Competitive Project SP2-1: *Identifying Genes Responsible for Failure of Grain Formation in Rice and Wheat under Drought*

Participants

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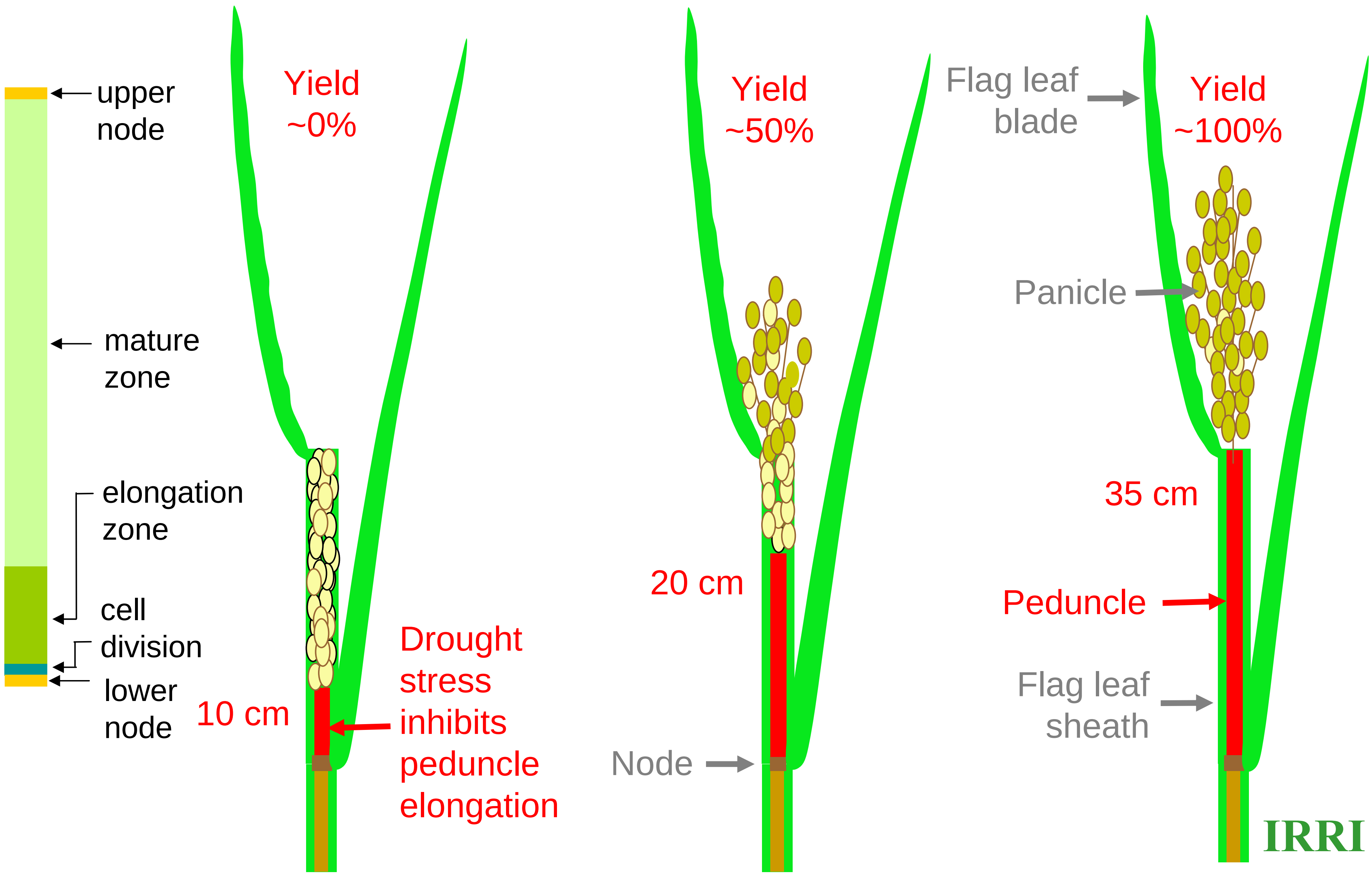
Generation

Goal

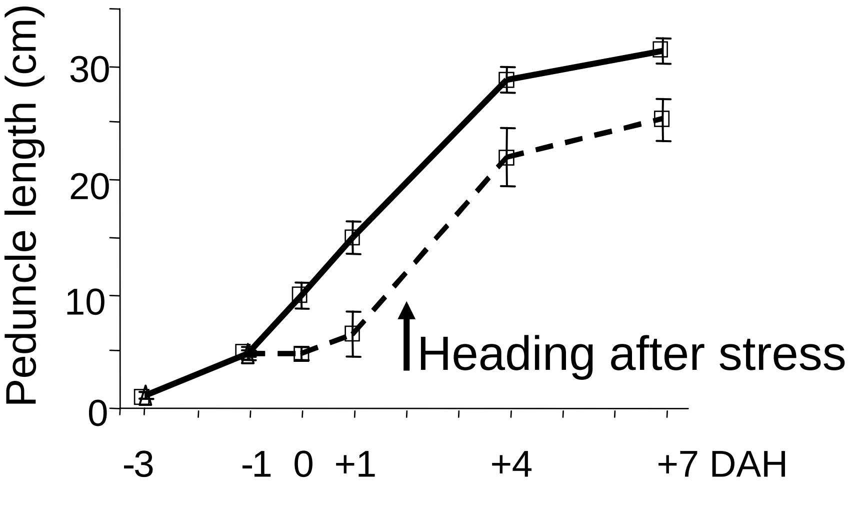
To identify opportunities to enhance reproductive-stage drought tolerance in rice and wheat through physiological, genetic, and molecular analyses of two yield determinants that are highly sensitive to field-level stress—panicle exsertion and floret fertility.

Stress prevents peduncle elongation from driving panicle exsertion



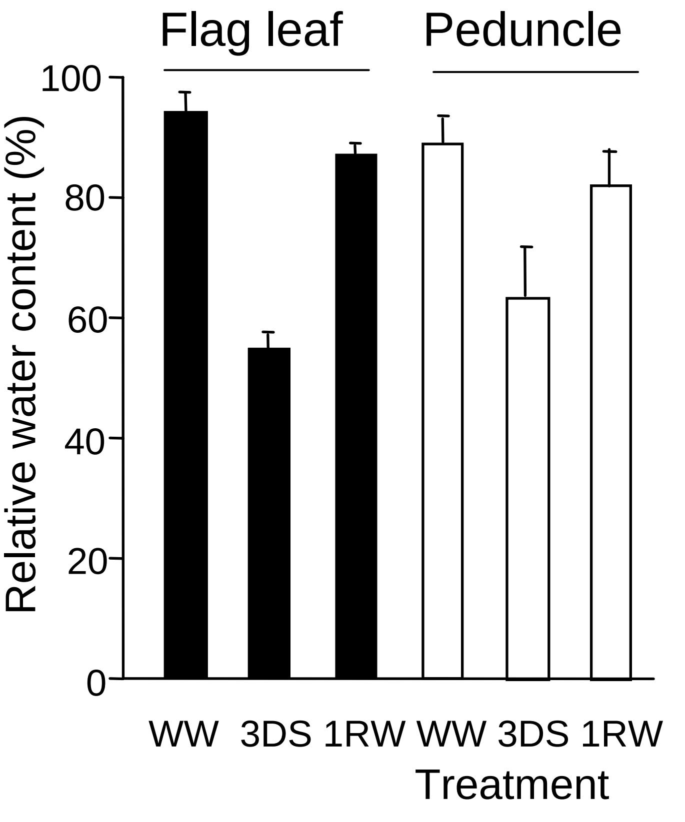
Drought causes reversible inhibition of peduncle elongation

Elongation



Stress began at -3 DAH
Re-watering was 3 days later

Relative water contents



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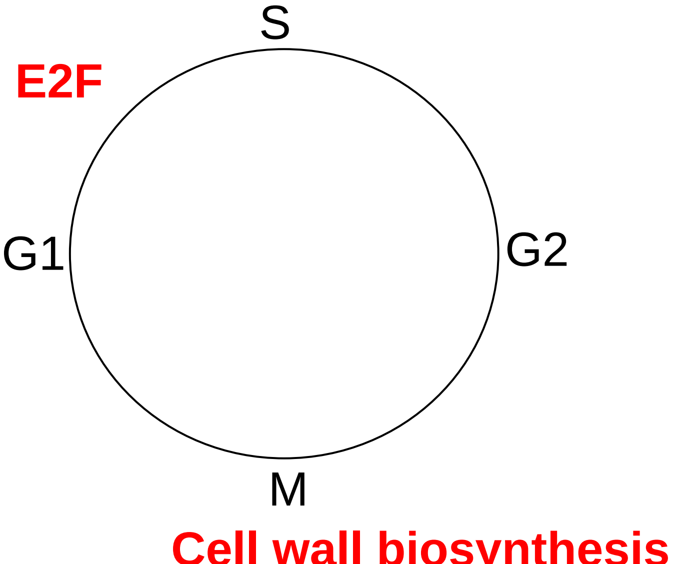
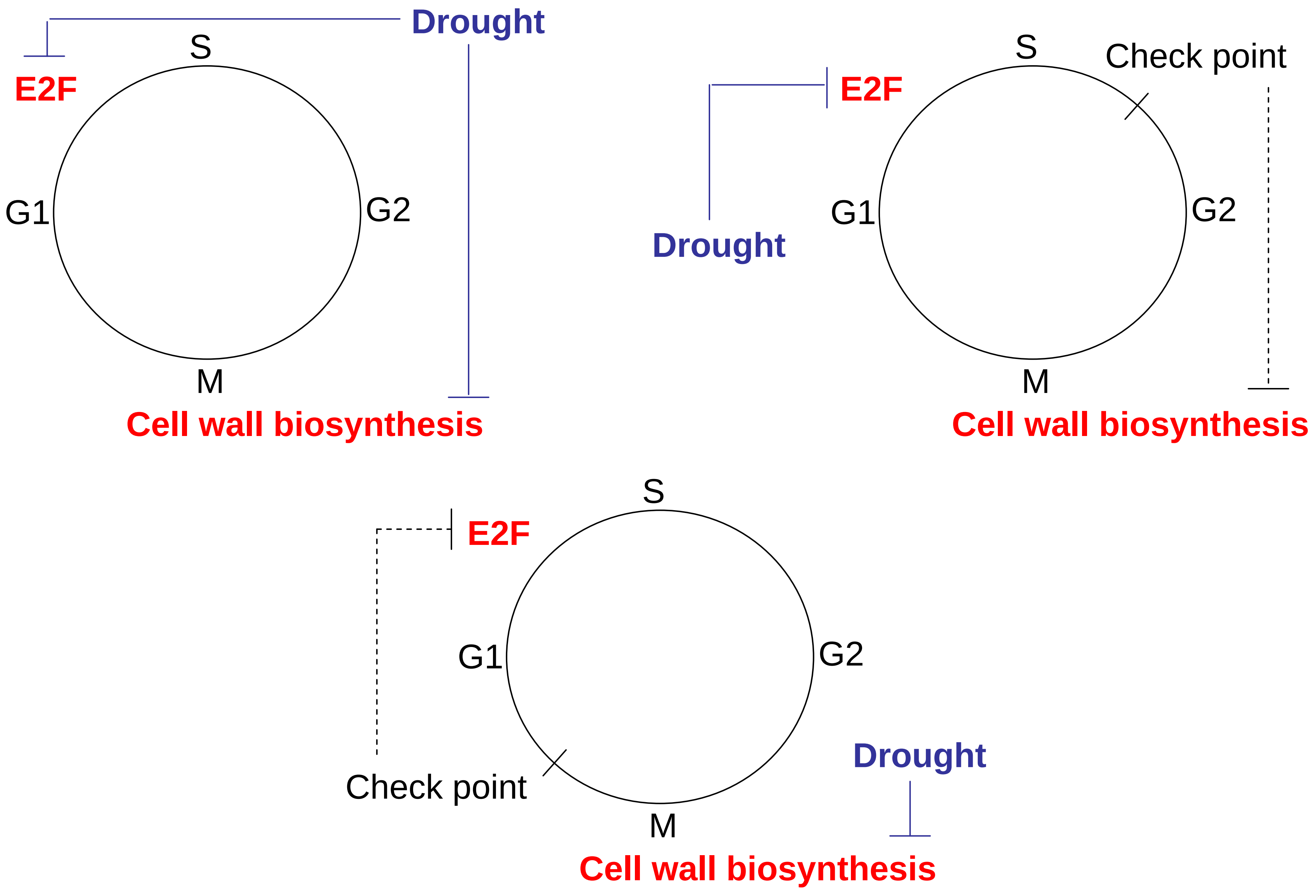
Two gene families down-regulated by drought in peduncle

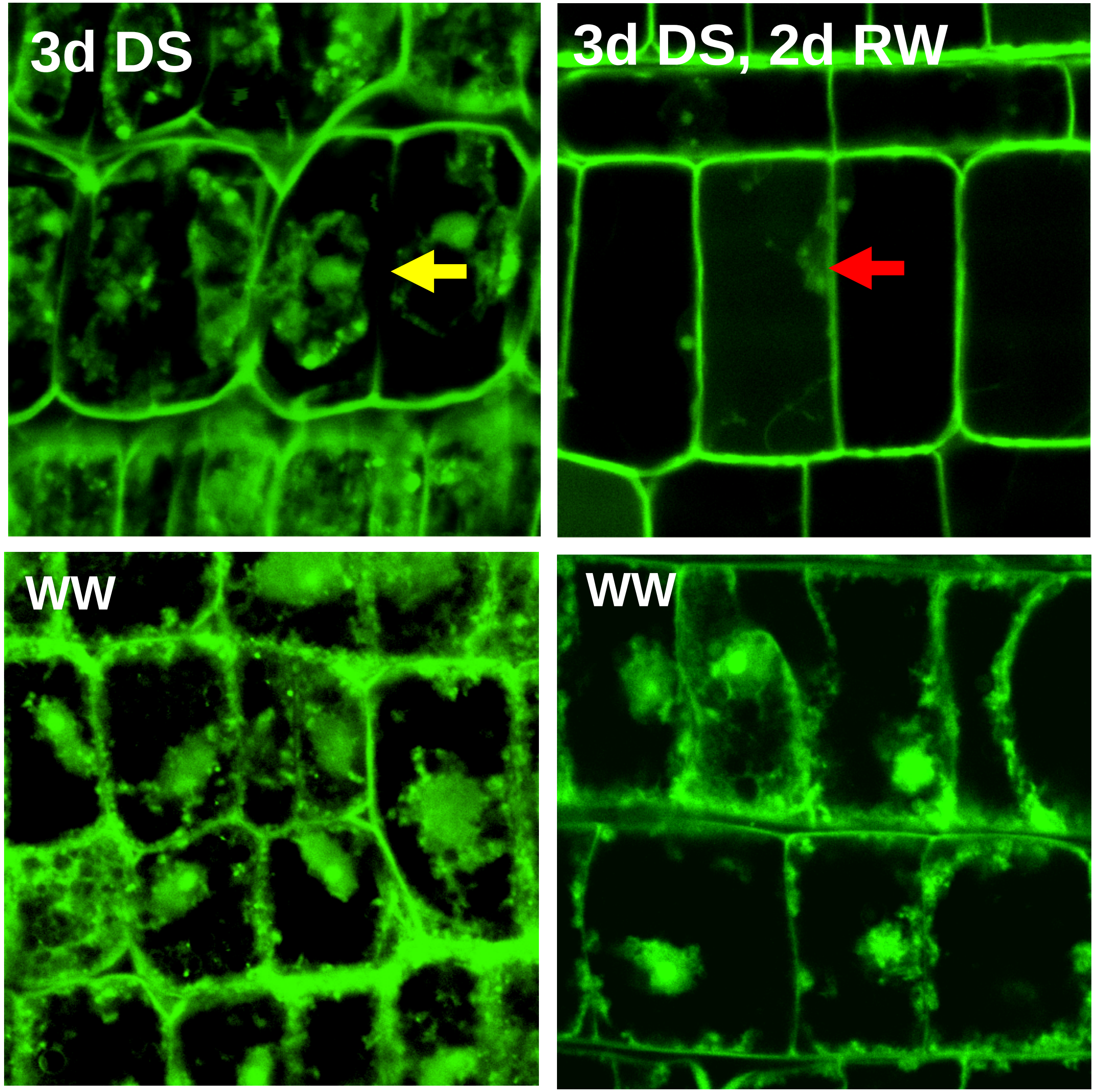
- **Targets of E2F transcription factors**
  (including replication proteins and cyclins needed for transition from G1 phase to S phase)
- **Enzymes involved in cell wall biosynthesis**
  (including cellulose synthases, sucrose synthases, glucosyl transferases)



Three models of drought regulation of cell cycle



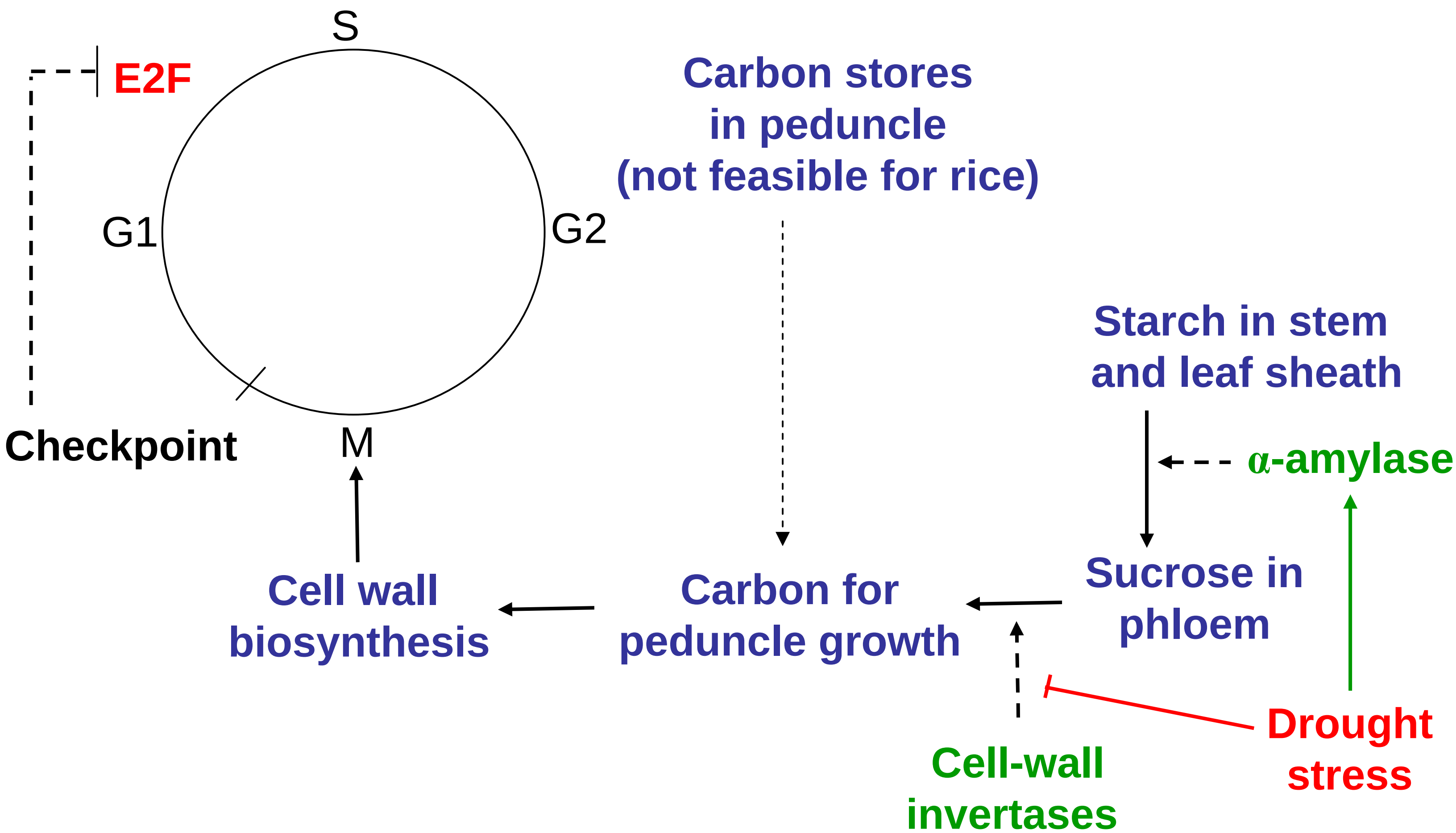
Impact of drought on cell division at peduncle base



2d before heading (2.5 cm)

Heading (10cm)

Hypothesis concerning control of peduncle elongation



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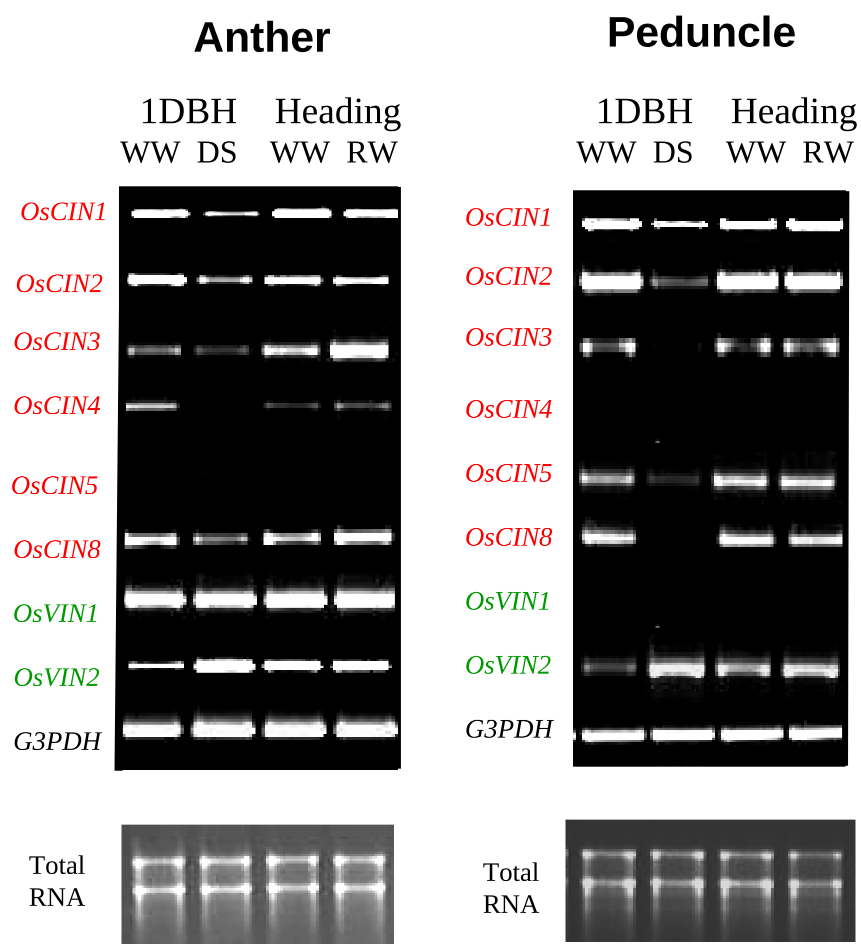
Expression of cell-wall and vacuolar invertases under reproductive drought stress in IR64

1. Cell-wall invertases may promote sucrose uptake by tissues
2. Vacuolar invertases may enhance osmotic potential of tissues



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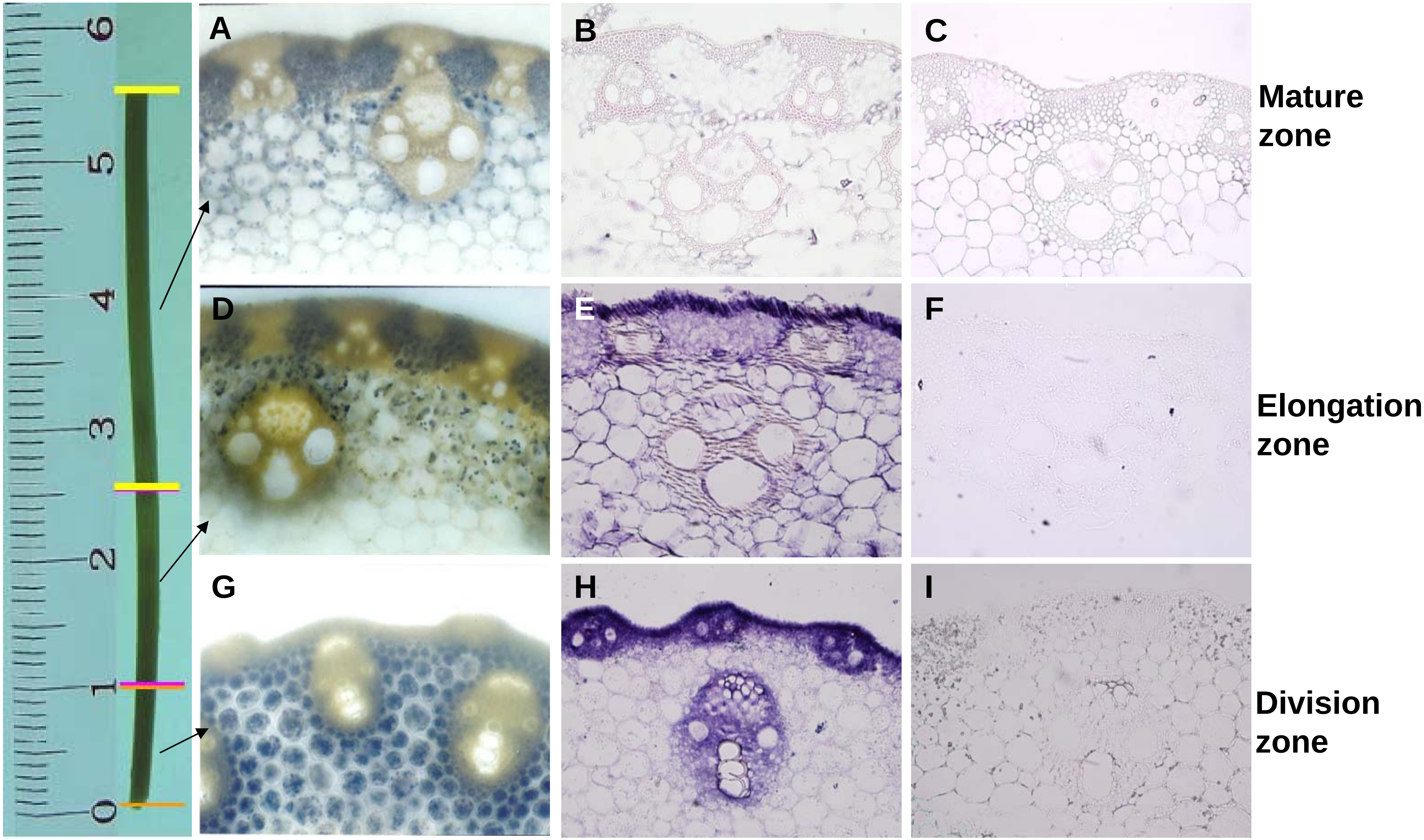
OsCIN2 expressed preferentially in division zone



IKI staining for starch

Anti-Dig-AP labeled anti-sense probe

Anti-Dig-AP labeled sense probe

Magnification = 200x.

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GA-ABA antagonism during peduncle elongation

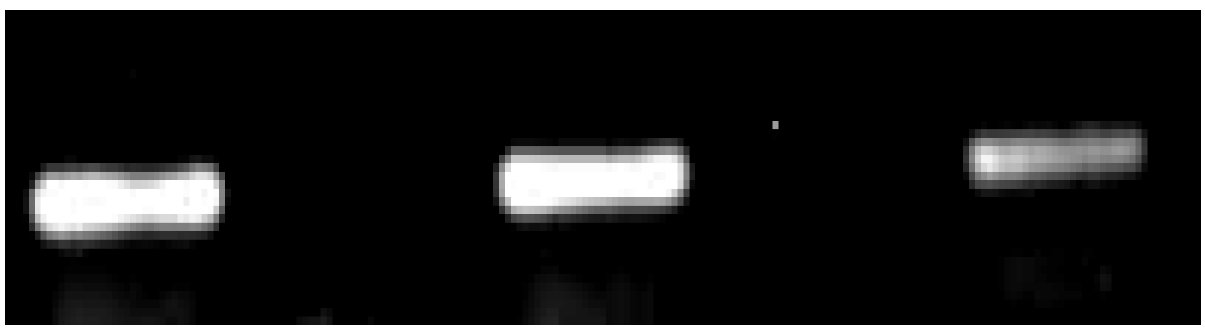
Cell-wall invertases assist sink tissues to take up sucrose from the phloem.

Attached peduncle 0 h

Peduncle floated for 18h on:

water | GA_3 | ABA | ABA + GA_3

OsCIN2



Rate of peduncle elongation:	3.4	0.1	2.5	0.2	0.5 cm/6h ->18h

GA_3 spray restores peduncle elongation under drought stress but only partially restores fertility

Treatment	Panicle length (cm)	Peduncle length (cm)	Panicle exsertion	Spikelet fertility (%)
Control	25	32	Full	91
Drought	22	25	5-6 cm not exserted	31
Drought + GA spray	25	33	Full	49

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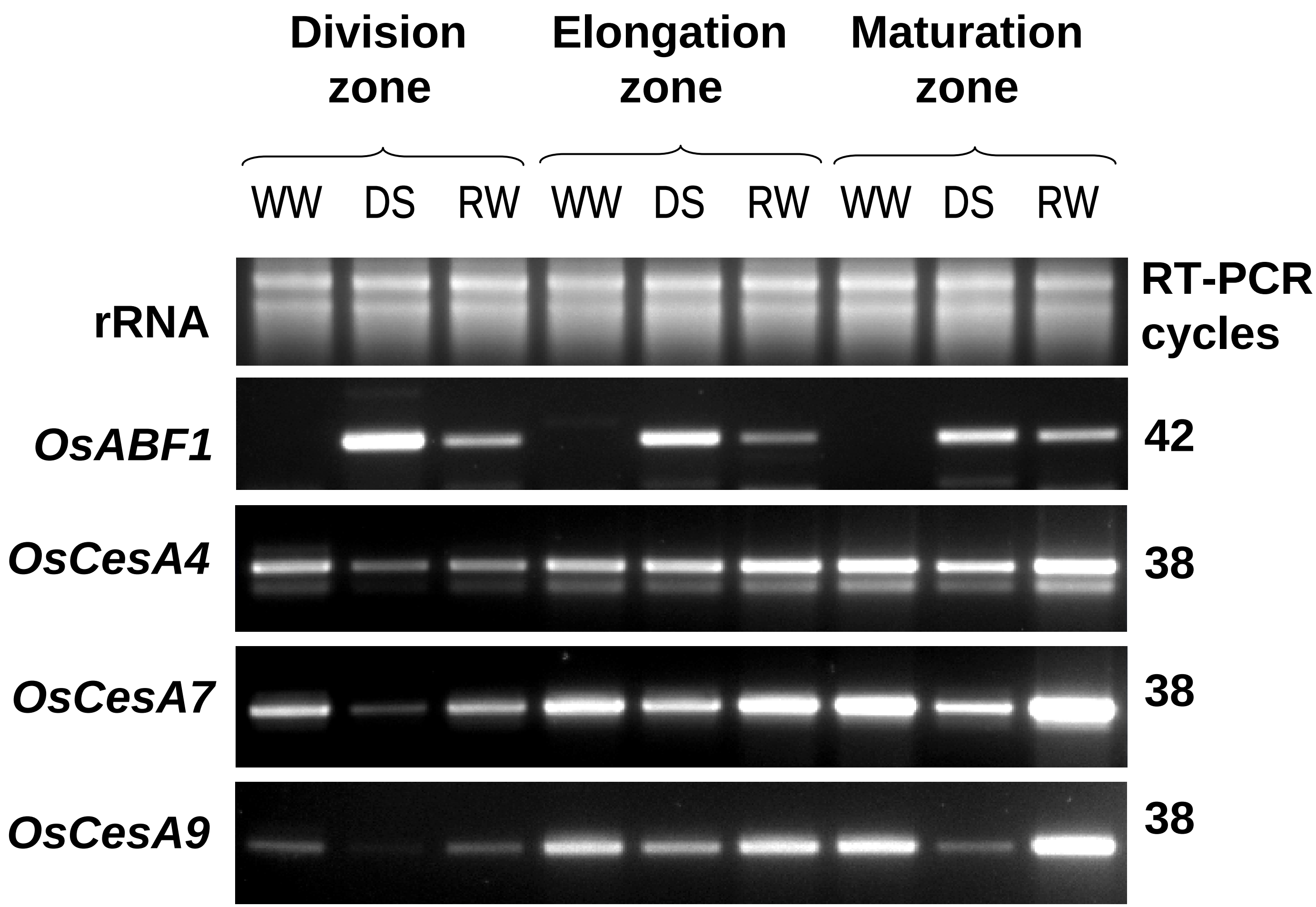
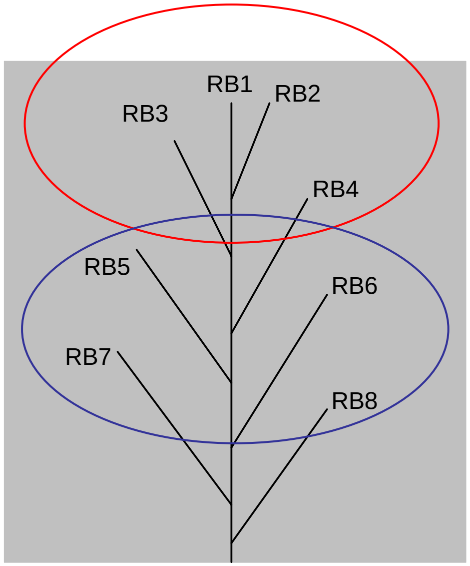
Impact of drought and re-watering on expression of cellulose synthase genes specific for secondary cell wall synthesis



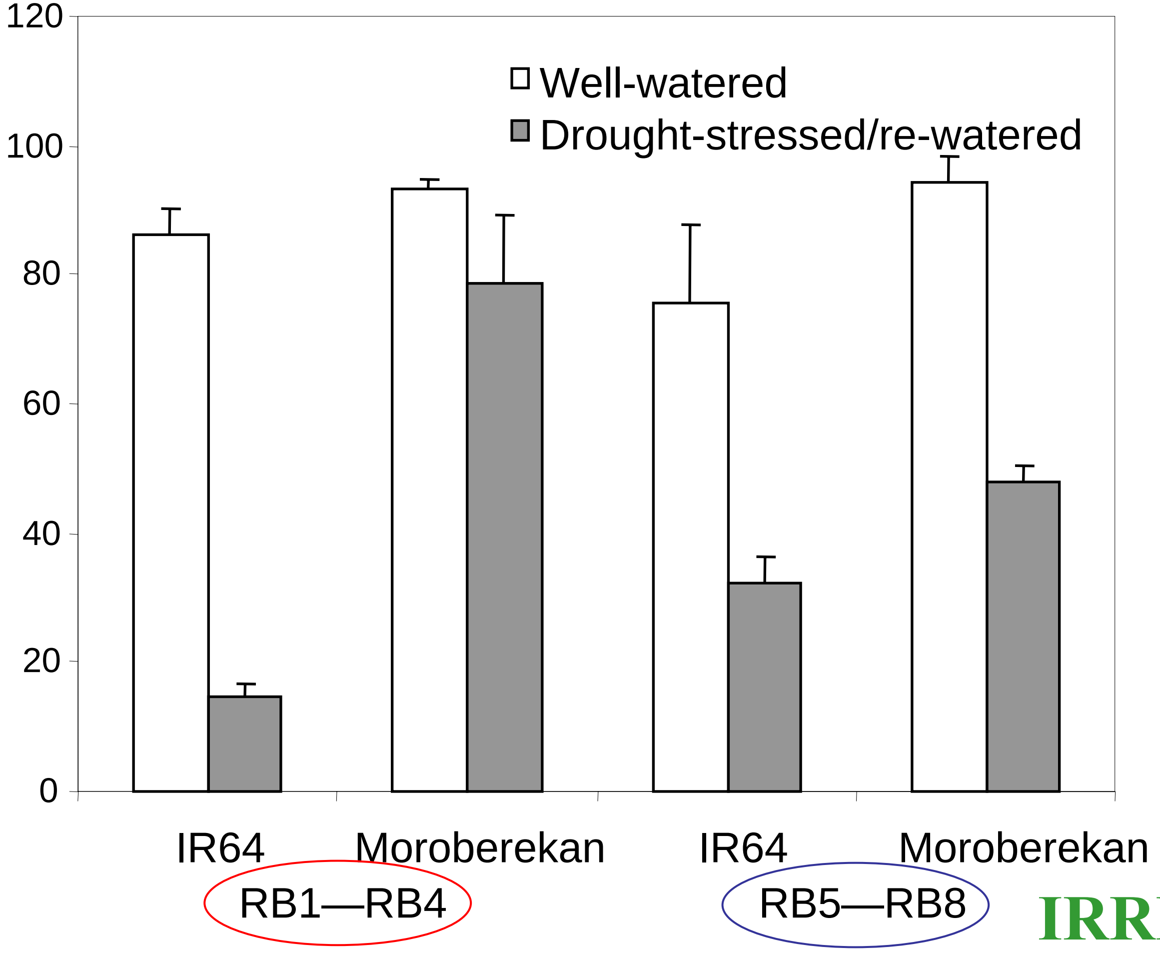
OsABF1 = rice orthologue of ABI5 of Arabidopsis

In top four rachis branches, IR64 is more drought-sensitive than Moroberekan, coinciding with anthesis

Panicle



Spikelet fertility (%)



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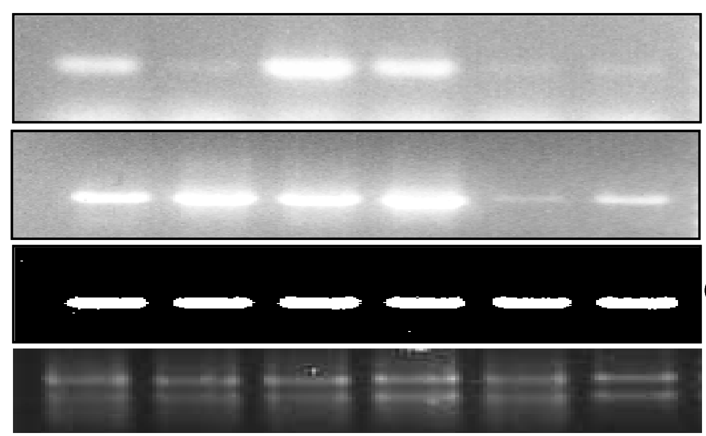
Expression of ABA 8’-hydroxylase genes may account for responses of ABA levels to re-watering

	ABA content (ng/g DW)		
	Well-watered	Drought	Rewatered
Anther	245	1232	1418
Peduncle	177	503	87

irreversible rise in ABA

reversible rise in ABA



C = Well-watered; D = Drought; R = Re-watered

Similar results in IR64 and Moroberekan

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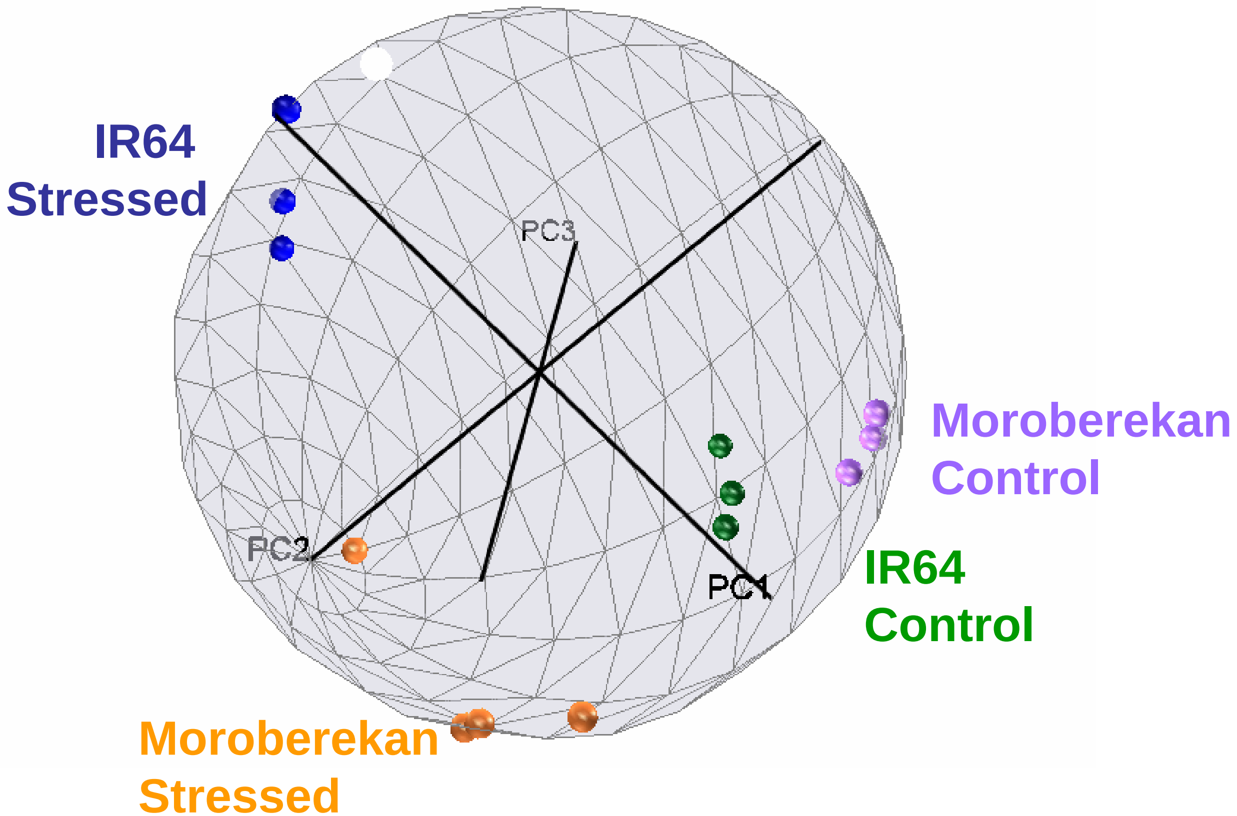
Anther metabolome: Principal component analysis

Genotypes: IR64 and Moroberekan
Treatments: (i) well-watered control and
(ii) 5 days drought-stressed starting 3 days before heading
Samples: Total lyophilized anthers
Metabolites: 1279 detected Mol. Wt. range: 100-1500



Analysis by Phenomenome Discoveries

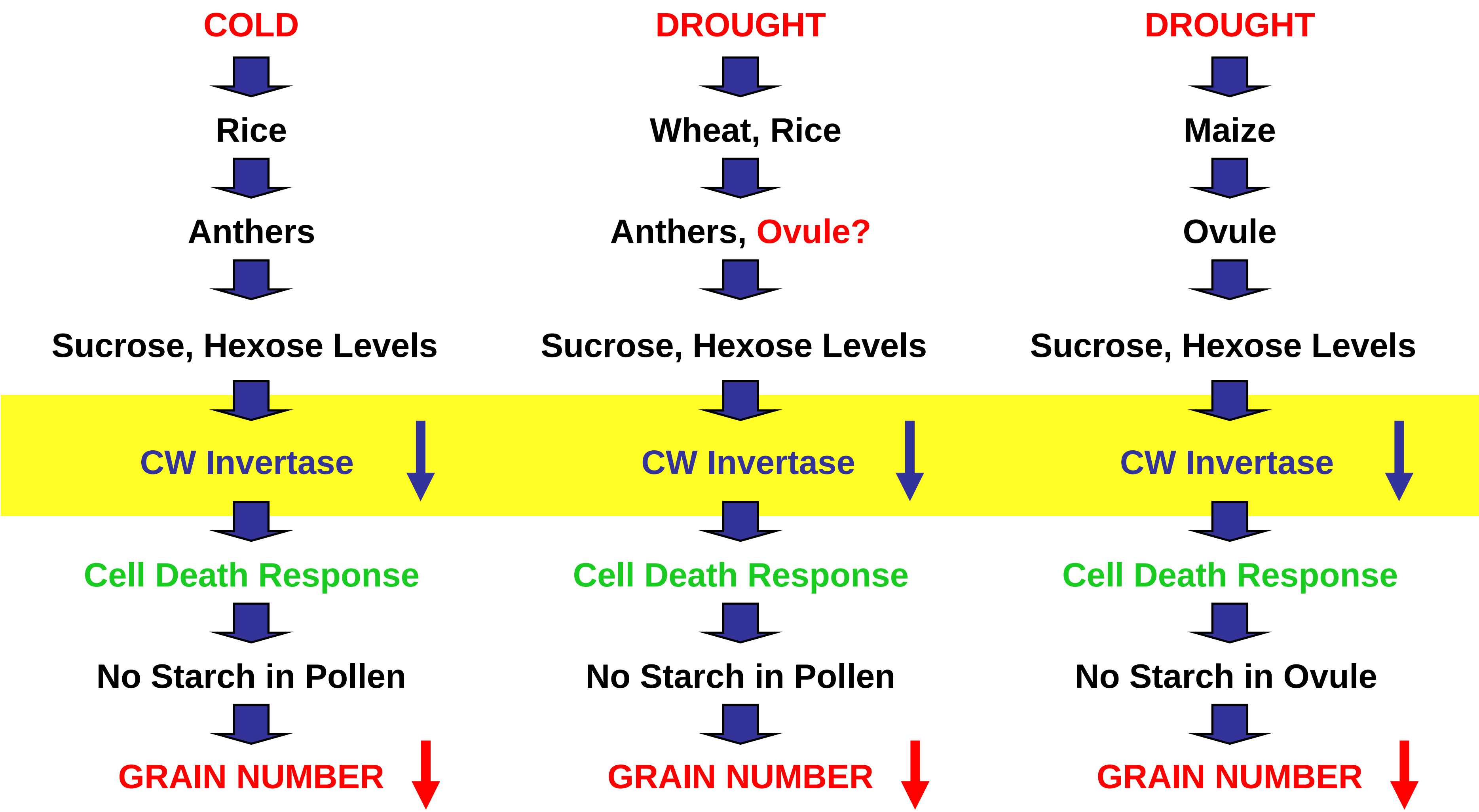
Rice spikelet fertility under drought stress for the most resistant and sensitive lines of the IR20 X PL population

Three F2 populations (IR20 x PL, IR20 x PMK3, CO43 x PL) were screened for spikelet fertility under reproductive-stage drought stress, and 10 lines at each extreme were again field-tested as F3s (e.g., Table). These lines will now be subjected to molecular analysis.

No.	Resistant Genotypes	Spikelet Fertility (%)	Susceptible Genotypes	Spikelet Fertility (%)
1	G2	100	A16	20
2	G17	97	A1	29
3	K2	97	G18	31
4	H13	96	F5	31
5	F19	93	M18	32
6	I12	93	C6	33
7	E15	93	E7	33
8	K6	93	I1	37
9	I18	92	F10	37
10	C2	90	M19	37

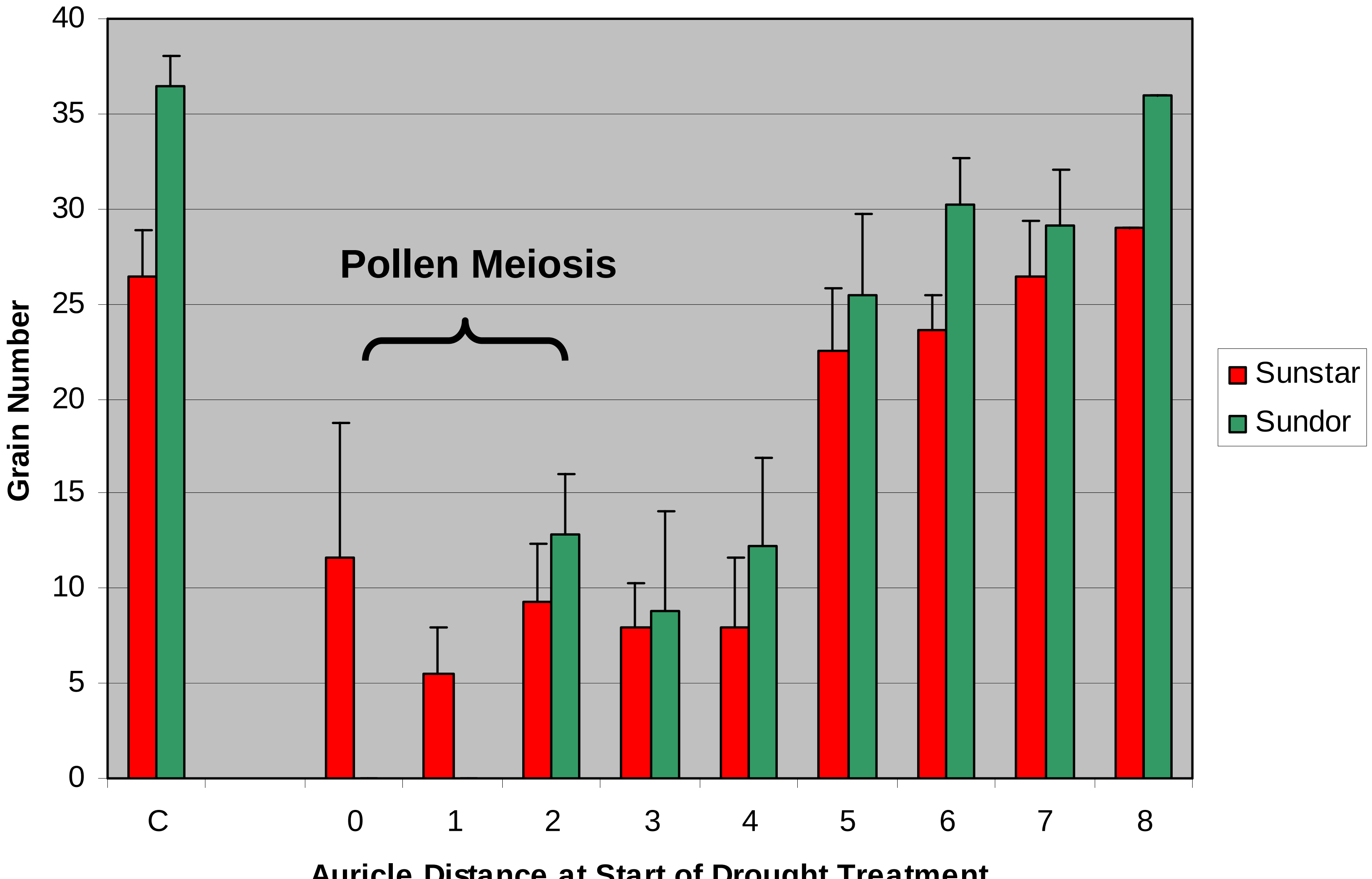
R. Chandra Babu, TNAU

Abiotic stresses induce gametophyte sterility: Importance of cell-wall invertases



Rudy Dolferus, CSIRO

Impact on wheat grain number of drought stress starting when interauricle distance is 0-8 cm.



Rudy Dolferus, CSIRO