TALLER

Avances y desafíos para optimizar el rendimiento y calidad del grano de trigo y cebada

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Wheat responsiveness to N in <u>rainfed</u> Mediterranean conditions

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The large variability in grain yields that occurs frequently under Mediterranean environments often determines conservative strategies by farmers (Sadras *et al*., 2002).

In dryland agricultural systems of Mediterranean regions (particularly in the WANA region)**, farmers usually avoid investing in N-fertilizer**

This is because it is assumed that responsiveness would be negligible: under (the very frequent condition of) **yield limitation due to water stress, crops would not respond to other inputs than water**

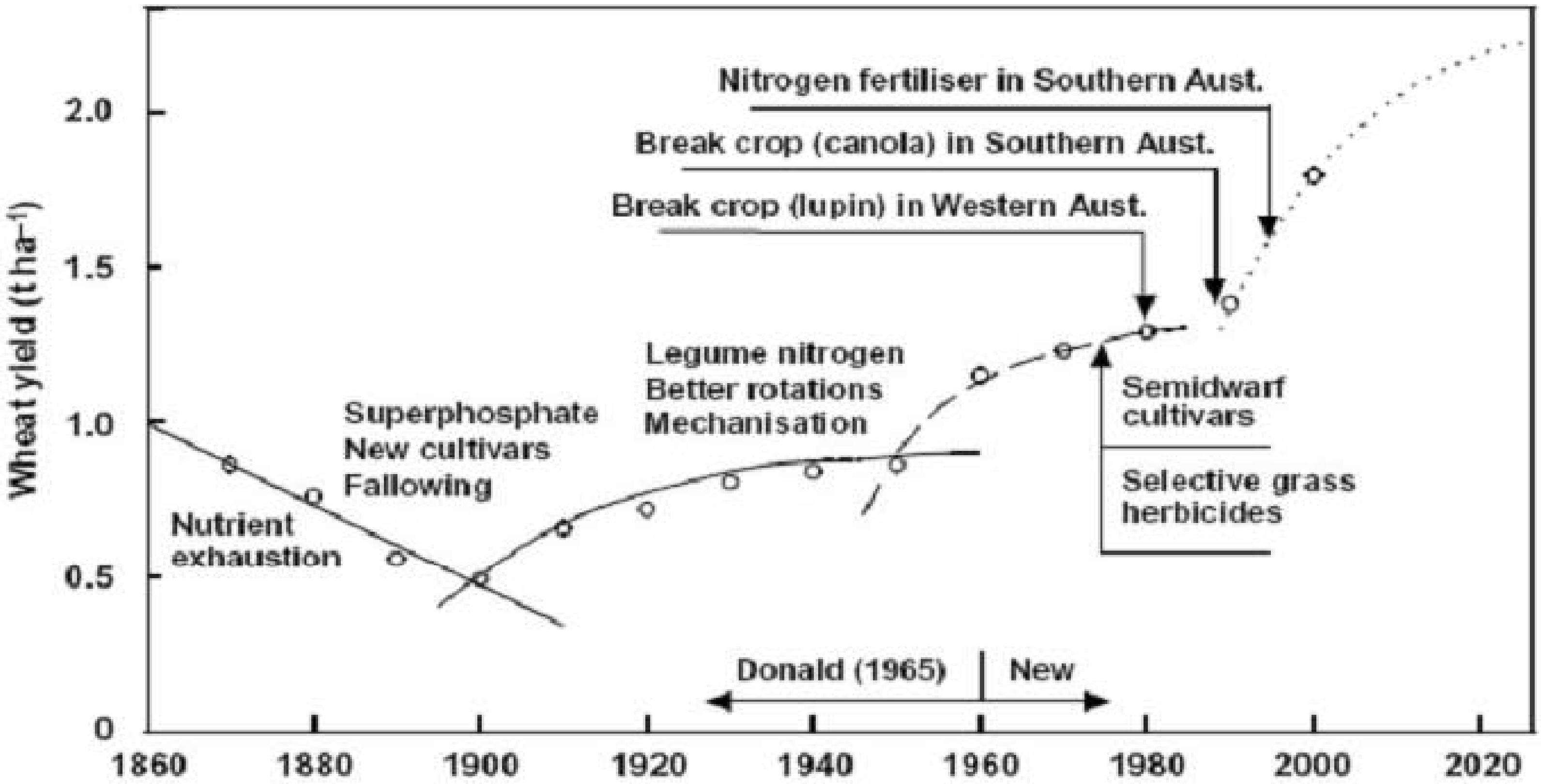

Fig. 1. Average decadal wheat yields in Australia since 1860, an extension by Angus (2001) of an earlier analysis by Donald (1965). Reproduced from the *Australian Journal of Experimental Agriculture* **41**, 277–288 (Angus JF, 2001) by permission of CSIRO PUBLISHING.

Passiuora (2002), suggested that the ***increase*** *in the* ***yield of wheat*** *in recent years (southeastern Australia) was associated with* ***nitrogen fertilization****.*

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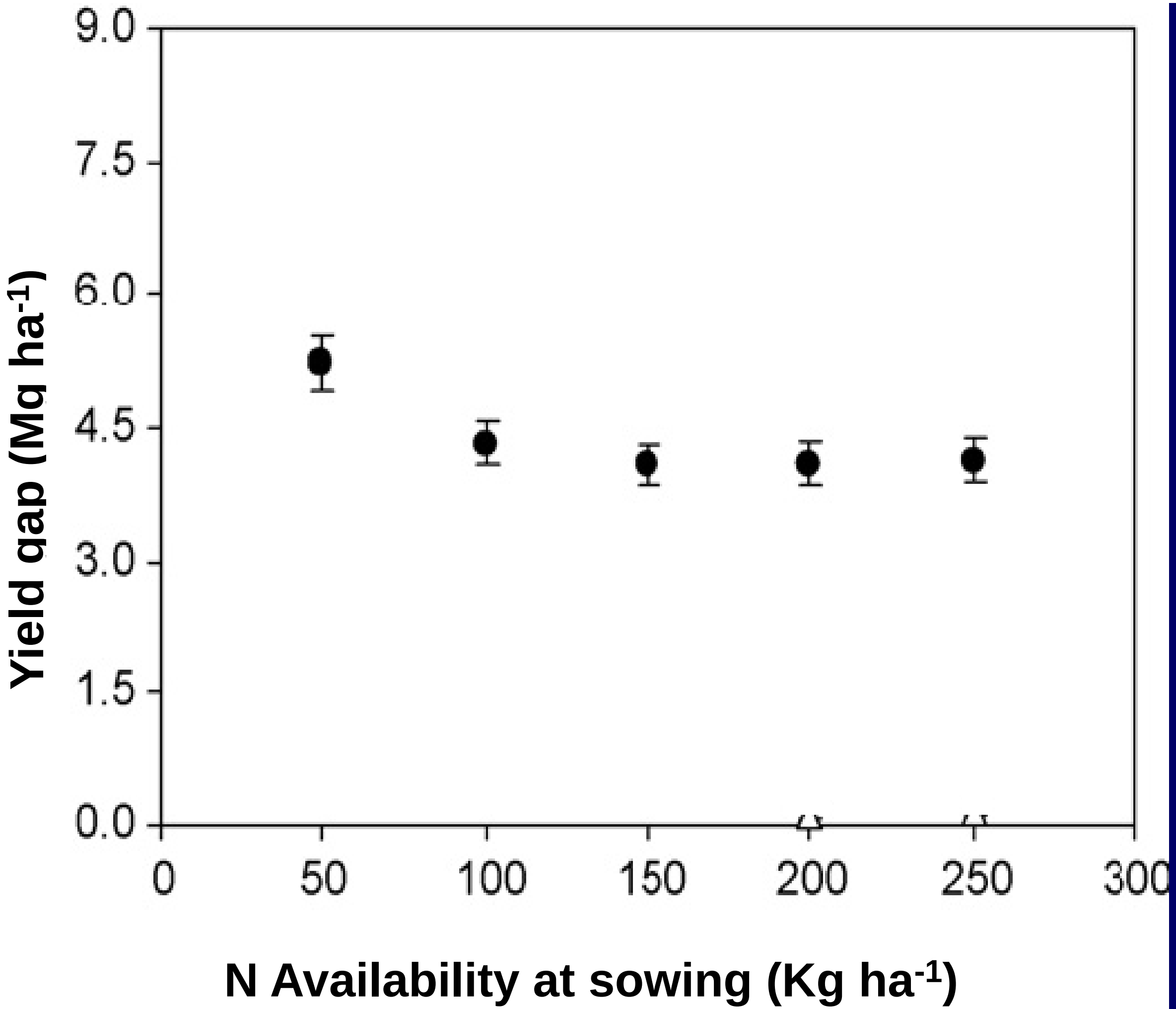
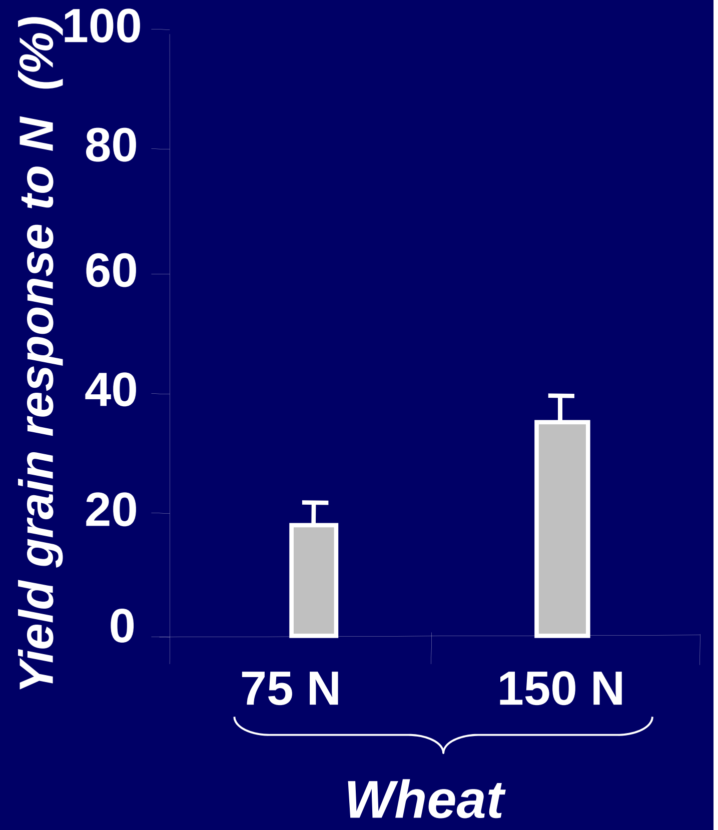


Mediterranean environmet (Agramunt-Catalonia)



Cossani, Slafer & Savin (2007). Annals of Applied Biology, 151:167-173

Abeledo, Savin & Slafer (2008). European Journal of Agronomy, 28:541-550

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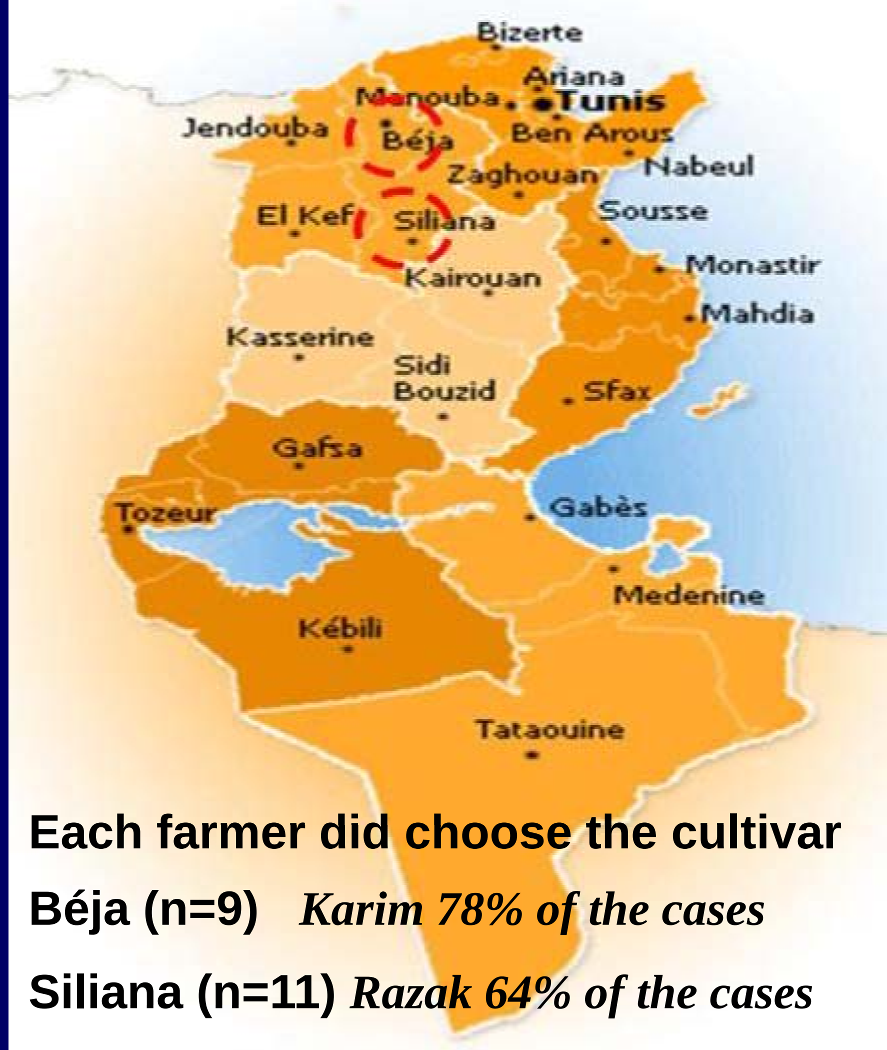
However, it is unclear

- **whether this responsiveness in simulations or in "field experiments" do actually represent what can be expected in realistic field conditions of actual farms** (very few studies in actual farms)**, further up-scaling knowledge from field experiments to real fields**

- **which are the physiological causes behind this likely response in terms of the generation/degeneration of structures responsible for the determination of the number of grains** (few studies on physiological responses to N in general and none on the dynamics of floret development)

Field experiments on actual farmer's paddocks at Agramunt (Catalonia) during the 2005/06 and 2006/07 growing seasons and complemented with a pilot experience in Tunisian farmers fields

cv. Claudio exposed to different combinations of irrigation (rainfed or irrigated) and N fertilization treatment)



Each farmer did choose the cultivar

Béja (n=9) *Karim 78% of the cases*

Siliana (n=11) *Razak 64% of the cases*

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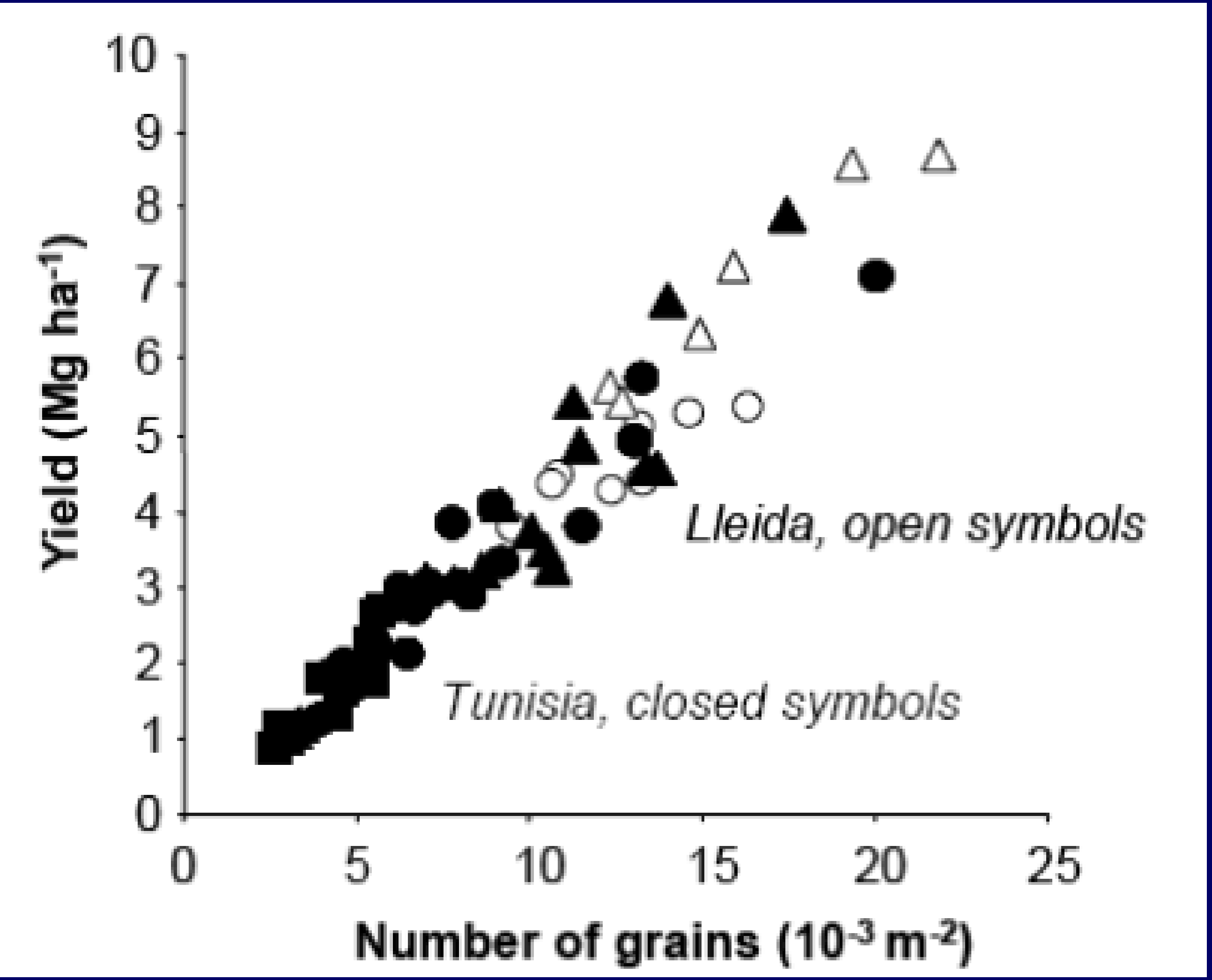
- **N fertilization resulted a right tool to increase durum wheat grain yield in realistic Mediterranean dryland systems**



- **In all the cases,** *and despite of the general terminal stress characteristic of Mediterranean conditions,* **grain number was the key component to produce grain yield**

Cossani, Slafer & Savin. 2011. Field Crops Research, 121:240–247
Cossani et al. 2011. Experimental Agriculture, 47:459–475

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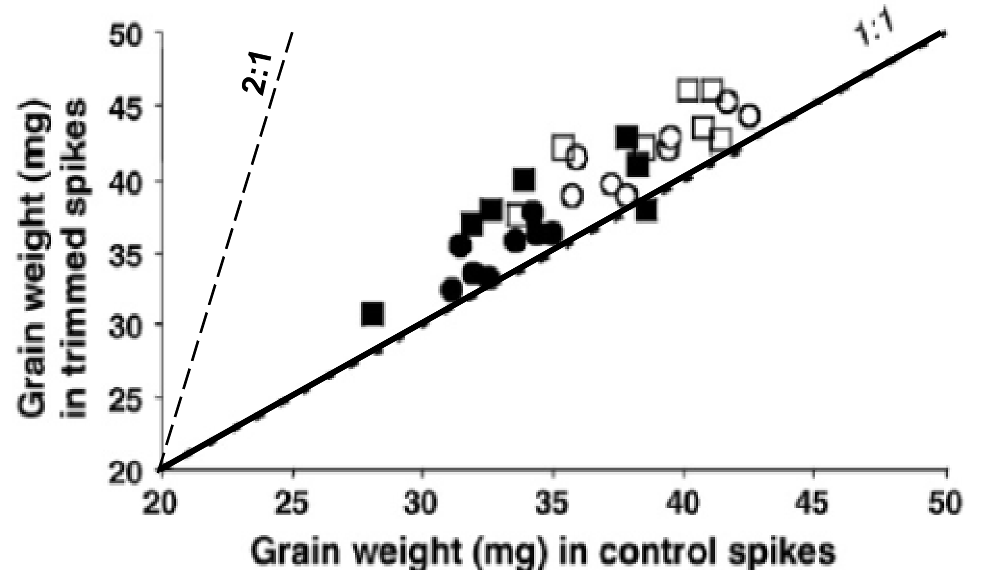
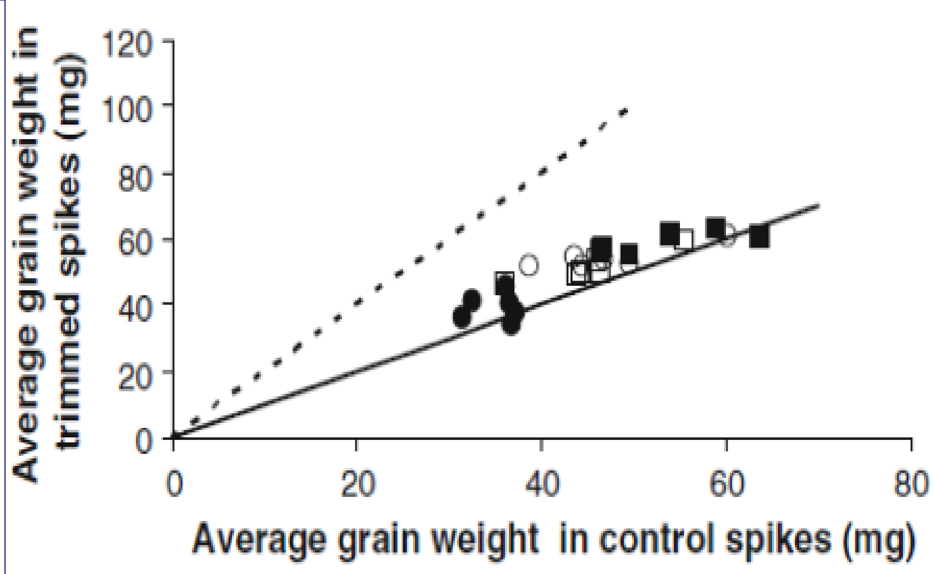
- This is due to the fact that grain growth in wheat seems to be far more limited by the capacity of the grains to grow than to the competition among growing grains after anthesis (even in Mediterranean conditions



Cartelle et al. 2006. Europ. J. Agronomy, 25:365–371



Pedro et al. 2011. Euphytica, 180:195-208

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Furthermore, we tested in a multilocation-multiyear study in four different areas of the Mediterranean Basin if rainfed cereals (wheat and barley) may respond positively to nitrogen fertilization

The study involved 16 experiments including different genotypes of wheat and barley, sown at Morocco, Jordan, North-eastern Spain, and Southern Italy

A total of 16 field experiments were carried out

Treatments consisted on different N doses applied at sowing or early in crop development under rainfed conditions from 2003/04 to 2007/08

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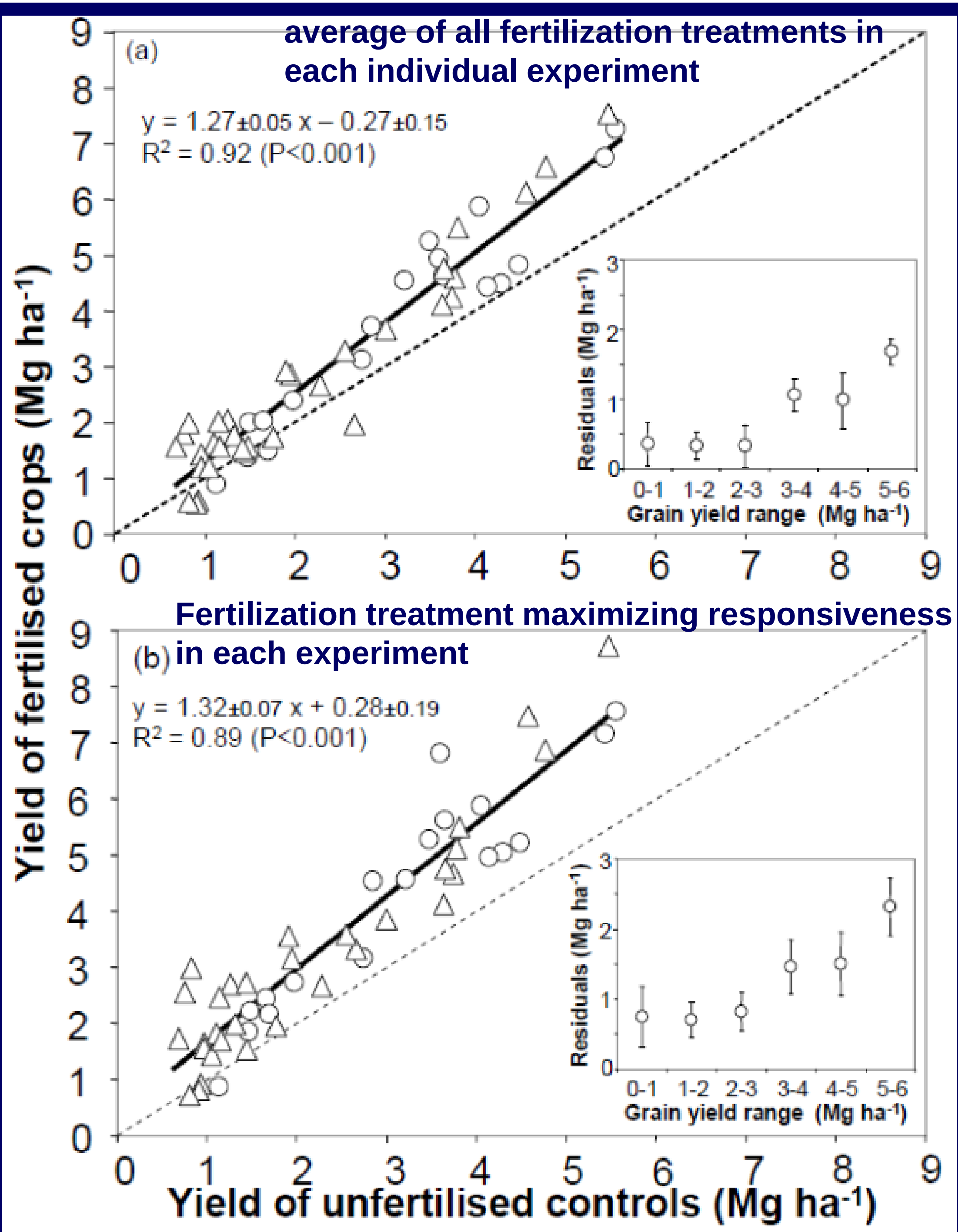

Relationship between yields of the fertilized and the unfertilized plots for barley (circles) and wheat (triangles). In both panels the dotted lines indicate the 1:1 ratio.

Inset each panel are the averaged residuals (and its standard deviation) to the 1:1 line for each interval of 1 Mg ha^{-1} in the unfertilized controls.

Savin et al., under revision

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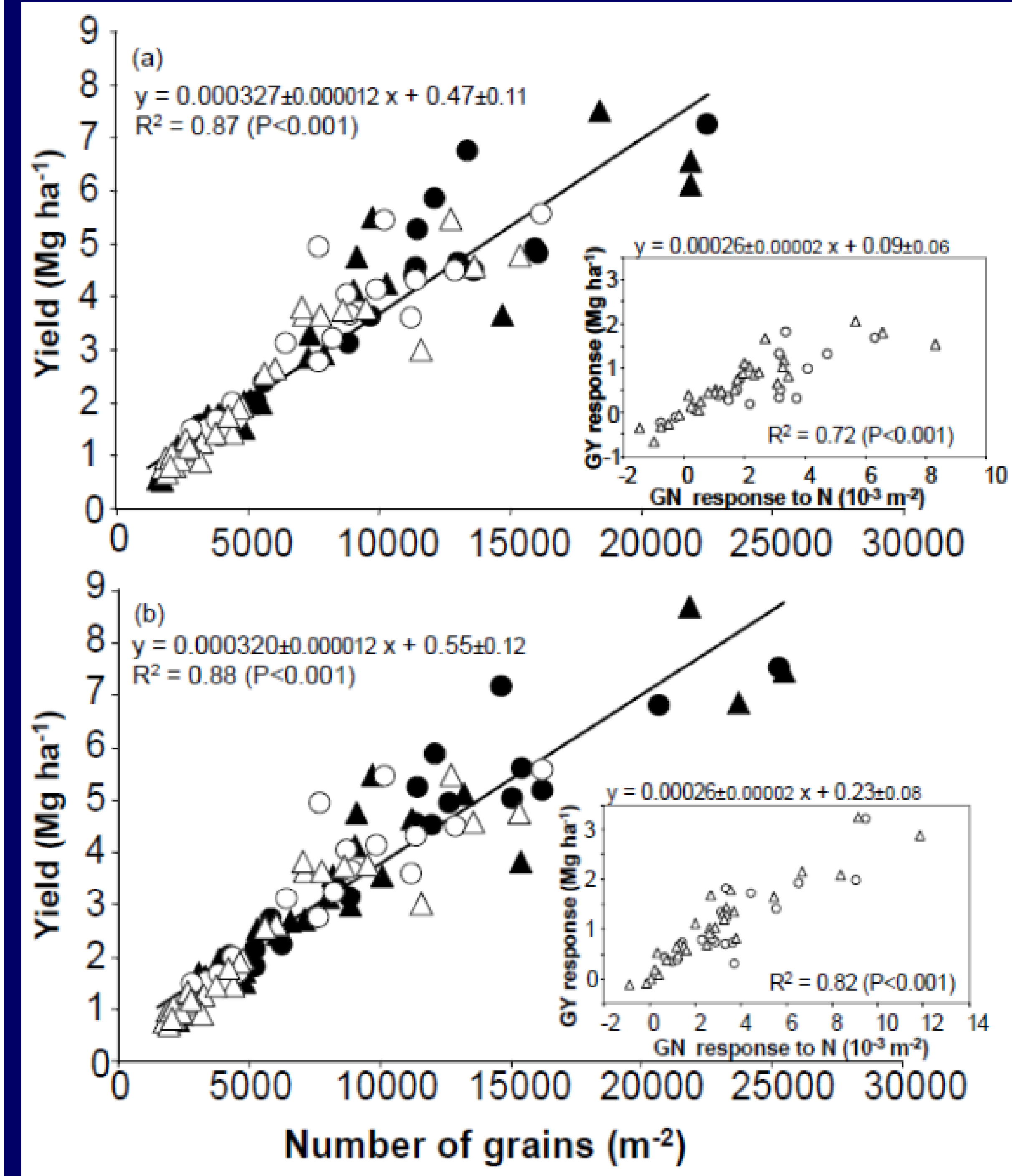

Relationship between yield and number of grains per m². Open and closed symbols represent the unfertilized controls and fertilized crops of both barley (circles) and wheat (triangles).

Inset are the yield and grain number responses to N fertilization for barley and wheat in each experiment

Savin et al., under revision

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Microcrops study of floret development

- ***Micro-crops in large containers (1 m height y 1 m2 area) filled with sand:soil placed outdoors in the campus. Conducted across two growing seasons:***
  Year 1: 2006-2007
  Year 2: 2007-2008

- ***Treatments***

Durum wheat cv. Claudio under two N levels (in both years) and two water regimes (in year 2)

N: control (N-) and fertilized (N+) [100 (y1) or 250 (y2) kg N ha-1]

Water: irrigated or rainfed.

Microcrops study of floret development

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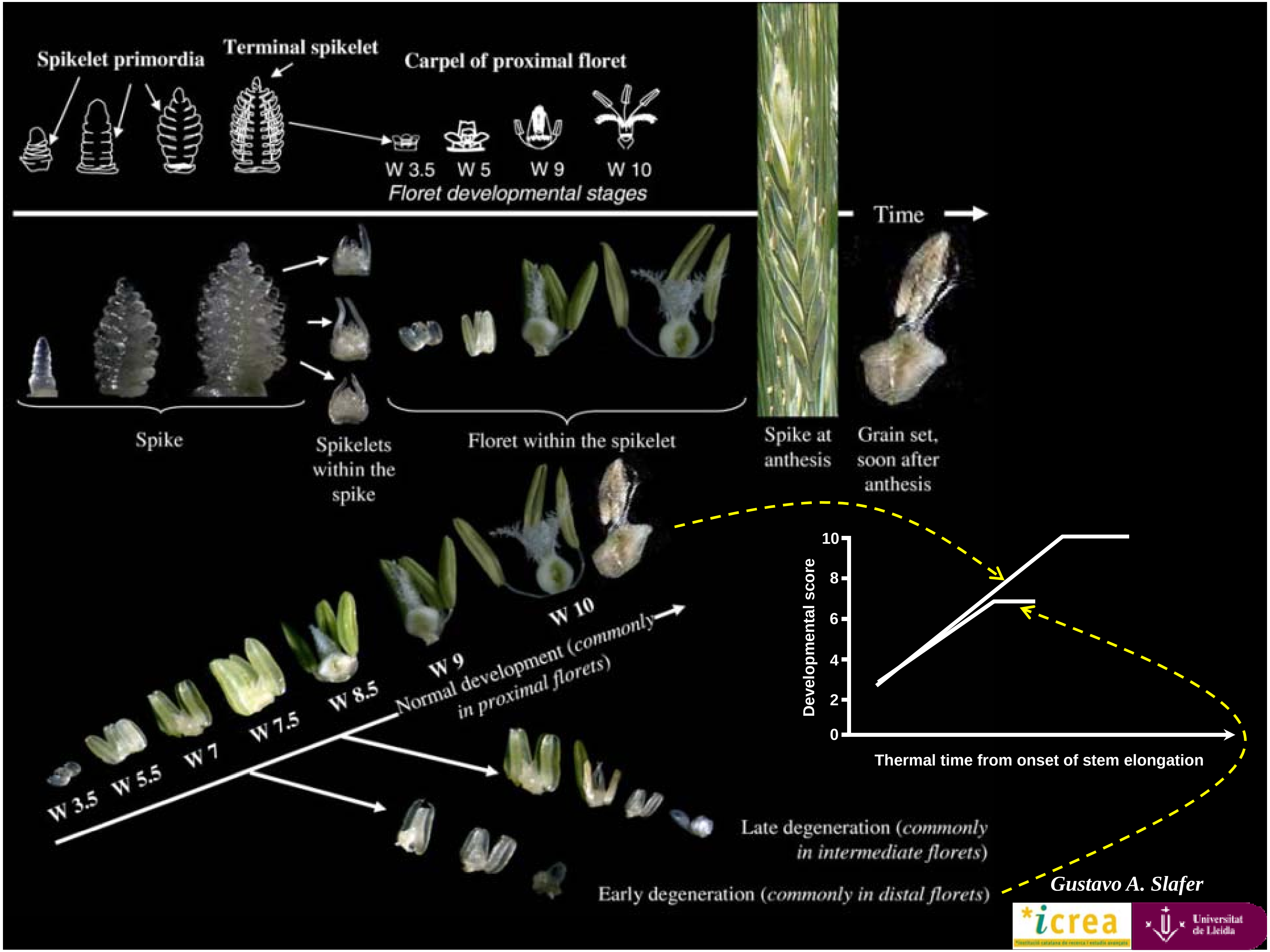
Spikelet primordia
Terminal spikelet
Carpel of proximal floret
W 3.5
W 5
W 9
W 10
Floret developmental stages
Time
Spike
Spikelets within the spike
Floret within the spikelet
Spike at anthesis
Grain set, soon after anthesis
W 3.5
W 5.5
W 7
W 7.5
W 8.5
W 9
W 10
Normal development (commonly in proximal florets)
Late degeneration (commonly in intermediate florets)
Early degeneration (commonly in distal florets)
Developmental score
0
2
4
6
8
10
Thermal time from onset of stem elongation
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			Yield ($g\ m^{-2}$)	Grain number ($10^{-3}\ m^{-2}$)	No. of grains ($spike^{-1}$)	No. of spikes (m^{-2})
Experiment 1 2006-07		N_0	272 b	7.59 b	16. 9 b	453 b
		N_{100}	512 a	14.12 a	28.0 a	504 a
Experiment 2 2007-08	Irrigated	N_0	283 b	6.82 b	22.4 b	304 b
		N_{250}	**727 a**	**16.13 a**	35.8 a	453 a
	Rainfed	N_0	235 b	5.91 b	18.7 b	315 b
		N_{250}	518 a	12.77 a	31.0 a	413 a

Ferrante, Savin, Slafer. 2010. Journal of Experimental Botany, 61:4351-4359

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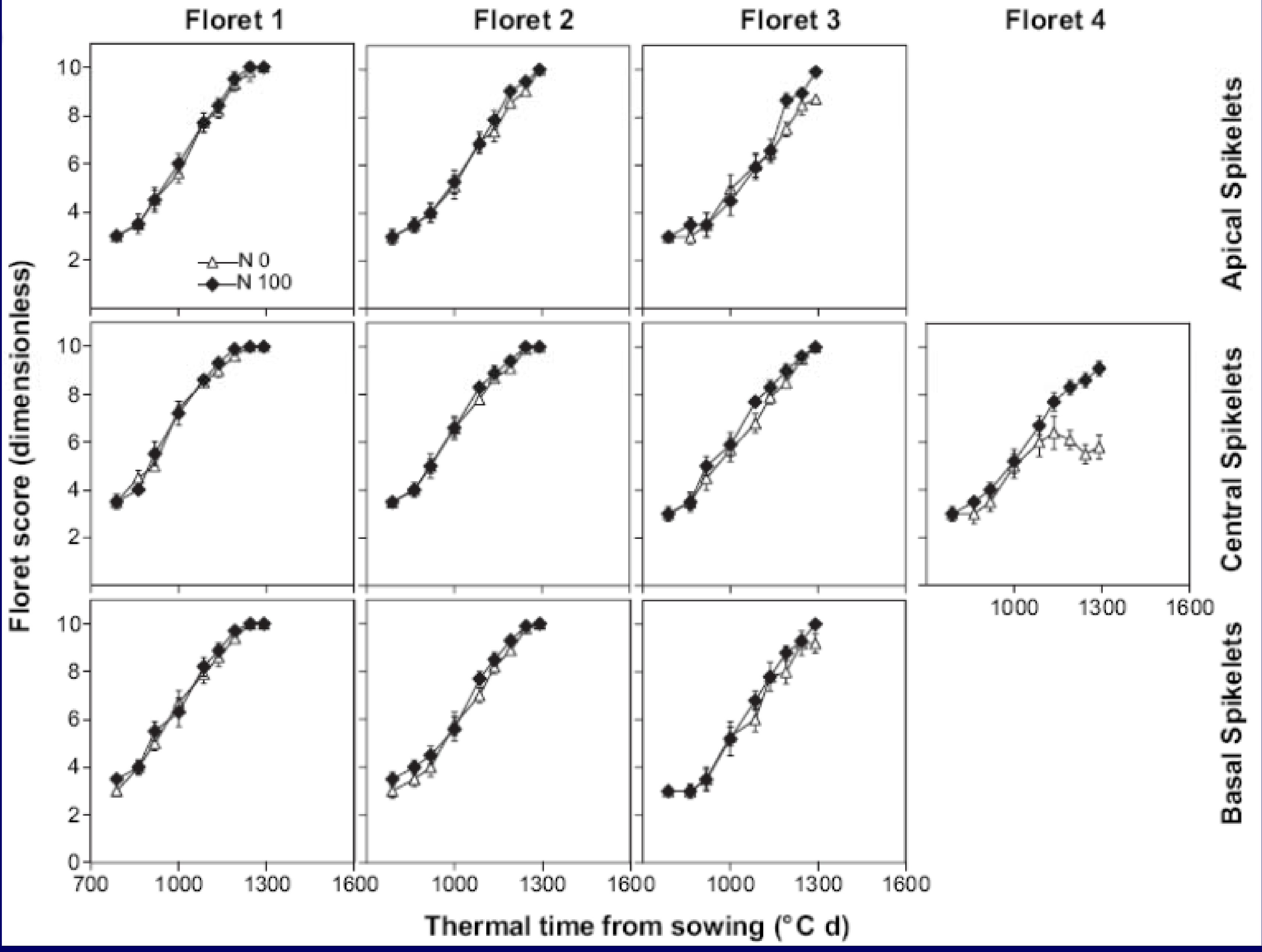
2006-2007



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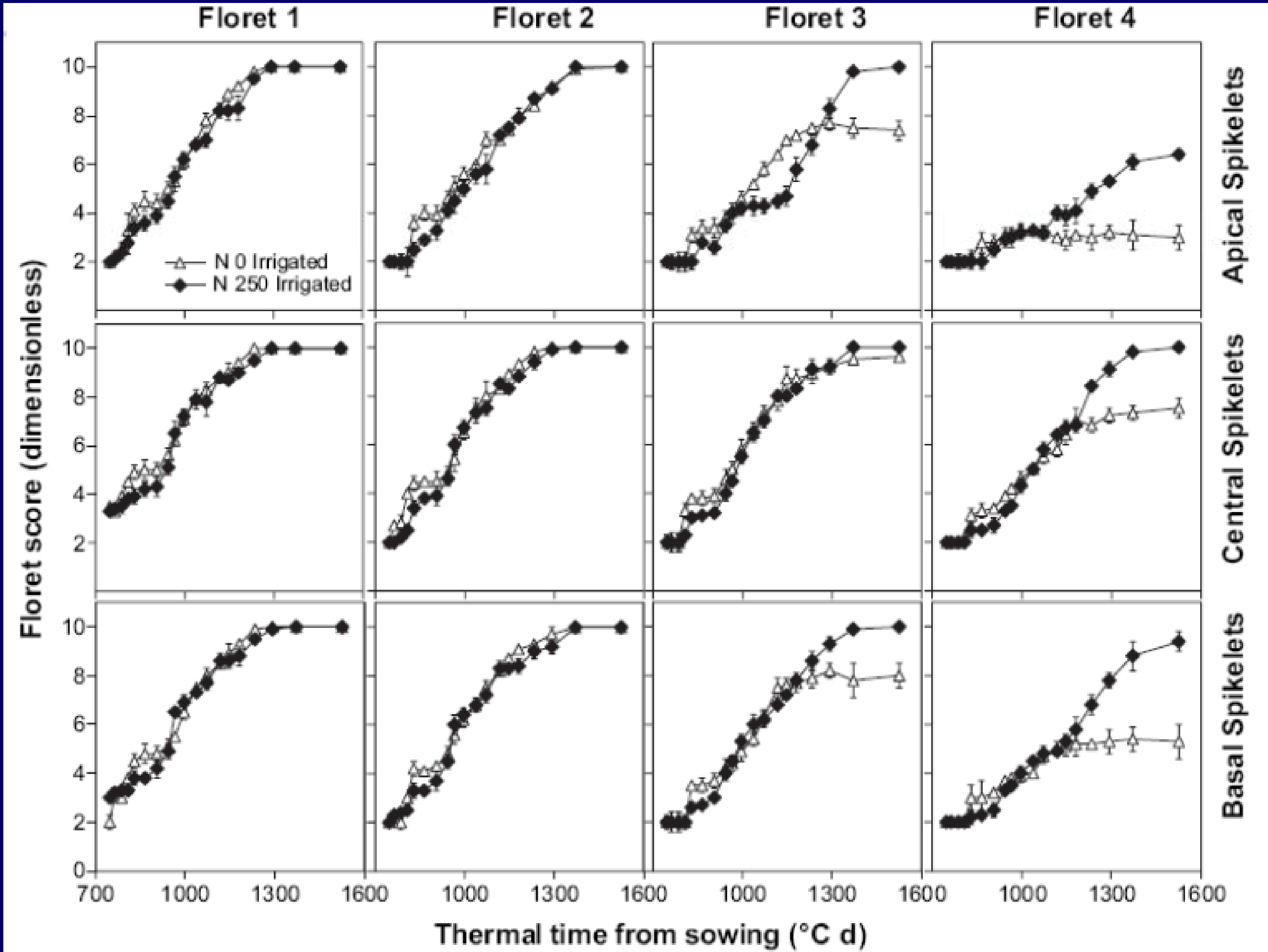
Ferrante, Savin, Slafer. 2010. Journal of Experimental Botany, 61:4351-4359

2007-2008 irrigated



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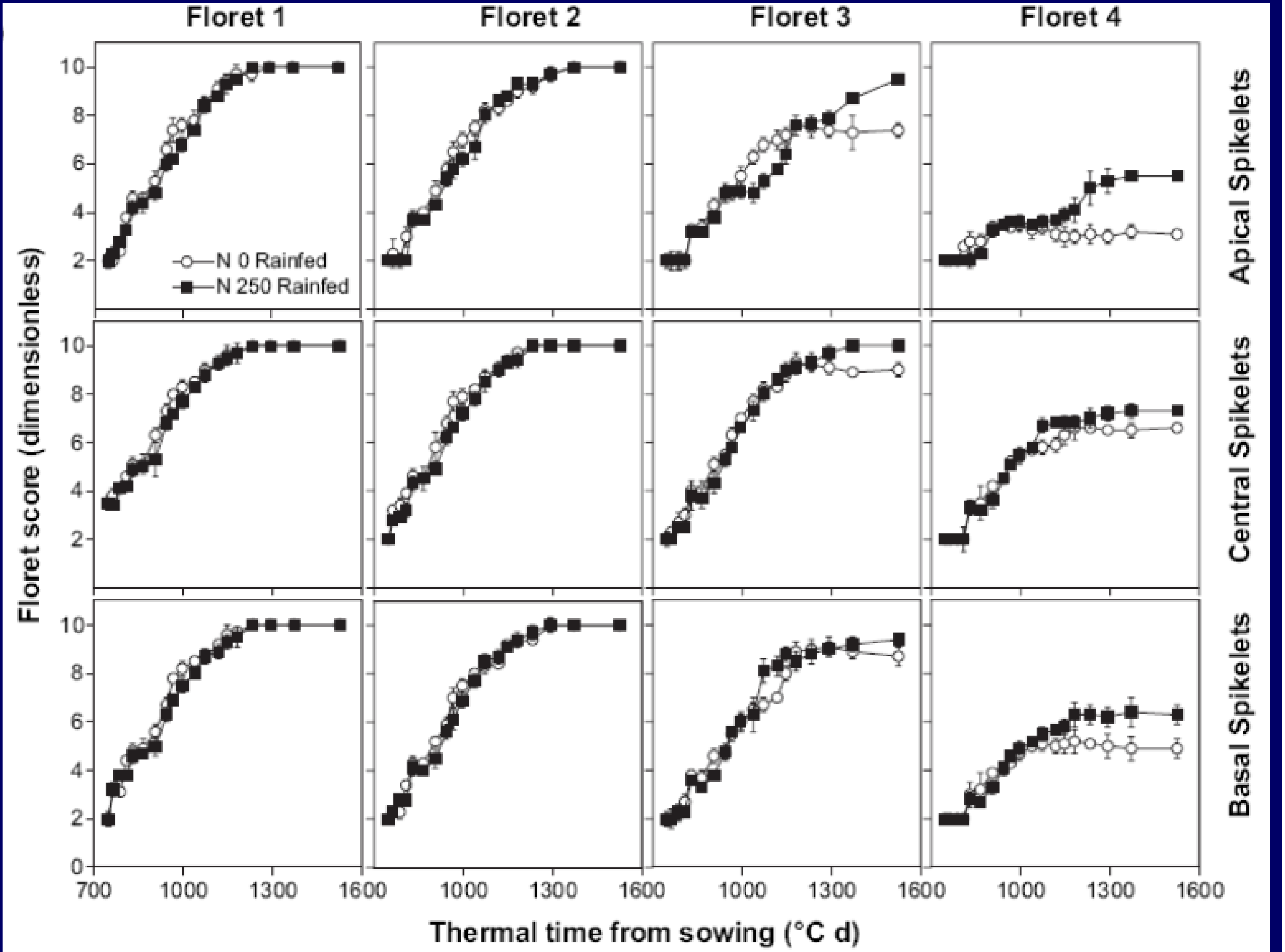
2007-2008 rainfed



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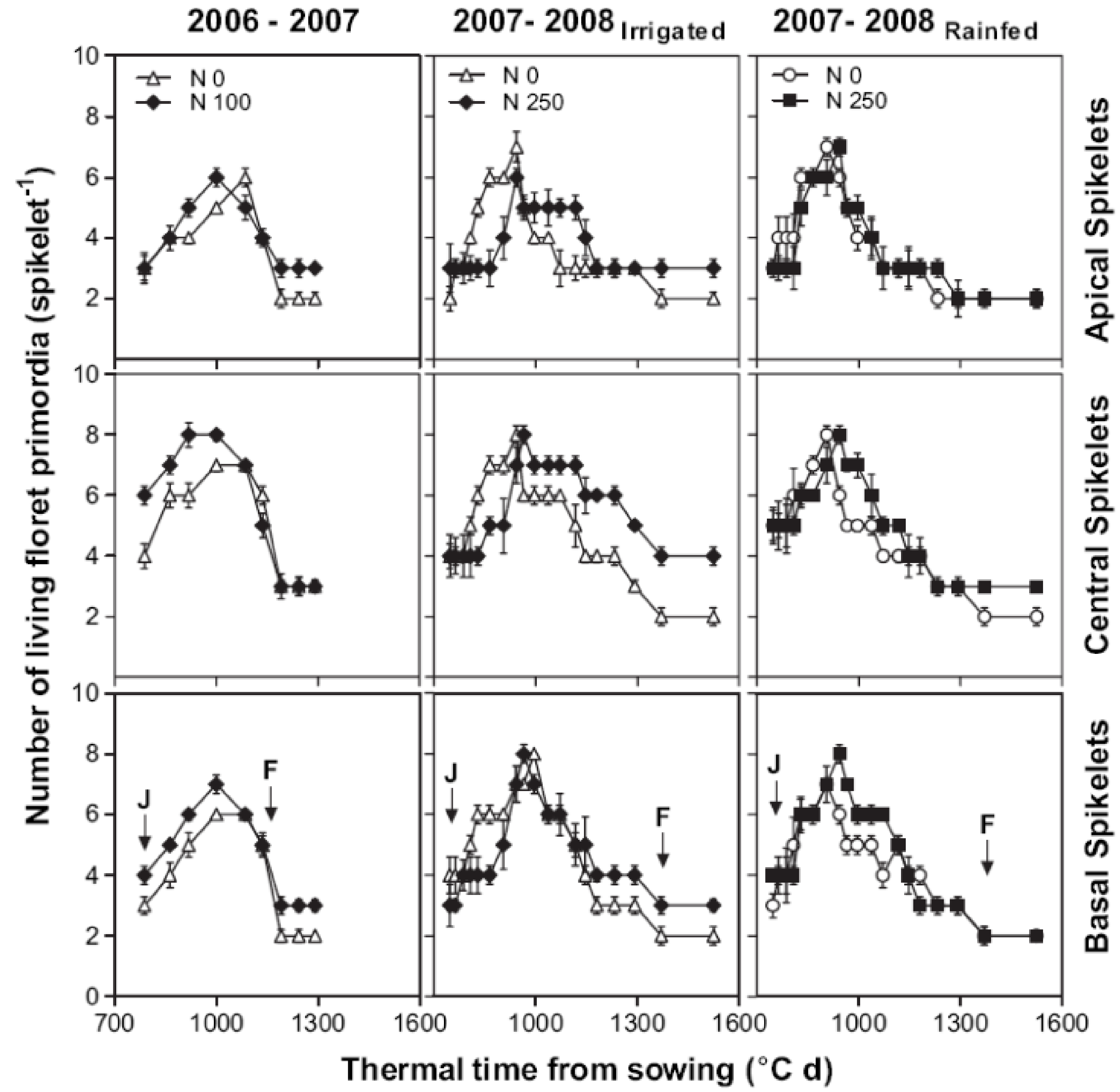

Ferrante, Savin, Slafer. 2010. Journal of Experimental Botany, 61:4351-4359

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Growing season	Experiment	Experimental design	Chemical and physical soils properties	Experimental approaches	Sowing date and density	Experimental treatments			Growing conditions label (Gc)
						Water availability	N availability	Cultivars	
2008–09	1	Completed randomised design (3 replicates)	pH: 8.2 ECe (dS/m): 0.13 Organic matter (Walkey + Black) (%): 0.25 Soil textural class(USDA): Loamy sand Clay (%): 3.9 Sand (%): 80.8 Silt (%): 15.3	Crops in large containers outdoors	28 Nov. 08 300 plants m^{-2}	Irrigated[a]	**50 kgN ha^{-1}**	**Claudio** **Donduro** **Simeto** **Vitron**	Gc 1
							250 kgN ha^{-1}	**Claudio** **Donduro** **Simeto** **Vitron**	Gc 2
	2	Randomised block design (3 replicates)	pH: 8 ECe (dS/m): 0.34 Organic matter (Walkey + Black): 3.11 Soil textural class(USDA): Sandy clay loam Clay (%): 27.8 Sand (%): 46.4 Silt (%): 25.8	Field	24 Nov. 08 300 plants m^{-2}	Rainfed	130 kgN ha^{-1}	**Claudio** **Donduro** **Simeto** **Vitron**	Gc 3
	3		pH: 7.9 ECe (dS/m): 0.85 Organic matter (Walkey + Black): 4.14 Soil textural class(USDA): Clay loam Clay (%): 28.3 Sand (%): 38.4 Silt (%): 33.3	Field	12 Dec. 08 300 plants m^{-2}	Irrigated[b]	580 kgN ha^{-1}	**Claudio** **Donduro** **Simeto** **Vitron**	Gc 4
2009–10	4	Completed randomised design (3 replicates)	pH: 8.2 ECe (dS/m): 0.13 Organic matter (Walkey + Black) (%): 0.25 Soil textural class(USDA): Loamy sand Clay (%): 3.9 Sand (%): 80.8 Silt (%): 15.3	Crops in large containers outdoors	26 Nov. 09 250 plants m^{-2}	**Irrigated[a]**	**50 kgN ha^{-1}**	**Donduro** **Vitron**	Gc 5
							250 kgN ha^{-1}	**Donduro** **Vitron**	Gc 6
						Rainfed	**50 kgN ha^{-1}**	**Donduro** **Vitron**	Gc 7
							250 kgN ha^{-1}	**Donduro** **Vitron**	Gc 8

Ferrante, Savin & Slafer. 2012. Field Crops Research, 136:52-64

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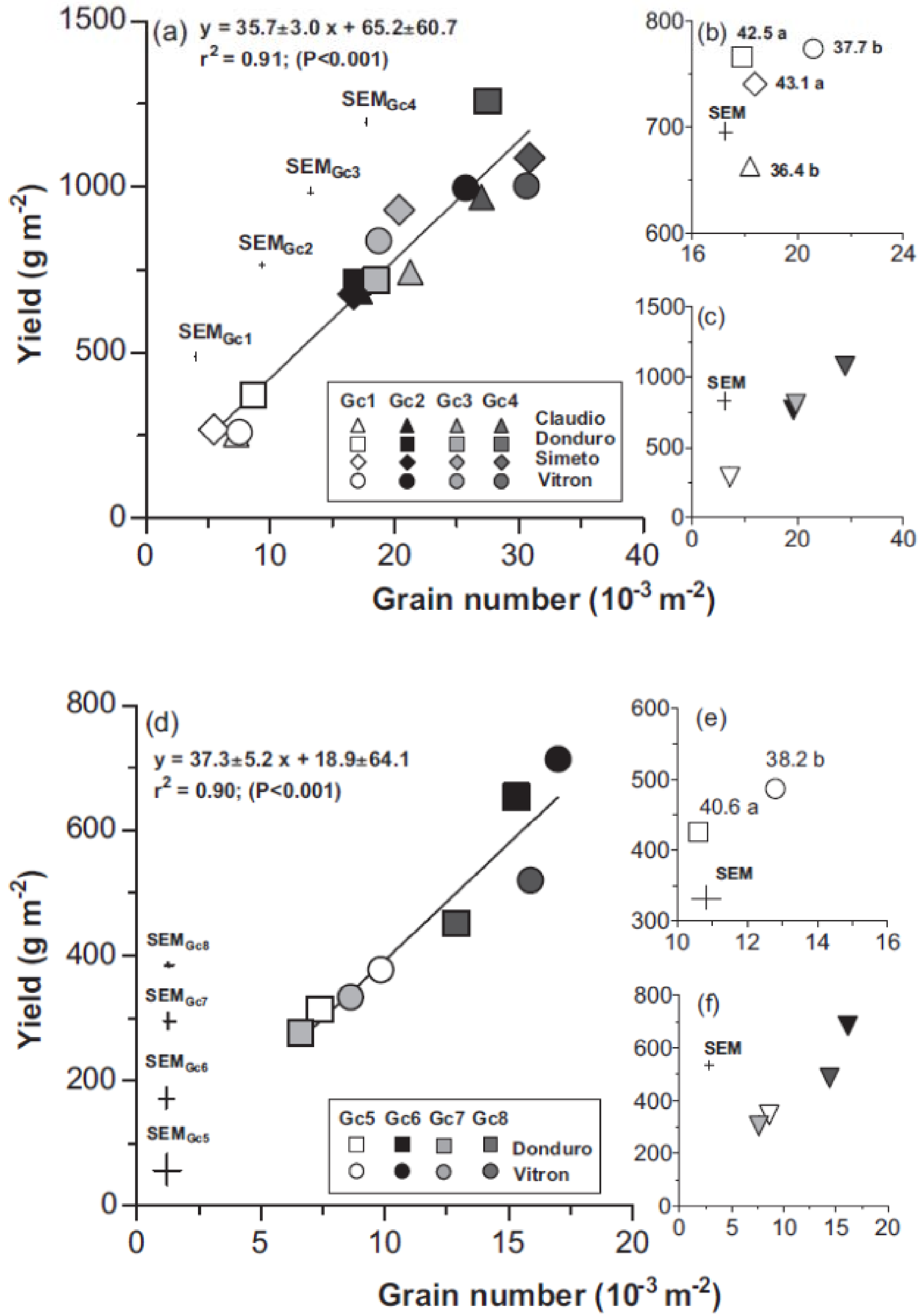

Gc1 vs Gc2 N-fertilisation

Gc3 vs Gc4 Water+N-fertilisation

Gc5 vs Gc6
Gc7 vs Gc8 } ***N-fertilisation***

Ferrante, Savin & Slafer. 2012.
Field Crops Research, 136:52-64

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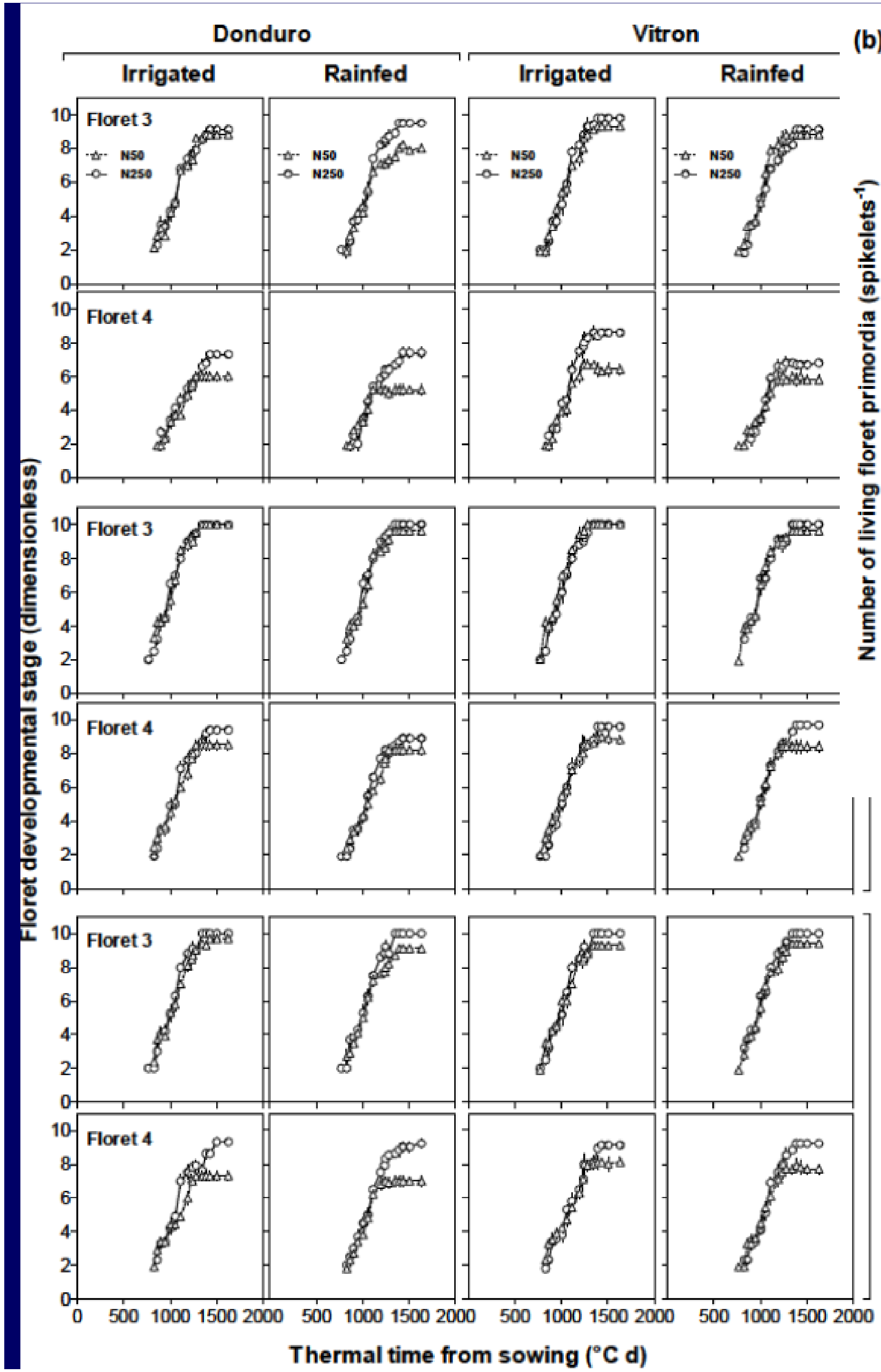

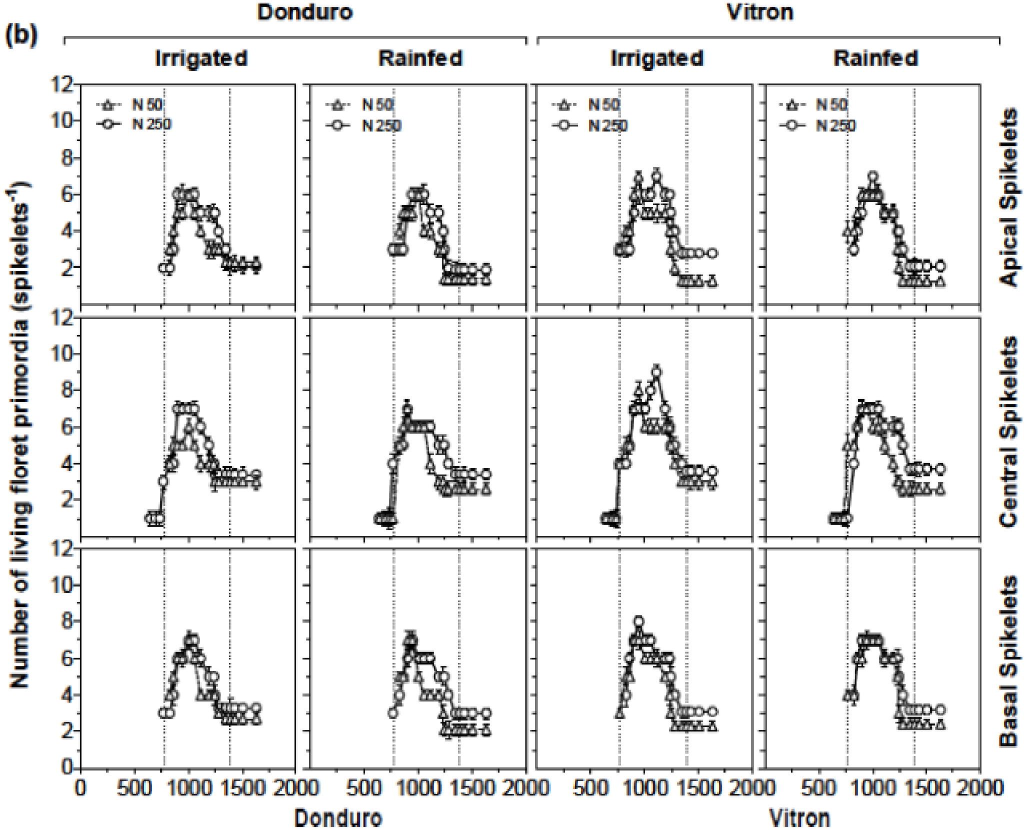

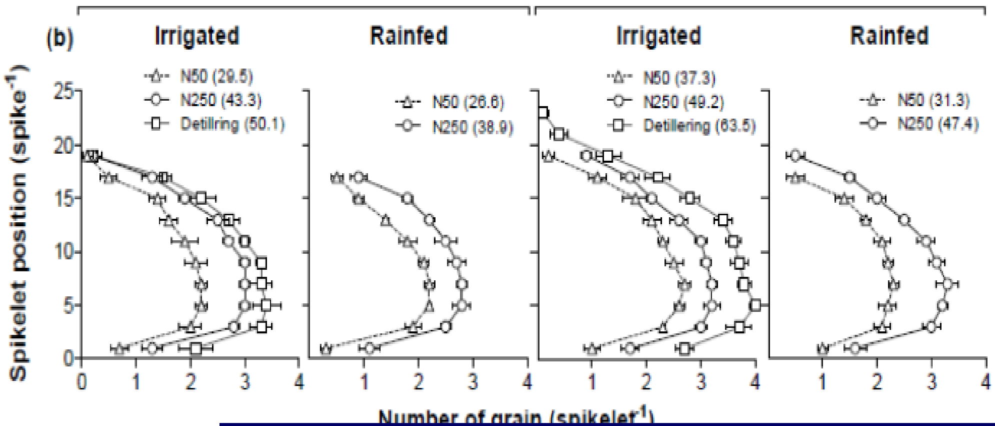

Ferrante, Savin, Slafer. 2012. Journal of Experimental Botany *in press*

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Conclusions of the agronomic part of the work

It had been shown in experimental set-ups (Fischer, 1993) **and through simulation exercises** (Abeledo et al., 2008) **that wheat tends to respond to N fertilization under a wide range of conditions. However, farmers in the Southern border of the Mediterranean Basin are reluctant to fertilize**

We demonstrated here that the attitude against fertilizing was not due to a problem of up-scaling experimental and simulation results and that farmers may on average get net benefits from fertilizing more (more often or higher rates)

Even though the region is clearly characterized by terminal stress (during grain filling), yield responsiveness to N was consistently related to increased number of grains per m^2 (Cossani et al., 2010)

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Conclusions of the physiological part of the work

It had been shown that N fertilization Improved to the growth of the juvenile spikes (Fischer, 1993; Prystupa, Savin & Slafer, 2004; Ferrante, Savin & Slafer, 2012)

We demonstrated here that the mechanism operates through accelerating rate of floret development, which caused a higher rate of survival of the rather large number of floret primordia that are normally initiated in all spikelets of wheat

This, in addition, confirms that floret survival is a major determinant of grain number in wheat and that the process seems to be mediated by resource availability (González, Miralles & Slafer, 2011)