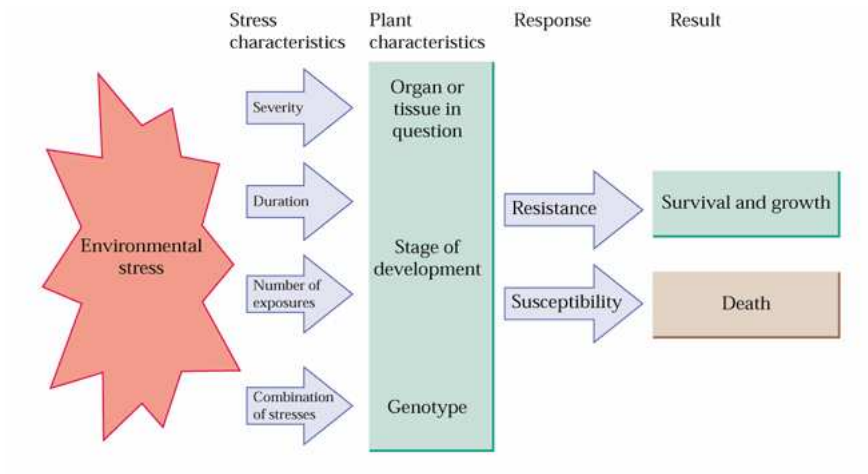
EFECTO DE ALTAS TEMPERATURAS SOBRE LA CALIDAD DE TRIGO Y CEBADA

1. Estrés térmico y consecuencias económicas de altas temperaturas
2. Qué son altas temperaturas?
3. Efecto de altas temperaturas sobre el crecimiento de los granos
   - Desarrollo celular
   - Suministro de carbohidratos
4. Efecto de altas temperaturas sobre la composición
   - Almidón
   - Proteína



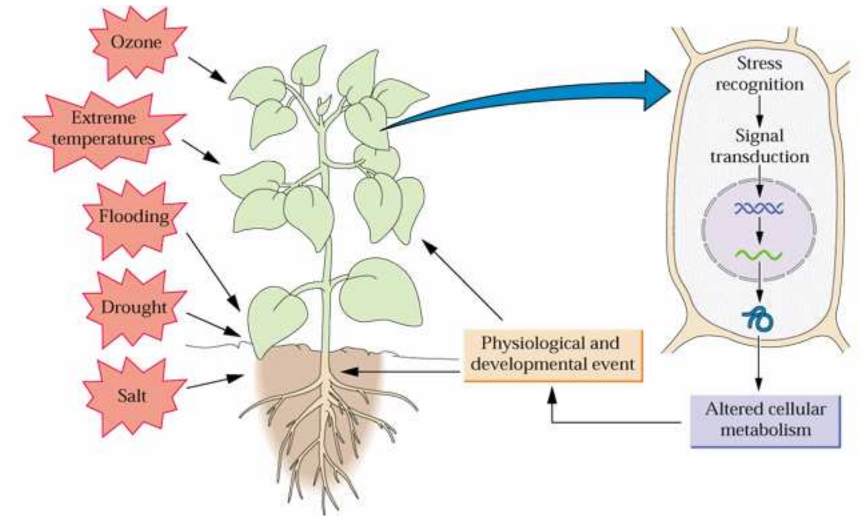


Table 1. Estimates of the effect of high temperature following anthesis on kernel weight in wheat

Reference (Country)	Temperature range (°C)	Fall in kernel weight per 1°C rise in temperature (mg)	(%)
(A) Field trials (Time of planting)			
Chinoy 1947 (India)	17–28	1.65	4.1
Beech and Norman 1966 (Aust.)	23–31	1.63	4.0
Marcellos and Single 1972 (Aust.)	17–23	–	6.0
Wiegand and Cuellar 1981 (USA)	16–26	3.00	7.5
McDonald *et al.* 1983 (Aust.)	14–27	1.46	3.6
Saini and Dadhwal 1986 (India)	13–27	1.99	4.3
Shpiler and Blum 1986 (Israel)	16–23	0.71	1.8
Stapper and Fischer 1990 (Aust.)	14–21	–	5.0
Cooper 1992 (Aust.)	16–21	2.23	5.5
(B) Controlled environment studies			
Hsia *et al.* 1963 (China)	18–23	1.18	3.9
Asana and Williams 1965 (Aust.)	17–24	1.45–1.73	2.7–3.6
Spiertz 1974 (Netherlands)	15–25	1.70–1.90	2.7–3.5
Ford *et al.* 1976 (UK)	15–25	1.13	2.0
Warrington *et al.* 1977 (NZ)	13–23	2.0	2.9
Chowdhury and Wardlaw 1978 (Aust.)	12–24	1.17	2.0
Wardlaw *et al.* 1980 (Aust.)	18–27	2.22	4.0
Al-Khatib and Paulsen 1984 (USA)	22–32	0.85	2.8
Vos 1985 (Netherlands)	16–22	1.67	2.8
Skinnes and Buras 1987 (Norway)	12–21	0.94–1.55	1.4–2.7
Wardlaw *et al.* 1989 (Aust.)	15–27	1.63–2.78	3.2–5.2
Tashiro and Wardlaw 1989 (Aust.)	18–27	2.78	5.2

¿Qué son altas temperaturas?

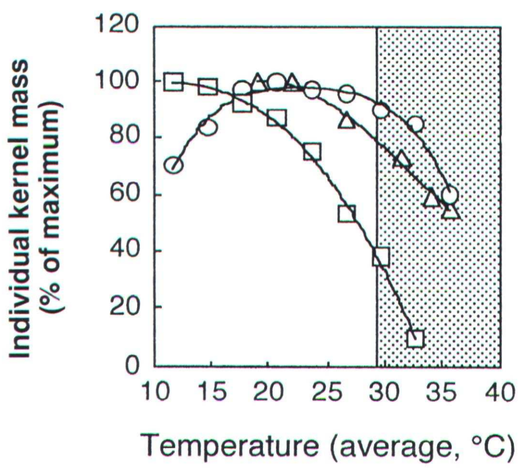
Cambios en la tasa y duración de los procesos

➔Moderadamente altas temperaturas (>15 a 32ºC)

➔Breves períodos de altas temperaturas (>32 ºC)

Algunos procesos pueden retardarse y otros nuevos inducirse

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.

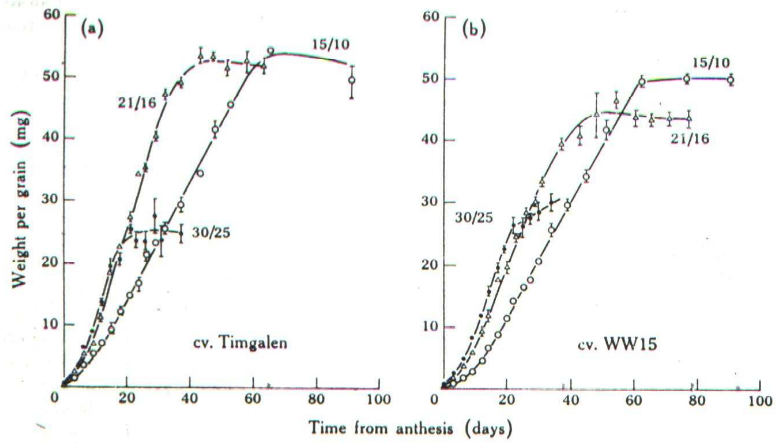
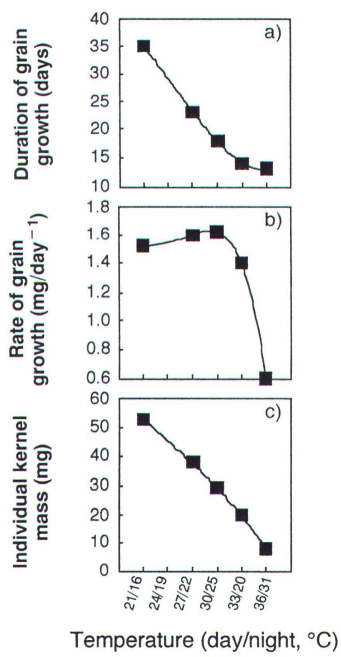


Fig. 1. Increase in dry weight of wheat grains as influenced by temperature after anthesis in experiment II: (*a*) first floret grains in the middle four spikelets of cv. Timgalen; (*b*) first floret grains in the middle four spikelets of cv. WW15. Vertical bars indicate the standard errors of the mean.

FIGURE 8.5. Effect of Temperature on Components of Grain Growth of Wheat



Note: Figure 8.5a, duration of grain growth; Figure 8.5b, rate of grain growth; Figure 8.5c, mature individual kernel mass.

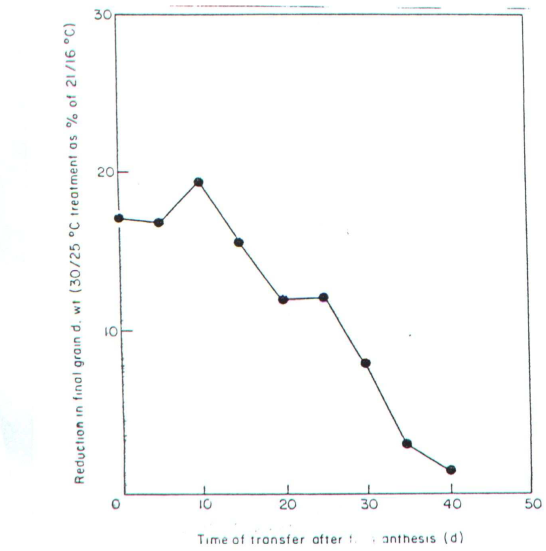


FIG. 3. The percentage reduction in grain d. wt with a 10-d increase in temperature from 21/16 °C to 30/25 °C. (Expt 1) applied at various periods following anthesis. The data relate to floret 'a' grains from the four central spikelets in an ear and are expressed as a percentage of the control (21/16 °C) value at maturity.

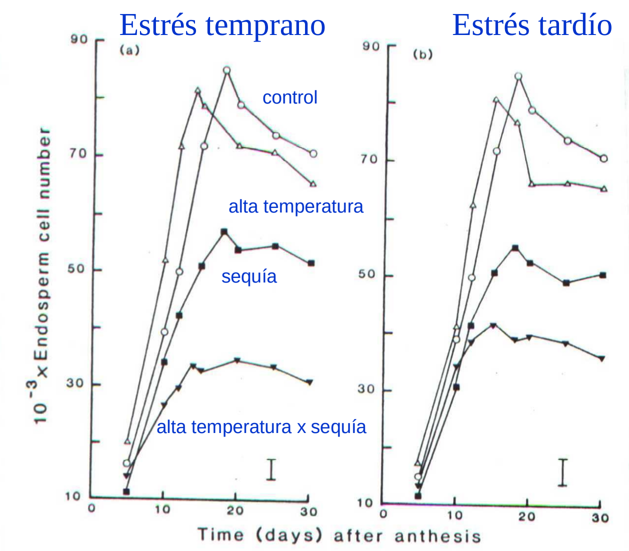
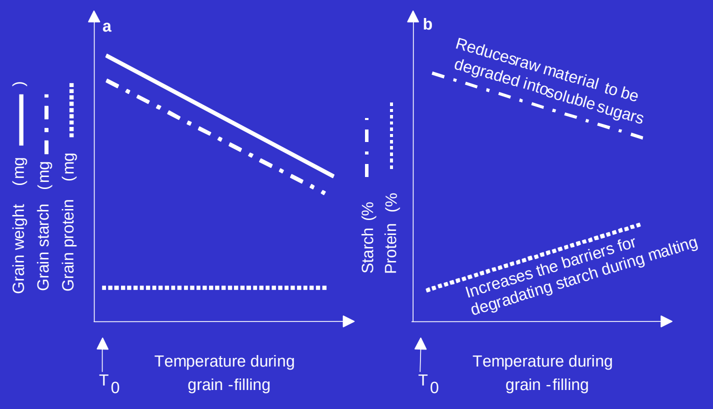


Fig. 3. Number of endosperm cells for plants subjected to treatments during the early period (*a*) and late period (*b*) of cell division. Error bars represent the l.s.d. ($P = 0{\cdot}05$) between means of treatments at any one time. Symbols as for Fig. 2.

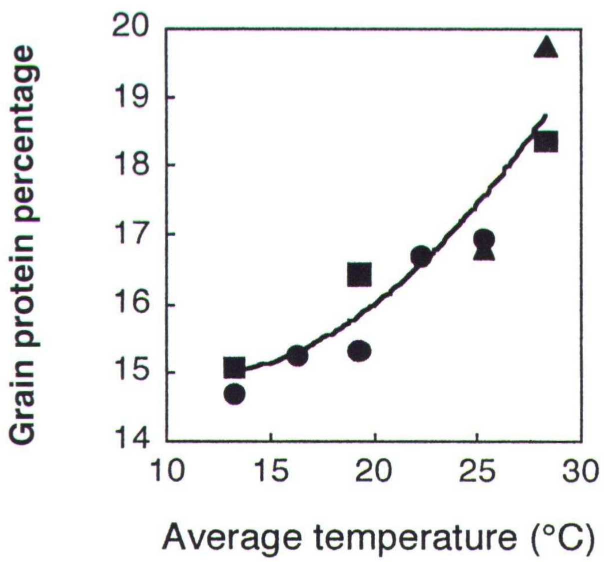
Nicolas *et al.* (1984)
AJPP 1:553-566

Sensibilidad de los procesos de acumulación a la temperaturas moderadas durante todo el llenado



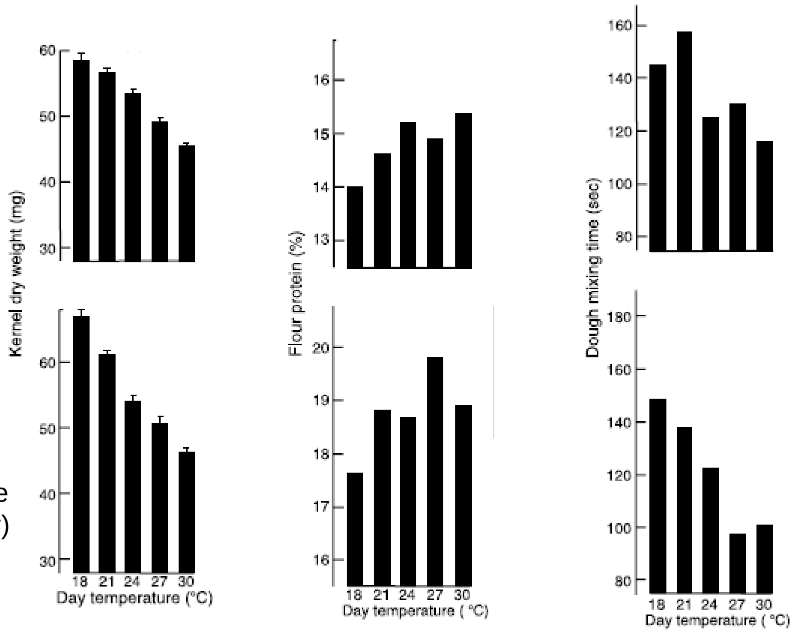
Savin, Passarella & Molina-Cano, 2004
In Handbook Seed Physiology
Eds. R. Benech & R. Sanchez

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

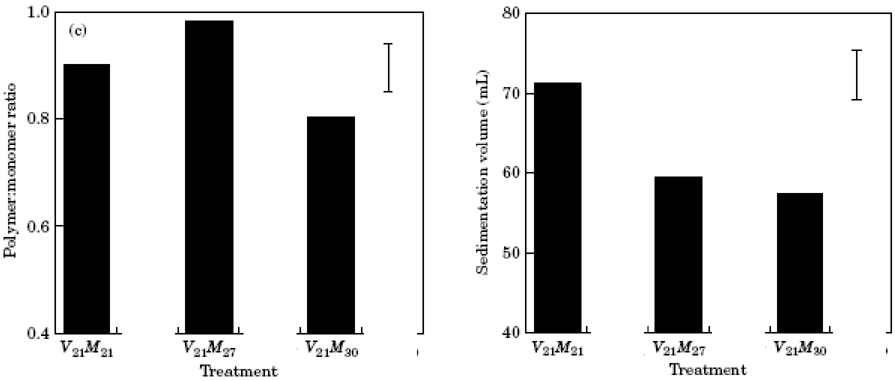


High tolerant genotype (Trigo 1)

Low tolerant genotype (Lyallpur)



Wardlaw *et al. (*2002). FPB 29:25-34

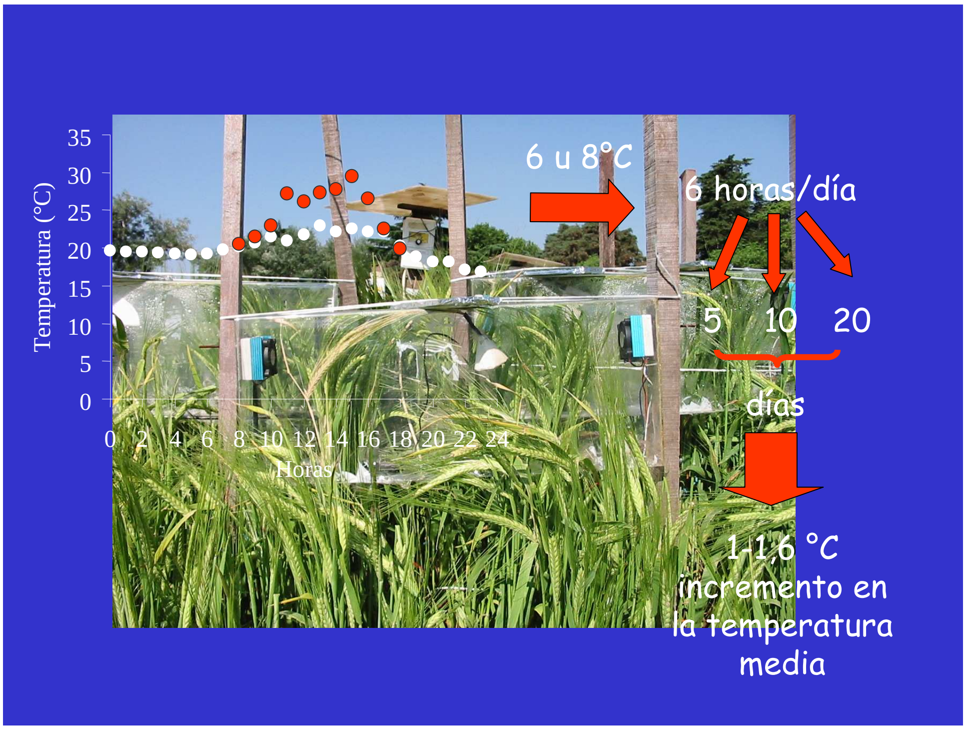


↓ Glu:Gli

↓ volumen sedimentación

↓ calidad panadera

Stone *et al.* (1997)
JCS 25: 129-141



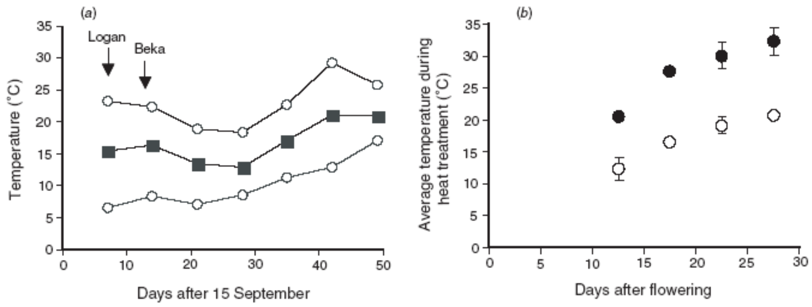
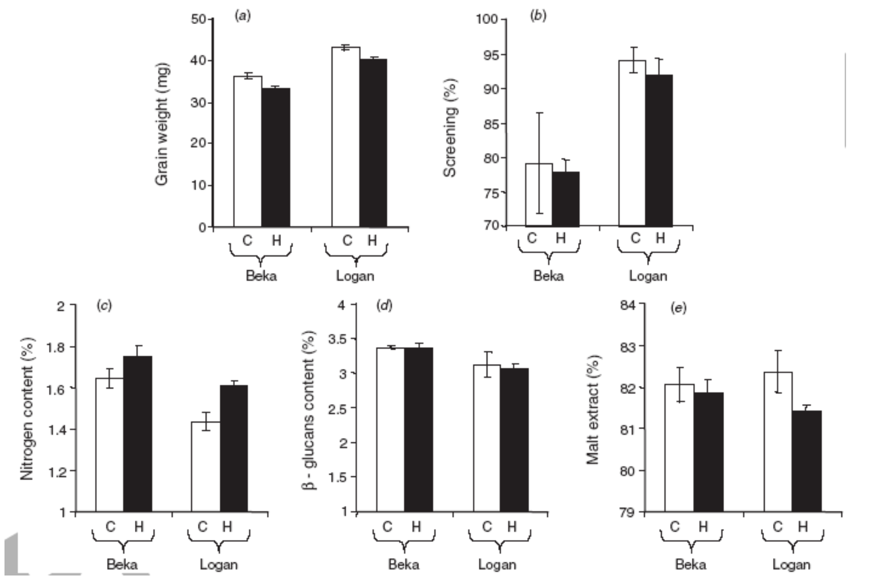


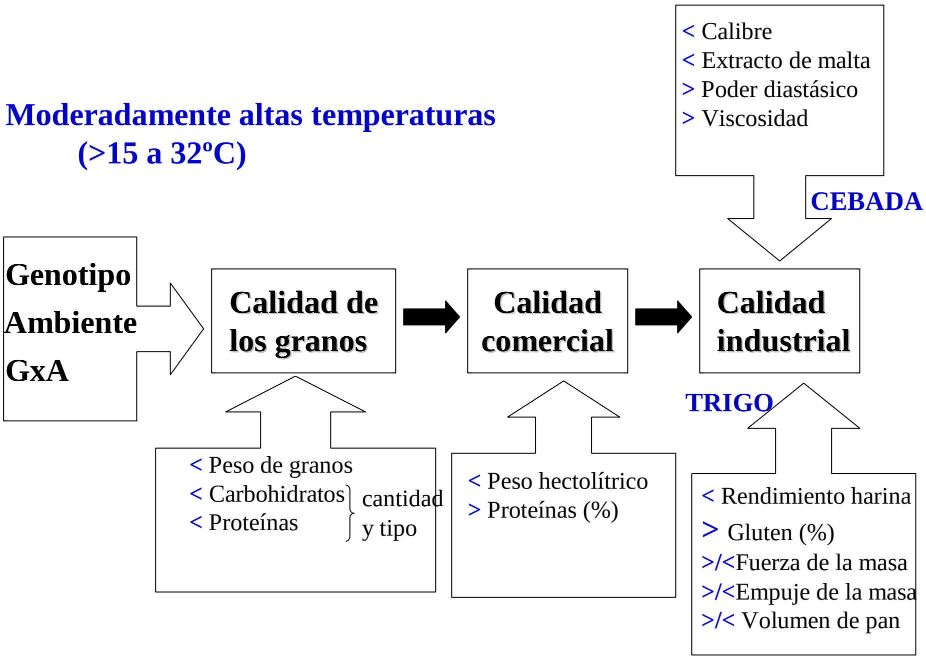
Fig. 2. (*a*) Ambient mean (closed squares), maximum, and minimum temperatures (open circles) during grain filling, and (*b*) the average temperatures during each treatment period both outside (control, open circles) and inside (heated, closed circles) the boxes (averaged across genotypes). Data in (*a*) are weekly averages of daily measurements. The arrows indicate flowering date for each genotype and the bars are 2× standard error.

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



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

Moderadamente altas temperaturas
(>15 a 32ºC)



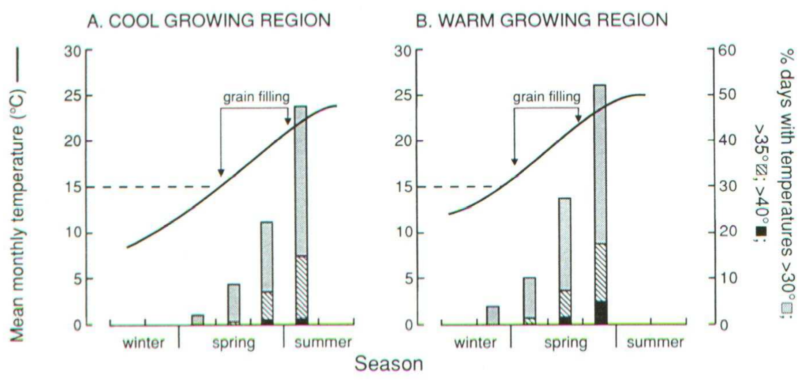


Fig. 1. Changes in mean monthly temperatures during grain filling and the frequency of high maximum day temperatures during that period. Two cereal growing regions in Australia have been selected to represent a cool (*A*) and a warm (*B*) region. The Spring period for Australia includes the whole of each of the months September, October and November.

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)

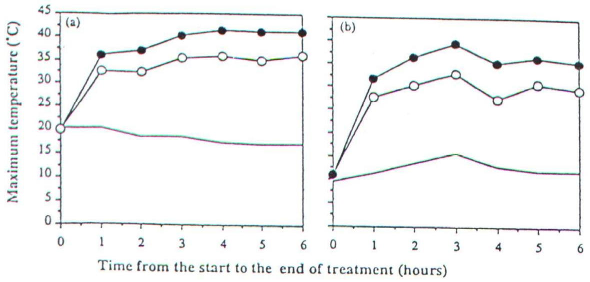


Fig. 2. Grain (○) and ambient temperature inside (●) and outside (—) the heated chambers for Schooner in 1993(*a*) and Parwan in 1994(*b*) during the second day of the heat stress treatment.

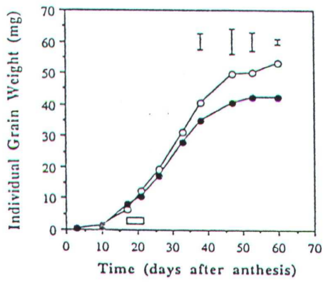


Fig. 3. Change in individual grain weight with time after anthesis for the control (○) and heat (●) treatment for Schooner in 1993. The vertical bars are l.s.d. at $P = 0 \cdot 05$ and the horizontal bar the time when the heat stress was applied.

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

Treatment	Malting quality Character		
	Screening (%)	Malt extract (%)	Diastatic power (mmol s^{-1} kg^{-1})
Schooner			
no chamber LT	1.24	79.00	4.80
chamber HT	24.51	73.30	6.56

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

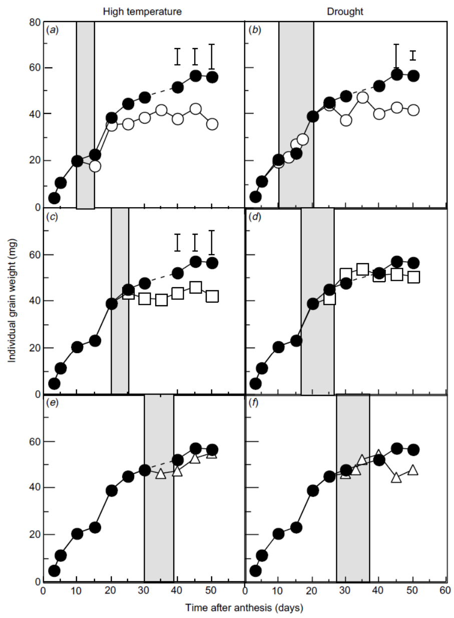


Fig. 1. Dry matter accumulation during grain filling for the control (●) and stressed treatments. Treatments were applied during phases of grain filling: early (*a*, *b*; ○), intermediate (*c*, *d*; □), and late (*e*, *f*; △). Bars represent l.s.d. ($P = 0.05$) and are only included when the differences between treatments were significant. There was a missing value for the control on Day 35 after anthesis, so the data points of Days 30 and 40 after anthesis were joined with a dashed line. Shaded areas indicate the duration of the stress periods.

Savin & Nicolas (1999)
AJAR 50: 357-364

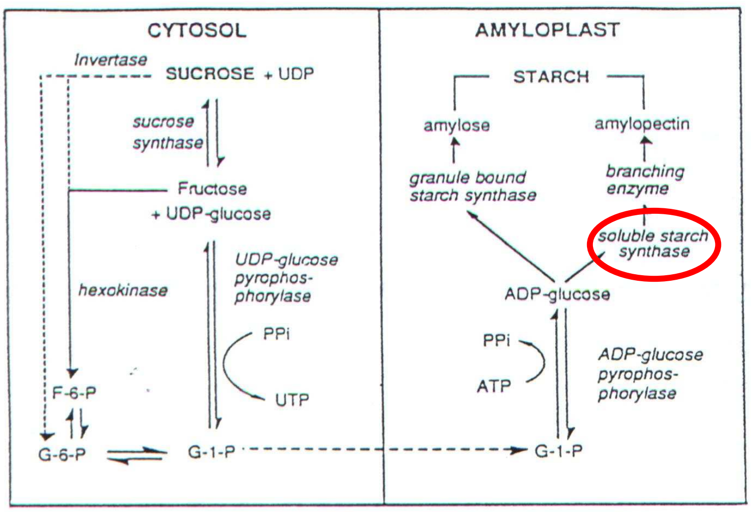
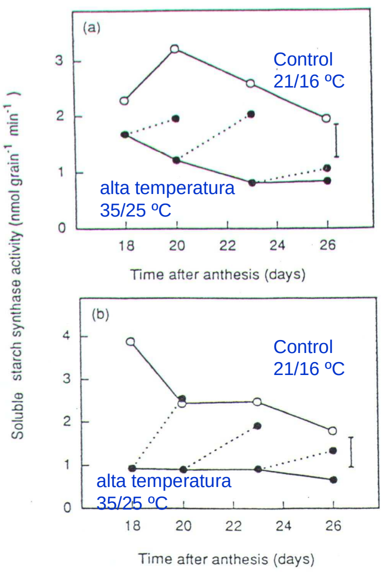


Fig. 4. Biochemical pathway from sucrose to starch in developing wheat endosperm; source Keeling *et al.* (1988).



Low tolerant genotype

High tolerant genotype

Hawker & Jenner (1993)
AJPP 20: 197-209

Altas temperaturas

Reducen el peso de los granos

efecto sobre desarrollo de los granos
(menor tasa y duración el período)

efecto directo sobre los granos

Ford *et al*. 1976
Bhullar & Jenner 1983, 1986
Wardlaw *et al.* 1980
Jenner 1991
Passarella *et al*. 2002

Reducción del peso de los granos (4-30%) y además disminución del calibre (granos < 2.5 mm > 20%)

Disminución del material potencialmente **`malteable´** (material fermentable) y **`panificable´** (menor rendimiento de harina y con mayor % de cenizas)

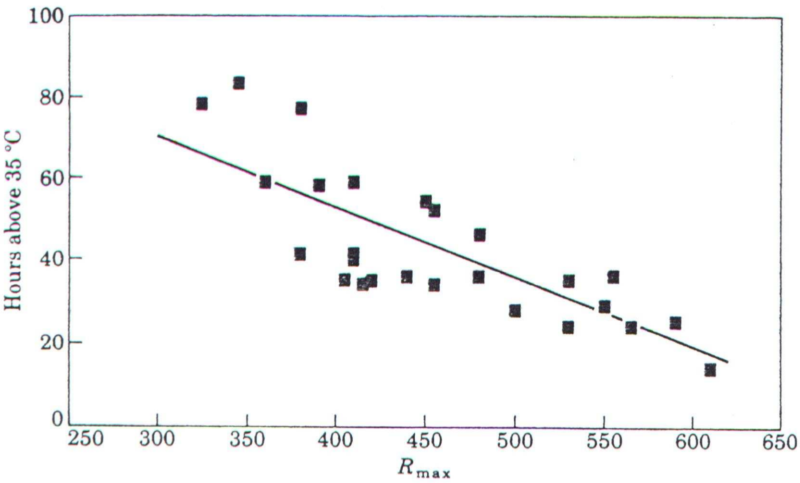
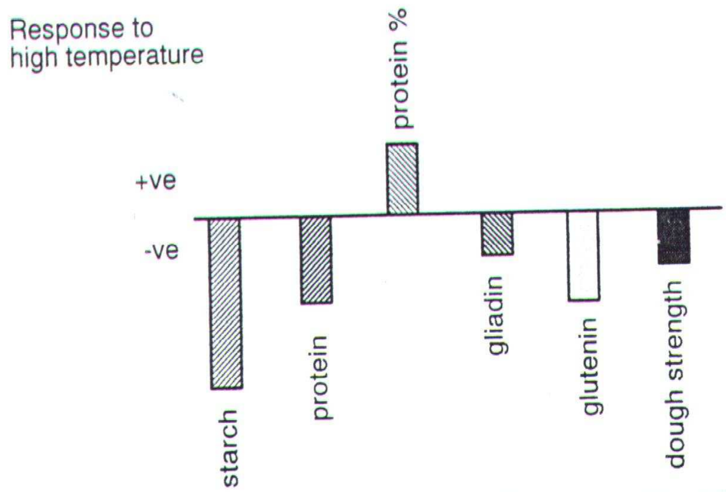
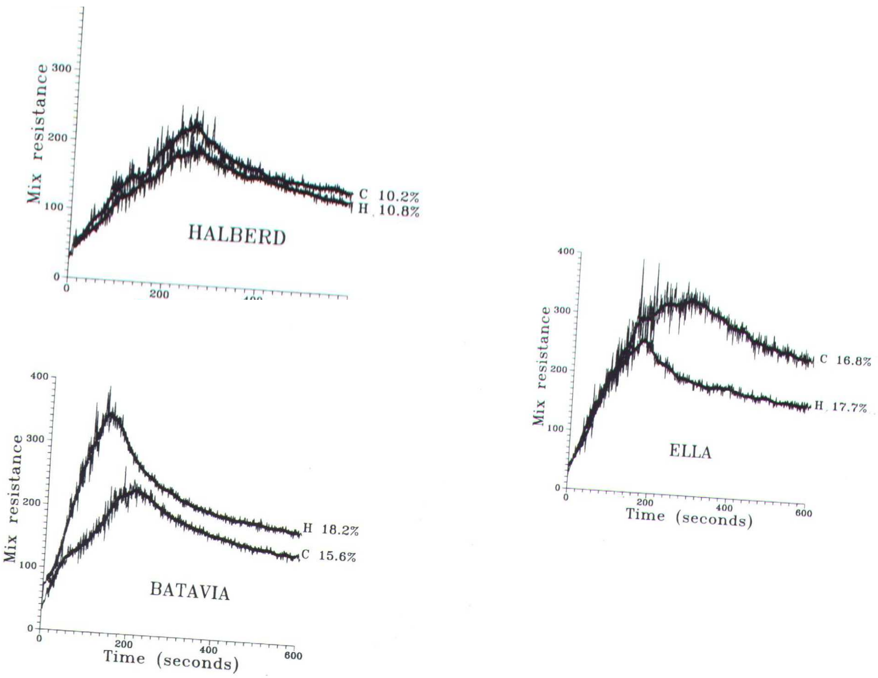
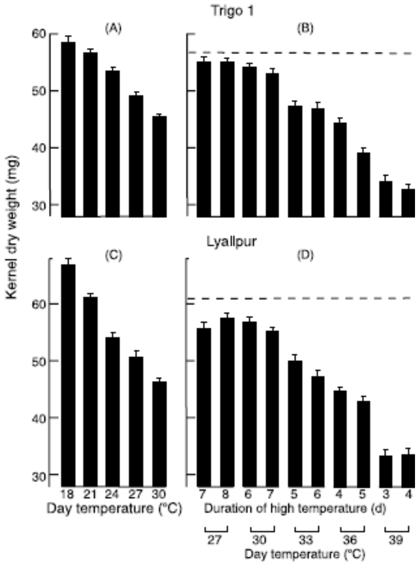


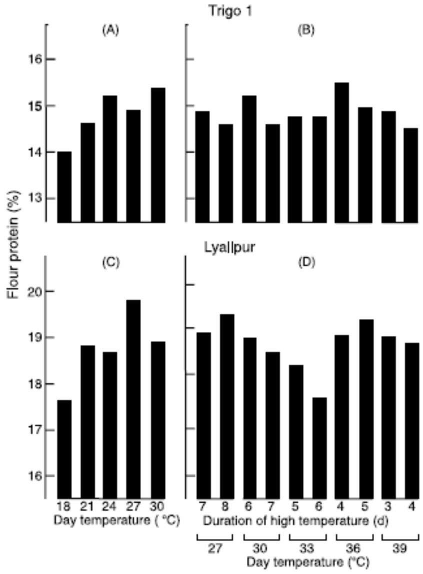
FIGURE 3. Variation in dough strength (R_{max}) for N.S.W. crop samples of Prime Hard wheat for seasons 1960 to 1989 with mean cumulative hours above 35 °C during 75 days starting 1 October at three sites (Moree, Myall Vale and Narrabri). The correlation coefficient for this data was $-0{\cdot}787$ ($P < 0{\cdot}001$). Reproduced from Blumenthal *et al.*[20].

FIGURE 5.9. A Model Describing the Response of Grain Composition and Dough Strength to Elevated Temperature

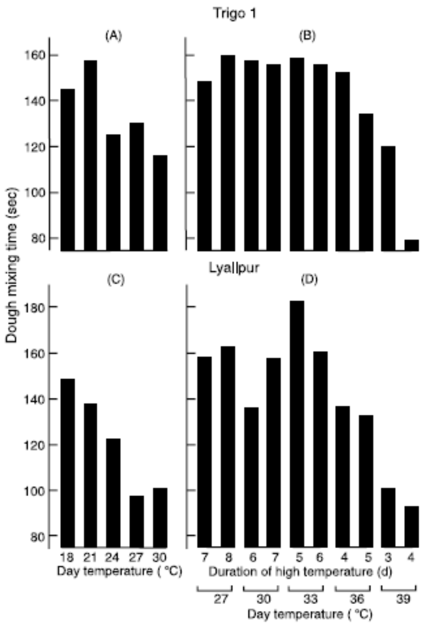








Wardlaw *et al. (*2002). FPB 29:25-34



Wardlaw *et al. (*2002). FPB 29:25-34

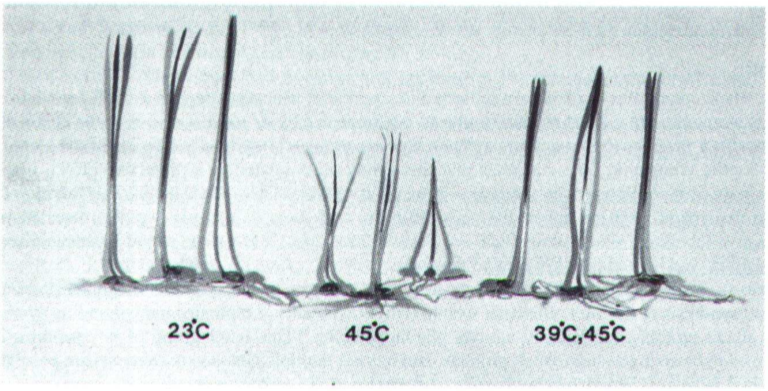


Fig. 1. Growth of coleoptiles of cv. Vulcan wheat. Left, control plants, maintained at 23°C. Middle, plants heat stressed for 2 h at 45°C. Right, plants subjected to 2 h at 39°C before the 2 h stress at 45°C.

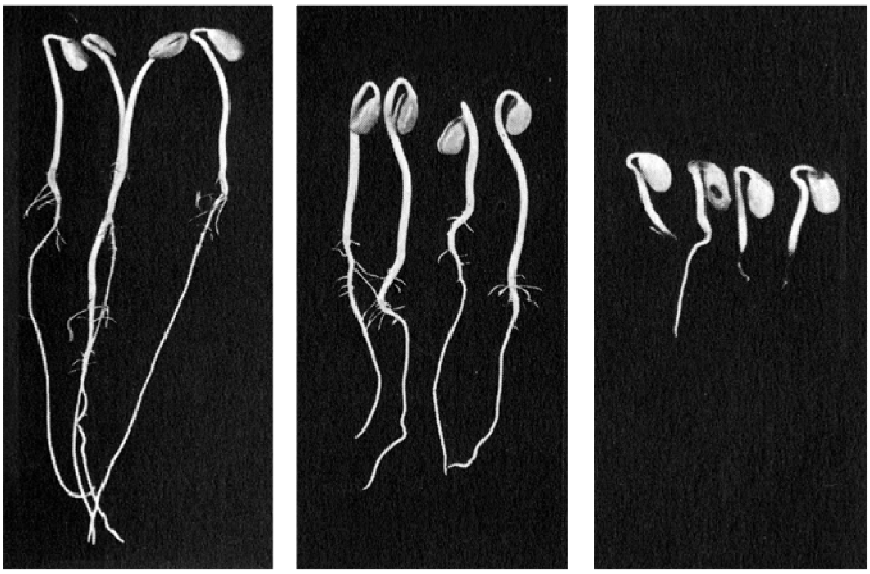
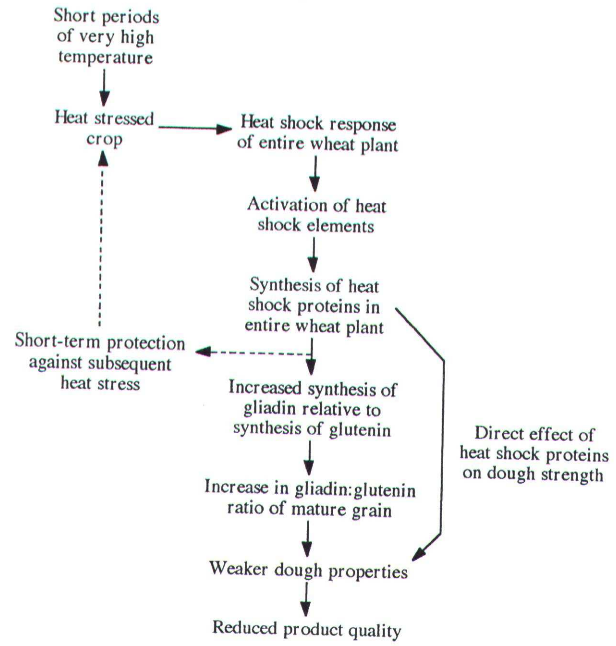
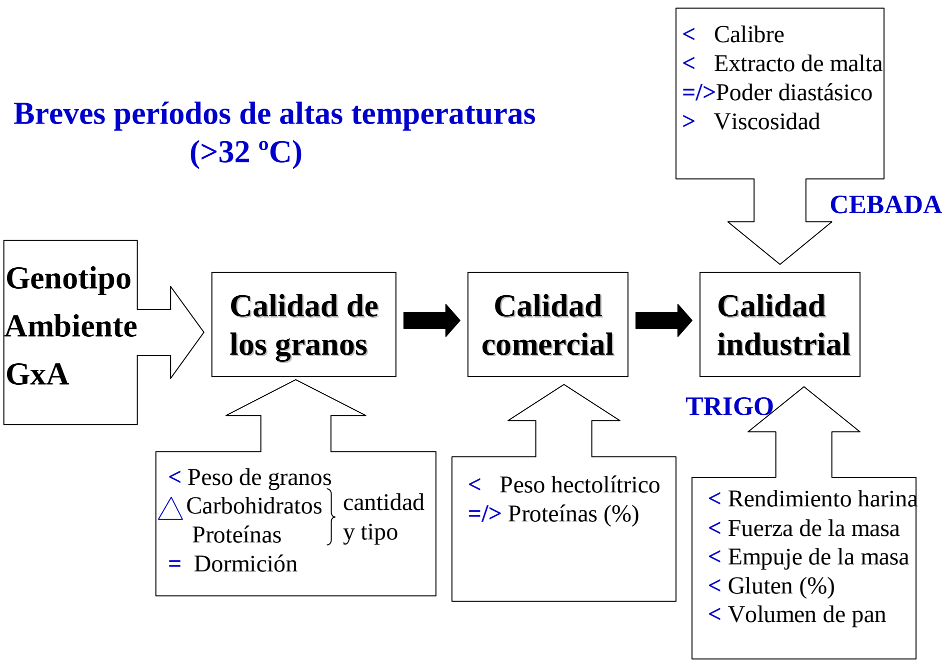


FIGURE 8.11. Schematized Hypothesis of the Mechanism by Which Very High Temperature Reduces Dough Strength



Source: Adapted from Blumenthal, ...



Es el efecto de la temperatura modificado por la disponibilidad de recursos?

El nivel de N podría modificar el efecto de altas temperaturas sobre la calidad de los granos

Altenbach *et al*. 2003; Zahedi *et al*. 2004; Dupont *et al*. 2006

Objetivo

Estudiar el efecto de breves períodos de temperaturas moderadamente altas en combinación con variaciones en la disponibilidad de recursos en post-floración sobre el peso y la calidad final en cebada

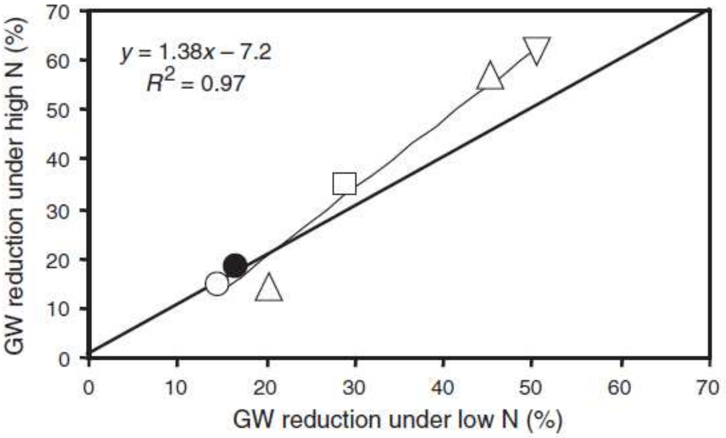


Fig. 2. Reduction in grain weight (GW) in response to heat stress under high and low nitrogen status. Open symbols are data from Dawson and Wardlaw 1984 (circle); Altenbach *et al*. 2003 (triangles); Zahedi *et al*. 2004 (square); Dupont *et al*. 2006 (inverted triangle); and the closed circle is data from this paper.

Passarella et al. 2008