# The Related Research of a Chlorophyll-Deficient Mutant in Chlorophyll Biosynthesis

an example from rice

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# Outline

Introduction

Background、Significance、Research advance

- The Process of Chl Biosynthesis
- Chlorophyll-Deficient Mutant (Oryza sativa)
- Results and Discussion
- Acknowledgments

### Background

- 1.叶绿素分子广泛存在于进行光合作用的有机体中, 起着吸收光能、传递电子的功能。
- 2.20世纪30年代,在叶绿素合成缺陷突变体方面就 有所研究。我们在棉花中称这一突变性状为"芽黄 "virescent (南京农业大学)。
- 3.腺体、蜜腺、卷曲叶、长柱头、芽黄等众多的棉 花突变性状,在利用杂种优势育种时可以作为指 示性状,尤其是芽黄这一性状易于观察。

### Significance

- 1.棉花杂种优势利用中作为标记性状
- 2.水稻等两系法杂交制种中做标记性状保证 种子纯度
- 3.转基因用于雄性不育制种

### **Research advance**

1. 芽黄性状一般是由隐性基因控制的可遗传性状,并在拟南 芥、水稻、玉米、烟草、番茄等开花植物中表现。

- **2.**芽黄性状一般在苗期表现明显,花期或者盛花期时,子叶或者真叶在苗期表现出的不同程度的黄色将会慢慢变绿。
- 3.Wu等已培育出携带转绿型黄叶标记的水稻光敏雄性不育 系"Xinguang S",这种将叶色突变与雄性不育相结合 的方法,为保证杂交种纯度提供了有效途径。
- 4.在陆地棉异源四倍体中已鉴定的芽黄基因有26个,其中有 部分同源基因对存在于22个芽黄突变体。
- 5.目前在棉花中,芽黄基因的核酸序列还没有报道。
- 6.水稻上的芽黄基因已有报道,以水稻为例,可为以后棉花 芽黄基因的预测做准备。

### The process of Chl biosynthesis



#### Phase I



**第二阶段:** 4 分子的PBG聚合形成卟啉结构,经过6步 酶促反应,最终形成原卟啉IX。以上反应是合成叶绿 素和血红素共有的。



Phase II



# 第三阶段: 原卟林IX 螯合镁;环化形成 E环,甲酯化; D环被还原.



原叶绿酸酯a



最后阶段: 叶绿酸酯a 在叶绿素合成酶作用 下被叶醇酯化形成叶 绿素a





- 1 谷氨酰-tRNA还原酶(glutarnyi tl\NA reductase)
- 2 谷氨酸-1-半醛转氨酸(glutamate 1-semialdehyde aminotransferase)
- 3 胆色素原合酶(porphobilinogen synthase) [5-氨基酮戊酸脱水酶(5-aminolevulinate dehydratase)]
- 4 羟甲基后胆色素原合酶(hydroxymethylbilane synthase) [胆色素原合酶脱氨酶 (porphobilinogen deaminase)]
- 5 尿卟啉原 III 合酶(uroporphyrinogen III synthase) [尿卟啉原 III 共合酶 (uroporphyrinogen III co-synthase)]
- 6 尿卟啉原脱羧酶(uroporphyrinogen decarboxylase)
- 7 粪卟啉原氧化脱羧酶(coproporphyrinogen oxidative decarboxylase)
- 8 原卟啉原氧化酶(protoporphyrinogen oxidase)
- 9 镁螯合酶 D 亚基(Mg chelatase D subunit) 镁螯合酶 H 亚基(Mg chelatase H subunit) 镁螯合酶 I 亚基(Mg chelatase I subunit)
- 10 镁原卟啉 IX 甲基转移酶(Mg-protoporphyrin IX methyltransferase)
- 11 镁原卟啉原 IX 单甲酯环化酶(Mg-protoporphyrinogen IX monomethylester cyclase)
- 12 二乙烯还原酶(divinyl reductase)
- 13 NADPH 原叶绿素酸酯氧化还原酶(NADPH:protochlorophyllide oxidoreductase)
- 14 叶绿素合酶(chlorophyll synthase)
- 15 叶绿素酸酯a氧化酶(chlorophyllide a oxygenase)

### **Chlorophyll-Deficient Mutant**

### The ygl1 Mutant

- A, Four-week-old plants.
- B,Ten-week-old plants.
- C, Fifteen-week-old plants



●The ygl1 Mutant showed yellow-green leaves in young plants with decreased ChI synthesis, increased level of tetrapyrrole intermediates, and delayed chloroplast development.

●Leaves of the ygl1 mutant had 20% to 70% reduction of Chl, and 30% to 40% reduction of Car levels compared to those in wild type at different stages, with the most significant differences detectable in 4-week-old plants.

●The Chl a/b ratio appeared highest at the seedling stage, due likely to the potential of Chl b synthesis in suffering a more severe decline than Chla . The Chl a/b ratio then declined to eventually reach the wild-type level.

●this suggests that the ygl1 mutant exhibited delayed greening during photomorphogenesis because of slow rates of Chl accumulation.

 Granal stacks in the ygl1 mutant appeared less dense and lacked granal membranes compared to those of wild type in developing leaves.

Granal development in the ygl1 mutant was slower than that of wild type, and granal membranes in the ygl1 mutant increased when the leaf became mature.

# How the ygl1 mutation affects chloroplast development?

### **Protein BLAST**

#### Sequences producing significant alignments:

Accession	Description	Max score	
EEC79019.1	hypothetical protein OsI_19554 [Oryza sativa Indica Group]	655	
NP 001055272.1	Os05g0349700 [Oryza sativa Japonica Group] >sp Q5W6H5.1 CHLG_	655	
XP 002440929.1	hypothetical protein SORBIDRAFT_09g016840 [Sorghum bicolor] >gb	611	
NP 001142204.1	uncharacterized protein LOC100274372 [Zea mays] >gb ACF87878.1	608	
XP 003568641.1	PREDICTED: chlorophyll synthase, chloroplastic-like [Brachypodium d	604	
Q9M3W5.1	RecName: Full=Chlorophyll synthase, chloroplastic; AltName: Full=Pol	599	
XP 002263271.1	PREDICTED: chlorophyll synthase, chloroplastic [Vitis vinifera] >emb	588	
AEI83422.1	chlorophyll synthase [Camellia sinensis]	585	
ACQ44245.1	chlorophyll synthase [Nicotiana tabacum]	580	
XP 002530507.1	bacteriochlorophyll synthase, putative [Ricinus communis] >gb EEF3	577	
ACQ44244.1	chlorophyll synthase [Nicotiana tabacum]	577	
XP 002877826.1	ATG4/CHLG/G4 [Arabidopsis lyrata subsp. lyrata] >gb EFH54085.1  /	578	
XP 002308227.1	predicted protein [Populus trichocarpa] >gb ABK95029.1  unknown [	<u>577</u>	
NP 190750.1	chlorophyll synthase [Arabidopsis thaliana] >sp Q38833.1 CHLG_ARA	576	

#### Distribution of 100 Blast Hits on the Query Sequence 😡

Mouse-over to show defline and scores, click to show alignments





Oryza sativa Indica Group		MA	r s H	LL <u>AA</u>	A SI SI	T <mark>a a</mark>	S S <mark>A</mark> -	- T F	R F	P P <mark> </mark>	L L S	LR	SPP	P S -	S L R	LNF	R R	Η				<mark>F</mark> (	VV	AA	E T D -	K E 1	K	<mark>a</mark> n <i>i</i>	P <mark>e</mark> k	AF	A <mark>G G</mark>			5 5	F [70]
Vits vinifera		MAS		LLNT	/SS	VRL	SN	- <mark>a r</mark>	Ţ		T	ΡR	FLP	PI	S L S	LHF	RR					· · · <mark> </mark>	<u> </u>	AA	E T D A	NE	A V	SQ/	A P <mark>d</mark> k	i <mark>a</mark> P	A <mark>G</mark> S			- <mark>G</mark> SI	F [64]
Ricinus communis					• • •							• •		• •	- <u>M L</u>	FSC	RR					· · ·	TI.	AT	E T D /	Ν.	EV	( P <mark>e </mark> /	A P <mark>D</mark> K	i <mark>a</mark> P	<mark>a</mark> ss	S		<mark>G G</mark> S S	F [38]
Protein G4ShortAtG4		M T S		I L N T	V <mark>S</mark> T	I H S	SRV-	- T S	V	D <mark>R</mark> V	V <mark>G</mark> V	LS	LRN	I S D	<mark>s</mark> V E	FTF		S <mark>G</mark> F	STL	. I Y	E S P	<mark>g</mark> r r f	V V	A A	E T D T	0.	KV	S Q 1	' P <mark>d</mark> k	i <mark>a</mark> P	A <mark>G G</mark>	· · ·			[81]
Nicotiana tabacum		MAS		L L N S	VPS	IKL	SN <mark>F</mark> -	- S N	N	NPI	L <mark>R</mark> S	SQ	I S S	PF	CLS	LSF	RR				• • •	<mark> </mark>	. V V	AT	TDK		EV	A O /	P DK	AF	AAG			- <mark>6</mark> 5 5	I [67]
Micromonas sp. RCC299	MAAVA	FTF	V S	I Q <mark>a</mark> si	A <mark>a</mark> ri	p r <mark>a</mark>	T <mark>V R (</mark>	AR A	V	R <mark>a</mark> 1	V S <mark>G</mark>	LG	s s <mark>a</mark>	AL	<mark>a</mark> p <u>r</u>	P S <mark>A</mark>	MR	<u>A</u>			• • •	L <mark>GL(</mark>	V A	RR	) <mark>a</mark> r s	A D L	. A V	A M A	DEE	K	) D <mark>K</mark> G			<mark>A</mark> (	V [82]
Micromonas pusilla CCMP1545	· · · ·	ISS F	V S	S <mark>G G</mark> F	V P T	PVS	SSKF	SS F	V	V R /	AS-			• •	· P D							(	E A /	<mark>a</mark> K. K.				· · /	GEE	N	E S G			51	[48]
Ectocarpus siliculosus		MV	S <mark>P</mark> W	V V <mark>a</mark> s	V <mark>G</mark> A	LSV	G G <mark>A</mark> G	AFH	V	P <mark>a l</mark>	L <mark>P</mark> S	AR	ATA	AA	N <mark>r</mark> H	V S F	MS	T <mark>a d</mark>	DKF	<sup>P</sup> K S	FYP	FQRS	DA	ST	R P <mark>G</mark> S	I P F	RLE/	GV	I P T P	E	KGG	ΤK	E G E G	G A G G /	F [95]
Camelia sinensis		MA		LLNT	V S S	IRL	S N	- <mark>A</mark> K	ΤI	NR	L <mark>R</mark> T	RT	V P P	PI	S L S	LTF	(R R			• • •	• • •	<mark> </mark>	TV.	AT	E T D A	N E -	AI	A E /	A P <mark>d</mark> K	AF	VAS			- <mark>6</mark> 83	F [68]
Brachypodium distachyon		MA	r s H	LLAA	AV T	SSS	S S <mark>A</mark> -	- <mark>A</mark> F	R F	r p <mark>i</mark>	L R R	L-	S P P	ΡL	S <mark>L</mark> T	LSF		• •			• • •	• • <mark>F</mark>	VV	AA	) <mark>a</mark> d a	KET	[T -	( P K <mark>/</mark>	A P <mark>e</mark> k	i <mark>a</mark> P	AAG			5 5	F [71]
Avena sativa		MA	r s H	P L A A I	A A A	TSS	S S <mark>A</mark> -	- T F	R F	P P <mark>I</mark>	L <mark>R</mark> F	L-	SSP	P S -	S <mark>L</mark> T	LNF	R R	s.,				• • <mark>F</mark>	V V (	AA	) <mark>a d</mark> A	KET	F T <mark>K k</mark>	(PT I	P <mark>d</mark> k	i <mark>a</mark> P	AAG			8 8	F [72]

Oryza sativa Indica Group	NQ	LL (		( <mark>G</mark> A	KQE	ND	WK	I R	L۵	T K	PV	T۱	V P	Ρ	LV	N G	۷L	0(	<mark>g</mark> a a	AS	G	FHW	Ι.	• • •	•••		• •	۰.۱	ED	V A K	SI I	/ C	A I M	S <mark>G</mark>	CL	T <mark>g</mark> y	IQ.	T	N <mark>D</mark> W	Y D P		AI	N <mark>e</mark> P	[157]
Vits vinitera	NQ	LL (		( <mark>G</mark> A	A K E	ΤN	WK	I R	L۵	L T K	PV	Τl	V P	Ρ	LV	N G	γV		<mark>g</mark> a a	AS	G	FHW	N.	• • •	• •		• •	• • <mark> </mark>	ED	V A K	S <mark>I 1</mark>	/ C	A I M	S <mark>G</mark>	CL	T <mark>g</mark> y	TQ.	ΤL	N <mark>D</mark> W	YD	E	A I	NEP	[151]
Riainus communis	NQ	LL <mark>(</mark>		( <mark>G</mark> A)	A Q	T N	WK	I R	L۵	L T K	PV	T۱	V P	Ρ	LV	N G	γV		<mark>g</mark> a a	AS	G	( <mark>F</mark> HW	Ν.		• •		•••	· •	ΕD	V A K	S <mark>V V</mark>	/ C	I L M	S <mark>G</mark>	FL	T <mark>g</mark> y	TQ.	T I	N <mark>d</mark> y m	YD	E	AL	N E P	[125]
Protein G4ShortAtG4	NQ	L L <mark>(</mark>		( <mark>G</mark> A	s Q <mark>e</mark>	T N	WK	I R	L۵	T K	PV	T۱	V P	Ρ	LV	N G	VV		<mark>g</mark> a a	AS	G	( <mark>F</mark> HW	Ι.	• • •	• •		• •		E D	V A K	S <mark>I I</mark>	. C I	A M M	S <mark>G</mark>	CL	T <mark>g</mark> y	IQ.	T I	N <mark>D</mark> W	YD	DI	) A I	N <mark>e</mark> P	[168]
Nicotiana tabacum	NQ	I L <mark>(</mark>		GA	KQ	ET D	WK	I R	۷Q	. T K	PV	Τl	V P	Ρ	LV	N G	VV		<mark>g</mark> a a	AS	G	( <mark>F</mark> HW	Ι.	• • •	• •		• •		E D	V <mark>a</mark> K	SV V	/ C	I L M	S <mark>G</mark>	FL	T <mark>g</mark> y	IQ.	T I	N <mark>D</mark> W	YD	E	A I	NEP	[154]
Micromonas sp. RCC299	KQ	LL (		GG	E R I	DDI	WK	I R	L۵	L T K	P۷	ΤV	V	Ρ	LI	NG	VM		<mark>g</mark> a a	AS	G	Y T W	Ι.		• •		• •	• •	EN	V <mark>G</mark> K	A M I	. C I	I F N	S <mark>G</mark>	LL	T <mark>g</mark> y	IQ.	T I	NDW	E D	E	AL	NEP	[169]
Micromonas pusilla CCMP1545	RQ	LL		GG	E Q1	T D	WK	I R	L۵	T K	PV	TΙ	V	Ρ	LI	N G	۷L		<mark>g</mark> a a	AS	G	F T W	٦.		• •		• •	•••	EN	V <mark>G</mark> K	S <mark>M I</mark>	. C I	I F N	S <mark>G</mark>	LL	T <mark>g</mark> y	IQ.	T I	N <mark>D</mark> W	YD	E	A I	NEP	[135]
Ectocarpus siliculosus	RQ	LV	B L	( <mark>G</mark> A	S T I	DE	LK	I R	L۵	L T K	P۷	T۱	V I	Ρ	LI	N G	۷L		<mark>g</mark> a a	AS	G	N Y H W	WN	FG	GG	٥٧	FD	L G	00	LLK	AL	G C I	/	S <mark>G</mark>	FL	T <mark>g</mark> y	IQ.	T I	N <mark>D</mark> W 1	YD	DI	Al	NEP	[195]
Camelia sinensis	NQ	LL (		( <mark>G</mark> A	KQE	T D	WK	I R	L۵	T K	PV	T۱	V P	Ρ	LV	N G	VV		<mark>g</mark> a a	AS	G	( <mark>F</mark> HW	Τ.	• • •	• •		• •	•••	DD	V A K	SI	/ C	I L M	S <mark>G</mark>	CL	T <mark>g</mark> y	IQ.	T L	N <mark>D</mark> W 1	YD	E	A I	NEP	[155]
Brachypodium distachyon	NQ	LL		( <mark>G</mark> A	K <mark>e</mark> e	SN	WK	I R	L۵	T K	PV	Τl	V P	Ρ	LV	N G	۷L	0	<mark>g</mark> a a	AS	G	FQW	Ι.	• • •	• •		• •	۰. ۱	ED	V A K	S۱۱	/ C	I L M	S <mark>G</mark>	CL	T <mark>g</mark> y	1Q'	T I	N <mark>D</mark> W	YD		AL	NEP	[158]
Avena sativa	NQ	LL (		( <mark>G</mark> A	KQ	ΤN	WK	I R	L۵	TK	PV	T۱	V P	Ρ	LV	N G	۷L	0(	<mark>g</mark> a a	AS	G	FHW	Ι.	• • •	• •		• •	•••	ED	V T K	S I	/ C	I L N	S <mark>G</mark>	CL	T <mark>g</mark> y	TQ.	ΤI	N <mark>D</mark> W	YDR	DI	) A I	N E P	[159]
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Oryza sativa Indica Group	Y R P <mark>I</mark> P	SG	A I S	ENE	VI	Q	WAL	LLA	GLG	LG	ΑL	LD	V W A	A <mark>g</mark> h		+1	FYL	ΑV	<mark>g g</mark> s l	LS	Y <mark>I</mark> Y	S <mark>a P</mark>	PLK	. <mark>K</mark> QN	GW	GN	FAL	GAS	YI <mark>G</mark> L	PWV	V <mark>a g</mark> o	AL	F <mark>g t</mark> l	TPD	I V V	[257]
Vitis vinifera	Y R P I P	SG	A I S	ENE	VI	QI	WLL	L L <mark>G</mark>	GL G	LΑ	GL	LD	V W A	A <mark>G</mark> H	O F P	۱V	FYL	ΑL	<mark>g g s</mark> l	LS	Y <mark>I</mark> Y	S <mark>a P</mark>	PLK	. <mark>K</mark> QN	GW	GN	FAL	GAS	YISL	PWV	V <mark>a g</mark> o	AL	F <mark>gt</mark> l	NPD	II V	[251]
Ricinus communis	Y R P I P	SG	A I S	ESE	VI	QI	WVL	LL <mark>G</mark>	GL G	LG	GL	LD	V W A	A <mark>G</mark> H	O F P	IV	FYL	ΑL	<mark>g g s</mark> l	LS	Y <mark>I</mark> Y.	S <mark>a P</mark>	PLK	. <mark>K</mark> QN	GW	GN	FAL	GAS	YISL	PWV	V <mark>a g</mark> o	AL	F <mark>gt</mark> l	TPD		225
Protein G4ShortAtG4	Y R P I P	SG	A I S	EPE	VI	QV	WVL	L L <mark>G</mark>	GL G	ΙA	GI	LD	V W A	A <mark>G</mark> H	T T P	ΤV	FYL	ΑL	<mark>g g s</mark> l	LS	Y <mark>I</mark> Y	S <mark>a P</mark>	PLK	. <mark>K</mark> QN	<mark>G</mark> W 1	/ <mark>G</mark> N I	FAL	GAS	YI SL	P W V	V <mark>a g</mark> o	AL	F <mark>gt</mark> l	T P D	VVV	288
Nicotiana tabacum	Y R P I P	SG	A I S	GQE	VI	IQI	WVL	L L <mark>G</mark>	GL G	LΑ	GI	LD	V W A	A <mark>g</mark> h	O F P	ΤL	FYL	ΑL	<mark>g g</mark> s l	LS	Y <mark>I</mark> Y	S <mark>a P</mark>	PLK	KQN	GW	GN	FAL	GAS	YI SL	P W V	V <mark>a g</mark> o	AL	F <mark>gt</mark> l	T P D	IIV	254
Micromonas sp. RCC299	<mark>d</mark> r p i p	SG	A I S	EFC	۷Q۱	Q	YVL	L F <mark>G</mark>	G W A	CA	WT	LD	QWO	CEH	O F P	۱V	TAL	T L I	F <mark>g</mark> sv	/ I S	Y <mark>I</mark> Y	S A P	PLK	KQE	GW	GN	YAL	GAS	YIAL	P W V	V <mark>a g</mark> o	AV	FGEL	S L D	V M V	289
Micromonas pusilla CCMP1545	N R P I P	SG	A I S	EFC	۷Q	Q M	Y A L	L L <mark>G</mark>	G W A	A A	WΤ	LD	Q W Q	CEH	D W P	γγ	TVL	V L I	F <mark>g</mark> s v	/ <mark>V</mark> S	Y <mark>I</mark> Y	S A P	PLK	KQE	GW	GN	Y A L	GAS	YI AL	P W V	V <mark>a g</mark> o	ΑV	FGEL	S L D	VMV	235
Ectocarpus siliculosus	Y R P I P	SG	AIS	EKO	VI	QI	WFL	LL <mark>G</mark>	SL A	I A	Υ <mark></mark>	LD	V W A	GH	O F P	ΜV	FAL	SV	<mark>g g s</mark> f	I S	Y <mark>I</mark> Y	S A P	PIKI	KQN	GW	G N	Y A L	GSS	YI SL	PWV	VCGC	A M	FGEL	NIQ	VVI	295
Camellia sinensis	Y R P I P	SG	A I S	ENE	VI	QI	WVL	L L <mark>G</mark>	GL G	LΑ	GL	LD	V W A	A <mark>g</mark> h	O F P	ΤI	FYL	AI	<mark>g g s</mark> l	LS	Y <mark>I</mark> Y	S <mark>a P</mark>	PLK	. <mark>K</mark> QN	<mark>G</mark> W I	GN	FAL	GAS	YI SL	P W V	V <mark>a g</mark> o	AL	F <mark>gt</mark> l	T P D	IIV	255
Brachypodium distachyon	Y R P I P	SG	A I S	ENE	VI	QI	WVL	LLA	GL G	LG	ΑL	LD	V W A	A <mark>g</mark> h	D Y P	ΓI.	FYL	ΑL	<mark>g g s</mark> l	LS	Y <mark>I</mark> Y	S <mark>a P</mark>	PLK	. <mark>K</mark> QN	<mark>G</mark> W	GN	FAL	GAS	YI <mark>G</mark> l	P W V	V <mark>a g</mark> o	AL	F <mark>g</mark> tl	T P D	I V V	258
Avena sativa	Y R P I P	SG	A I S	ENE	VI	QI	WVL	LL <mark>G</mark>	GL G	LG	ΑL	LD	I W A	A <mark>g</mark> h	O F P		FYL	ΑL	<mark>g g s</mark> l	LS	Y <mark>I</mark> Y	S A P	PLK	. <mark>K</mark> QN	GW	GN	FAL	GAS	YI <mark>g</mark> l	P W V	V <mark>a g</mark> o	AL	F <mark>gt</mark> l	T P D	I V V	259
		1 1			111																111	1					11								1 1 1	
On an estim Index Court		/ 0	101	C I A					A 1	01	<u> </u>			n u	ст л	V W					VAC	v I	<b>c</b> c c /		V A I	<u> </u>	01	T   D /	VVE		VCI					[257]
Vita sana nuca oloup			ADL							G L		1.	V M F V A E	N M							V A	VI				. M L L										10541
Vits Villea Deixe executio			ADL							C L	0 0	1.	V M F V A F																							1225
Partice CARbathaca			ADL						A M		0 0	1	V M F V A F	0.4												ALL										1000
Protein G4 ShortAtG4			AUL					200	AL		U 3	μ.	VAT	0		K W					VA					ALI	AL									300
Nicotana tabacum		S V	AUL				K SI	EGU		O L	0.5	۲.	VAI	0	A A	KW		O A			V A				Y <mark>a I</mark>	ALI			V F F		M F L		Y Y		U <mark>A</mark> -	304
Micromonas sp. RCC299	MIVL		AGL				KSI	EGD	Q M	GL	MS	5	VAI	U V		KW		G				IY L	AI		YS I	MLL	. A L		1 + +		F F L		I K N	DVK.	<u> </u>	309
Micromonas pusilla CCMP1545			AGL	GIA	IV	DF	KSI	EGD	RQC	GL	MS	Ľ	VAF	GV	e K A	KW		G	DAT		V A	YL	RTI		Y S I	ALI	A L	I F P C	I F F	QFK	FFL	P D F	V K N	DVK	Q A _	335
Ectocarpus silicubsus		S W	AGL	GI A	IV	I D F	KSV	EGD	REM	GL	QS	LP	VAF	GV	E K A	KW		GS	DAT			WL	YYI	EPT	YA A		A L	V L P C	VFA	QFK	YFL	P D F	Y <mark>G</mark> N	DVK		395
Camelia sinensis			AGL	GI A		I D F	KSV	EGD	A L	GL	QS	LP	VAF	GS	ET A	KW		<mark>g</mark> a i		QLS	V A C	YL		) K P F	YA L	ALI	G L		VFF	QFK	YFL	K D F	2 <mark>V</mark> K Y	DVK	( Q <mark>A</mark> _	355
Brachypodium distachyon	LICL	( S I	AGL	GI A	IV	I D F	KSI	EGD	RT L	GL	QS	LP	VAF	GM	DT A	KW		<mark>g</mark> a i		QLS	VA	YL	LST	) K L Y	YA L	ALL	. <mark>G</mark> L	TIPO	VIL	QFQ	YFL	K D F	2 <mark>V</mark> K Y	DVK	( Q <mark>A</mark> _	358
Avena sativa	LTCL		AGL	GI A	IV	I D F	KSI	EGD	RTL	GL	QS	LP	VAF	GM	E T A	KW	ICV	<mark>g</mark> A I		Q <mark>L</mark> S	V A A	AY L	LST	K L Y	YAL	ALI	. <mark>G</mark> L	T I P (	VIL	Q <mark>F</mark> Q	YFL	K <mark>D</mark> F	1 <mark>V</mark> K Y	DVK	( Q <mark>A</mark> _	359
Onga sative Indica G	nin		5 /			FV	1		VT				н				-	[376	RI												1 1 1					
Vitis vinifera	o up		š /		F	ίv	ī.	G I	v	AL	Â	- š	Ĥ.					1370	01																	
Ricinus communis			s /		Ē	īν	Ē	B L	v	AL	A	r s	Ĥ.				-	1325	5																	
Protein G4ShortAtG4			s /		F	ιv	ī.	GI	F V T	AL	A	εā	H				-	[38]	7																	
Nicotiana tabacum			s /		F	LI	L	G L I	. V T	AL	A	S	н				-	373	3																	
Micromonas sp. RCC	299		s /	A Q P	F	LV	F	G L I	L T T	GL	A	NG	н	ΗI	ΝA		A	[398	5																	
Micromonas pusilla C	CMP15	45	s /	A Q F	F	LV	F	GLI	<u> </u>	GL	A	N G	н	ΗI	NA		A	[361	1]																	
Ectocarpus siliculosu	5		T /	A Q F	F	LV	F	GII	TT	A L	A I	/ G	н	ΗT	<b>F</b> -		-	[41]	7]																	
Camellia sinensis			S /	A Q P	F	LΙ	L	G L I	L V T	A L	A	° S	н				-	[374	4]																	
Brachypodium distact	iyon		S /	A Q P	F	FΥ	F	GL	_ V T	ΑL	A	S	Н				-	[37]	7																	
Avena sativa			S /		F	FV	F	3 L		AL	A	S	Н				-	[378	8																	



PEPSTATS	5 of [Oryza f	rom 1 to	376									
Molecular	weight = 40	578.88	Res	idues = 376	5							
Average Residue Weight = 107.923 Charge = 4.5												
Isoelectric Point = 8.2793												
A280 Molar Extinction Coefficient = 80510												
A280 Extin	nction Coeff	icient 1n	ng/ml = 1.98	\$								
Improbabil	lity of expres	ssion in i	nclusion bo	dies = 0.819	9							
Residue	Numb	er	Mole%	Dayho	offStat							
A = Ala	43	11.436	5 1.33	30								
B = Asx	0	0.000	0.0	00								
C = Cys	4	1.064	0.3	67								
D = Asp	15	3.989	0.7	25								
E = Glu	10	2.660	0.44	43								
$\mathbf{F} = \mathbf{Phe}$	16	4.255	1.18	32								
G = Gly	32	8.511	1.0	13								
H = His	5	1.330	0.6	65								
I = Ile	25	6.649	1.47	8								
J =	0	0.000	0.0	00								
K = Lys	16	4.255	0.6	45								
L = Leu	47	12.500	0 1.6	89								
M = Met	4	1.064	0.62	26								
N = Asn	11	2.926	0.68	0								
O =	0	0.000	0.0	00								
$\mathbf{P} = \mathbf{Pro}$	24	6.383	1.22	7								
Q = Gln	15	3.989	1.02	3								
R = Arg	11	2.926	0.59	7								
S = Ser	29	7.713	1.10	12								
$\mathbf{T} = \mathbf{Thr}$	20	5.319	0.87	72								
U =	0	0.000	0.00	0								
V = Val	24	6.383	0.967	7								
W = Trp	11	2.926	2.25	0								
X = Xaa	0	0.000	0.00	0								
Y = Tyr	14	3.723	1.095	5								
Z = Glx	0	0.000	0.00	D								
Property	Residues		Number	Mole%	6							
Tiny	(A+C+G+	-S+T)	128	34.043								
Small	(A+B+C+I	D+G+N+	P+S+T+V)	202	53.723							



. [

Tmap

```
# Program: tmap
# Rundate: Tue 21 Feb 2012 04:12:57
# Commandline: tmap
# -auto
# -graph png
# -sequences 509968
 -goutfile 509969
#
# -outfile 509970
# Report format: seqtable
# Report file: 509970
#______
# Sequence: Consensus from: 1 to: 376
# HitCount: 4
Start End TransMem Sequence
  175 203 1 IWALLLAGLGLGALLDVWAG
  239 265 2 LPWWAGQALFGTLTPDIVVL
  300 320 3 WICVGAIDITQLSVAGYLFS
  325 345
             4 YALALLGLTIPOVVF0F0YF
_____
_____
**
# Sequence: [Orvza from: 1 to: 376
# HitCount: 4
Start End TransMem Sequence
  175 203 1 IWALLLAGLGLGALLDVWAG
  239 265
300 320
             2 LPWWAGQALFGTLTPDIVVL
             3 WICVGAIDIT@LSVAGYLFS:
  325 345
            4 YALALLGLTIPOVVF0F0YF
 _____
 _____
# Total sequences: 2
# Total hitcount: 8
#------
```

# Results

- The ygl1 mutant was a spontaneous mutant which has reduced chl accumulation and delayed chloroplast development
- 1. Genetic analysis demonstrated that the phenotype of ygl1 was caused by a recessive mutation in a nuclear gene. The ygl1 locus was mapped to chromosome 5 and isolated by map-based cloning.
- 2. A point mutation (Pro-198 to Ser) in YGL1 was found at the highly conserved Pro-198, which compromised the esterification activity of Chl synthase.

### •四个跨膜区

•位于类囊体膜上

## •突变位点(Pro-198 to Ser)几乎位于第一 个跨膜螺旋的终点

•突变位于保守位点

# DISCUSSION

Why the ygl1 mutation affects Chl biosynthesis most dramatically in the early developmental stage but is restored in later stages is not yet completely understood?

- 1.One possible explanation is that there might be other ChI synthase homologs with redundant functional activities in later stages
  - However, no other rice Chl synthase genes were identified from a survey of the rice genome database.
- 2.Since there are not find significant differences in transcription level of the YGL1 gene at the different development stages, one possibility is that the enzyme is regulated at the translational level.

# Why the Pro-198 residue is important in YGL1 ?

It could be attributed to its location in or proximity to the binding site of Chlide

The Car content was significantly lower in the mutant plants compared to wild type, even in older leaves in which the ChI content was the same as wild type?

This result might be related to the parallel degradation of pigments and pigmentbinding proteins of the photosynthetic apparatus.

# Literature cited

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# Thanks for your attention !