Zonas agrícolas en expansión: impactos y desafíos impuestos por limitaciones a la productividad de cereales

Paysandú, 26 y 27 de octubre de 2010

CYTED
CIENCIA Y TECNOLOGÍA PARA EL DESARROLLO

Limitantes a la expresión del potencial asociadas al estrés térmico

- Rendimiento potencial
  - relevancia en condiciones de campo
  - determinantes
- Estrés térmico
  - que es un estrés térmico?
  - efecto sobre determinantes del rendimiento

Gustavo A. Slafer
& Roxana Savin

Universitat de Lleida

ESCOLA TÈCNICA SUPERIOR
D'ENGINYERIA AGRÀRIA
(*ETSEA*)

Departament
de Producció Vegetal
i Ciència Forestal

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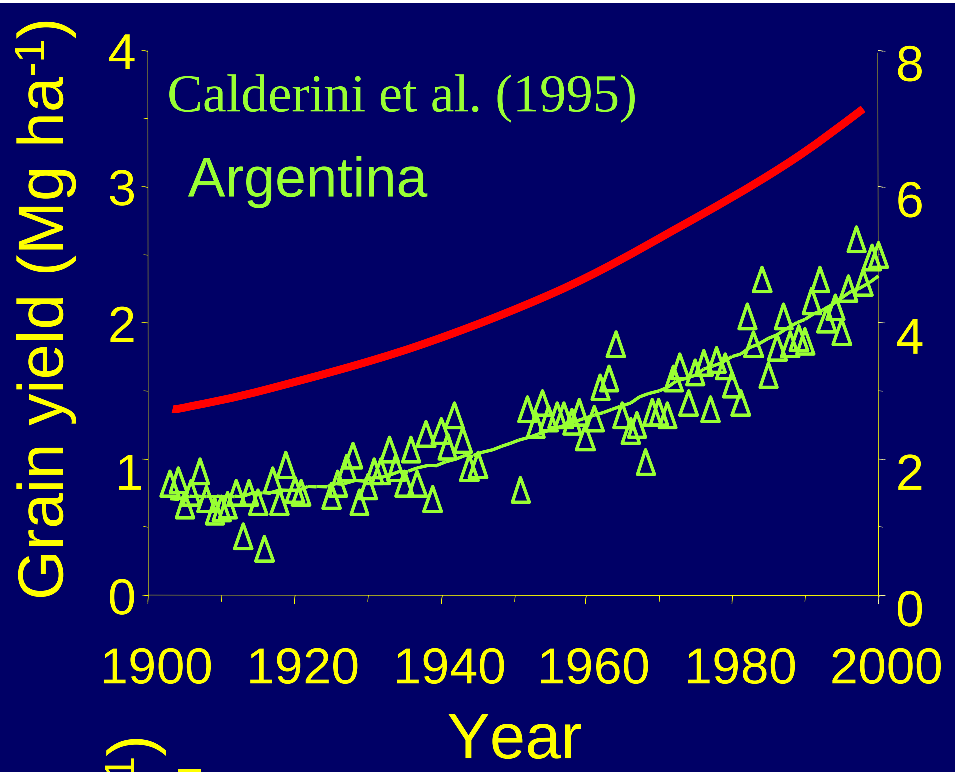

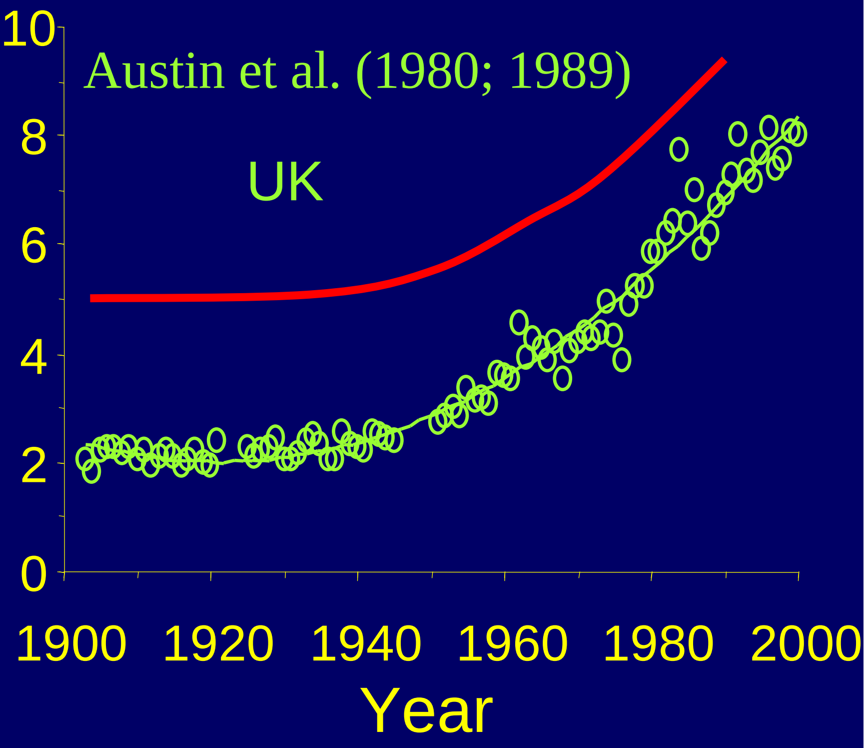

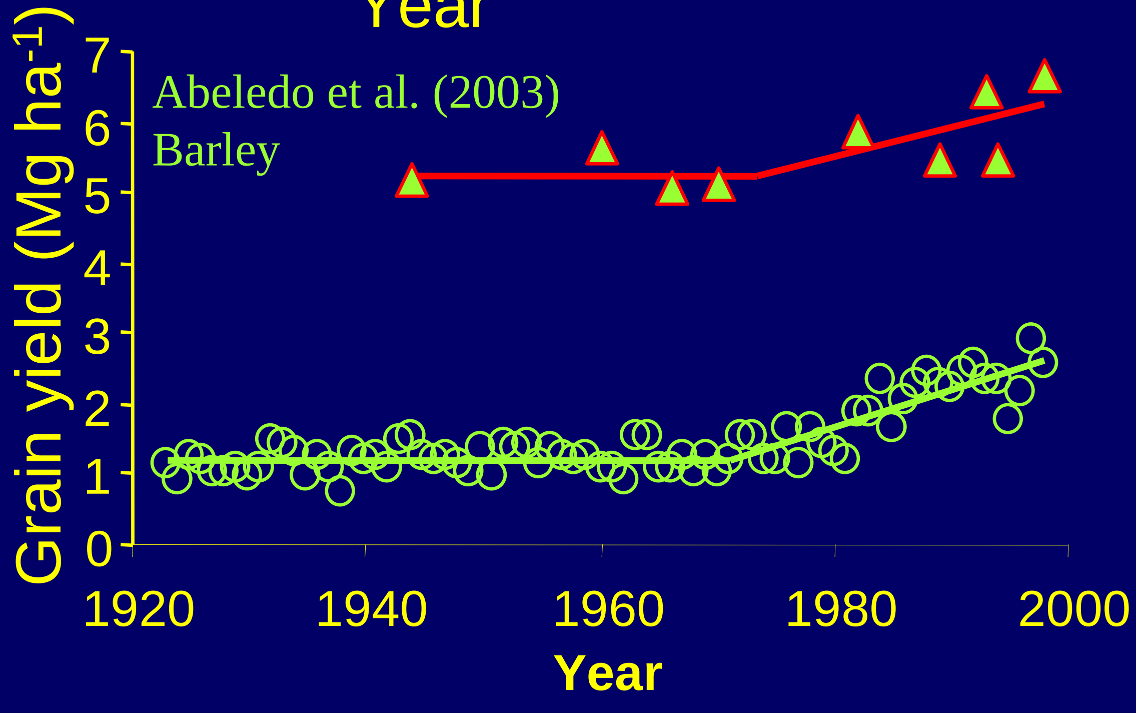

Similar evidences for <u>maize</u> and <u>soybean</u> in the US can be found in Evans, 1998. Feeding the 10 billion... (Camb. Univ. Press)

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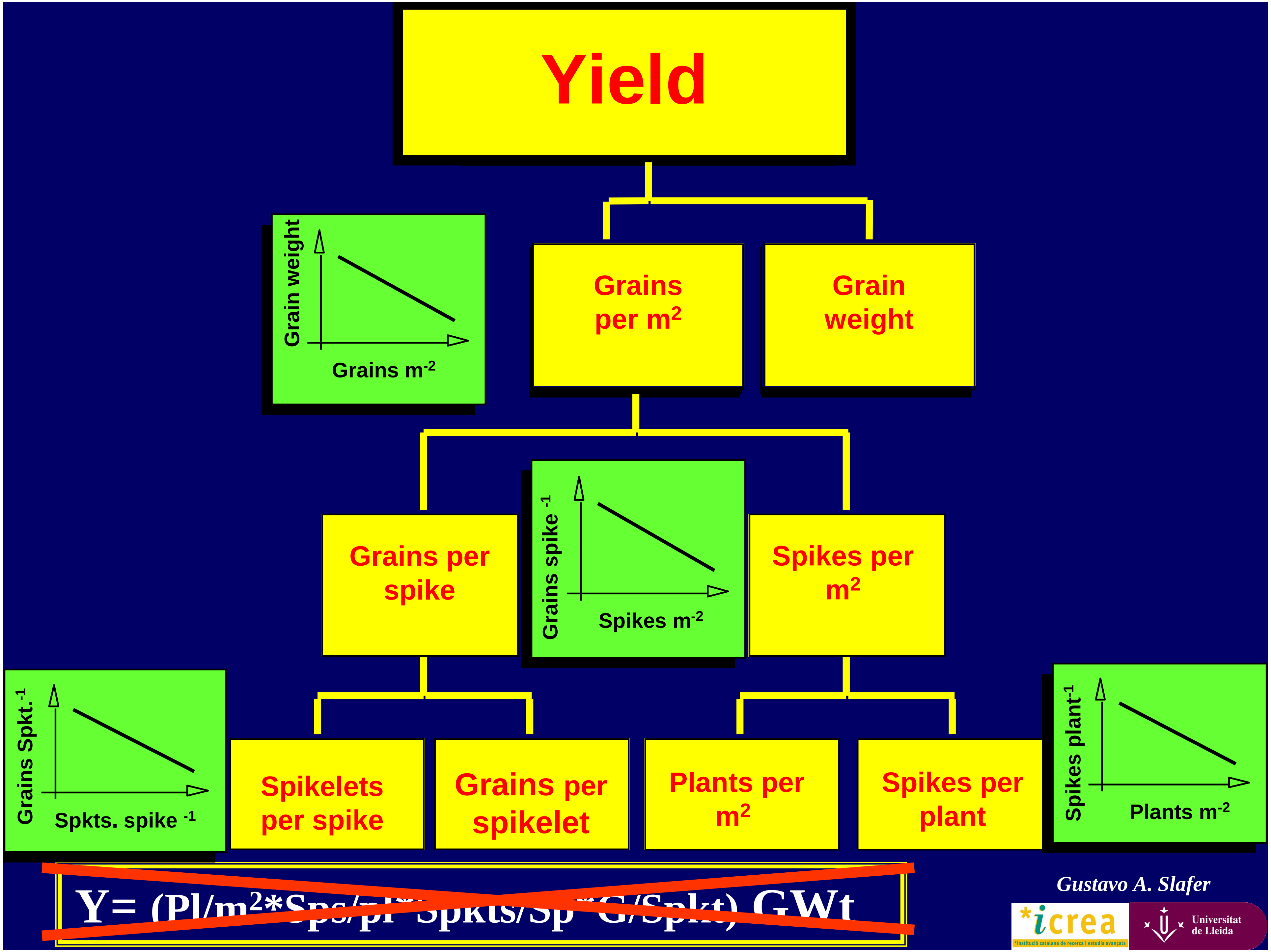
Yield
Grains per m2
Grain weight
Grain weight
Grains m-2
Grains per spike
Grains spike -1
Spikes m-2
Spikes per m2
Grains Spkt.-1
Spkts. spike -1
Spikelets per spike
Grains per spikelet
Plants per m2
Spikes per plant
Spikes plant-1
Plants m-2
Y= (Pl/m2*Sps/pl*Spkts/Sp*G/Spkt) GWt
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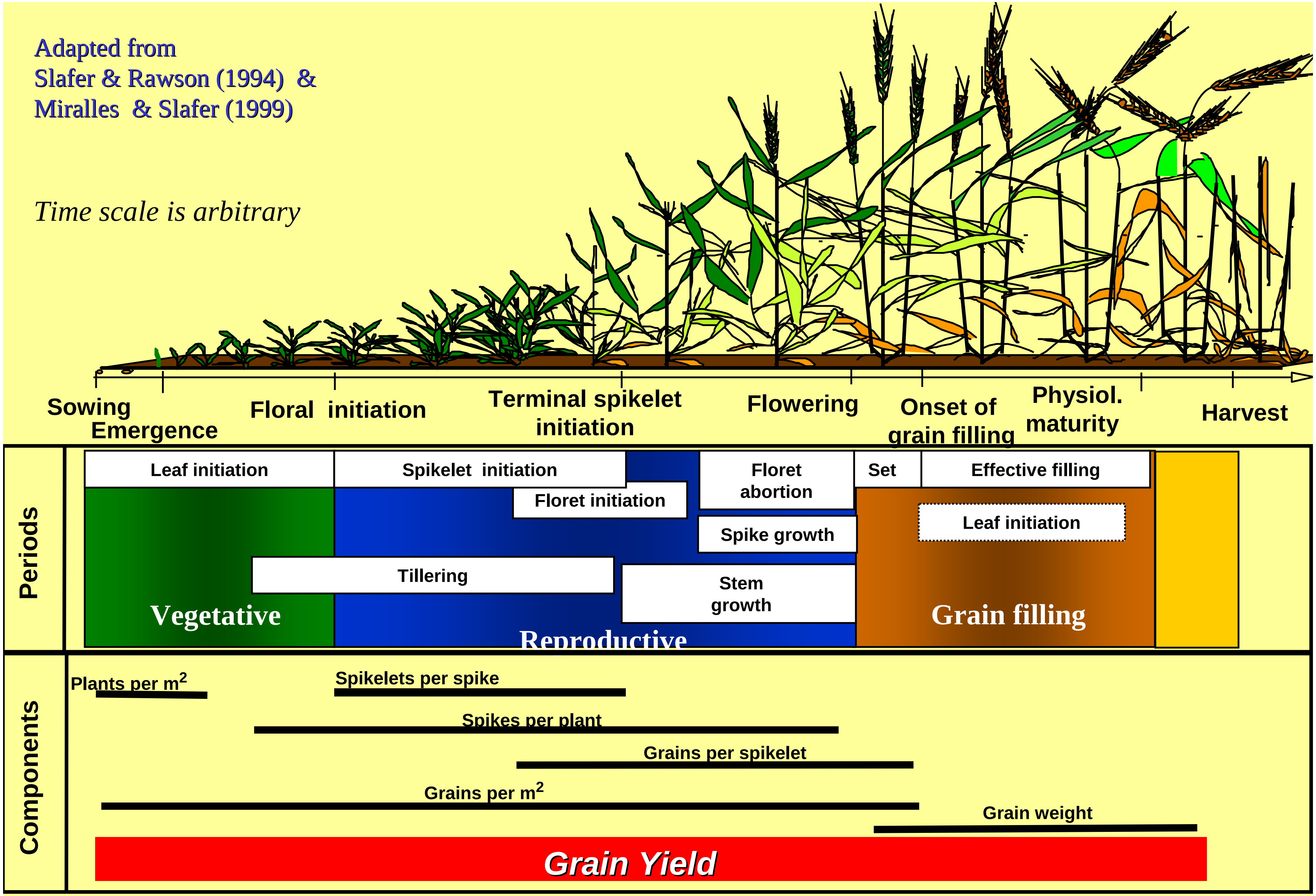

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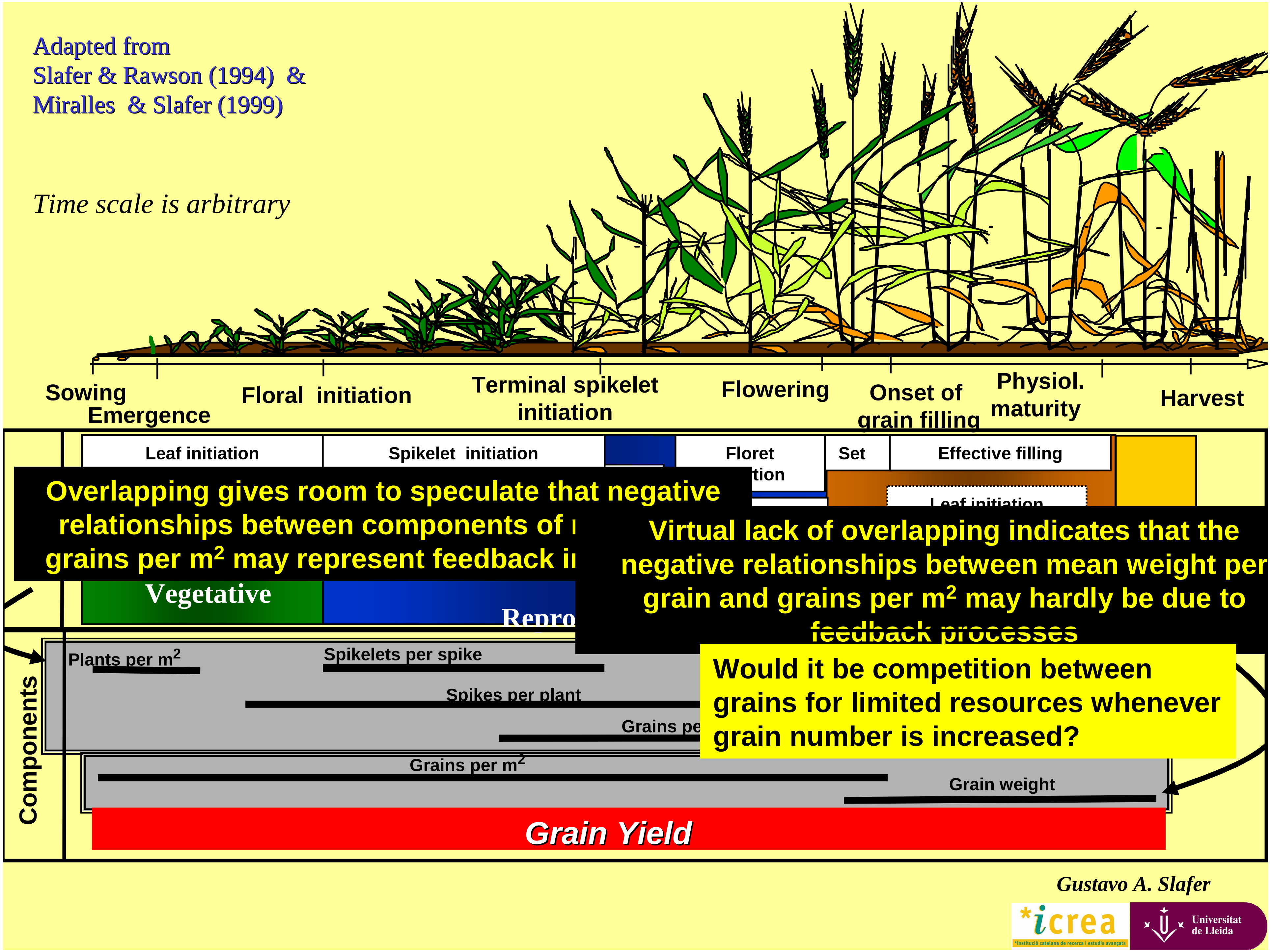

Adapted from
Slafer & Rawson (1994) &
Miralles & Slafer (1999)
Time scale is arbitrary
Sowing
Emergence
Floral initiation
Terminal spikelet initiation
Flowering
Onset of grain filling
Physiol. maturity
Harvest
Leaf initiation
Spikelet initiation
Floret
Set
Effective filling
Overlapping gives room to speculate that negative relationships between components of
grains per m² may represent feedback i
Vegetative
Repro
Virtual lack of overlapping indicates that the negative relationships between mean weight per grain and grains per m² may hardly be due to feedback processes
Would it be competition between grains for limited resources whenever grain number is increased?
Plants per m²
Spikelets per spike
Spikes per plant
Grains pe
Grains per m²
Grain weight
Components
Grain Yield
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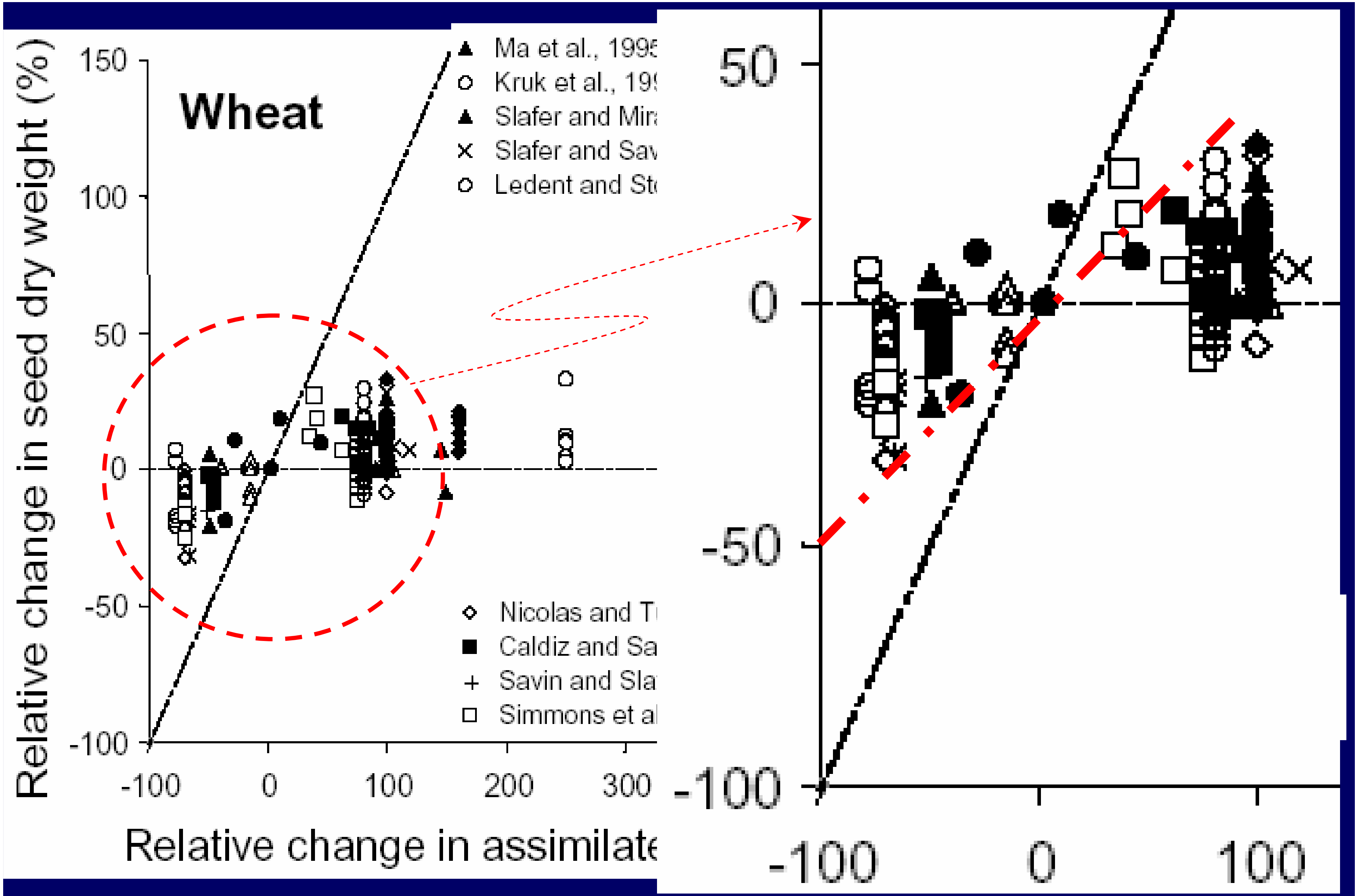

Borras, Slafer & Otegui (2004).
Field Crops Res. 86, 131-146

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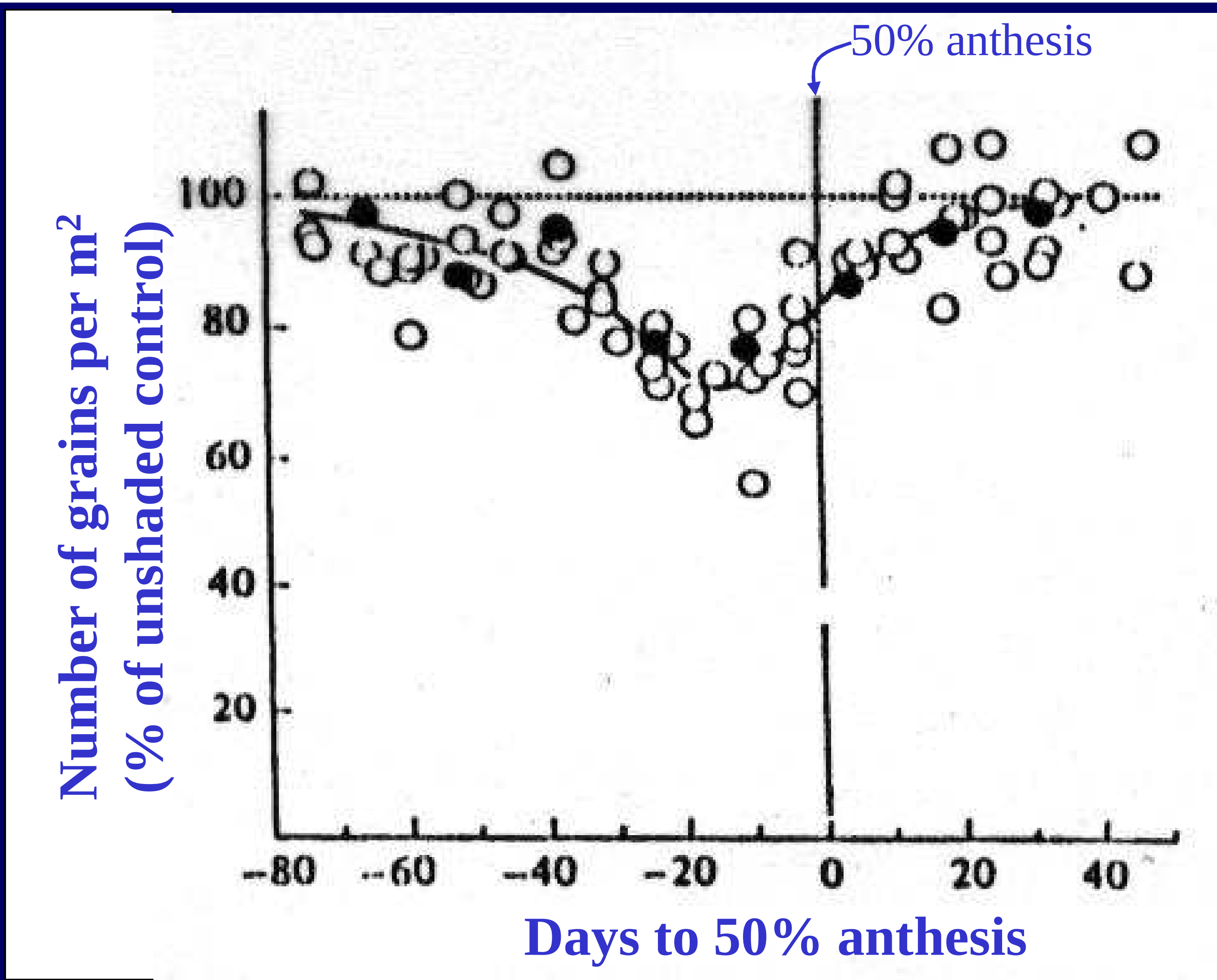
- **The lack of a competitive relationship between grain number and individual grain weight (**Slafer & Andrade, 1993, Slafer & Miralles, 1993, 1995**)**
- **and the fact that grain weight does frequently not respond to source – sink manipulations during grain filling –even in interaction with streses (***Slafer & Miralles, 1992; Slafer & Savin 1994; Kruk, Calderini & Slafer, 1997; Borras, Slafer & Otegui, 2003***); in line with what can be seen in a more general analysis of yield determination in UK Barley (***Bingham, Blake, Foulkes & Spink, in press***)**
- **is in line with the almost universally fund positive relationship between yield and grain number in wheat** (and other cereals) **which would be less clear if grains were strongly competing for assimilates after anthesis**
- **which in fact may well have evolutionary bases (***Sadras, 2006***)**

- **Therefore, yield potential is dependant of the capacity of the crop in terms of determining high**
  - **number of grains per m^2**
  - **potential weight** *(proxima presentacion de Calderini)*
  - **realisation of potential weight**



Fischer (1985) J. Agric. Sci.

Savin & Slafer (1991) J. Agric. Sci.

Slafer, Miralles, Calderini & Dreccer (1994) Field Crops Res.

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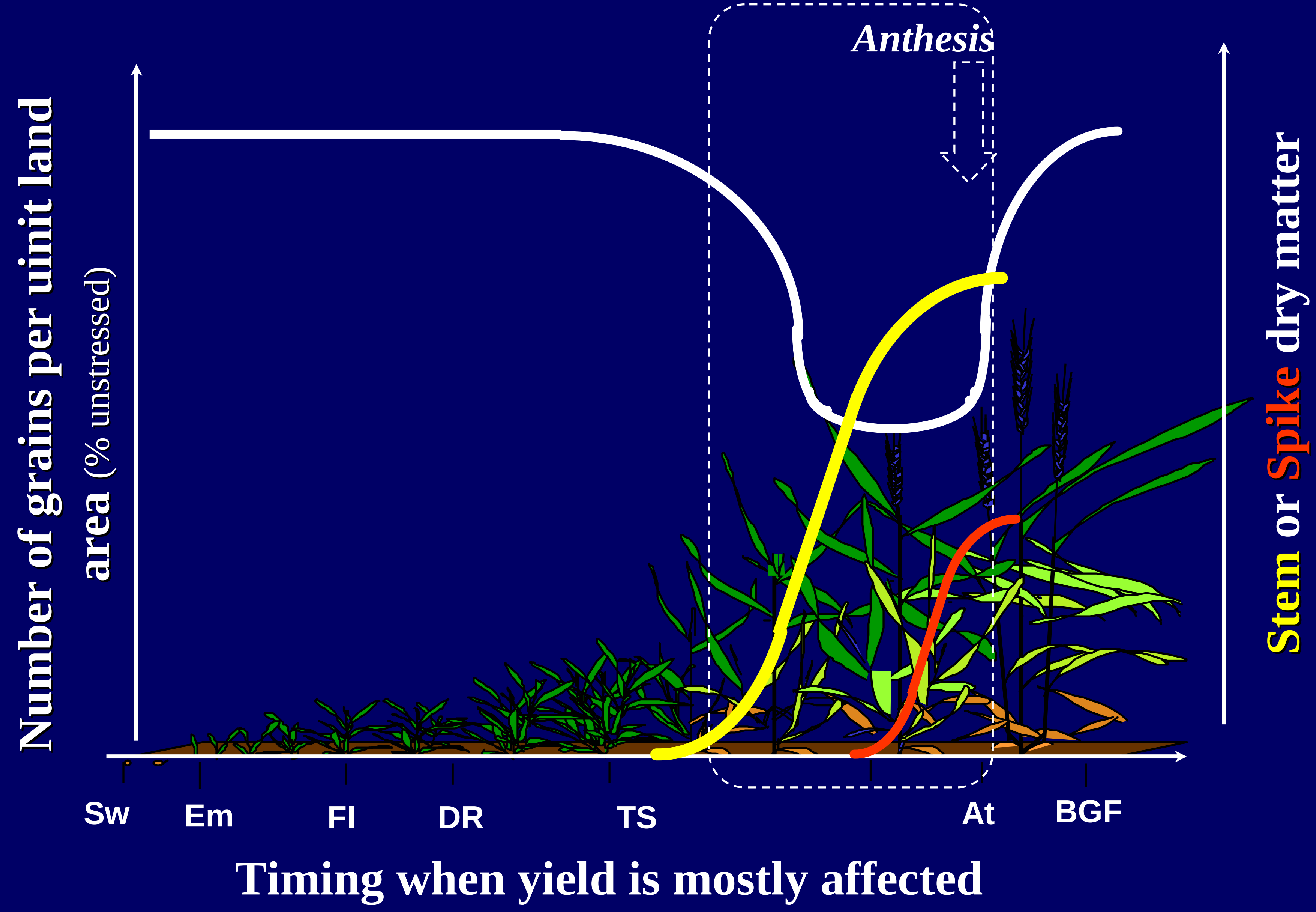

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*icrea
*institució catalana de recerca i estudis avançats
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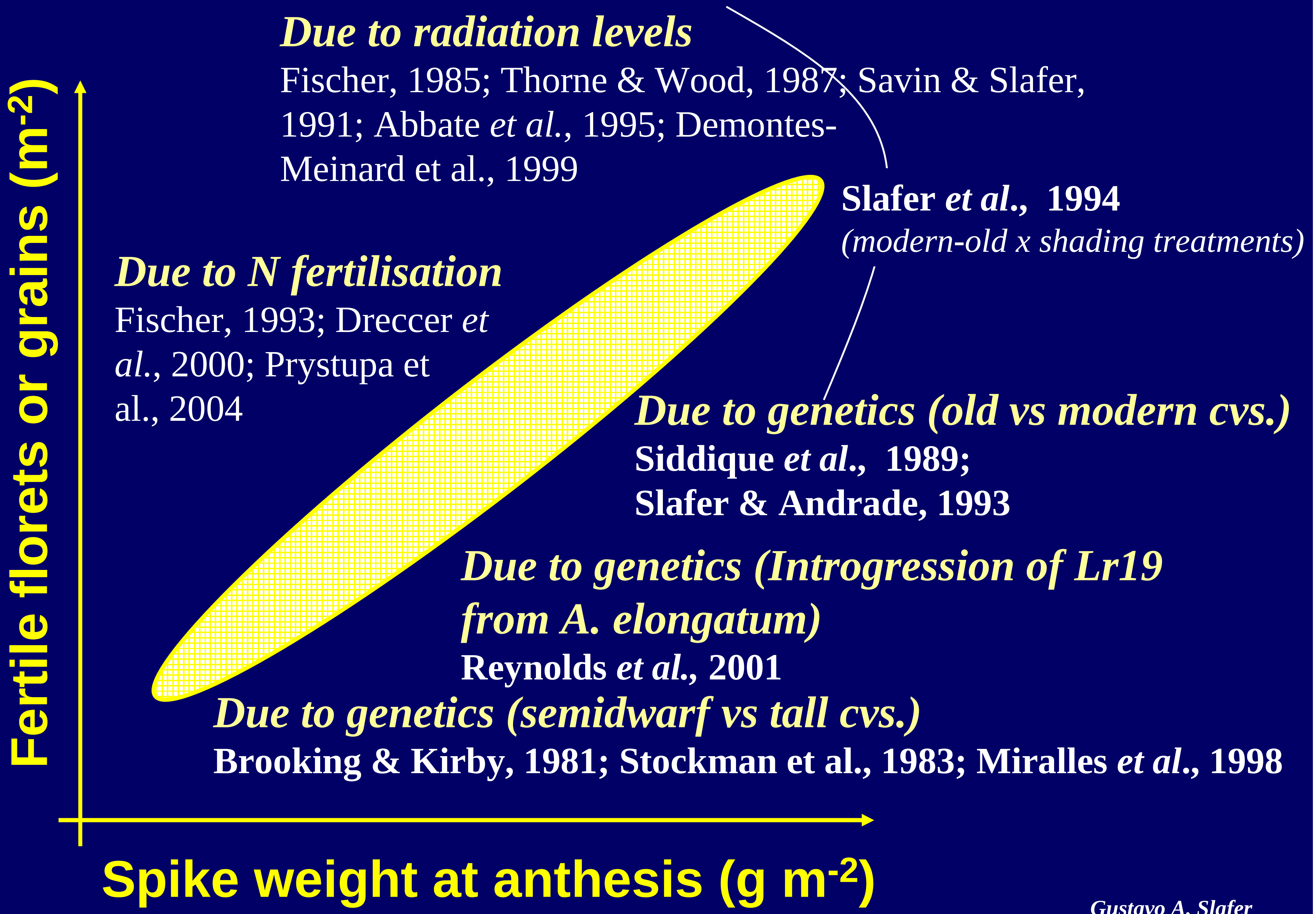

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Slafer et al 2005, Ann Appl Biol 146,61-70

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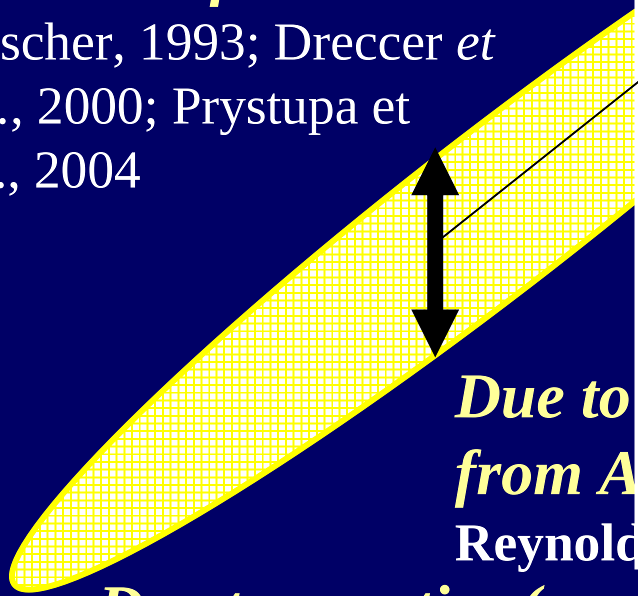
Fertile florets or grains (m^{-2})

Due to radiation levels

Fischer, 1985; Thorn
1991; Abbate *et al.*,
Meinard et al., 1999

Due to N fertilisation

Fischer, 1993; Dreccer *et al.*, 2000; Prystupa et al., 2004



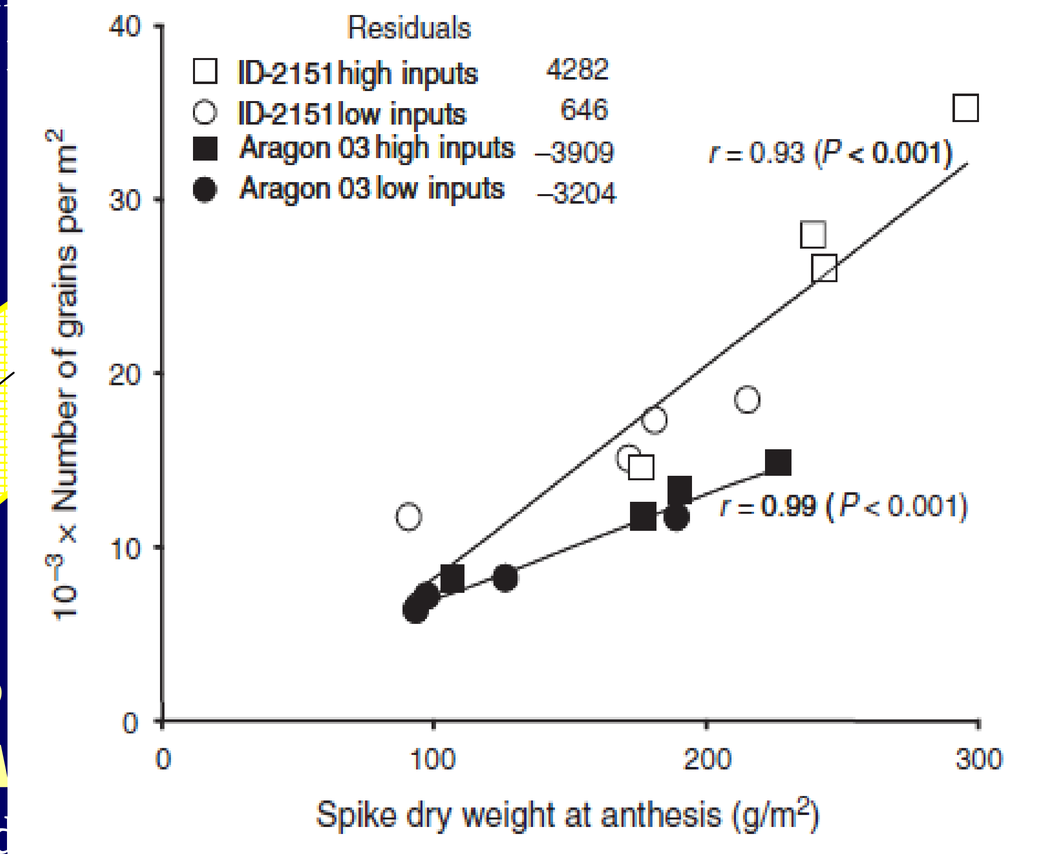
Due to
from A
Reynold

Due to genetics (semidwarf vs ta
Brooking & Kirby, 1981; Stockman e

Spike weight at anthesis (g m

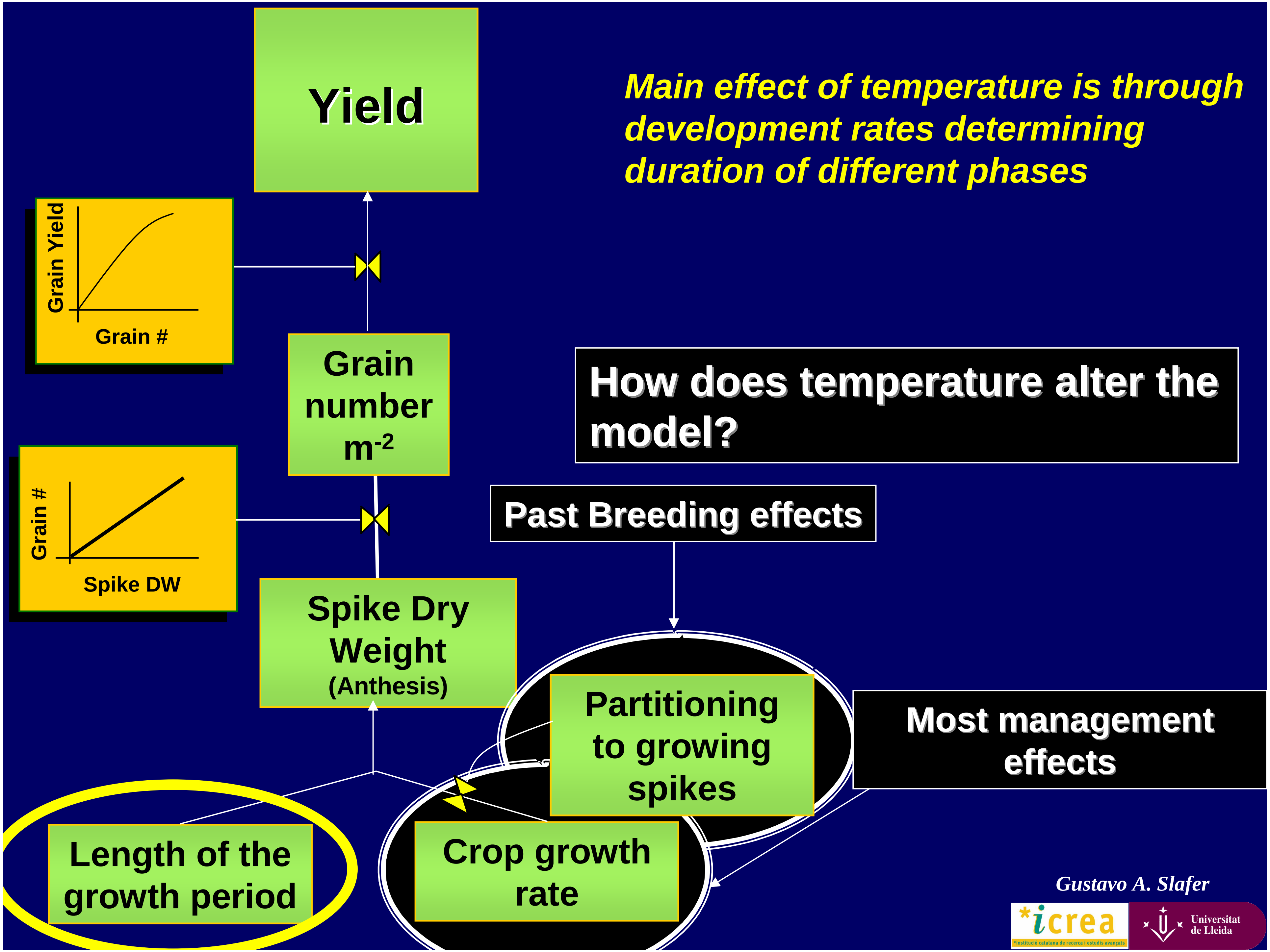
Slafer et al 2005, Ann Appl Biol 146,61-70

Acreche, Briceño, Martin S & Slafer 2009
Crop & Pasture Science, 60:271-279



Probably reflecting a better partitioning of resources within the spike between florets and structural parts (*e.g.* Slafer & Andrade, 1993; FCR 31:351-367)

Presentacion de González



Yield
Main effect of temperature is through development rates determining duration of different phases
Grain Yield
Grain #
Grain number m-2
How does temperature alter the model?
Grain #
Spike DW
Past Breeding effects
Spike Dry Weight
(Anthesis)
Partitioning to growing spikes
Most management effects
Length of the growth period
Crop growth rate
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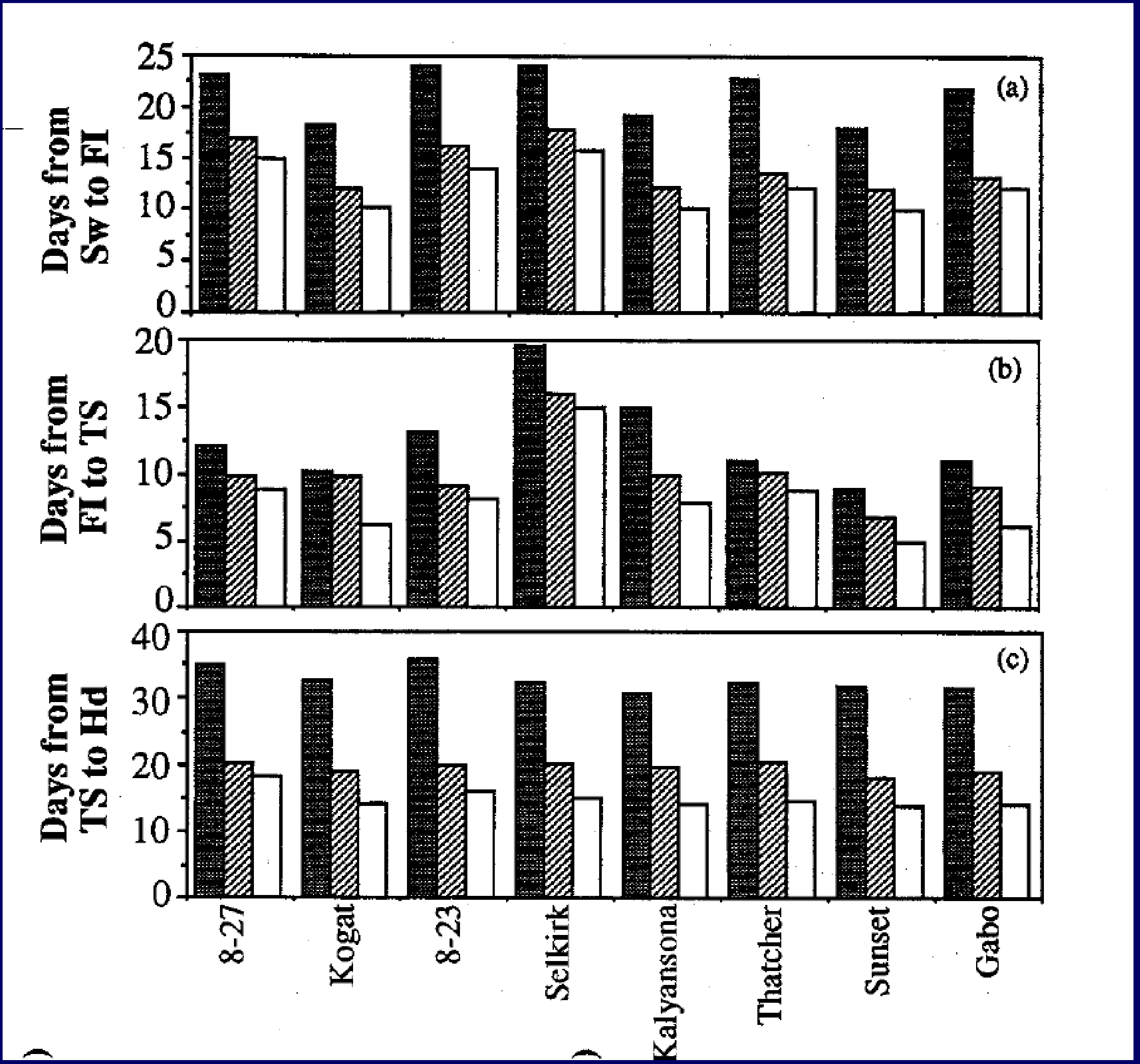

Slafer & Rawson 1994

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Sensibilidad en antesis

Table 5. *The influence of cooling and heating the wheat crop on number of kernels and components; Yecora 70 CIANO, Mexico, mean of 1972–3 and 1973–4. Published (first three columns) and unpublished (last two columns) data of Fischer & Maurer* (1976)

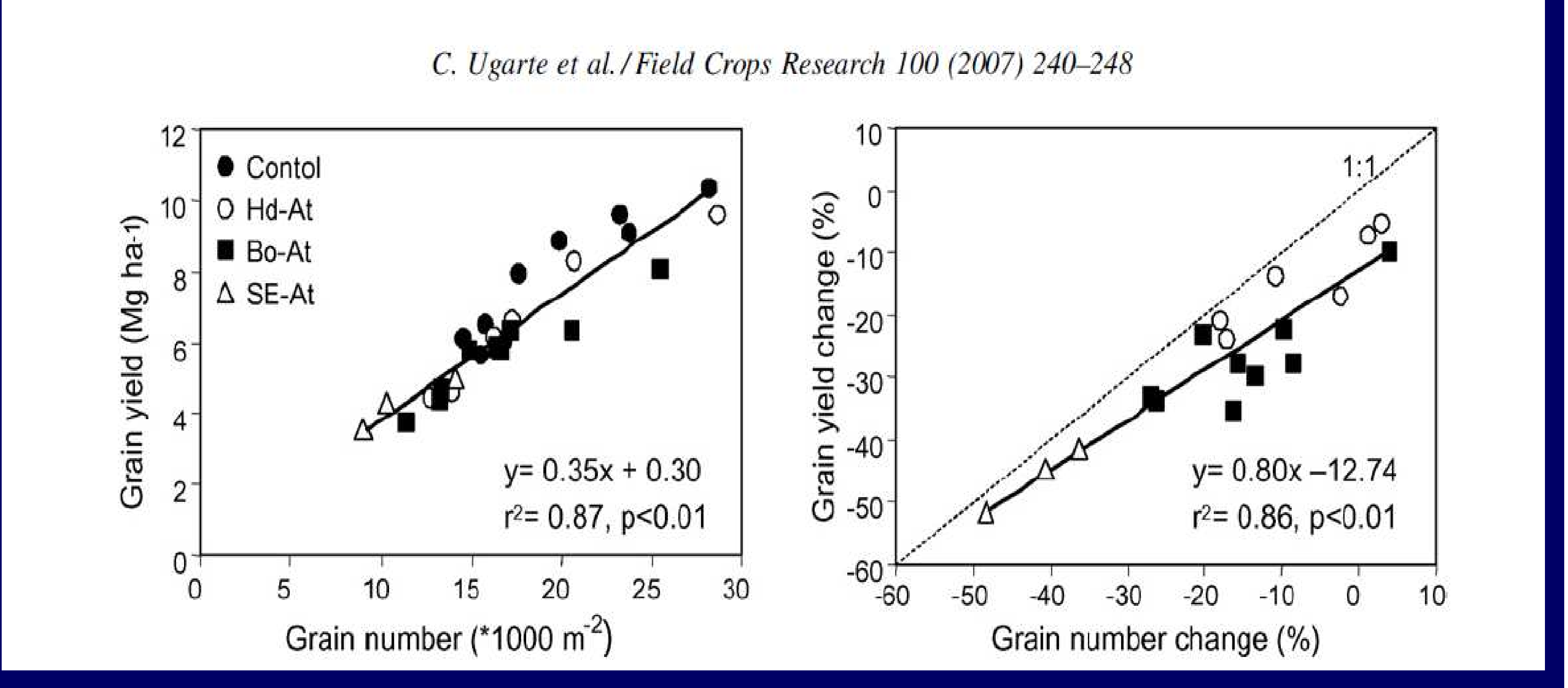
Treatment	Anthesis (days from sowing)	No. of kernels ($10^2/m^2$)	No. of spikes/m²	Chaff dry wt. (g/m²)	No. of kernels/g chaff wt.
		11–39 days after sowing			
Control	85	138	392	228	59·8
Heating	78	139	470	235	59·2
		40–67 days after sowing			
Cooling	86	152	383	233	65·2
Control	85	121	368	214	56·5
Heating	78	91	319	173	54·5
		68–92 days after sowing			
Cooling	88	136	416	248	54·3
Control	85	139	390	222	62·0
Heating	85	123	352	191	64·2
S.E.	1·2	3·0	12·4	5·1	2·59

Fischer 1985

mayor sensibilidad en el periodo inmediatamente previo a la antesis **4% de disminución en el Nº de granos por 1 ºC de aumento en la temperatura media**

Generación de estructuras reproductivas

Diferenciación de primordios florales y fecundación



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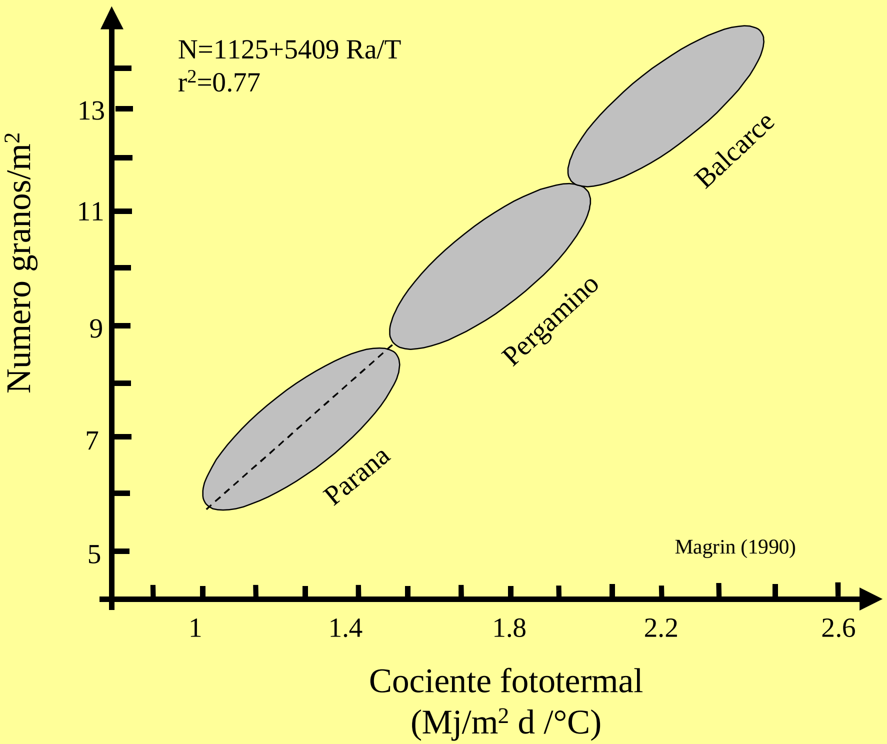
Uso del cociente fototermal durante el periodo critico

$Q=R/T$

R=radiacion

T=temperatura



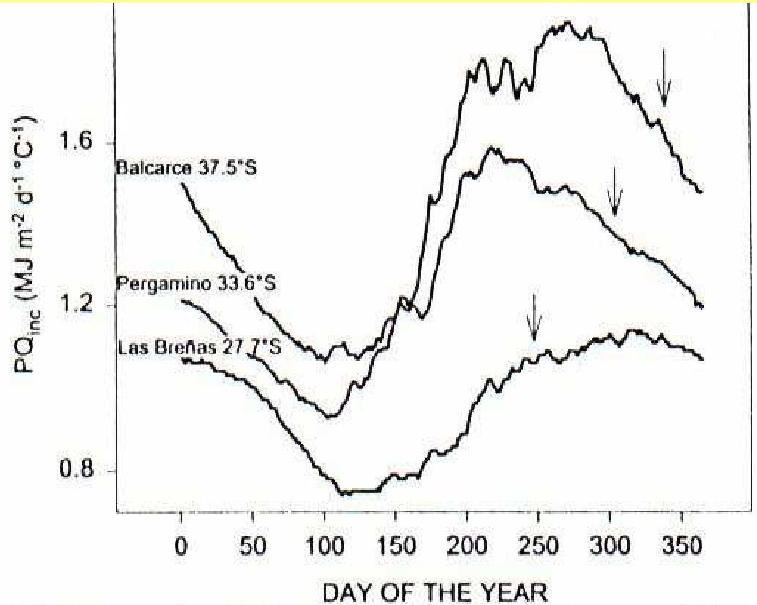


Fig. 5. Dynamics of PQ_{inc} for 3 sites in Argentina (means of 10 yr). The values of PQ shown were calculated using mean incident radiation and mean temperature for the 30 d before and 20 d after each day of the year. Arrows show the day at which mean temperature of the critical period becomes greater or equal to 18°C, the start of the optimal temperature plateau for photosynthesis in sunflower (Warren Wilson, 1966; Horie, 1977; Paul et al., 1990; Paul et al., 1991).

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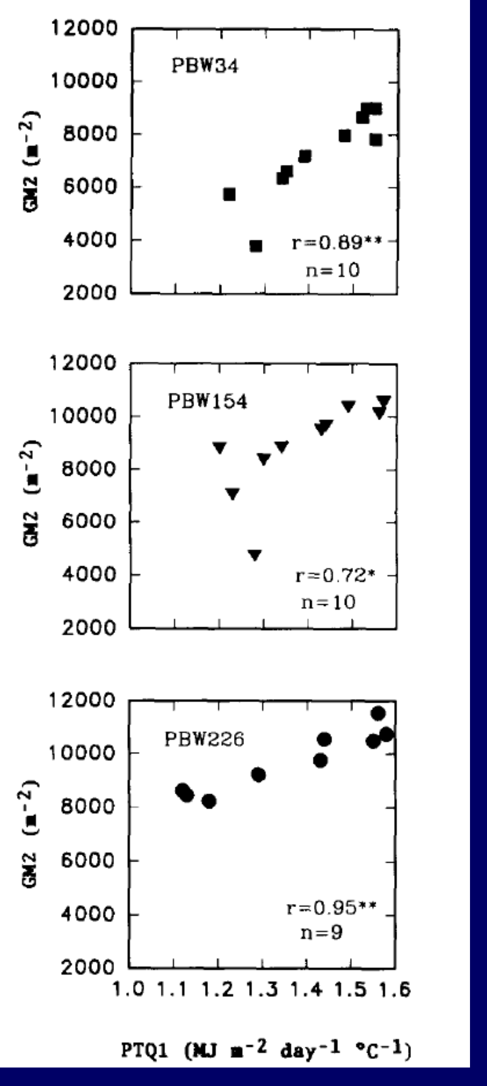
¿Qué temperaturas maximizan el número de granos?

Efectos de radiación y temperatura: cociente fototermal



Q=R/T-Tb

R=radiación

T=temperatura

Fig. 4. Relationship between grains per square meter (GM2) and photothermal quotient for the period 20 days before heading to 10 days after heading (PTQ1) in three cultivars averaged over all years.

Ortiz-Monasterio et al. 1994

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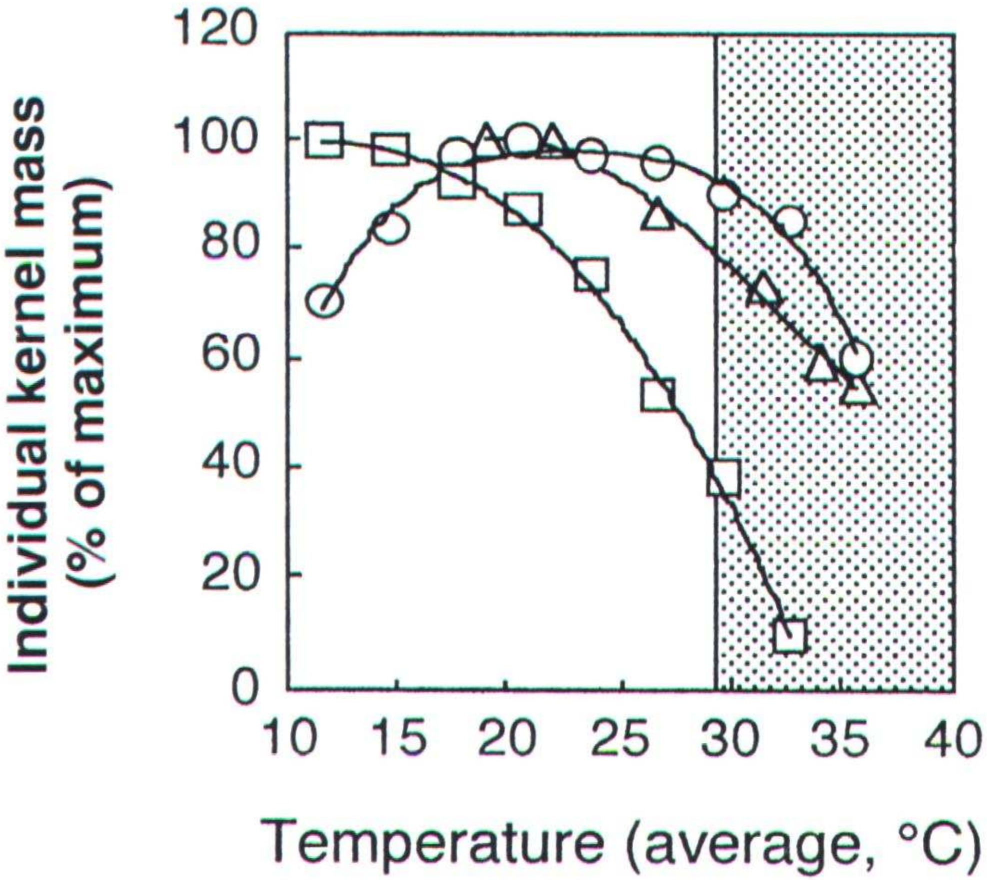
FIGURE 8.4. The Effect of Temperature on Individual Kernel Mass of Cereals



Note: □ wheat; ○ rice; and Δ maize. Shading shows very high temperature range.

Source: Data for wheat and rice calculated from Chowdhury and Wardlaw, 1978, p. 216, and Tashiro and Wardlaw, 1989, p. 61; and for maize from Singletary, Banisadr, and Keeling, 1994, p. 833.

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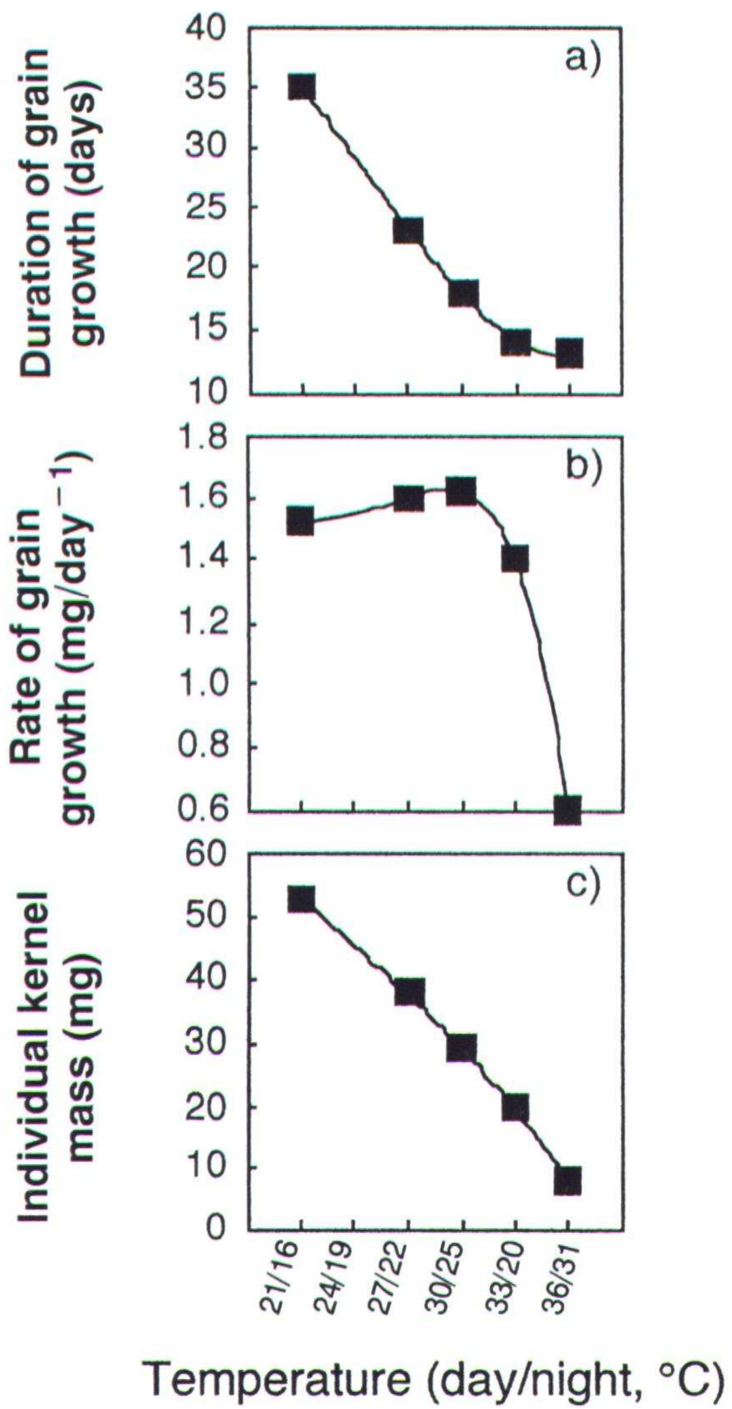

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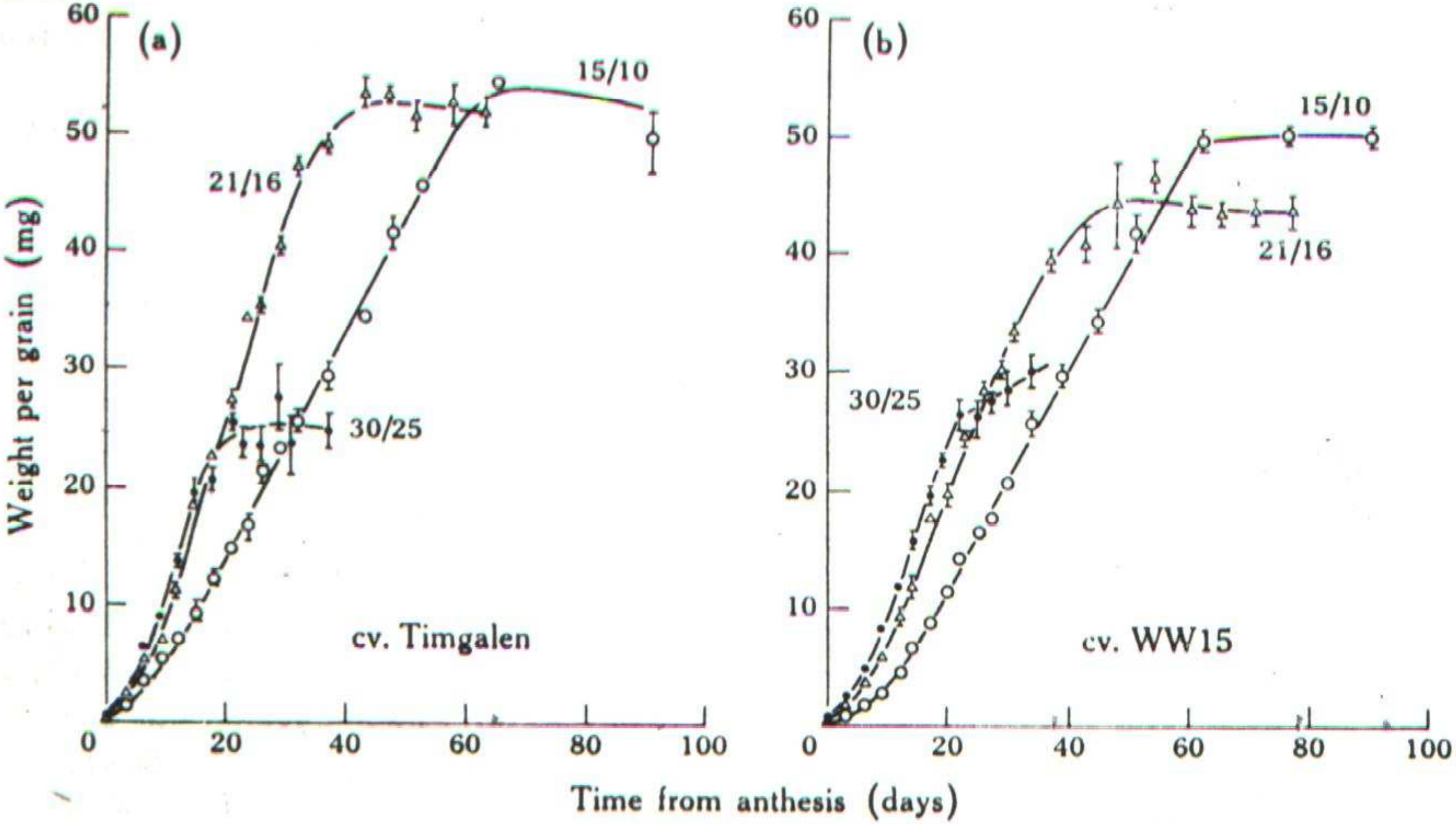
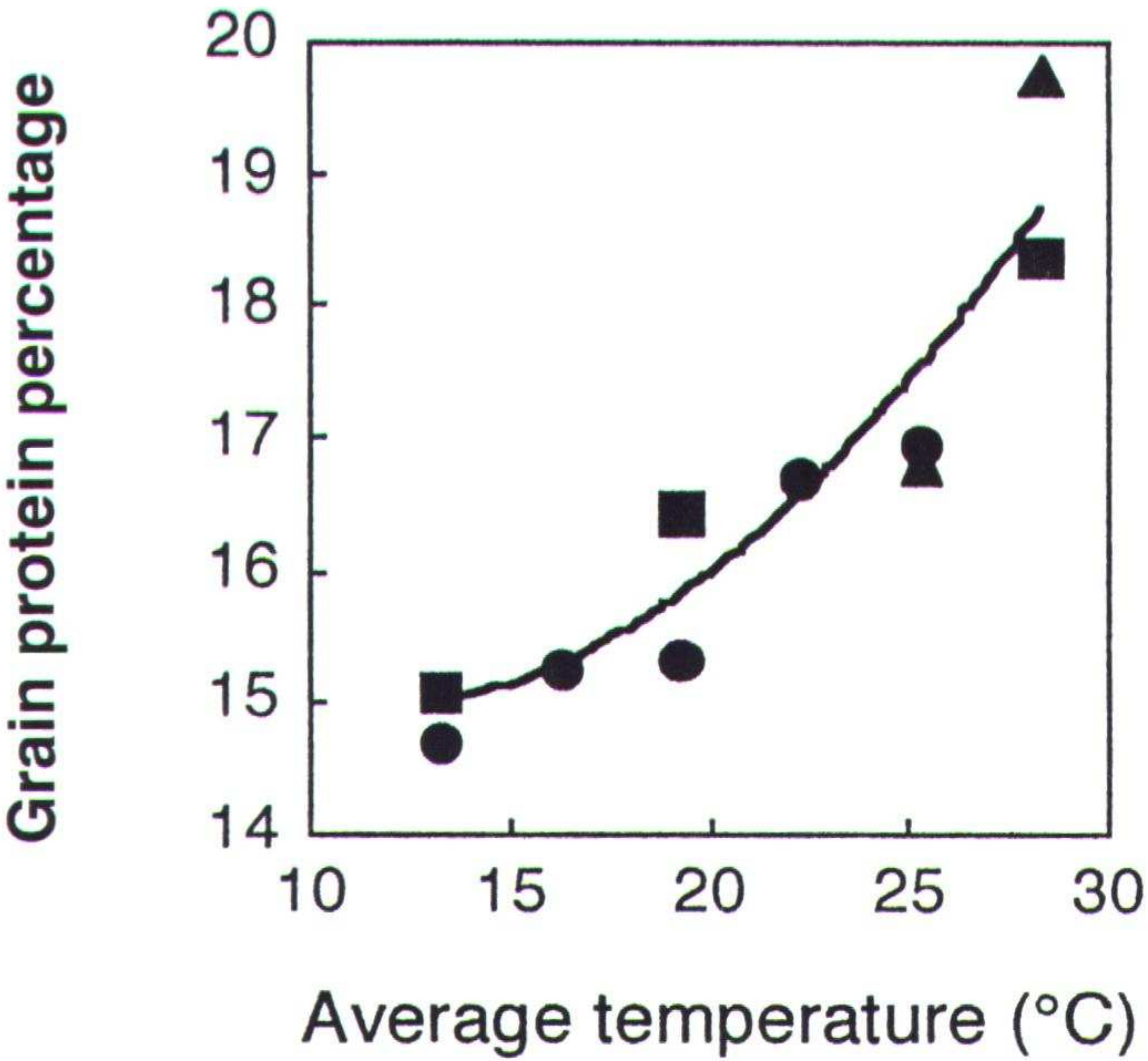


Fig. 1. Increase in dry weight of wheat grains as influenced by temperature after anthesis in experiment II: (*a*) first floret grains in the middle four spikelets of cv. Timgalen; (*b*) first floret grains in the middle four spikelets of cv. WW15. Vertical bars indicate the standard errors of the mean.

FIGURE 8.10. The Effect of Moderately High Temperature on Grain Protein Percentage of Wheat



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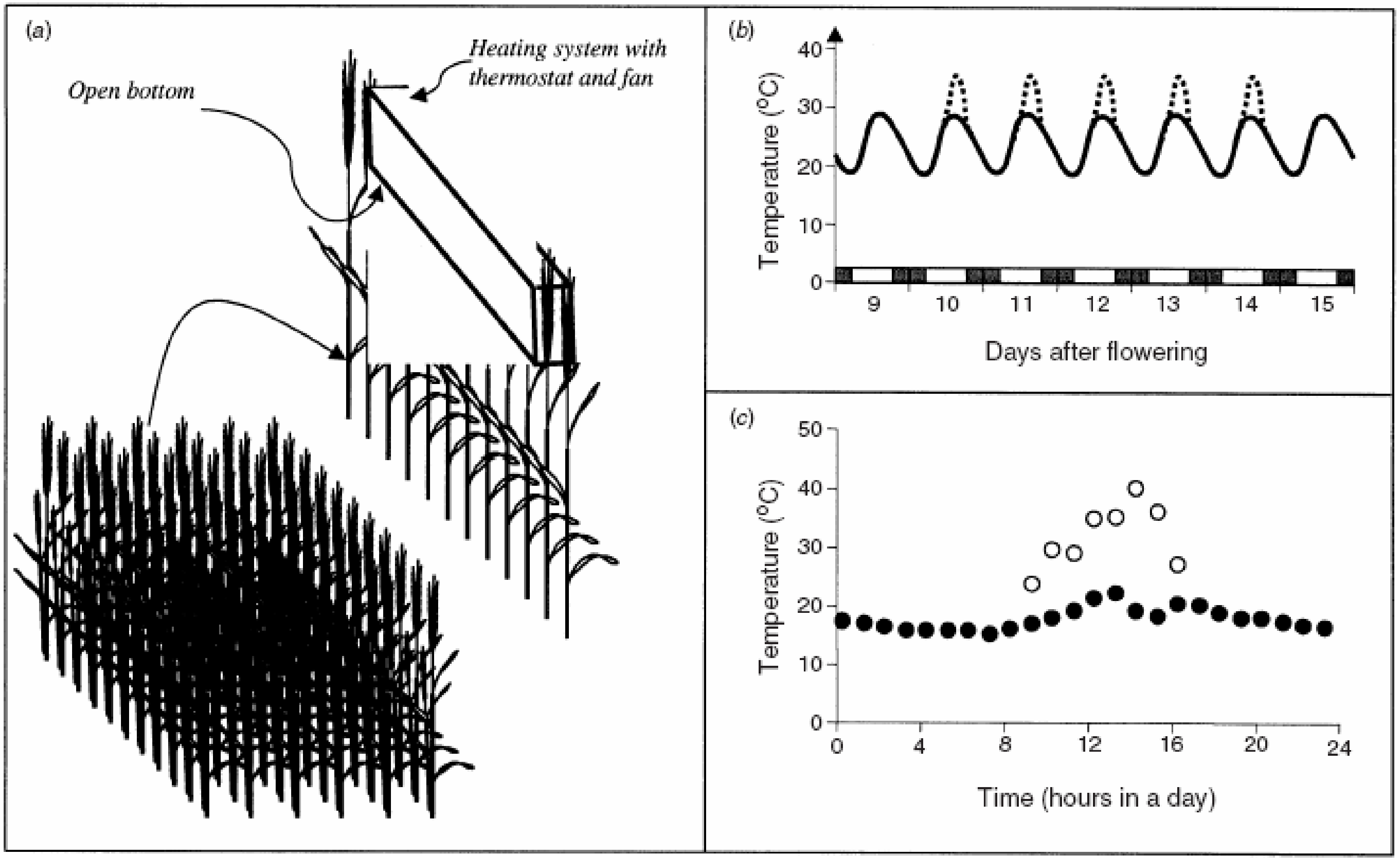
Efectos directos mas alla de los que pueda haber sobre la fuente



Passarella *et al.* (2002)
AJAR 53:1219-1227

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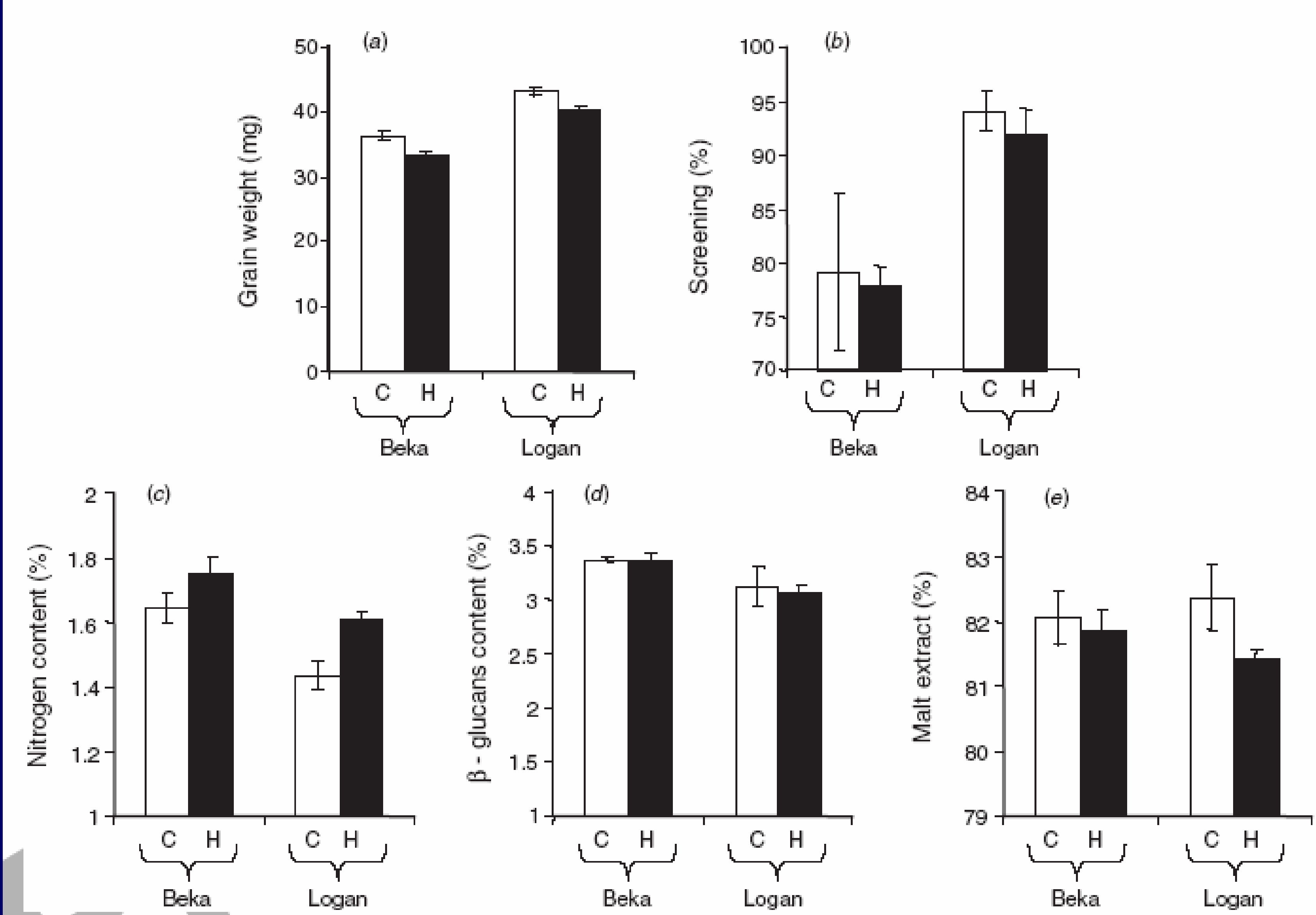

Passarella *et al.* (2002)
AJAR 53:1219-1227

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Reductions in individual grain weight (IGW) caused by short periods of high temperature during grain filling in wheat and barley.

IGW (%)	Factors Investigated	Temperature day/night (°C)	Duration days	h d^{-1}	Type of experiment	Ref.
25-28*	Genotype	30/30	7	24	Chamber	[1]
5-9	Timing of exposure	35/25	5	5	Chamber	[2]
4-23	Duration of exposure	40/15	5-10	6	Galsshouse	[3]
13-24	Genotype	40/20	5	6	Field	[4]
34		40/16	5	6	Chamber	[5]
4-13	Temperature regime	40/16	5	6	Chamber	[6]
30*		35/25	3	12	Chamber	[7]
13-24	Genotype	35/25	3	12	Chamber	[8]
5-24	Timing of exposure	40/15	5	6	Chamber	[9]

*starch dry weight per endosperm

[1] MacLeod & Duffus (1988a)
[2] Macnicol *et al.* (1993)
[3] Savin & Nicolas (1996)
[4] Savin *et al.* (1996)
[5] Savin *et al.* (1997a)
[6] Savin *et al.* (1997b)
[7] Wallwork *et al.* (1998a)
[8] Wallwork *et al.* (1998b)
[9] Savin & Nicolas (1999)

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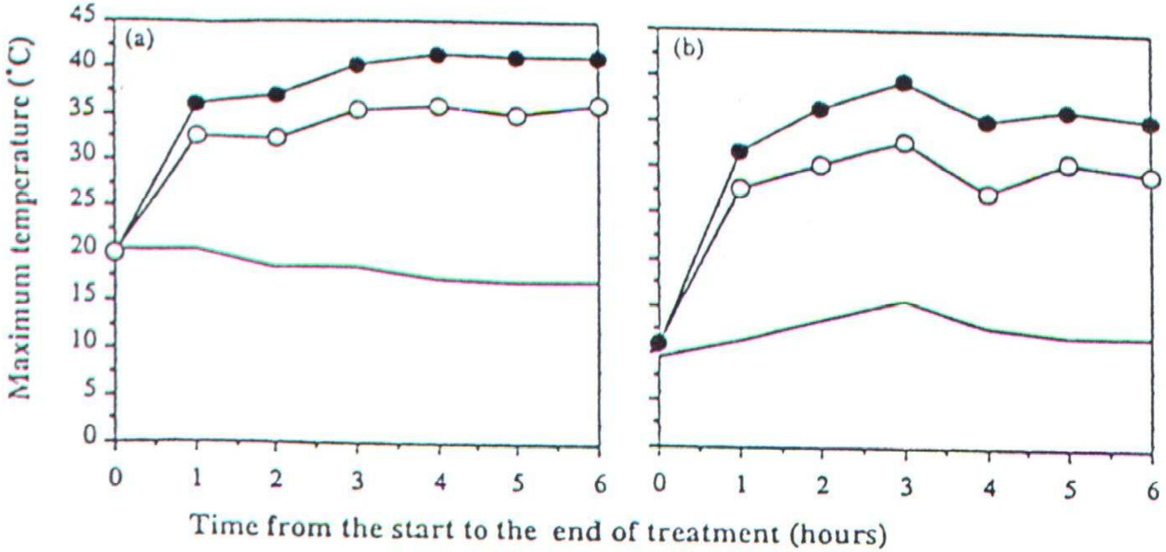

Fig. 2. Grain (○) and ambient temperature inside (●) and outside (—) the heated chambers for Schooner in 1993(*a*) and Parwan in 1994(*b*) during the second day of the heat stress treatment.

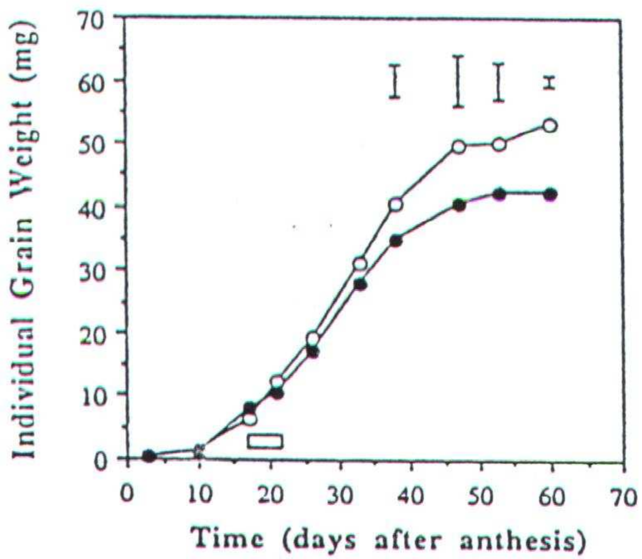

Fig. 3. Change in individual grain weight with time after anthesis for the control (○) and heat (●) treatment for Schooner in 1993. The vertical bars are l.s.d. at $P = 0 \cdot 05$ and the horizontal bar the time when the heat stress was applied.

Savin *et al*. (1996)
AJAR 47:465-477

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Conclusiones

*Los cultivos de grano frecuentemente enfrentan estrés térmico por alta temperatura, tanto en ambientes tropicales y subtropicales como en ambientes templados.

*Mermas en el rendimiento y la calidad son funciones de la intensidad, duración y momento de ocurrencia del estrés en relación al estado de desarrollo del cultivo y al proceso de crecimiento afectado.

*Al expandir las zonas agricolas tener en cuenta que "pequeños" cambios en temperaturas medias o en frecuencia de eventos de temperaturas extremas pueden afectar signbificaticvamente la generacion del numero y peso de los granos.

*Existen conocimientos descriptivos del efecto de altas temperaturas sobre el número y peso de granos en varios cultivos de grano, pero sabemos menos acerca de los mecanismos involucrados.

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