Red METRICE (110RT0394)

Mejorar la eficiencia en el uso de insumos y el ajuste fenológico en cultivos de trigo y cebada (METRICE)

CYTED

EEA Balcarce-INTA, 28/29 septiembre 2013

INTA

IV Workshop Internacional

Bases ecofisiológicas y genéticas para mejorar el rendimiento y la calidad en trigo y cebada

Aspectos fenológicos determinantes de la adaptación y rendimiento potencial en trigo y cebada

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I will focus on work within the EU project ADAPTAWHEAT

together with previous work (in wheat and barley) which gave room to parts of ADAPTAWHEAT

Aims of ADAPTAWHEAT: achieving adaptation of reproductive growth across the wide range of latitudes in which wheat is grown as well as identifying developmental traits which may help increasing yield potential

Bottom – up approach

•NILs for Ppd, Eps alleles in different backgrounds

- Phenological characterization throughout consortium
- Phyllochron/Plastochron dynamics by selected partners
- Floret development on selected populations and partners

Quantifying "globally" the effects of particular alleles (x background) **on developmental attributes conferring adaptation and yield potential**

Top – down approach

•Mapping populations derived from parents of different developmental characteristics // CIMCOG population

- Phenological characterization by several partners
- Phyllochron/Plastochron dynamics on selected partners

Identifying genetic bases of particular developmental attributes conferring adaptation, beyond the effects of major genes, and yield potential through developmental attributes

Many studies showed that yield in wheat and barley is mainly sink-limited during grain filling in a wide range of environmental conditions, including rain-fed crops in Mediterranean conditions

Evidences concurring to that conclusion include

- **Grain weight is mostly unresponsive to increases of sources during grain filling**
- **Photosynthesis seems to be down-regulated during grain filling, due to lack of enough sink-strength** (if we remove grains, photosynthesis tends to be reduced, if we remove part of the photosynthetic capacity of some organs that of the other organs increase)
- **Potential supply of CH_2O to growing grains does, in general, exceed yield actually achieved**

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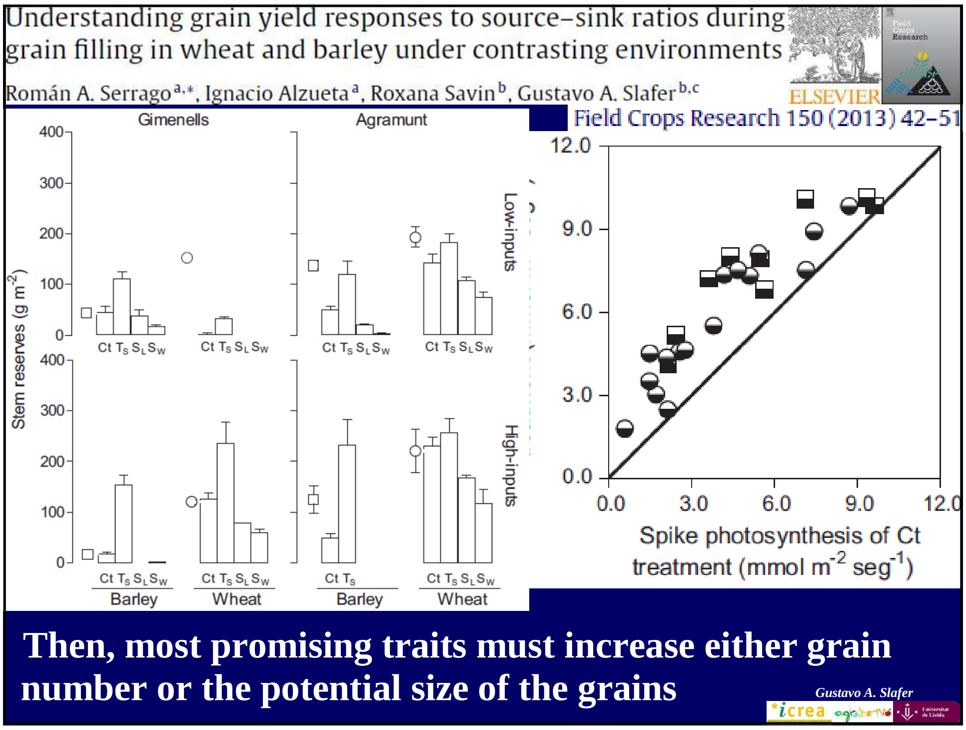

Understanding grain yield responses to source–sink ratios during grain filling in wheat and barley under contrasting environments
Román A. Serrago, Ignacio Alzueta, Roxana Savin, Gustavo A. Slafer
ELSEVIER
Field Crops Research 150 (2013) 42–51
Gimenells
Agramunt
Stem reserves (g m-2)
Low-inputs
High-inputs
Barley
Wheat
Barley
Wheat
Spike photosynthesis of Ct treatment (mmol m-2 seg-1)
Then, most promising traits must increase either grain number or the potential size of the grains
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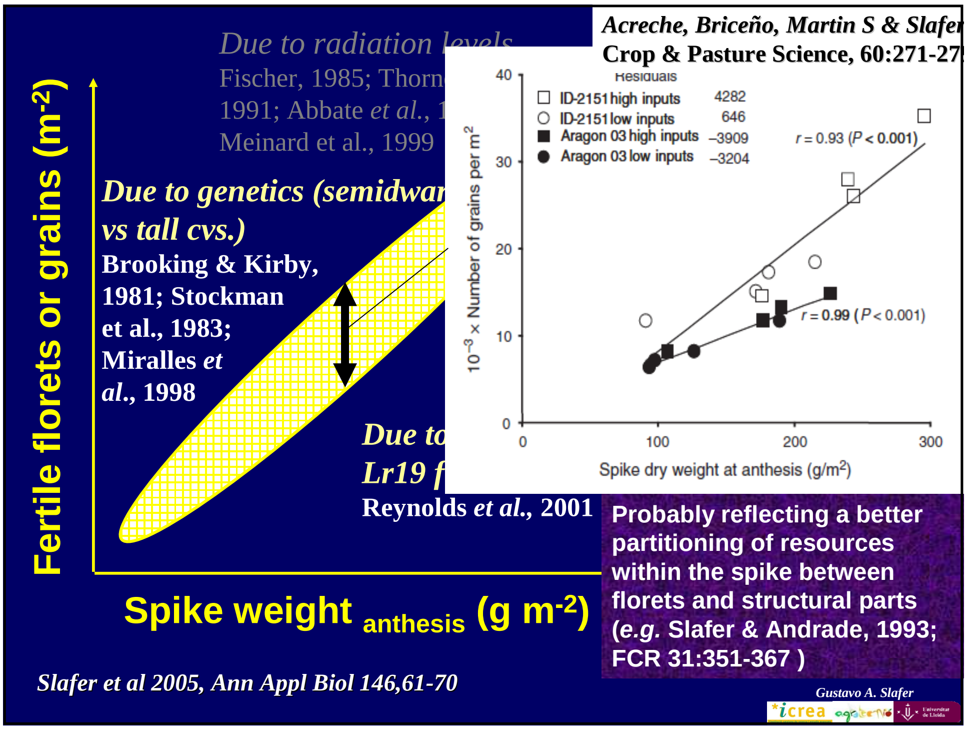

Due to radiation levels
Fischer, 1985; Thorne, 1991; Abbate et al., 1997; Meinard et al., 1999
Due to genetics (semidwarf vs tall cvs.)
Brooking & Kirby, 1981; Stockman et al., 1983; Miralles et al., 1998
Due to Lr19 f
Reynolds et al., 2001
Fertile florets or grains (m-2)
Spike weight anthesis (g m-2)
Acreche, Briceño, Martin S & Slafer
Crop & Pasture Science, 60:271-27
Residuals
ID-2151 high inputs 4282
ID-2151 low inputs 646
Aragon 03 high inputs –3909
Aragon 03 low inputs –3204
r = 0.93 (P < 0.001)
r = 0.99 (P < 0.001)
10-3 × Number of grains per m2
Spike dry weight at anthesis (g/m2)
Probably reflecting a better partitioning of resources within the spike between florets and structural parts (e.g. Slafer & Andrade, 1993; FCR 31:351-367)
Slafer et al 2005, Ann Appl Biol 146,61-70
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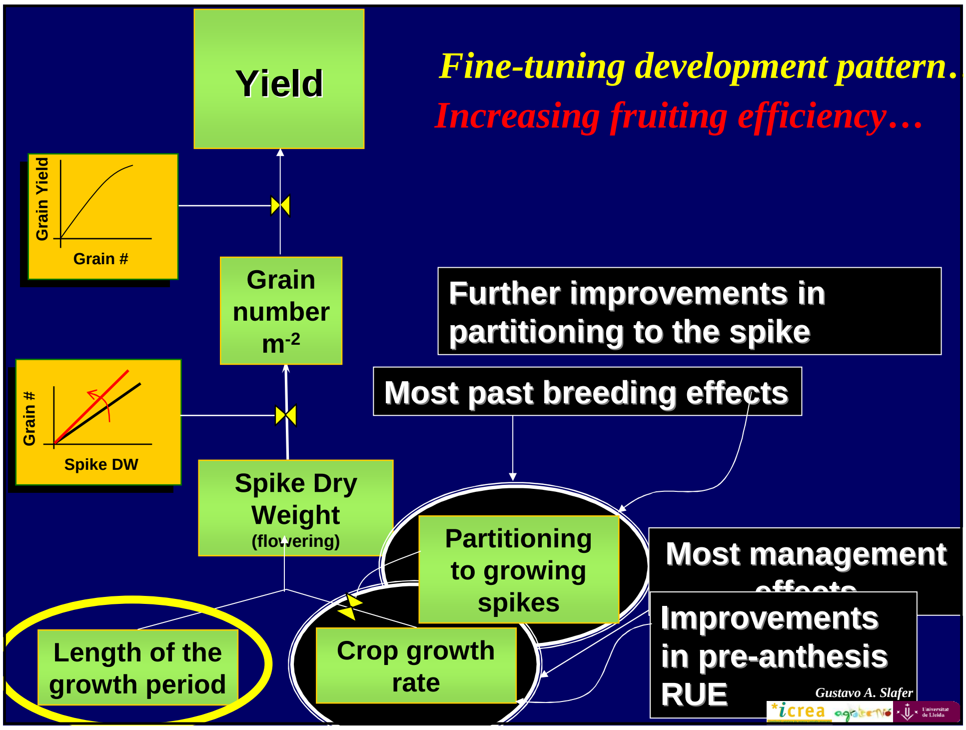

Yield
Fine-tuning development pattern…
Increasing fruiting efficiency…
Grain Yield
Grain #
Grain number m-2
Further improvements in partitioning to the spike
Grain #
Spike DW
Most past breeding effects
Spike Dry Weight (flowering)
Partitioning to growing spikes
Most management effects
Improvements in pre-anthesis RUE
Length of the growth period
Crop growth rate
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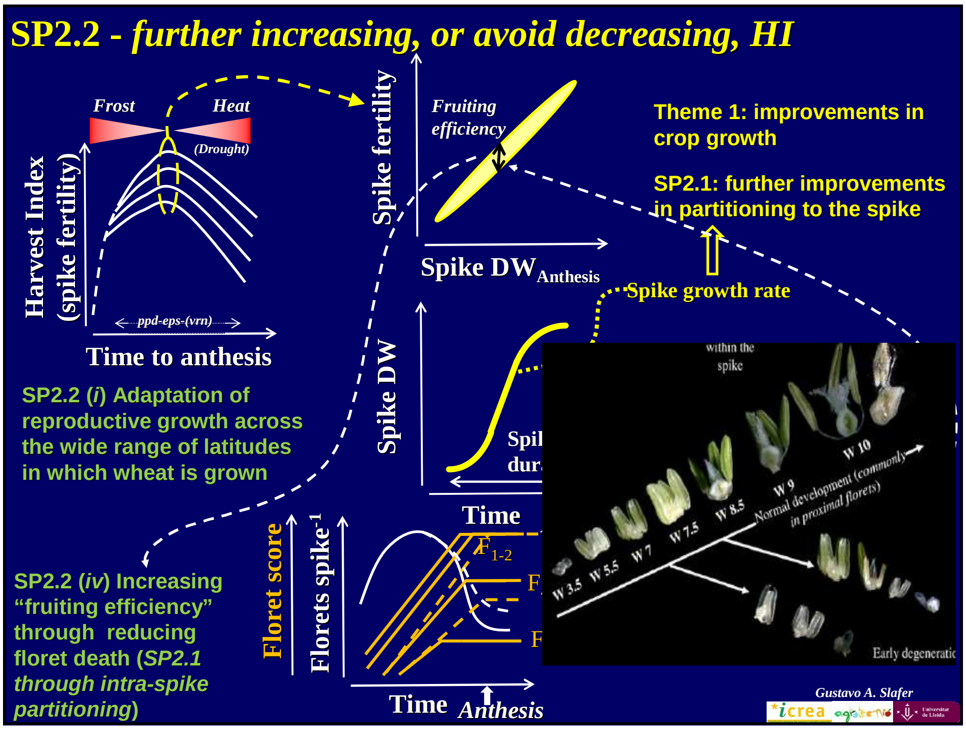

SP2.2 - further increasing, or avoid decreasing, HI
Frost
Heat
(Drought)
Harvest Index (spike fertility)
ppd-eps-(vrn)
Time to anthesis
SP2.2 (i) Adaptation of reproductive growth across the wide range of latitudes in which wheat is grown
Spike fertility
Fruiting efficiency
Spike DWAnthesis
Theme 1: improvements in crop growth
SP2.1: further improvements in partitioning to the spike
Spike growth rate
Spike DW
Time
SP2.2 (iv) Increasing "fruiting efficiency" through reducing floret death (SP2.1 through intra-spike partitioning)
Floret score
Florets spike-1
F1-2
Time
Anthesis
within the spike
W 3.5 W 5.5 W 7 W 7.5 W 8.5 W 9 W 10
Normal development (commonly in proximal florets)
Early degeneratic
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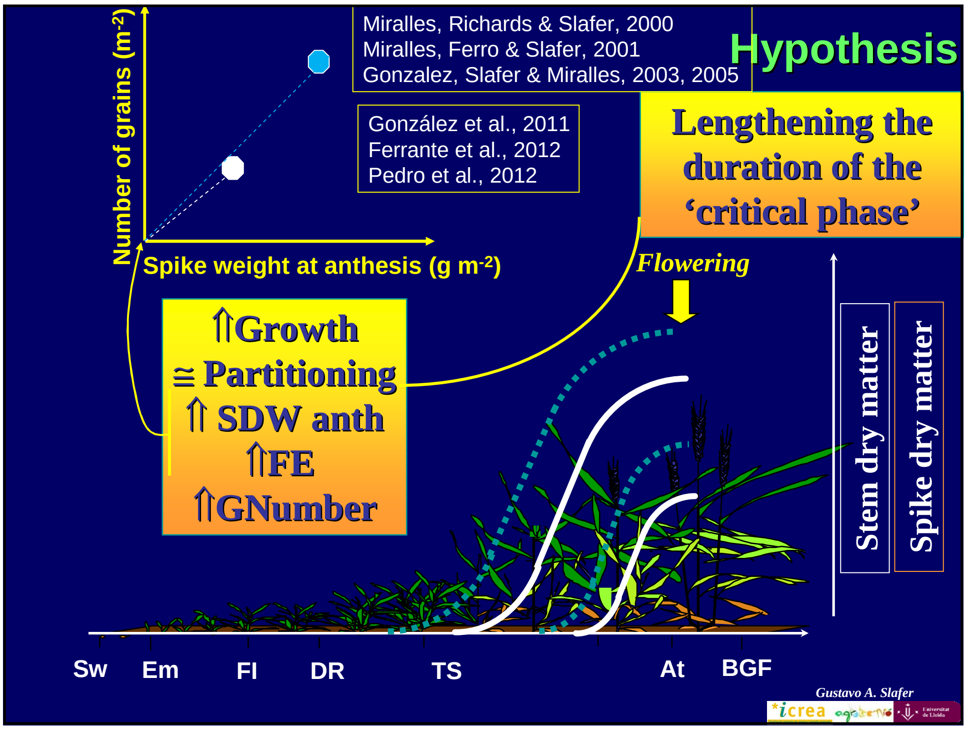

Hypothesis
Miralles, Richards & Slafer, 2000
Miralles, Ferro & Slafer, 2001
Gonzalez, Slafer & Miralles, 2003, 2005
González et al., 2011
Ferrante et al., 2012
Pedro et al., 2012
Number of grains (m-2)
Spike weight at anthesis (g m-2)
Lengthening the duration of the 'critical phase'
Flowering
⇑Growth
≅ Partitioning
⇑ SDW anth
⇑FE
⇑GNumber
Stem dry matter
Spike dry matter
Sw
Em
FI
DR
TS
At
BGF
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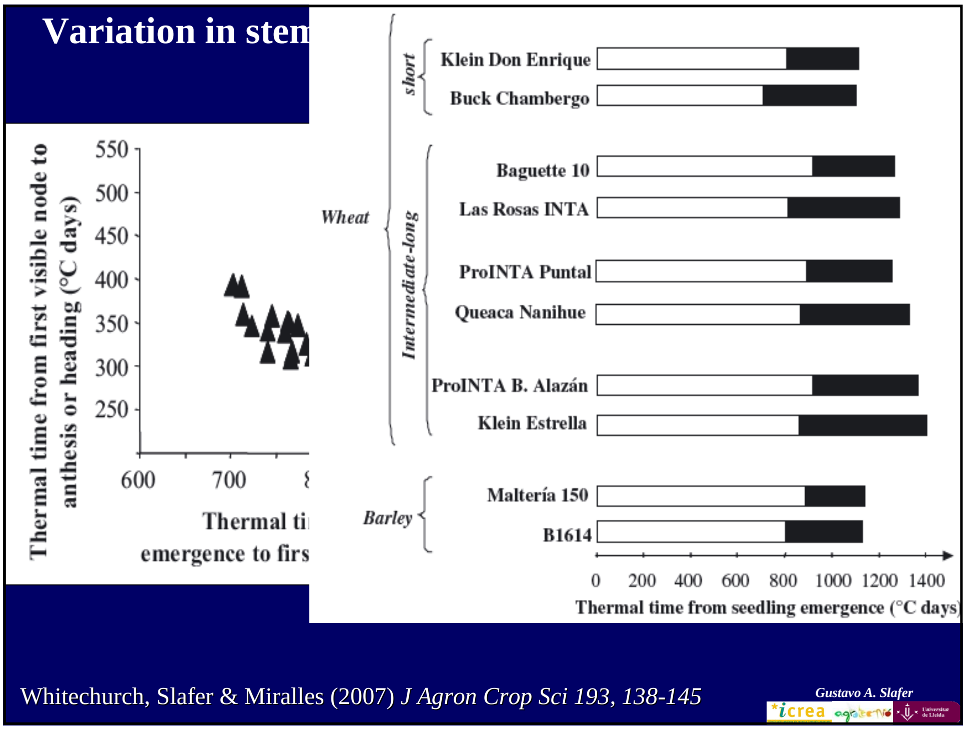

Variation in stem
Thermal time from first visible node to anthesis or heading (°C days)
550
500
450
400
350
300
250
600
700
Thermal ti
emergence to firs
Wheat
short
Klein Don Enrique
Buck Chambergo
Intermediate-long
Baguette 10
Las Rosas INTA
ProINTA Puntal
Queaca Nanihue
ProINTA B. Alazán
Klein Estrella
Barley
Maltería 150
B1614
0
200
400
600
800
1000
1200
1400
Thermal time from seedling emergence (°C days)
Whitechurch, Slafer & Miralles (2007) J Agron Crop Sci 193, 138-145
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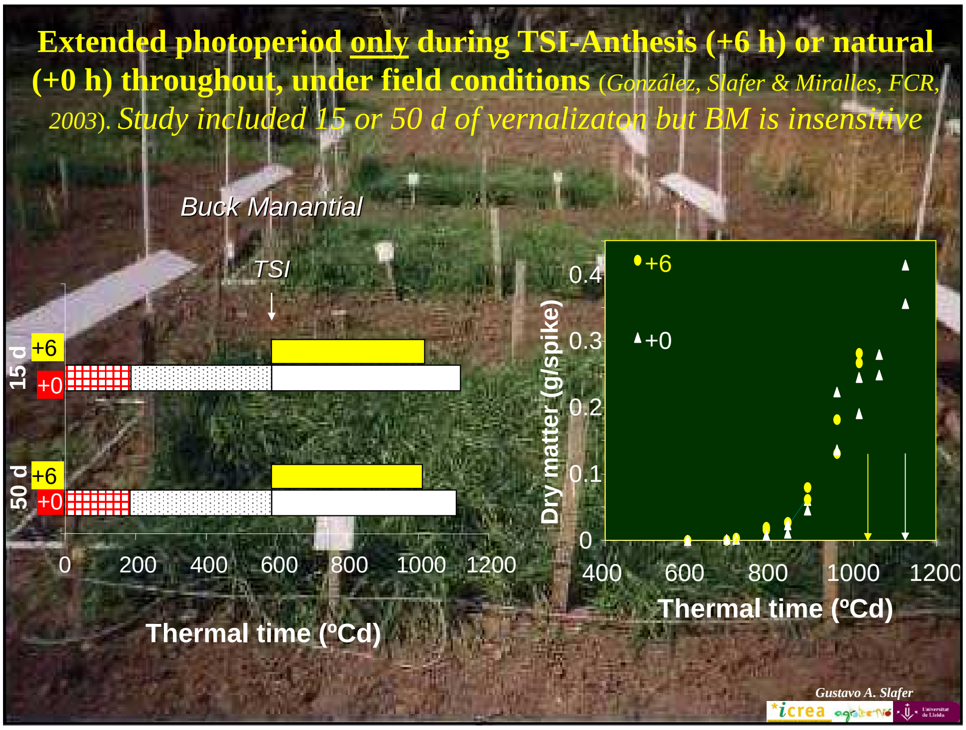
Extended photoperiod only during TSI-Anthesis (+6 h) or natural (+0 h) throughout, under field conditions (González, Slafer & Miralles, FCR, 2003). Study included 15 or 50 d of vernalizaton but BM is insensitive
Buck Manantial
TSI
15 d
50 d
+6
+0
0
200
400
600
800
1000
1200
Thermal time (ºCd)
Dry matter (g/spike)
0.4
0.3
0.2
0.1
0
400
600
800
1000
1200
Thermal time (ºCd)
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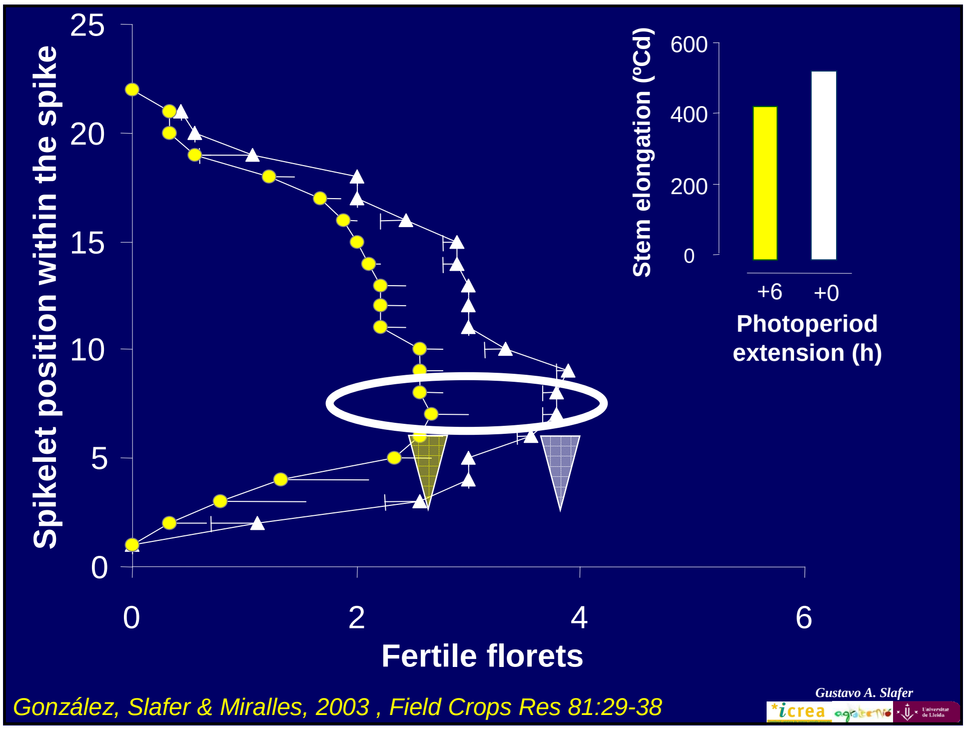
Spikelet position within the spike
25
20
15
10
5
0
0
2
4
6
Fertile florets
Stem elongation (ºCd)
600
400
200
0
+6
+0
Photoperiod extension (h)
González, Slafer & Miralles, 2003 , Field Crops Res 81:29-38
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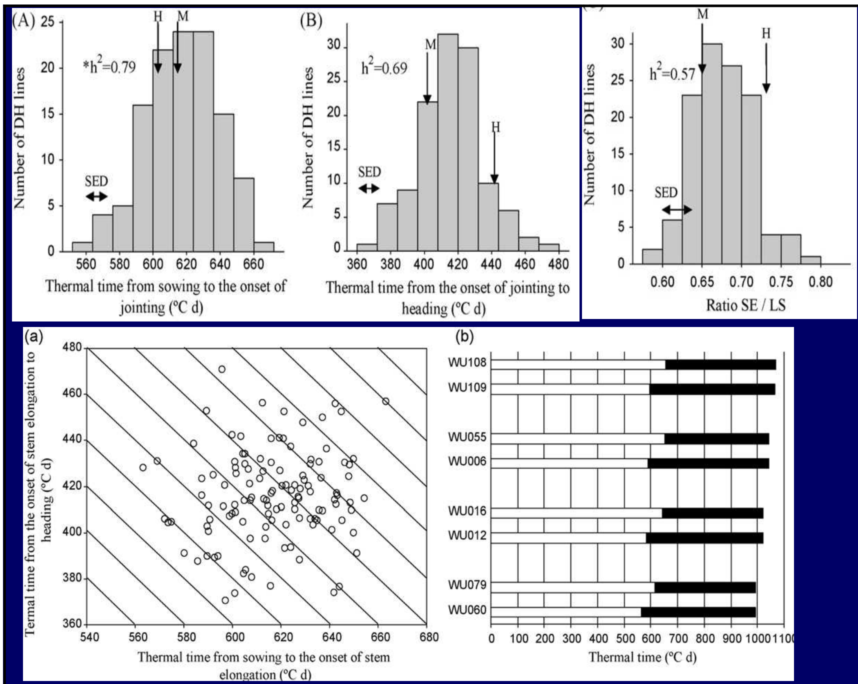

Borras, Romagosa, van Eeuwijk & Slafer (2009). Field Crops Res.

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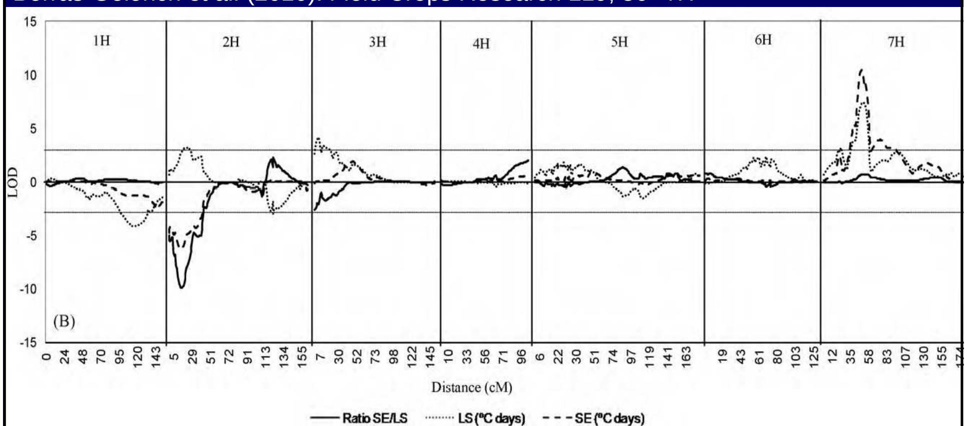
Borras-Gelonch et al. (2010). Field Crops Research 119, 36–47.



Horizontal dashed lines indicate the significance LOD-threshold.
Positive and negative LOD values mean that the positive additive effect comes from Henni or Meltan,

Trends in Plant Science February 2012, Vol. 17, No. 2

A genetic playground for enhancing grain number in cereals

Nese Sreenivasulu[1,2] and Thorsten Schnurbusch[3]

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Dynamics of floret development determining differences in spike fertility within the CIMCOG population

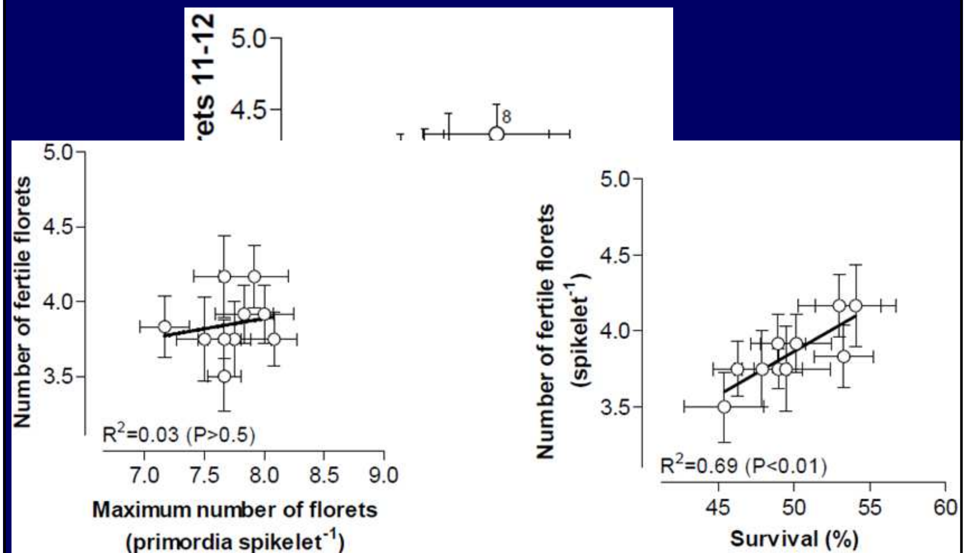
Oscar González[1,2], Simon Griffiths[2], Gemma Molero[1], Matthew Reynolds[1], Gustavo A. Slafer[3]

[1]CIMMYT, Mexico; [2]John Innes Centre, UK.; [3]ICREA and University of Lleida, Spain

To quantify differences in dynamics of floret development responsible for differences in number of fertile florets (basis of spike fertility) within a subset of 10 genotypes selected from the CIMCOG

Entry	Name	Trait
1	BACANORA T88	high grains/m2
2	BCN/RIALTO	late development
3	BRBT1*2/KIRITATI	large seed

Trait	Average		CIMCOG		Subset	
	CIMCOG	Subset	Range	$LSD_{0.05}$	Range	$LSD_{0.05}$
Yield (Mg ha^{-1})	6.11	6.05	4.48 - 7.20	0.68	5.55 - 6.52	0.68
Biomass (Mg ha^{-1})	13.58	13.41	11.05 – 15.60	2.24	12.37 – 15.04	1.57
Harvest index	0.45	0.45	0.40 – 0.51	0.02	0.41 – 0.49	0.03
Number of grains (m^{-2})	14379	15801	11357 – 21387	1622	12853 - 21387	2085
Number of grains (spike^{-1})	47	47	36 – 67	5.50	39 - 57	4.14
Grain weight (mg grain^{-1})	42.9	39	28 – 53	2.08	28 - 45	1.43
Days to anthesis	89	88	79 – 96	2.20	79 - 96	2.00



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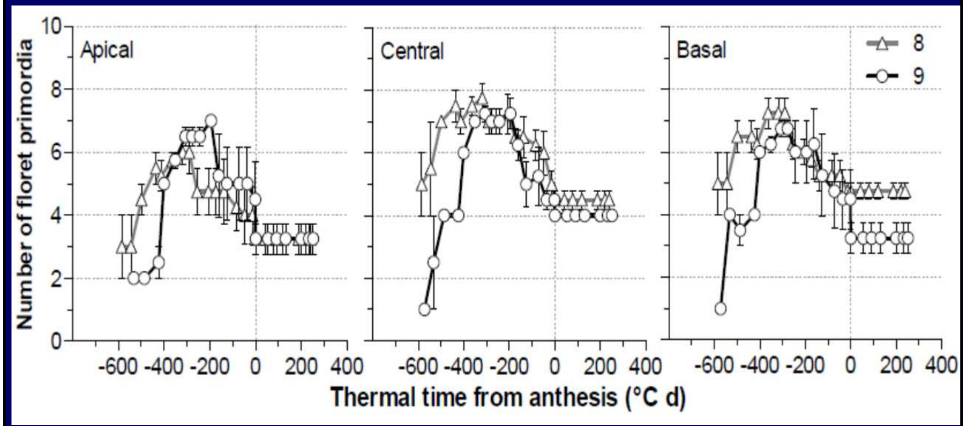
(i) improving spike fertility through identifying sources of accelerated floret development increasing the survival of primordia ton produce fertile florets



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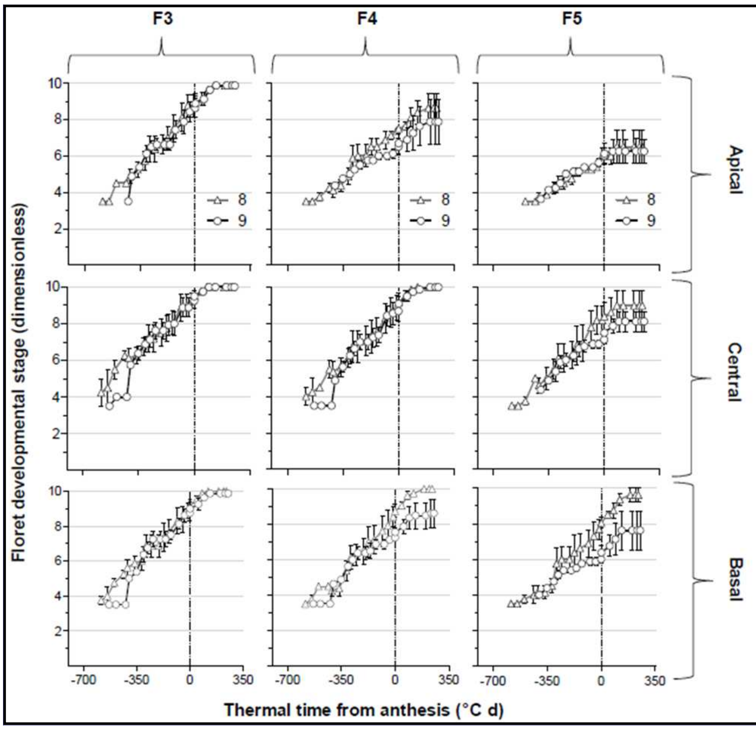

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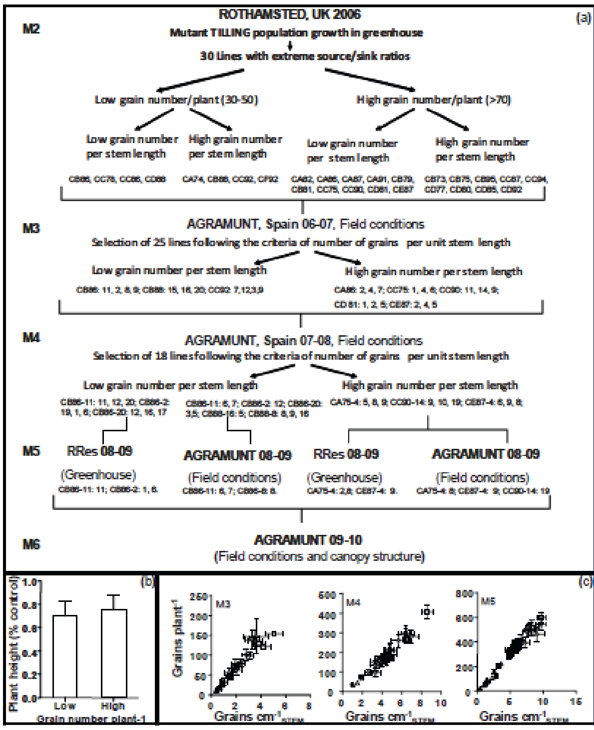
Differences in pattern of floret developmental was found in the subset of lines of the CIMCOG population studied at the MEXPLAT

It seems that much of the differences between genotypes of the CIMCOG panel in terms of spike fertility can be traced back to processes of floret development determining survival or death of labile primordia

Labile florets which start developing slightly earlier respect to anthesis increase their likelihood to survive and produce a fertile floret

Genetic work to identify genetic factors behind optimised developmental patterns and maximised spike fertility being carried out now (and in the next seasons) at JIC



Pedro, Savin, Parry, Slafer (2012)
Field Crops Research, 129:59–70

To test empirically to what degree fruiting efficiency would be a likely trait to select for we did an empirical exercise with a population of mutants almost NOT varying for plant height

We selected divergent lines for number of grains per unit stem length (as a non-destructive proxy for Fruiting efficiency)

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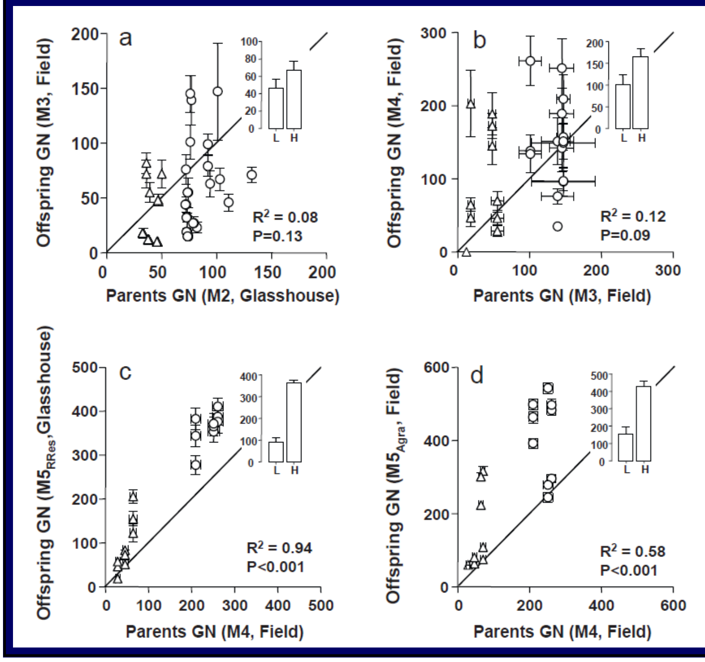
Pedro, Savin, Parry, Slafer (2012) Field Crops Research, 129:59–70



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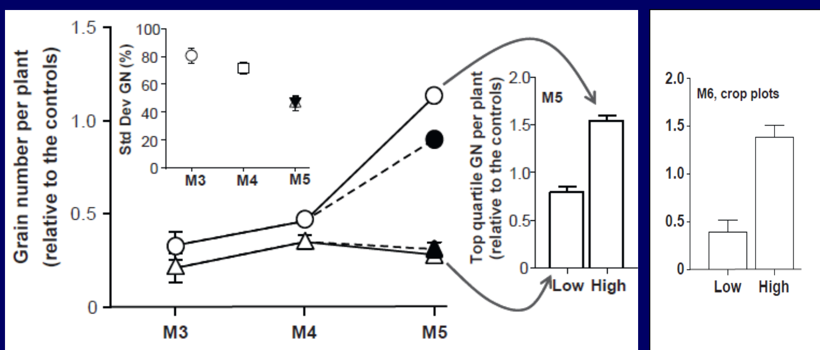
Pedro, Savin, Parry, Slafer (2012) Field Crops Research, 129:59-70



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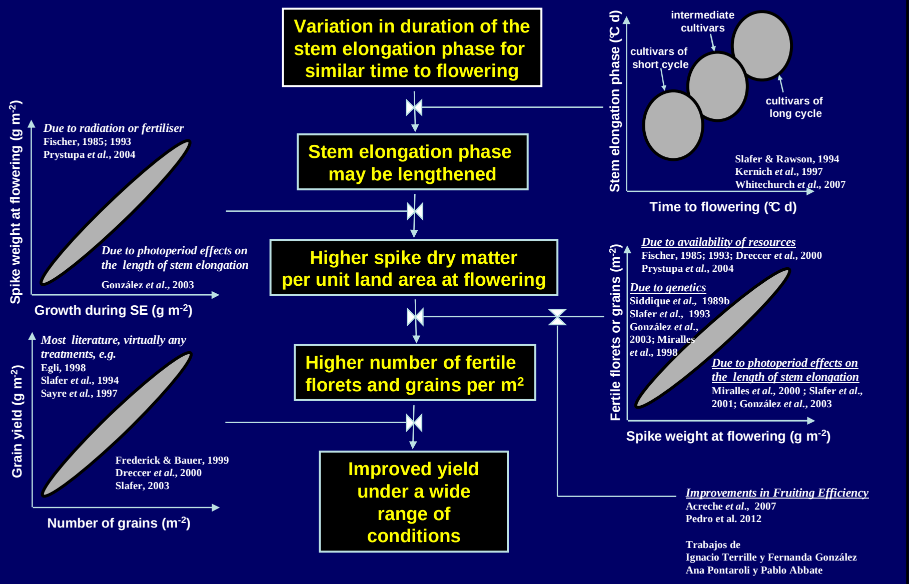
Conclusions

- As modern high-yielding wheats still seem to be mostly sink-limited during grain filling, further raising grain number is critical
- There are several different attributes which might have the potential (Reynolds et al., 2012; Plant Cell & Environment, 35:1799-1823)
- Fruiting efficiency (the efficiency with which dry matter allocated to spikes immediately before anthesis is used to set grains) may be a relevant trait to further raise yield of wheat
- There seem to be consistent cultivar differences in this attribute which most of the times is associated with genotypic differences in grain number and yield
- Developmental attributes of the florets and phasic developmental rates during stem elongation may be a relevant source of variation in FE

Conclusions

- At least for the rate of phasic development of stem elongation, QTLs may be identified
- However, when selecting for FE we must avoid compensations from reduced spike dry matter partitioning (Gaju et al., 2009; Foulkes et al., 2011) and reduced grain weight potential (Ferrante et al., 2013)
- Alternatively, further raising SDWa without further reducing plant height might be possible through fine-tuning developmental patterns

Conclusions



Adapted from Slafer *et al*. 2005. Annals of Applied Biology, 146:61–70

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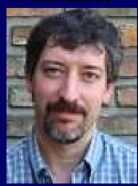
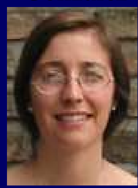


Eileen Whitechurch

Fernanda González



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