II

fi 2 (Φ 2),

3 . A g A
g , . ,
× 3 fl 1 00 µ −2 −1, 1
- 100 µ −2 −1. A g
A –fl , g ,
. - A -
A -fl . 0% 0%
(T 0%,A T 0%,A)
fi fi -
fi
' ' . 0 0% g (T 0%gs
T 0%gs) .
I
3
. ,
,
,
2 fi
A , - fi (I ,
. 2). , 2 ,A
A fi
- .
2 (. 2). I I
et al. (2002).

Statistical analysis

- ( ) - fi
(. . .)
( ).

Results

CO_2 response curve

- , 2 ,
A fi C
00 µ −1 (. 1).
2

4 ± 0.3 µ −1, 2
- (4 .4 ± 0. µ −1).
- , A fi
C ,
(1).
/ .I , V g ,
, ,
fi .
fi fi A , g , , C , ,
g , C , ,
fi
(1).
2
- fi
(. 1), A
fi
(1) 2
- fi
(. 1),
A
(1). I , fi
g , , V J 20% ,
fi .
, g , 42%
20% fi
20%
2 % 1 % ,
, V 42%
20% ,
1 % .

Induction states of photosynthesis and stomatal conductance

IS% A g
- (. 2).

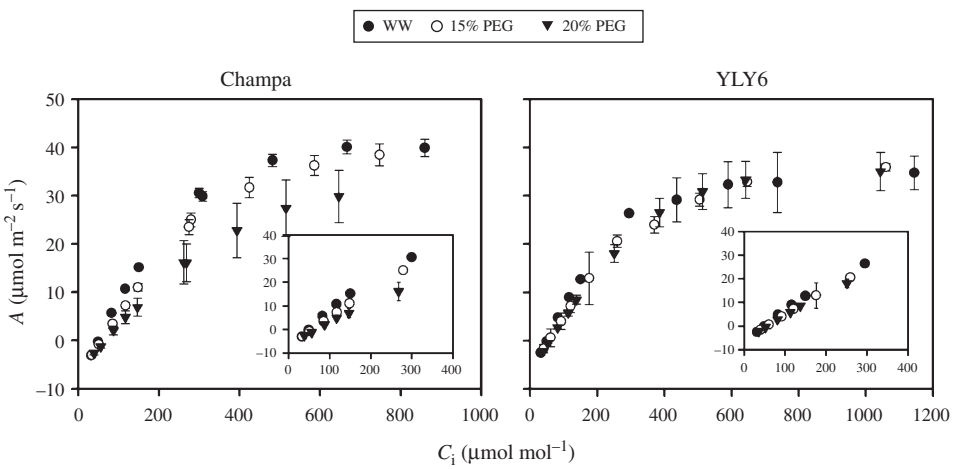

Fig. 1. - fi 2 . A,
C, 2 , - 1 % , 1 % fi
20% , 20% fi .

fi IS% A g 1 , A IS% g ,
- , fi . 10 - . IS% A
- , IS% A g , - (.4).
IS% g . IS% A 1 - , IS% A 0 2 , -0-0001 0 2 , -0-00
IS% g (.3). IS%

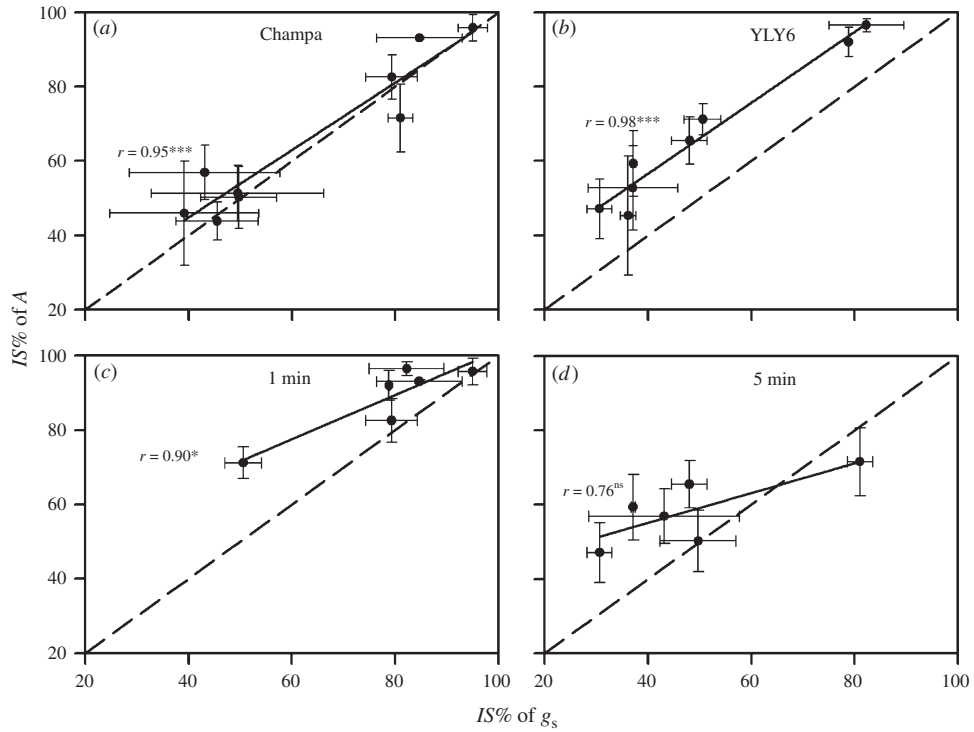

Fig. 3. *IS*% *A* *IS*% *g* ' -
(*a*, *b*), - ' (*c*, *d*). *IS*%, '
A, ' *g*, ' . fi ***, $P<0.001$.

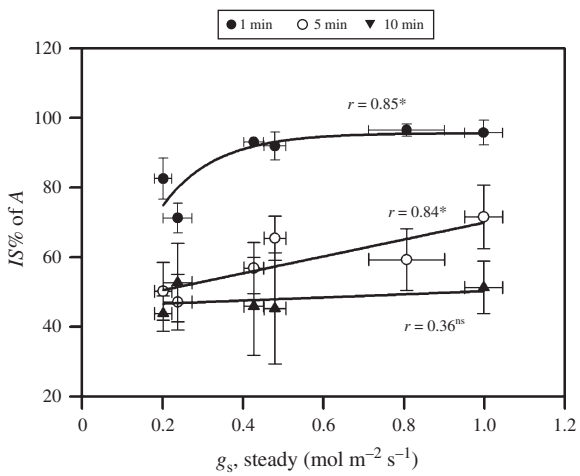

Fig. 4. *IS*% *A* *g*, ' '
- ' . *IS*%, ' *A*,
' *g*, ', ' - ' . fi
*, $P<0.0$, fi $P<0.0$.

' % *g*, '
0.4 −2 −1, *IS*% ' '
g, '. - ,
IS% ' *A* ' '
g, '. 10 - ,
IS% ' *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 ,
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 CO_2 fixation (PIF), and CO_2 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 .

Acknowledgements

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

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