Estrategias para incrementar el rendimiento de trigo quebrando el *trade-off* entre el peso y el número de granos

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Academia Chilena de Ciencias Agronómicas
Diciembre 2021

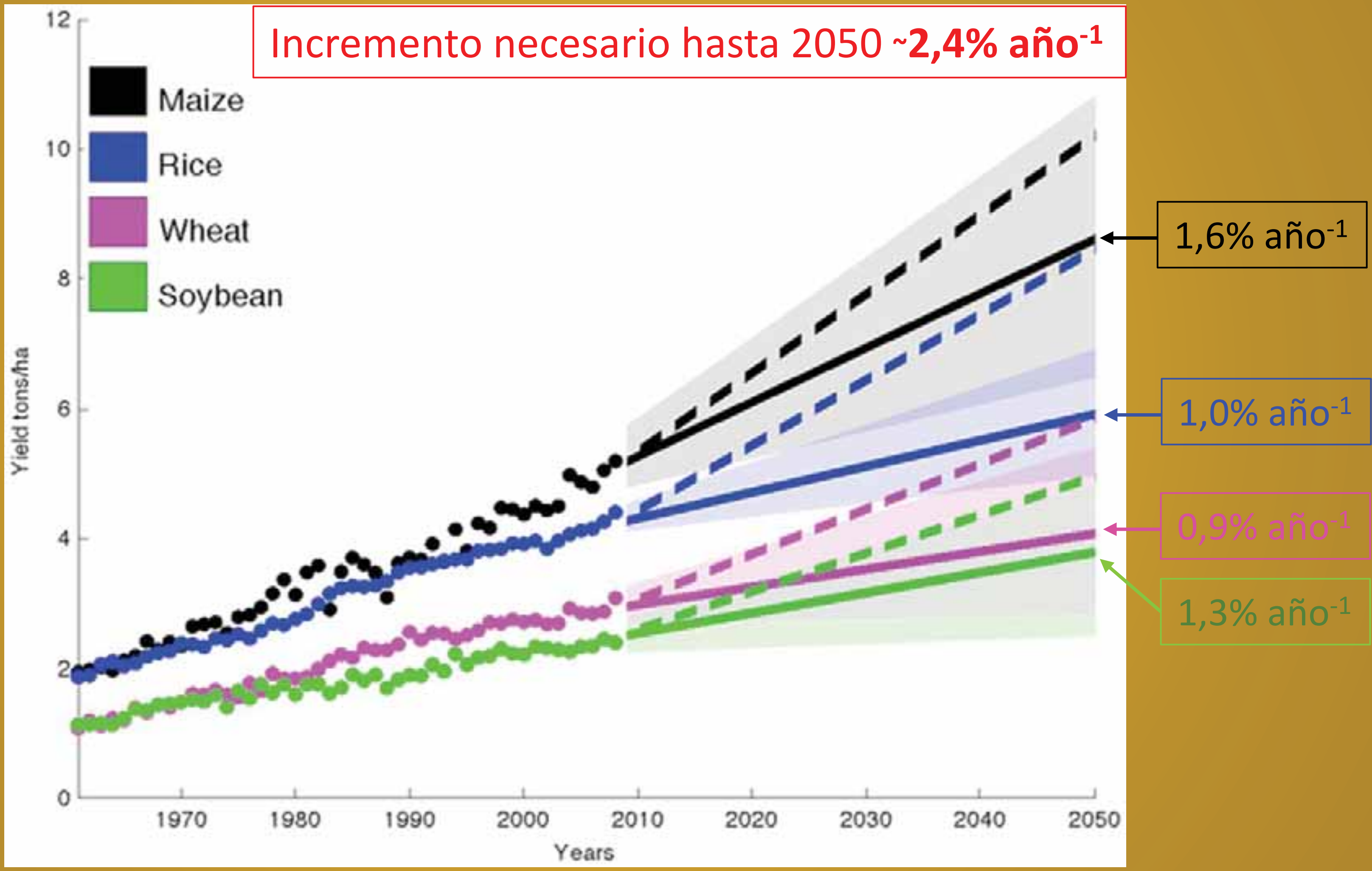
Estructura de la Presentación

- Desafíos que enfrenta la producción de trigo y los cultivos en general
- El mejoramiento genético de trigo y limitaciones para el éxito futuro
- *Trade-offs* entre los componentes del rendimiento de trigo
- Bases fisiológicas y moleculares de la determinación del peso de los granos en trigo
- Un ejemplo del quiebre del *trade-off* entre el peso y el número de granos en trigo
- Trabajos actuales y futuros

El Desafío de la Seguridad Alimentaria

- El rendimiento incrementarse ~6 mantener la segu et al., 2017; Fischer &
- El trigo provee proteínas de especialmente im d ll

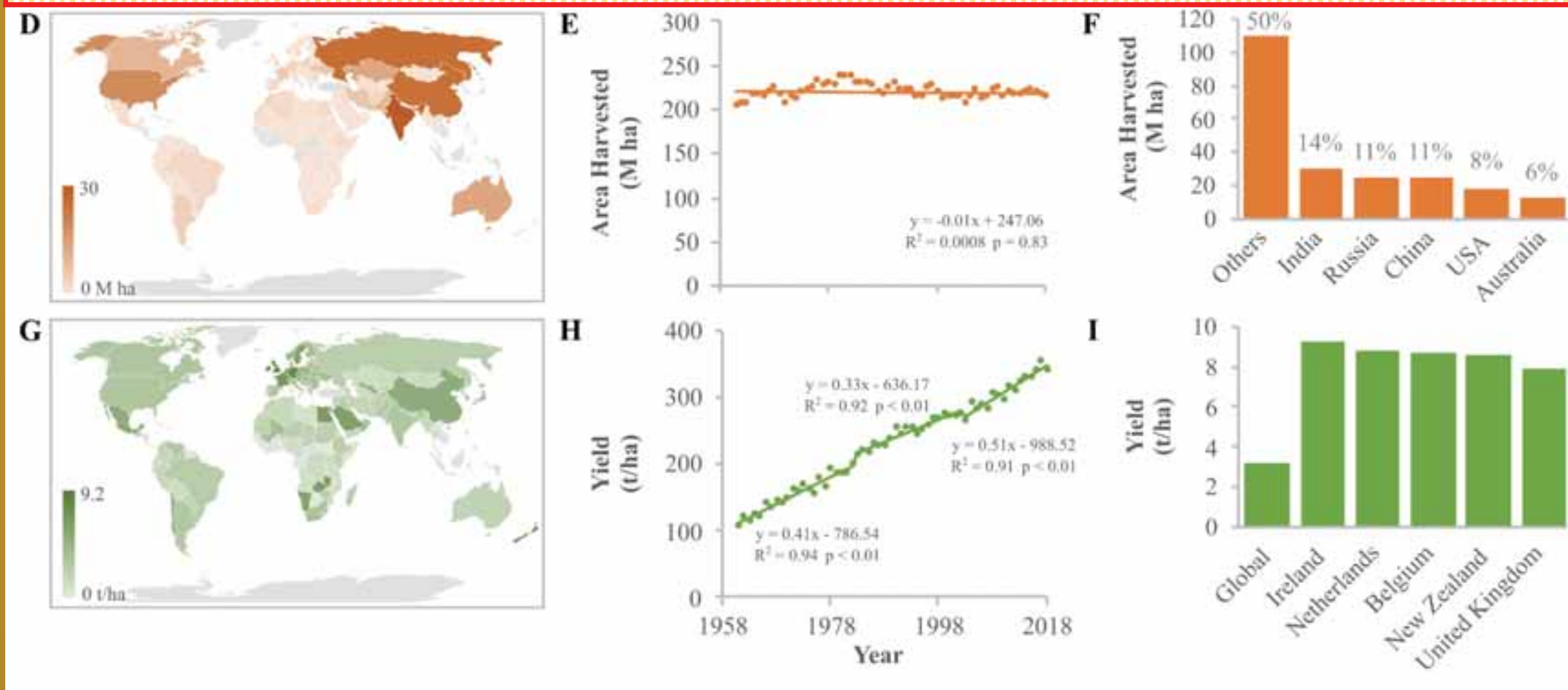
El Desafío de la Seguridad Alimentaria



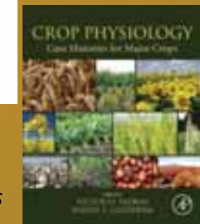
Ray et al. (2013)
Plos One

Producción, Área y Rendimiento Mundial de Trigo

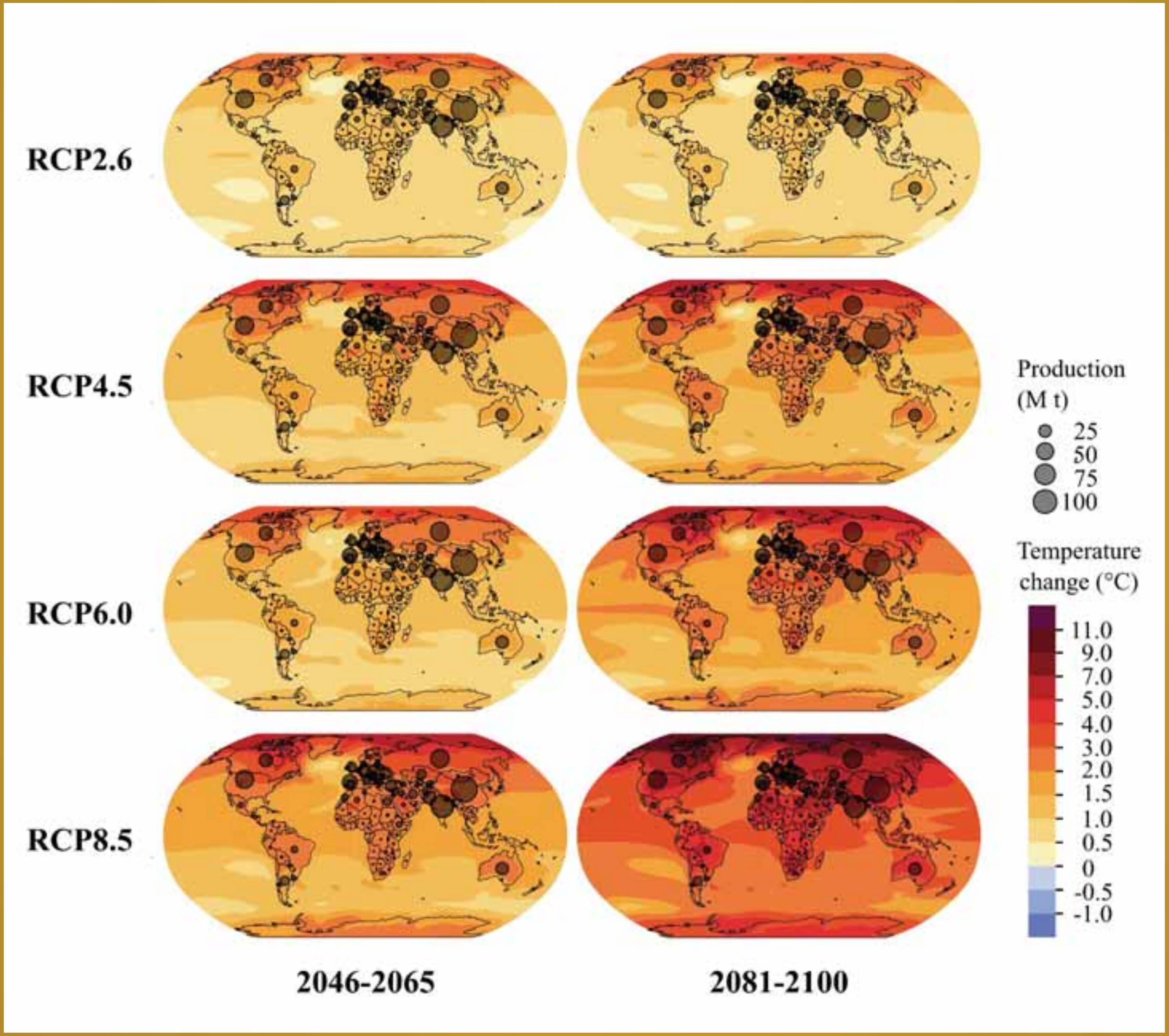
Existe consenso internacional que la alternativa para lograr la seguridad alimentaria es el incremento del rendimiento



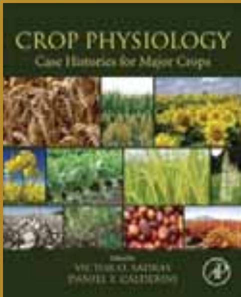
Slafer et al. (2020) – Wheat
Crop Physiology: Case History for Major Crops



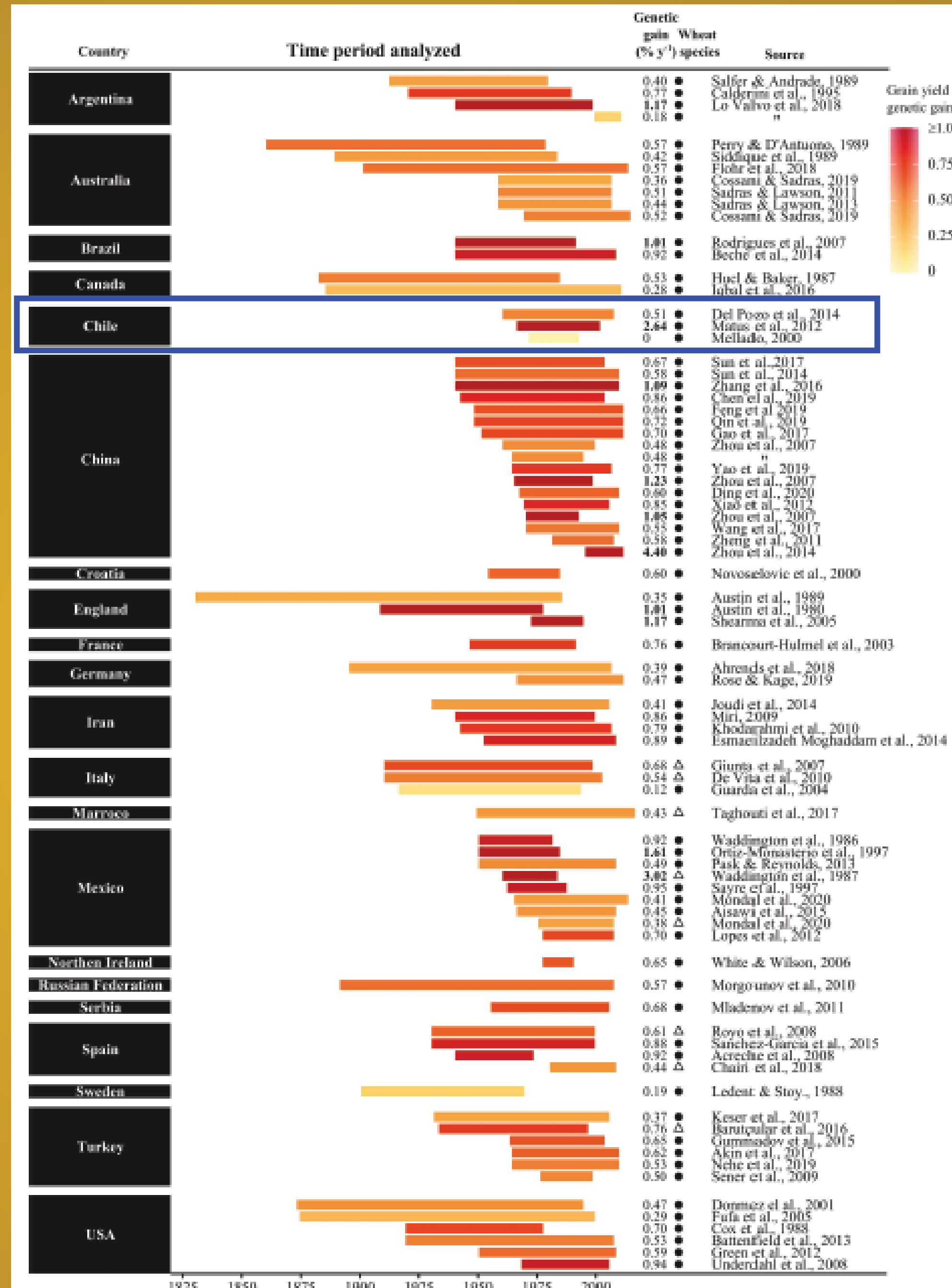
El Desafío del Cambio Climático Global

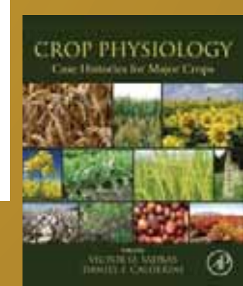


Chapter Wheat: Slafer et al. (2021)
Crop Physiology: Case History for Major Crops



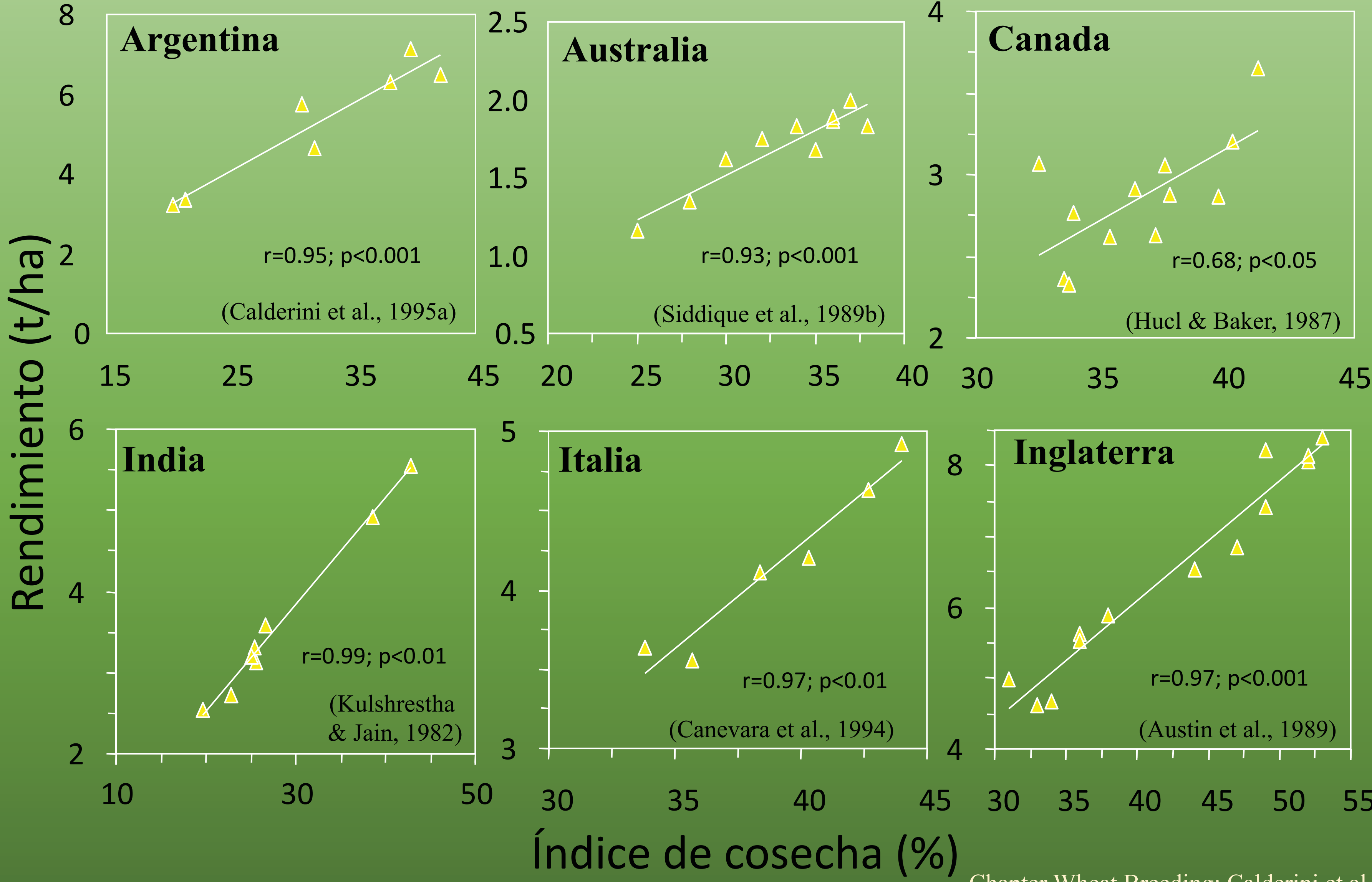
El mejoramiento genético como motor del incremento del rendimiento, en un contexto de cambio climático y sostenibilidad





Chapter Wheat: Slafer et al. (2021)
Crop Physiology: Case History for Major Crops

El incremento del índice de cosecha fue la principal causa del aumento del rendimiento



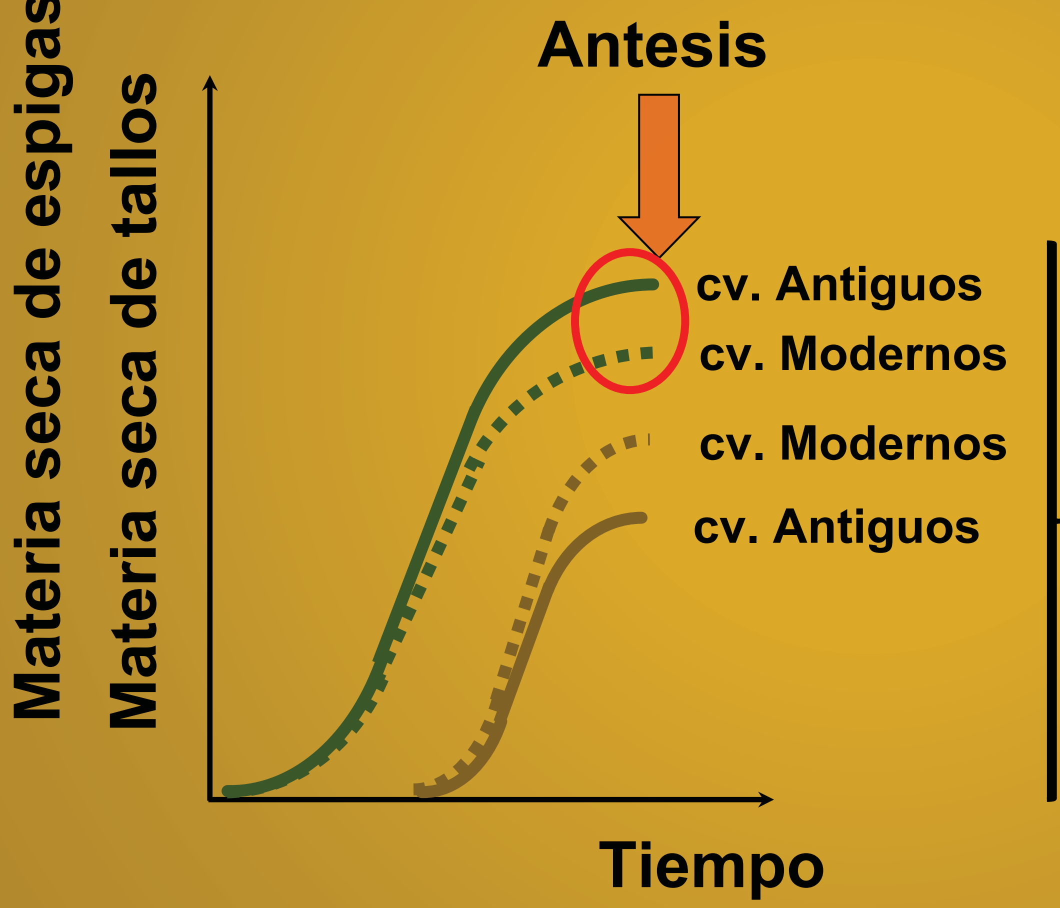
Chapter Wheat Breeding: Calderini et al. (1999)
Wheat Ecology and Physiology

Cambios en la partición de biomasa de cultivares argentinos liberados en distintos años

Año de liberación	Rendimiento ($g\ m^{-2}$)	Tallos ($g\ m^{-2}$)
1920	319.9	839.1
1990	649.1	496.4
Diferencia	+ 329.3	- 342.7

Calderini et al. (1995)
Plant Breeding

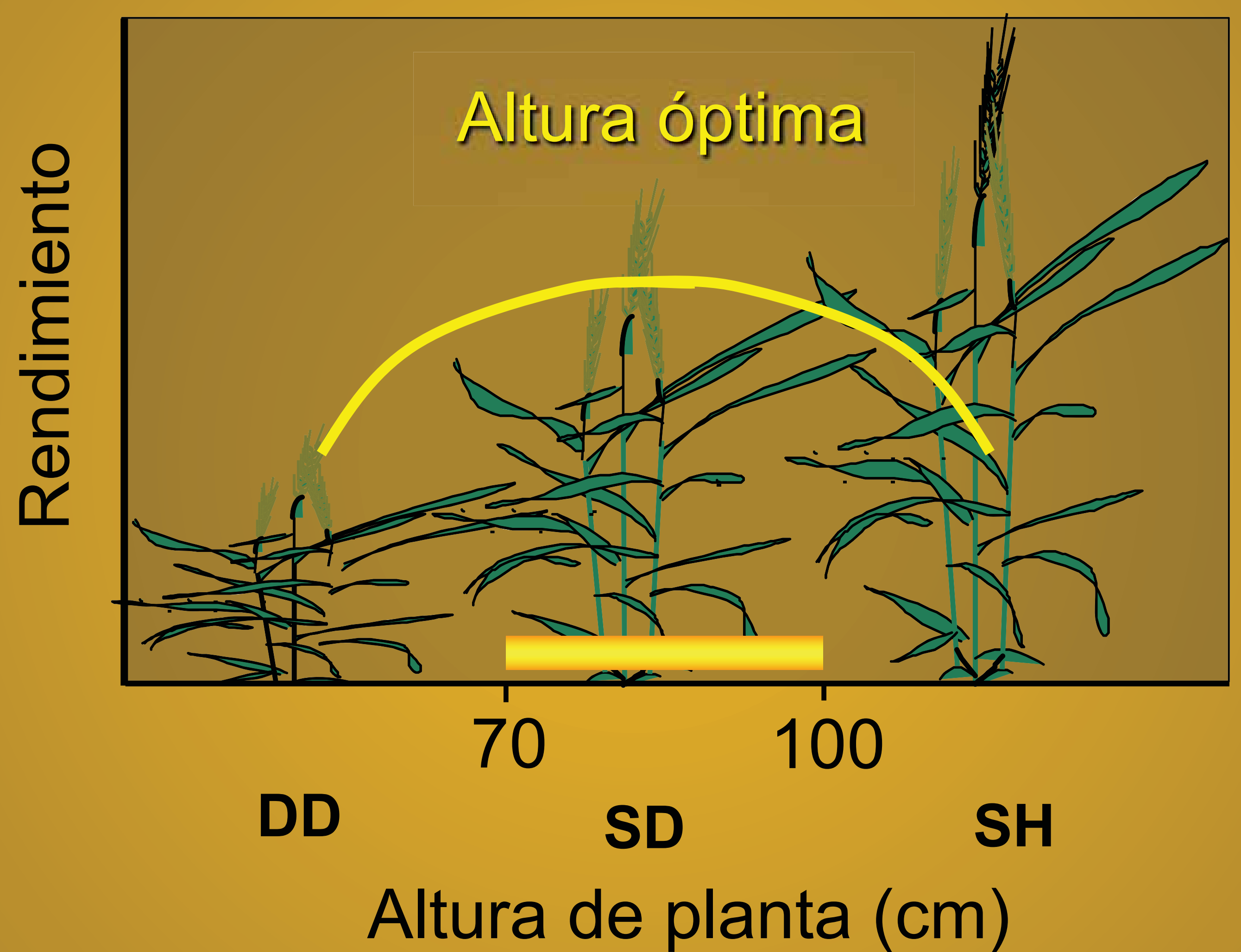
Determinantes fisiológicos del impacto del mejoramiento sobre el rendimiento potencial



Mayor índice de cosecha

Mayor número de granos

Cultivos como trigo ya están en la altura óptima



Richards (1992)

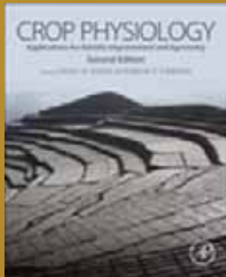
Miralles and Slafer (1995)

Partición de Biomasa Aérea en Trigo

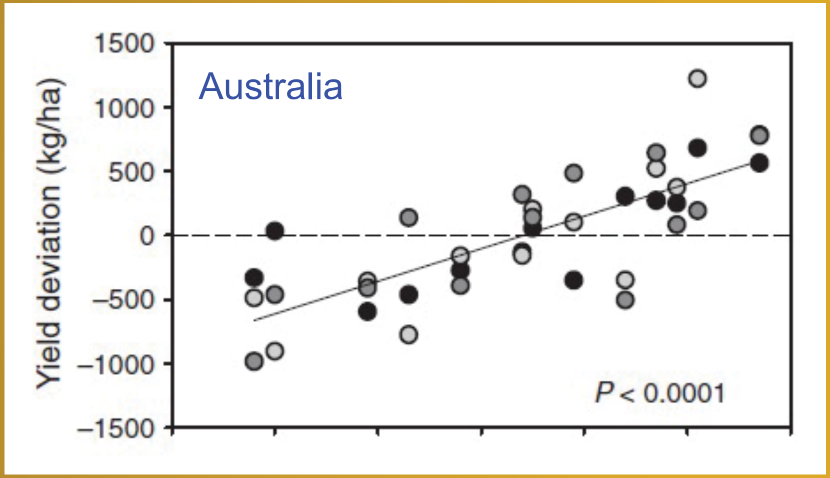
Crop component	Austin et al. (1980) (4 most modern cvs.)		Austin et al. (1980) (Theoretical Maximum HI)		Shearman et al. (2005) (4 most modern cvs.)		Consort Herefordshire, UK (Mean 1996/1997 and 1997/1998)		The best DH (Mean S1 and S2)	
	$g\ m^{-2}$	%	$g\ m^{-2}$	%	$g\ m^{-2}$	%	$g\ m^{-2}$	%	$g\ m^{-2}$	%
Grain	707	49	895	62	888	51	1,103	56	1,556	53
Chaff	143	10	181	13	171	10	195	10	329	11
Leaf lamina	139	10	139	10	151	9	183	9	273	9
Stem+sheaths	453	31	226	15	536	30	490	25	783	27
Biomass	1,442	-	1,141	-	1,746	-	1,971	-	2,941	

Calderini et al.
(data not published)

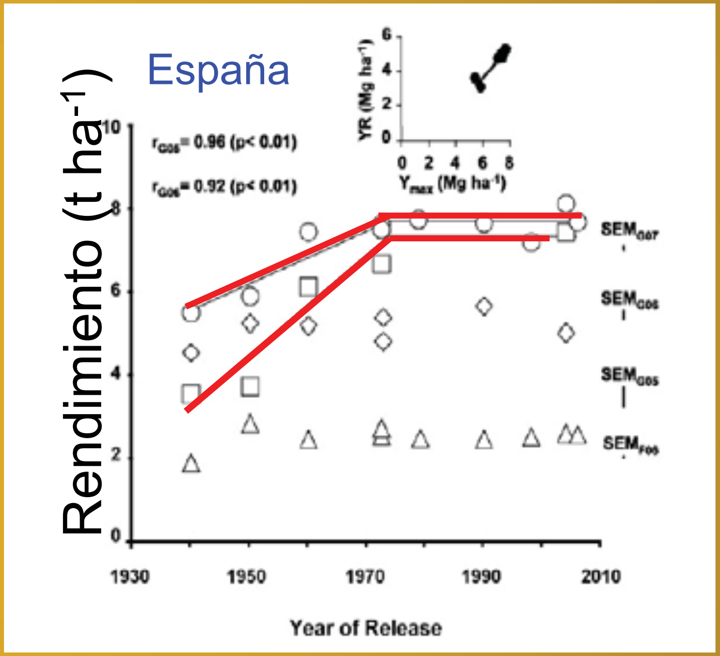
Adaptado de Foulkes et al. (2015)
Crop Physiology: Applications for
Genetic Improvement and Agronomy 2nd. Edition



El mejoramiento genético en distintos países

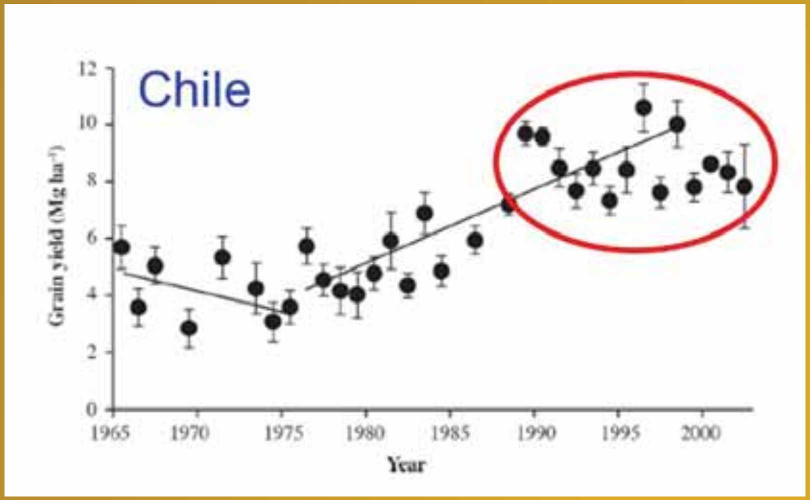


Sadras & Lawson (2011)
Crop & Pasture Science

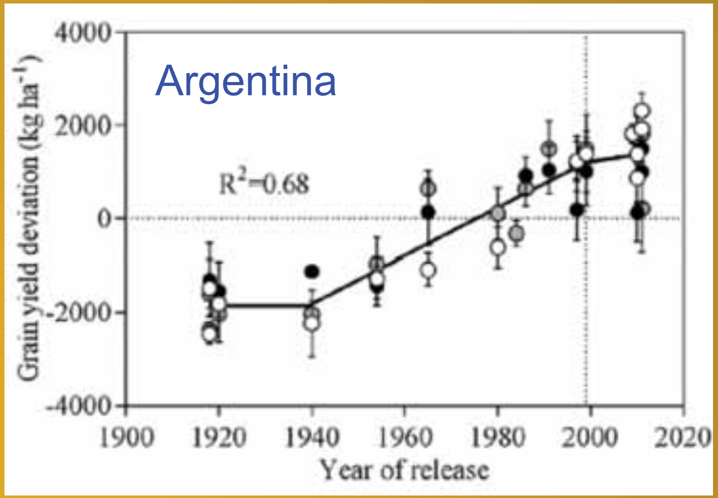


Acreche et al. (2012)
European Journal of Agronomy

El mejoramiento genético en distintos países



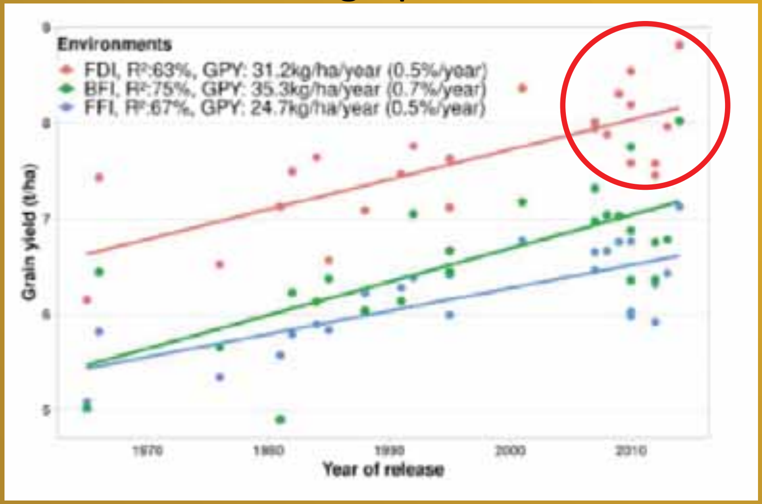
Matus et al. (2012)
Chilean Journal of Agricultural Research



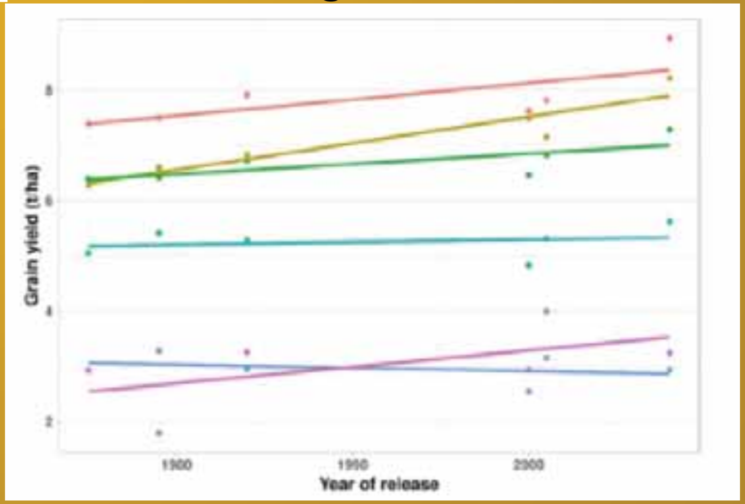
Lo Valvo et al. (2018)
Field Crops Research

CIMMYT

Trigo pan



Trigo duro



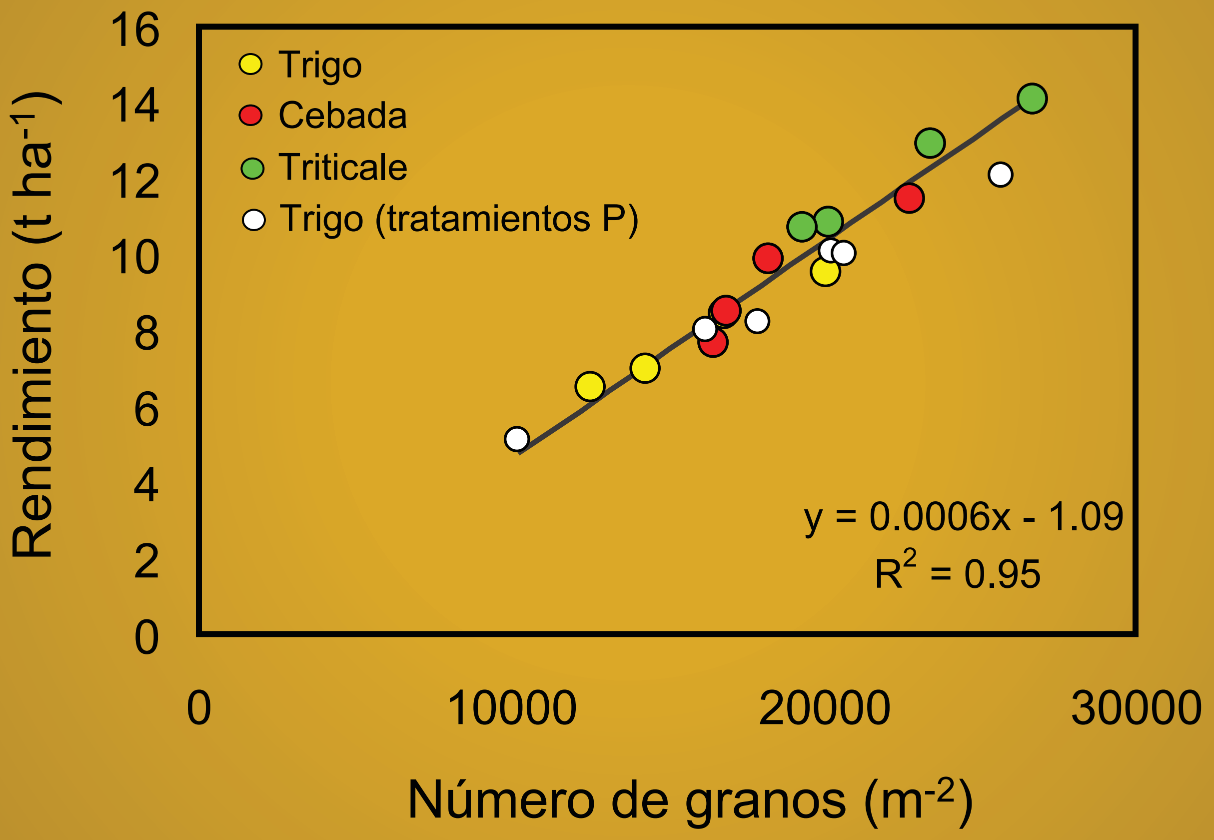
Mondal (2020)
Field Crops Research

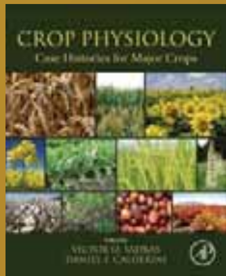
Aproximaciones al Rendimiento

- Rendimiento = Número de granos m^{-2} x PG promedio

- Rendimiento = Biomasa x Índice de Cosecha

Relación entre el rendimiento y el número de granos en trigo, cebada y triticale





Chapter Wheat: Slafer et al. (2021)
Crop Physiology: Case History for Major Crops

Período crítico para la determinación del número de granos en trigo

Contents lists available at ScienceDirect

Field Crops Research

journal homepage: www.elsevier.com/locate/fcr

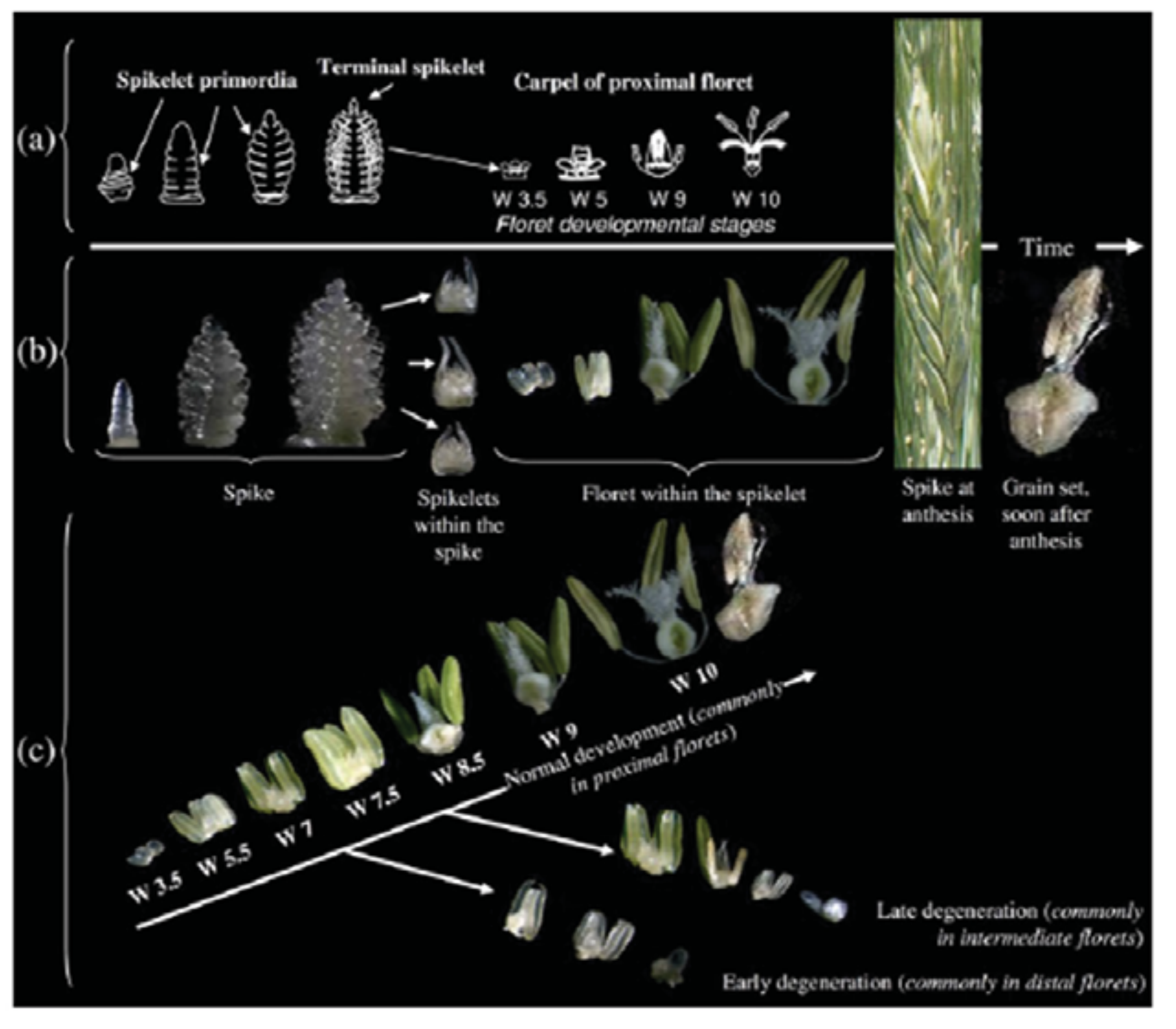
Critical developmental period for grain yield and grain protein concentration in lentil

Lachlan Lake[a,*,1], Diego Godoy Kutchartt[b,1], Daniel F. Calderini[b], Victor O. Sadras[a]

[a] South Australian Research and Development Institute, and School of Agriculture, Food and Wine, The University of Adelaide, Waite Campus, Australia
[b] Institute of Plant Production and Protection, Universidad Austral de Chile, Valdivia, Chile

Darwin (1859) observed "..very trifling changes, such as a little more or less water at some particular period of growth, will determine whether or not the plant sets a grain". This notion of a critical developmental period has become a physiological paradigm, with agronomic practices seeking to reduce the likelihood of stress in the more sensitive stage for yield (Flohr et al., 2017; Lake et al., 2021).

Evolución floral en trigo



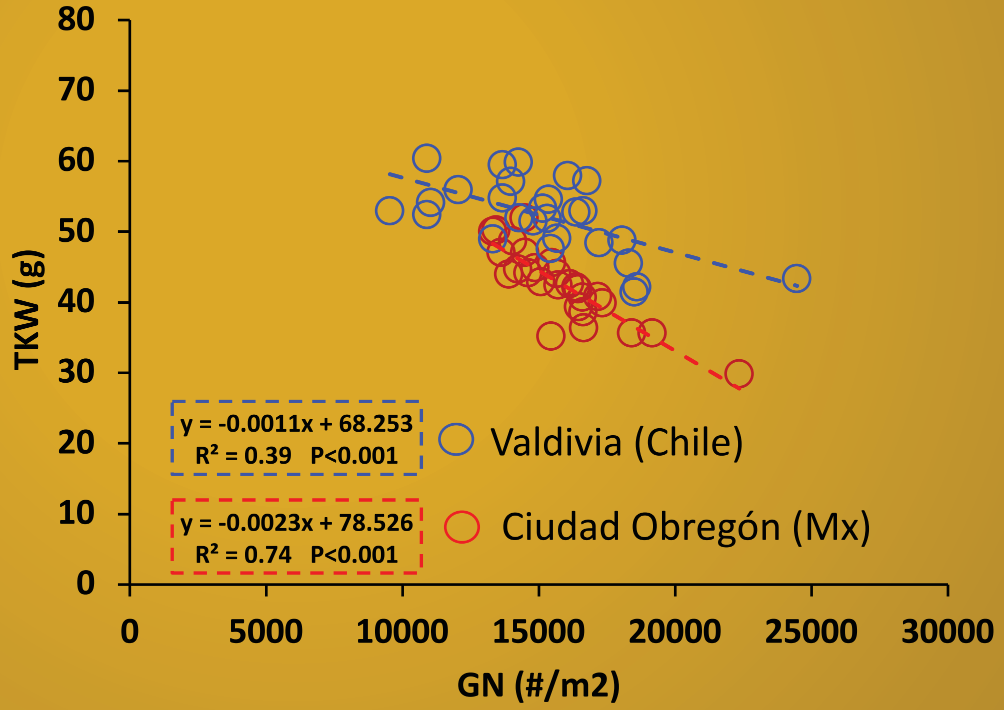
Ferrante et al. (2010)
Journal of Experimental Botany

El incremento del rendimiento en trigo y otros cultivos se enfrenta a un *trade-off* entre el peso el número de los granos

Asociación negativa entre el peso de grano y el número de granos en 27 genotipos elite de CIMMYT (CIMCOG) en Chile y México

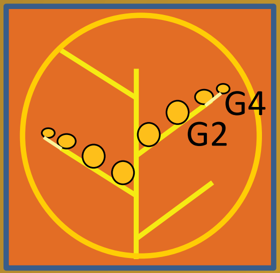
Otras evidencias de *trade-off* en trigo:

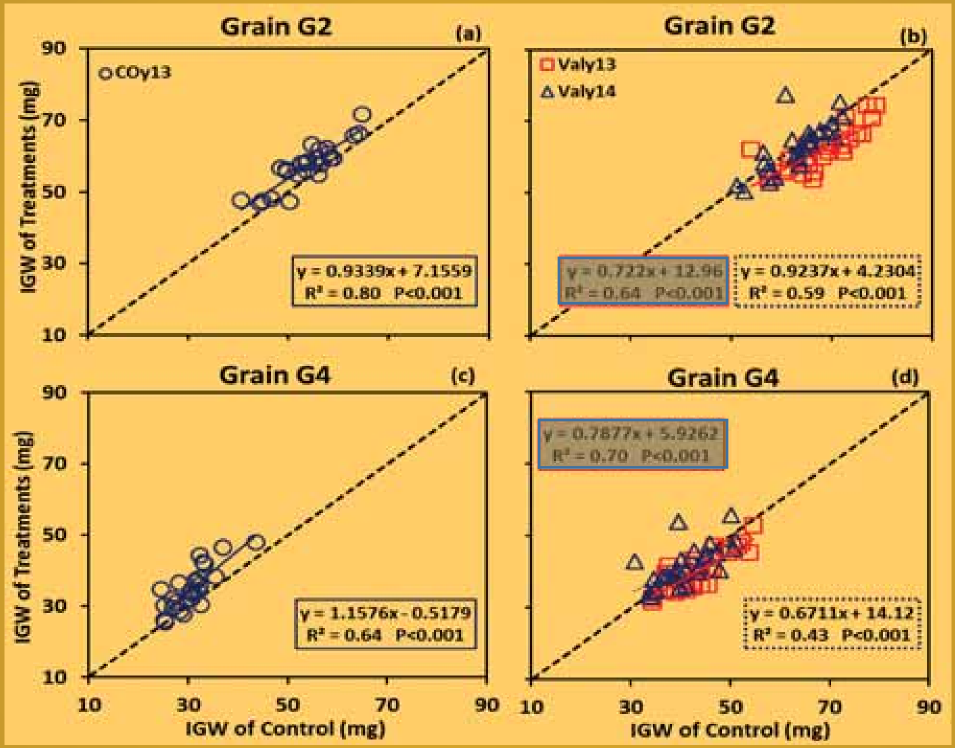
Molero et al. (2019); Rivera-Amado et al. (2019)



Quintero et al. (2018)
European Journal of Agronomy

El *trade-off* no es debido a limitaciones por la fuente de asimilados durante el llenado de los granos





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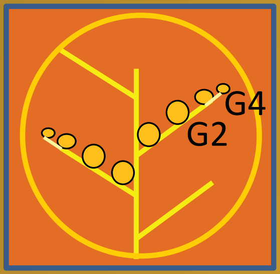
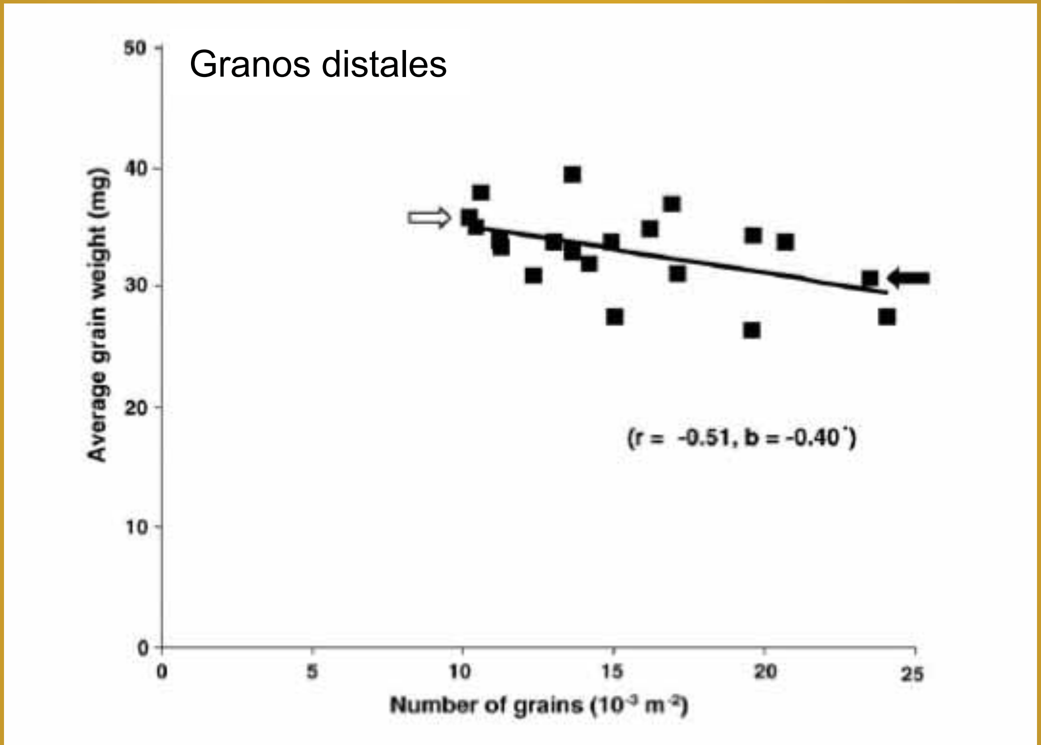




Acreche & Slafer (2006)
Field Crops Res.

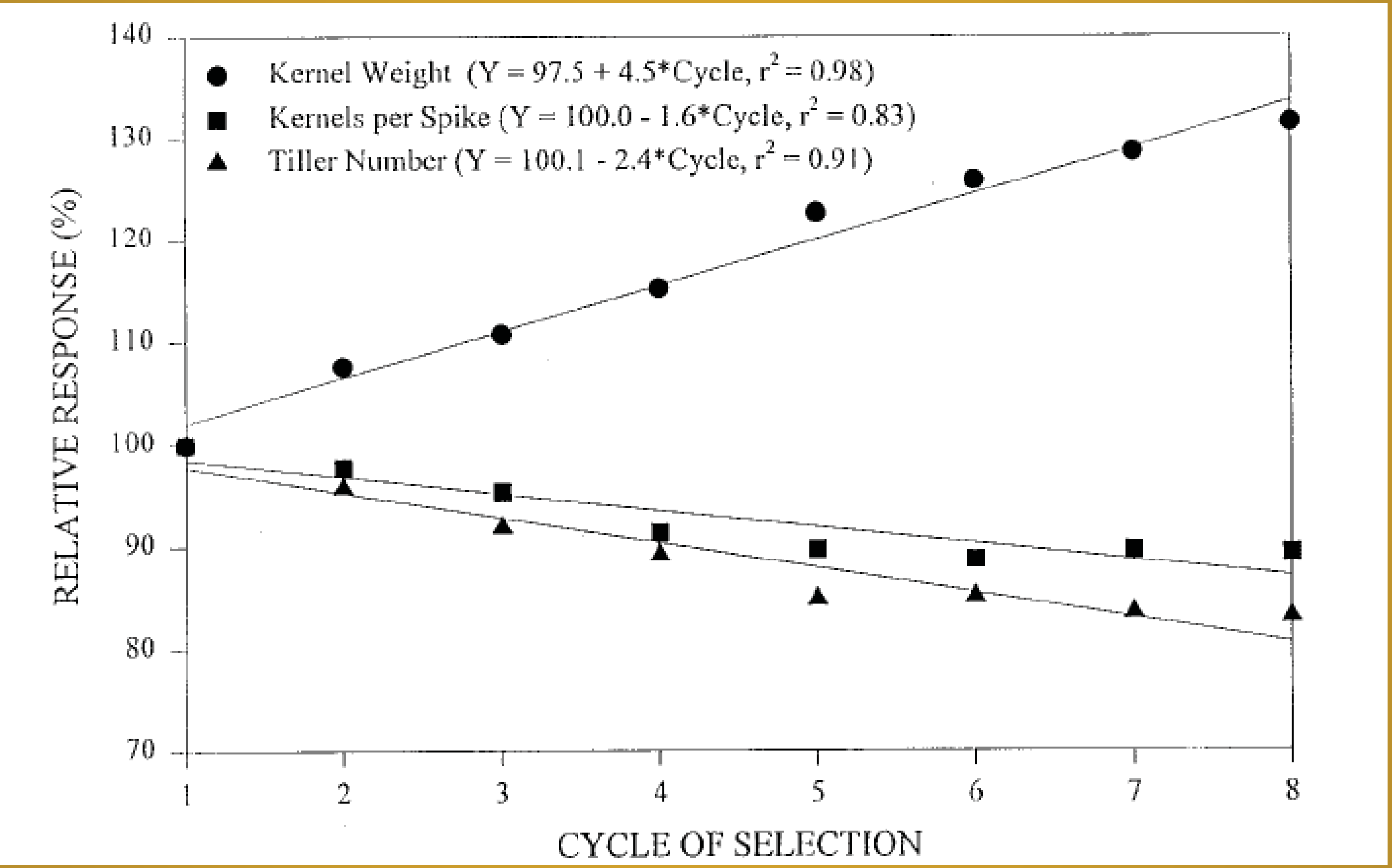
Intentos de Incrementar el Rendimiento de Trigo Mediante el Aumento del Peso de Grano

Rendimiento, número de granos y peso de granos en cultivares de trigo chilenos

Genotipo	Rendimiento ($Mg\ ha^{-1}$)	Número de Granos ($Nº\ m^{-2}$)	Peso de Grano (g)
Impulso Baer	10,0	20.818	47,9
Fritz Baer	10,5	15.200	68,8

A. Arenas (datos no publicados)

Efecto de la selección recurrente para peso de grano sobre los componentes del rendimiento en trigo



Ganancia en rendimiento ~ 0%

Wiersma et al. (2001)
Crop Science

Trade-off entre peso y número de granos en líneas isogénicas de trigo con o sin presencia de un QTL mayor para PG

Table 1 Mean thousand grain weight (TGW), yield and grain morphometric parameters of 5A near isogenic lines (NILs)

Year	Genotype	TGW (g)	Yield (kg per plot)	Grain area (mm^2)	Grain length (mm)	Grain width (mm)
2012	5A–	38.027	4.408	18.755	6.625	3.475
	5A+	41.554	4.437	19.930	6.900	3.557
		9.28%***	0.66%^{ns}	6.26%***	4.15%***	2.35%**
2013	5A–	40.772	6.157	19.969	6.705	3.674
	5A+	43.544	6.159	20.979	6.963	3.727
		6.80%***	0.02%^{ns}	5.06%***	3.86%***	1.44%***
2014	5A–	47.368	6.495	21.493	6.798	3.930
	5A+	50.729	6.636	22.579	7.063	3.979
		7.09%***	2.17%*	5.05%***	3.90%***	1.25%**
2015	5A–	42.734	7.582	18.044	6.426	3.479
	5A+	46.201	7.712	19.293	6.730	3.554
		8.11%***	1.72%^{ns}	6.93%***	4.72%***	2.16%***
2016	5A–	49.292	5.974	19.829	6.580	3.735
	5A+	51.266	6.064	20.610	6.816	3.745
		4.00%*	1.50%^{ns}	3.94%**	3.58%***	0.27%^{ns}
Overall	5A–	43.639	6.123	19.618	6.627	3.659
	5A+	46.659	6.201	20.678	6.894	3.712
		6.92%***	1.28%^{ns}	5.41%***	4.04%***	1.45%***,[1]

[1]Percentages (%) indicate amount gained in 5A+ NILs compared with 5A– NILs. Asterisks indicate significance determined by ANOVA for either each year, or across all years (final row). ns, nonsignificant; *, $P<0.05$; **, $P<0.01$; ***, $P<0.001$; 2012–2013, BC_2-NILs; 2014–2016, BC_4-NILs.

Brinton et al. (2017)
New Phytologist

Trade-off entre peso y número de granos en líneas transgénicas de trigo

Milner *et al. BMC Plant Biology* (2021) 21:524
https://doi.org/10.1186/s12870-021-03294-x

BMC Plant Biology

RESEARCH Open Access

Check for updates

Ectopic expression of *TaBG1* increases seed size and alters nutritional characteristics of the grain in wheat but does not lead to increased yields

Matthew J. Milner*, Sarah Bowden, Melanie Craze and Emma J. Wallington

Fig. 3 Comparison of seed length and width in *TaBG1-A* overexpression lines. **A** Ten seeds from the three independent *TaBG1-A* overexpression lines aligned to show differences in length and width relative to WT Fielder. Scale bar = 1 cm. **B** Average grain length in three independent *TaBG1-A* over expression lines relative to WT Fielder. **C** Average grain width in three independent *TaBG1-A* overexpression lines relative to WT Fielder. * = p val. < 0.05, *** = p val. <0.001 relative to WT Fielder

Milener et al. (2021)
BMC Plant Biology

Consideraciones para entender la determinación del peso de grano en trigo y los genes que la controlan

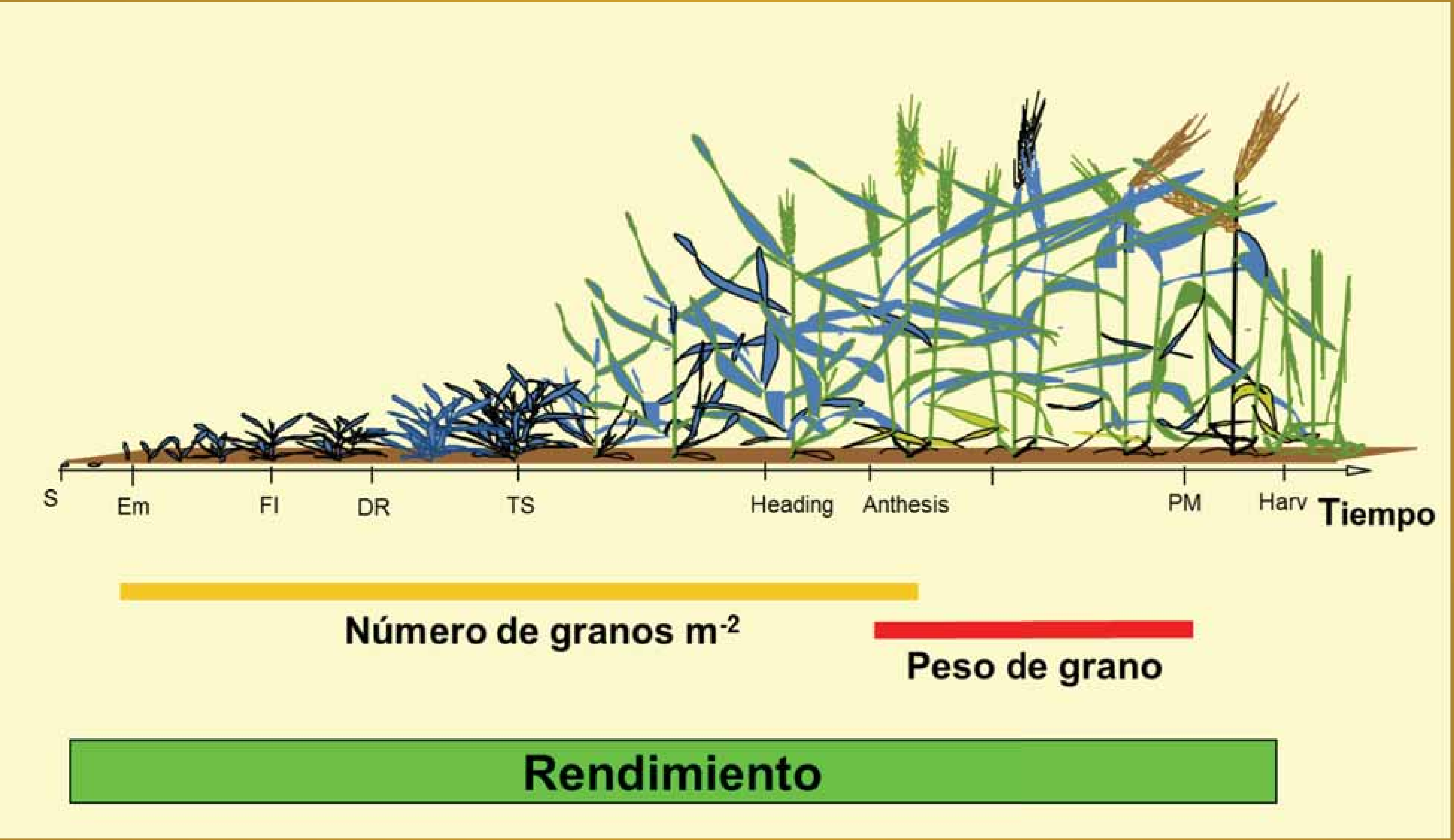
La búsqueda de QTL (fishing?)

TABLE 1 | QTLs for grain weight and size identified by all three mapping methods in the Jing 411/Hongmangchun 21 RIL population.

Trait	QTL	Physical Interval (Mb)[b]	Representative Marker	No. of Environments	Method[c]	Peak Position (cM)	LOD or *P*-value[d]	PVE[e] (%)	Additive Effect	References
TGW	*Qtgw.ahau-1B.1*	648.1–652.1	1B-JHMfel	5	ICIM	184.0–185.0	3.27–4.38	5.4–8.0	1.46–2.23	**Novel** for TGW;
					GCIM	184.8–185.4	2.74–5.42	3.5–6.3	1.85–2.17	Cui et al., 2014
					NWIM	187.2	0.00	19.8	2.37	(**KNS**)
	Qtgw.ahau-2D	543.5–561.9	2D-5137	2	ICIM	60.0–62.0	3.27–6.45	8.2–8.5	2.03	Liu et al., 2018
					GCIM	61.5	3.52	5.0	1.94	
					NWIM	61.3	0.00	30.4	3.34	
	Qtgw.ahau-4B.1[a]	540.3–542.9	4B-8621	5	ICIM	34.0–44.0	5.05–14.74	9.6–29.3	1.97–4.77	**Novel**
					GCIM	43.5	2.57–3.70	1.9–3.5	1.93–2.09	
					NWIM	35.0	0.00	17.8	4.13	
	Qtgw.ahau-4B.2[a]	660.1–660.4	4B-9051	10	ICIM	115.0–116.0	3.37–10.25	5.2–23.2	1.47–3.26	**Novel**
					GCIM	115.2–116.2	2.80–8.63	2.6–15.0	1.63–3.10	
					NWIM	115.2	0.00	33.9	5.72	
	Qtgw.ahau-6B.1	677.7–679.6	6B-9077	3	ICIM	73.0	4.22	8.2	1.80	Li et al., 2019
					GCIM	73.3	2.86	3.7	1.96	
					NWIM	73.4	0.00	18.1	3.82	
GW	*Qgw.ahau-2D.3*[a]	543.5–561.9	2D-5137	1	ICIM	62.0	8.36	14.0	0.09	Liu et al., 2018
					GCIM	60.5	4.98	14.7	0.10	
					NWIM	60.6	0.00	26.7	0.12	
	Qgw.ahau-4B.3[a]	660.11–660.13	4B-9051	2	ICIM	116.0	4.21–14.27	11.0–20.7	0.06–0.10	**Novel**
					GCIM	116.2	3.44–7.31	8.1–26.0	0.09–0.17	
					NWIM	115.2	0.00	34.2	0.17	
GL	*Qgl.ahau-2A.1*[a]	44.2–54.4	2A-CAPSmin	3	ICIM	105.0–107.0	6.54–8.96	13.8–15.5	0.21–0.25	**Novel**
					GCIM	103.8	6.42	10.4	0.22	
					NWIM	211.0	0.01	8.5	0.25	
	Qgl.ahau-4B.1	31.3–38.4	Marker13172883	2	ICIM	6.0	5.16–16.88	6.5–18.0	0.14–0.22	Garcia et al., 2019
					GCIM	6.3–7.2	4.75–3.68	2.1–5.3	0.12–0.20	
					NWIM	6.4	0.00	11.9	0.19	
	Qgl.ahau-6B	676.8–678.2	6B-6004	4	ICIM	80.0–86.0	3.11–5.79	4.8–5.8	0.12–0.14	Li et al., 2019
					GCIM	88.0	3.17	1.7	0.11	
					NWIM	91.8	0.01	7.7	0.22	
	Qgl.ahau-7A.2[a]	446.4–496.9	7A-3738	3	ICIM	123.0	3.75–15.88	9.7–22.8	0.17–0.38	**Novel** for GL;
					GCIM	122.8	5.59	6.3	0.22	Wang et al., 2017
					NWIM	63.2	0.02	9.5	0.20	(**KNS**)

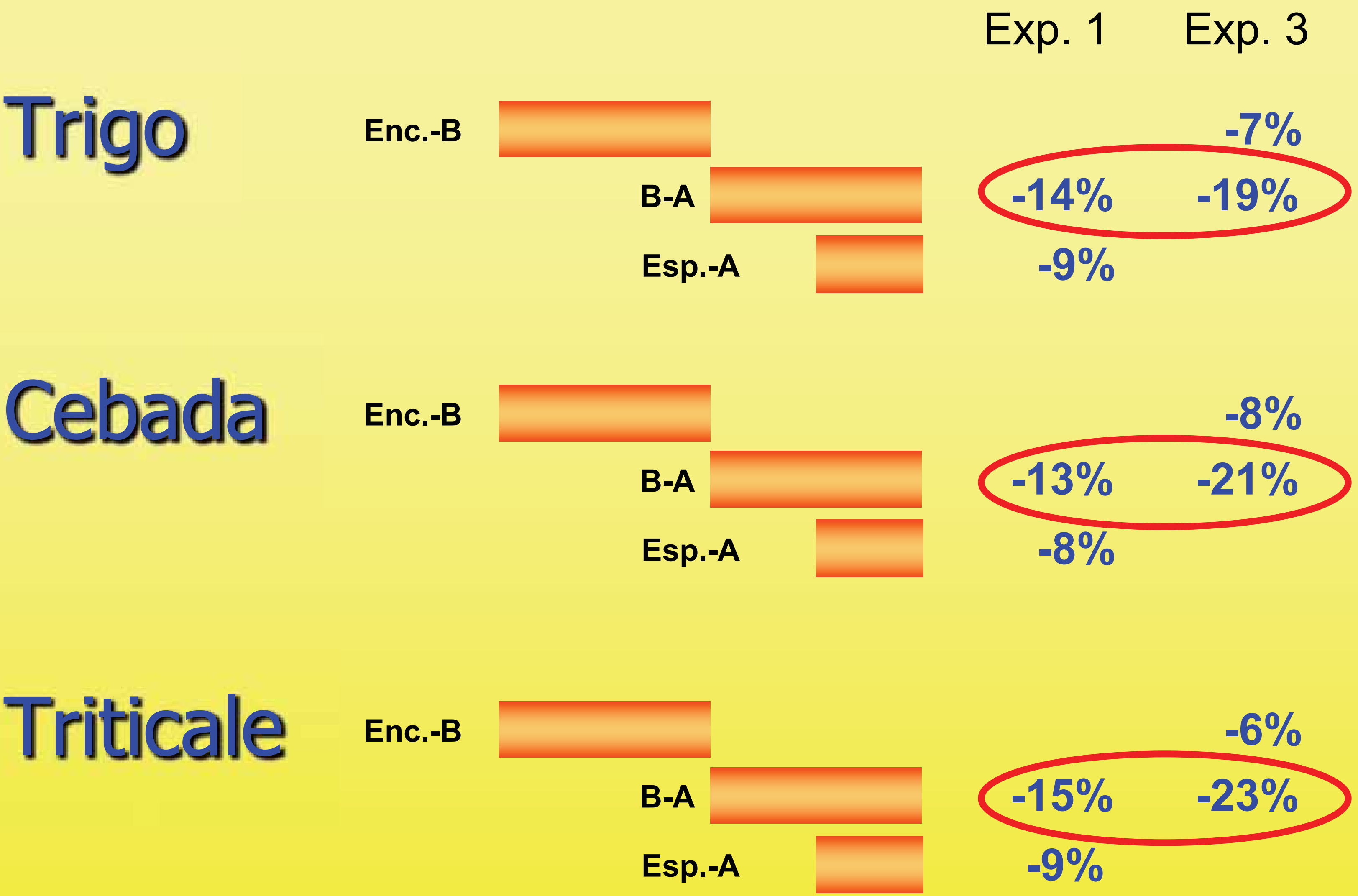
Cao et al. (2017)
Frontiers in Genetic

Determinación de los componentes del rendimiento en trigo



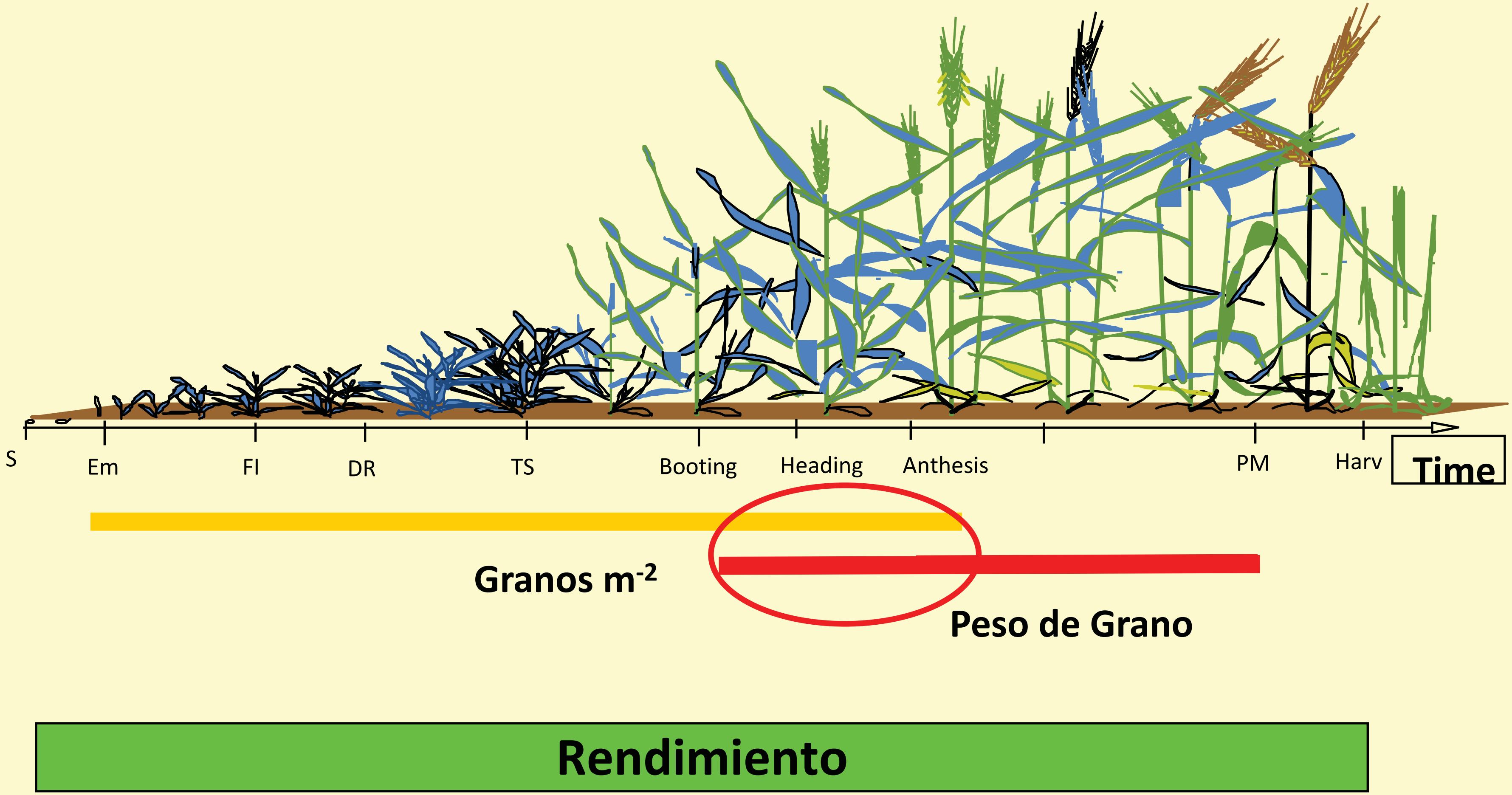
Adaptado de Slafer & Rawson (1995)

Incremento térmico pre-antesis sobre el peso de granos



Ugarte, Calderini & Slafer (2007)
Field Crops Research

Determinación de los componentes del rendimiento en trigo

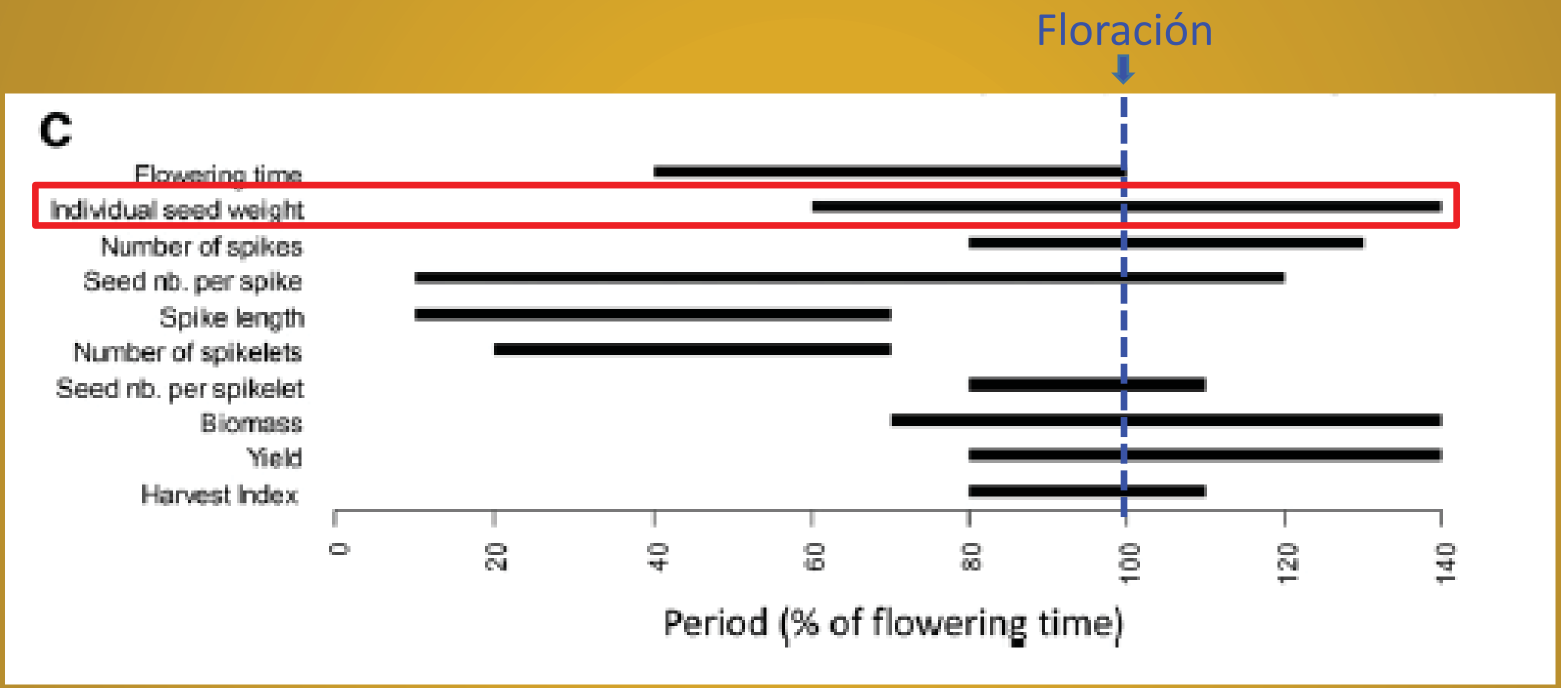


Esquema Slafer & Rawson (1995)

Calderini et al. (1999) Jounal of Agricultral Science

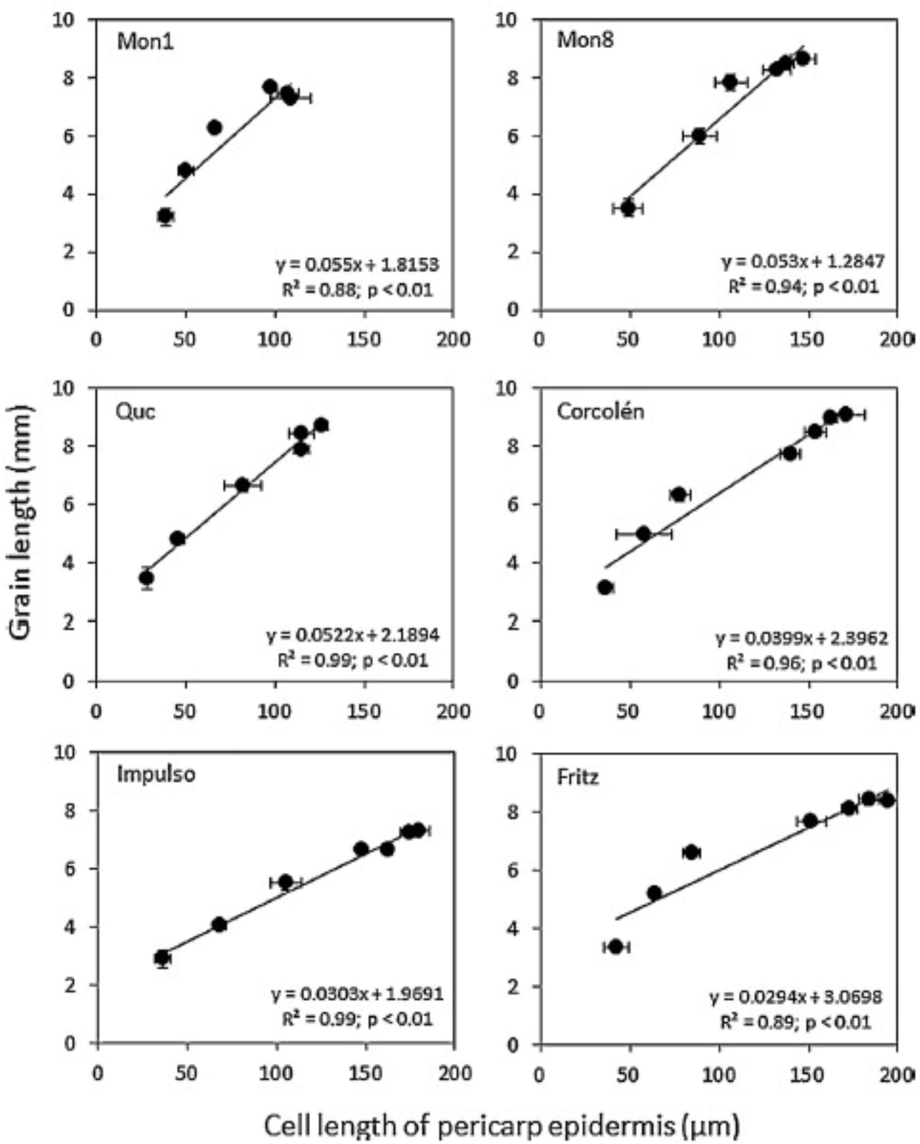
Calderini et al. (2001) Euphytica

Sensibilidad del peso de grano de trigo en distintas condiciones ambientales de Australia

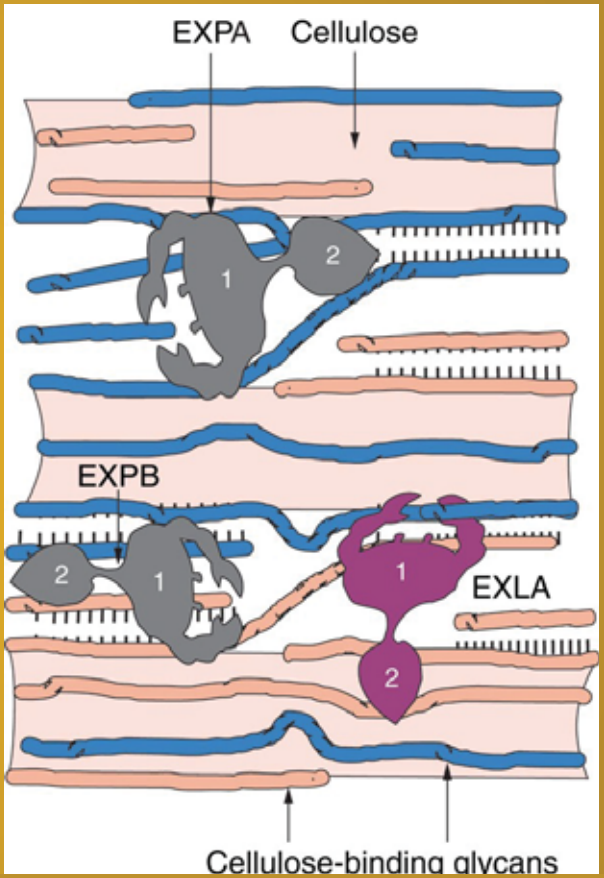


Parent et al. (2017)
Plant Physiology

Relación entre el largo de grano y el largo de las células del pericarpio en trigos de diferente ploidía



Las expansinas son agentes primarios en el ablandamiento de la pared celular

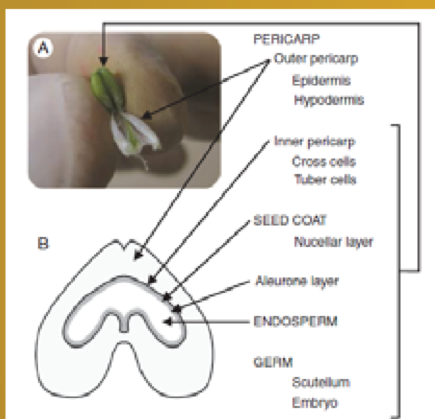


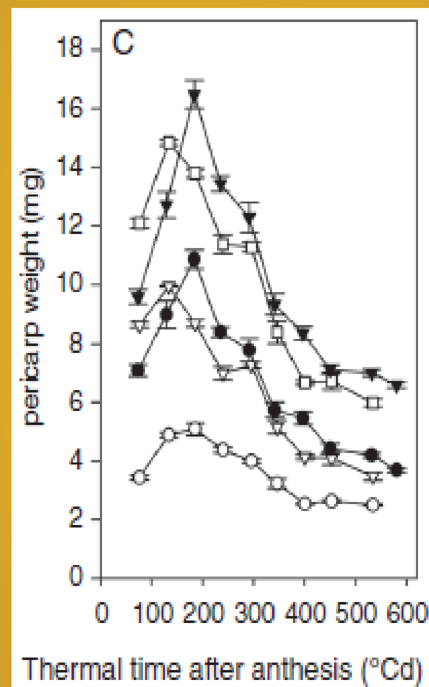
http://personal.psu.edu/fsl/ExpCentral/

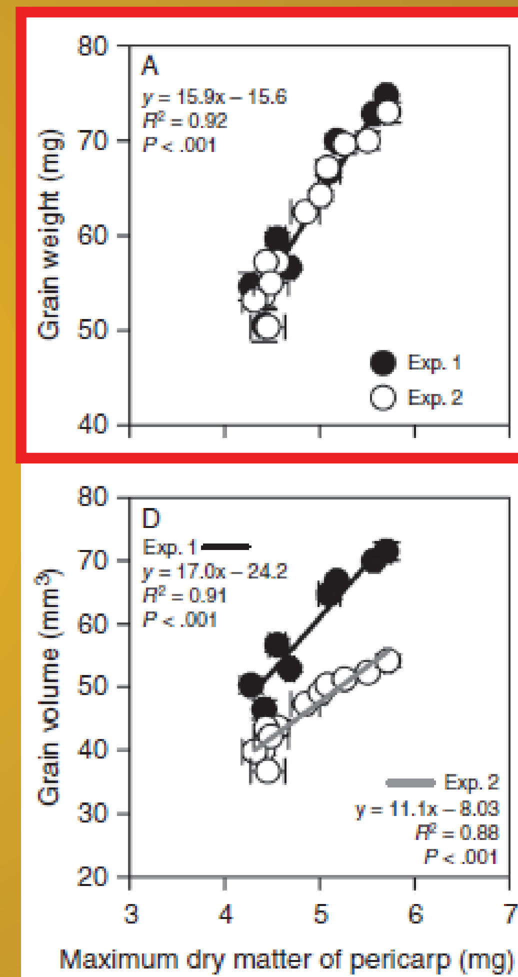
Muñoz & Calderini (2015)
Field Crops Research

Relación entre el peso final del grano y el peso máximo del pericarpio

(Experimentos de incremento térmico y reducción de la densidad de siembra)

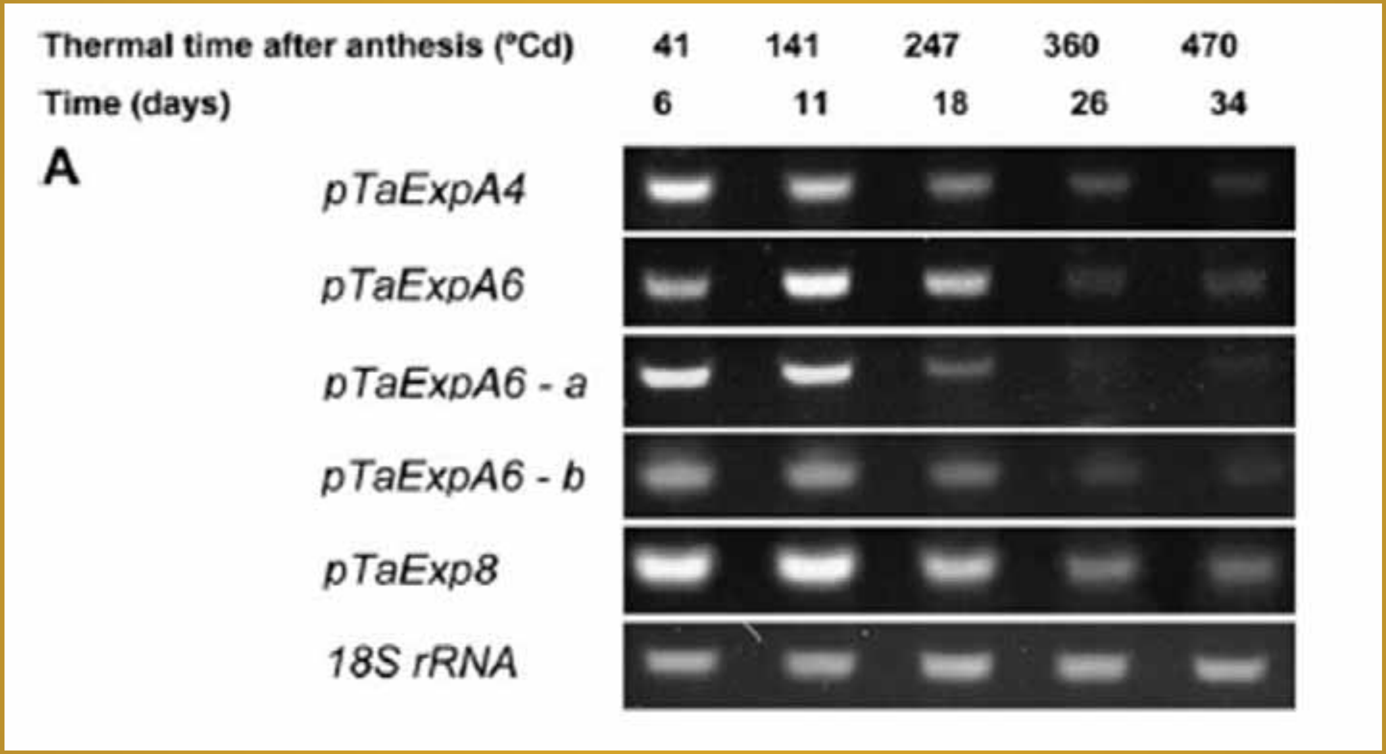






Herrera & Calderini (2020)
Annals of Botany

Expansin expression in grain wheat pericarp



Lizana et al. (2010)
Journal of Experimental Botany

Overexpresión de la expansina *Ib*Exp1 en *Arabidopsis* Incrementó el tamaño de semilla

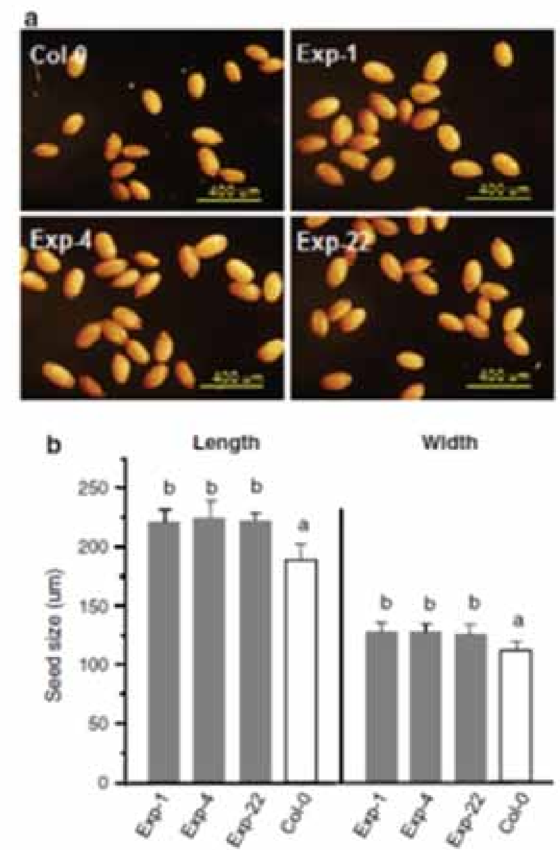


Fig. 2 Seed development in *IbEXP1*-ox plants. **a** Seed phenotype in *IbEXP1*-ox plants. Seeds were harvested at 10 weeks after planting and air-dried for more than 2 weeks. **b** Seed size comparison between *IbEXP1*-ox plants and Col-0 plants. Mean values of >50 seeds from at least six different plants with standard deviations are shown. *Different letters above the bars* indicate significantly different means ($P < 0.05$) as analyzed by Duncan's multiple range test using the IBM SPSS Statistics 21 program. **a, b** *Exp-1, 4,* and *22* represent *IbEXP1*-ox lines #1, #4, and #22, respectively

Bae et al. (2014)
Transgenic Research

El incremento térmico afectó la expresión de expansinas y las propiedades de la pared celular en trigo

Kino *et al. BMC Plant Biology* (2020) 20:170
https://doi.org/10.1186/s12870-020-02375-7

BMC Plant Biology

RESEARCH ARTICLE Open Access

Check for updates

High post-anthesis temperature effects on bread wheat (*Triticum aestivum L.*) grain transcriptome during early grain-filling

Richard I. Kino[1], Till K. Pellny[2], Rowan A. C. Mitchell[2], Asier Gonzalez-Uriarte[2,3] and Paola Tosi[1*]

Hierarchical clustering and gene ontology analysis resulted in the identification of a number of genes implicated in the regulation of cell wall expansion, predominantly expressed in the pericarp and significantly down-regulated under high p.a. temperatures, including endoglucanase, xyloglucan endotransglycosylases and a β-expansin. An over-representation of genes involved in the 'cuticle development' functional pathway that were expressed in the pericarp and affected by high p.a. temperatures was also observed.

Table 1 Knetminer output of the ten highest relevance scores of genes from pericarp specific cluster 2 cross-referenced with the search term 'cell wall'. *Unknown protein encoded.

Accession number	Gene name	Protein encoded	Protein Function	Relevance score
TRIAE_CS42_4AL_TGACv1_289281_AA0968300	GLU2/KOR3	Endoglucanase	cell wall assembly	544.88
TRIAE_CS42_4DS_TGACv1_363068_AA1183220	GLU2/KOR3	Endoglucanase	cell wall assembly	544.88
TRIAE_CS42_4BS_TGACV1_330027_AA1105540	GLU2/KOR3	Endoglucanase	cell wall assembly	537.96
TRIAE_CS42_7DL_TGACv1_603404_AA1983010	XTH17	Xyloglucan endotransglucosylase	cell wall reconstruction and expansion	248.43
TRIAE_CS42_7AL_TGACv1_556014_AA1752680	XTH	Xyloglucan endotransglucosylase	cell wall reconstruction and expansion	234.03
TRIAE_CS42_1DL_TGACv1_062395_AA0213780	NIP1-2	Nod26-like-intrinsic-protein/Aquaporin	facilitate water transport in and out of cells	122.99
TRIAE_CS42_6AS_TGACV1_485265_AA1542080	EXPB5	Beta-expansin	facilitate cell wall expansion	82.19
TRIAE_CS42_3AL_TGACV1_195682_AA0652690	PRP2	proline rich protein	specify cell-type specific wall structures	47.57
TRIAE_CS42_U_TGACv1_641891_AA2106790	PAS2	n/a*	Involved in cell division and differentiation	47.37

Estrategias para quebrar los *trade-off* e incrementar el rendimiento

Llamado de NIAB para propuestas de transformación de *Arabidopsis*, Trigo y Cebada

Community Resource for Wheat Transformation

Wheat transformation to increase grain yield and industrial quality by improving kernel weight

Simon McQueen-Mason & Daniel Calderini

We propose to **overexpress wheat ExpA 6**, using the previously characterized gene promoter. A common feature of this diverse group of genes is that their expression is restricted to the developing kernel but not to the embryo, leaf, root or shoot as the transcription was found restricted to the endosperm, aleurone and pericarp layers in developing kernels. The expression was confirmed later in aleurone and endosperm tissues and in endosperm and pericarp at very early stages (3–9 DPA) of kernel development.

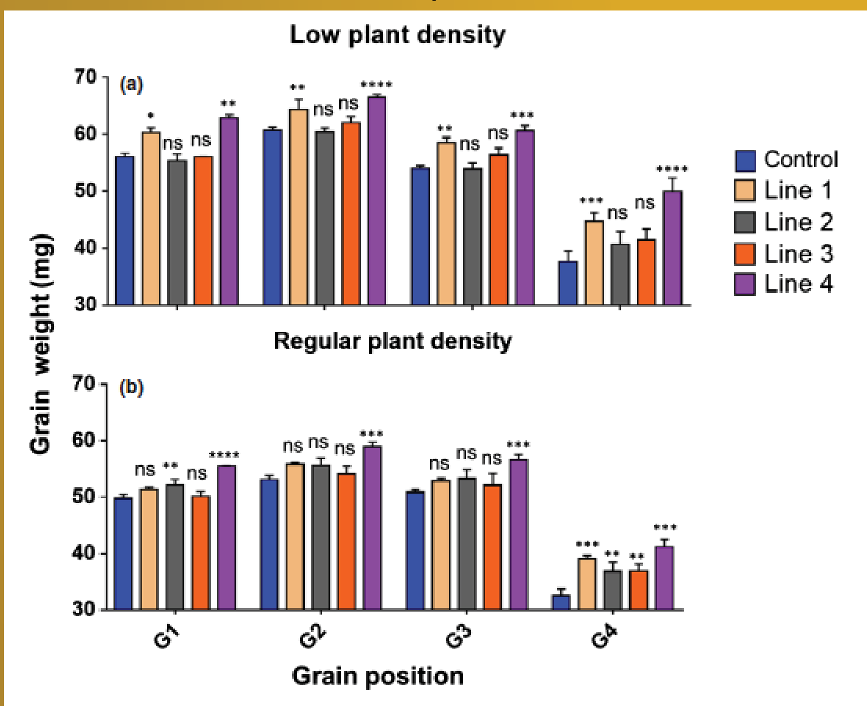
New Phytologist
Research

Overcoming the trade-off between grain weight and number in wheat by the ectopic expression of expansin in developing seeds leads to increased yield potential

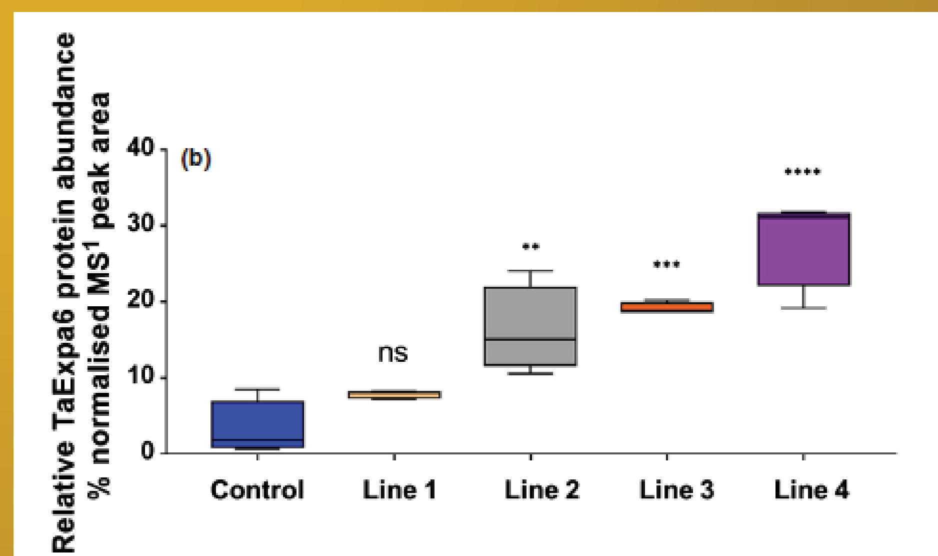
Daniel F. Calderini[1], Francisca M. Castillo[1,2], Anita Arenas-M[1,2], Gemma Molero[3], Matthew P. Reynolds[3], Melanie Craze[4], Sarah Bowden[4], Matthew J. Milner[4], Emma J. Wallington[4], Adam Dowle[5], Leonardo D. Gomez[5] and Simon J. McQueen-Mason[5]

[1]Institute of Plant Production and Protection, Universidad Austral de Chile, Campus Isla Teja, Valdivia 5090000, Chile; [2]Institute of Biochemistry and Microbiology, Faculty of Sciences, Universidad Austral de Chile, Valdivia 5090000, Chile; [3]International Maize and Wheat Improvement Center (CIMMYT), El Batán, Texcoco CP 56237, Mexico; [4]NIAB, 93 Lawrence Weaver Road, Cambridge, CB3 0LE, UK; [5]CNAP, Biology Department, University of York, Wentworth Way, Heslington, York, YO10 5YW, UK

Transcriptómica



Proteómica



Rendimiento y componentes en vástagos principales, macollos y total de líneas transgénicas con la ExpA6 y el WT

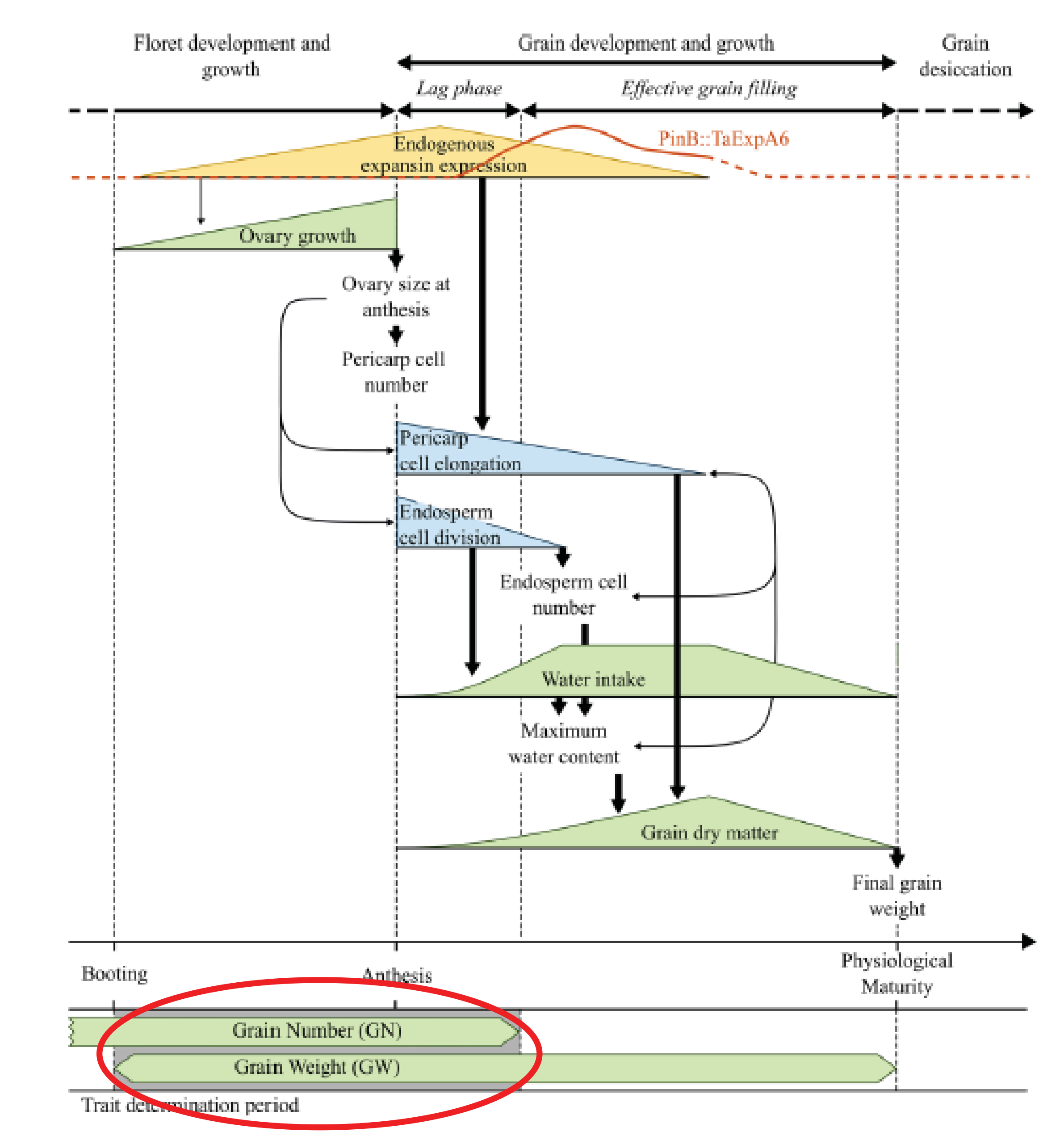
Table 2 Grain yield (GY), grain number (GN), and average grain weight (GW) per square metre of main stems, secondary tillers, and total in transformed lines and the control recorded in the field experiment at regular plant density of 300 m^{-2}.

	Main stems						Tillers						Total					
	GY (g m^{-2})		GN (m^{-2})		GW (mg)		GY (g m^{-2})		GN (m^{-2})		GW (mg)		GY (g m^{-2})		GN (m^{-2})		GW (mg)	
Wheat line	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
Line 4	524 **	10.3	11 124 ns	347	47.1 ****	0.6	563 ns	30.3	13 148 ns	499	42.7 **	0.8	1086 *	39.2	24 272 ns	814	44.8 **	0.4
Line 1	533 **	42.5	12 533 *	972	42.5 ns	0.1	516 ns	45.2	12 836 ns	1127	40.2 ns	0.4	1049 ns	77.2	25 369 ns	1803	41.3 *	0.3
Line 2	464 ns	9.1	10 756 ns	374	43.3 ns	1.5	469 *	39.7	11 627 *	1359	40.7 ns	1.5	934 ns	39.3	22 382 ns	1684	41.9 ns	1.6
Line 3	459 ns	45.0	11 520 ns	950	39.8 ns	1.7	449 **	35.0	12 709 ns	634	35.2 **	1.1	907 ns	79.9	24 229 ns	1572	37.4 ns	1.4
Control	441	19.7	10 781	424	40.6	1.0	535	17.0	13 513	322	39.1	0.5	976	35.8	24 294	724	39.8	0.6
ANOVA (*P*-value)	0.092*		0.270 ns		0.019**		0.039**		0.379 ns		0.010**		0.073*		0.455 ns		0.012**	
Line 4 and control (%)	18.9		3.2		16.0		5.1		−2.7		9.2		11.3		−0.1		12.3	

ANOVA *P*-value and relative difference (%) for each trait between line 4 and the control is shown at the bottom of the table.
All data are shown as mean and SEM. Control line corresponds to spring wheat cv Fielder that has undergone the same tissue culture process as the transformed lines. The phenotype data of each line was compared with control using Fisher's least significant difference test *post hoc*; asterisks indicate significant effects: *, $P < 0.10$; **, $P < 0.05$; ****, $P < 0.001$; ns, not significant.

Calderini et al. (2014)
New Phytologist

Esquema de la determinación del peso de grano en trigo



Calderini et al. (2020)
New Phytologist

Otras estrategias en trigo y otros cultivos

Número de granos en trigo

PNAS

Unleashing floret fertility in wheat through the mutation of a homeobox gene

Shun Sakuma[a,b,c,1], Guy Golan[d], Zifeng Guo[b], Taiichi Ogawa[a,e], Akemi Tagiri[a], Kazuhiko Sugimoto[a,f], Nadine Bernhardt[g], Jonathan Brassac[g], Martin Mascher[h,i], Goetz Hensel[j], Shizen Ohnishi[k], Hironobu Jinno[k], Yoko Yamashita[l], Idan Ayalon[d], Zvi Peleg[d], Thorsten Schnurbusch[b,m,1], and Taka

[a]Agrogenomics Research Center, National Institute of Agrobiological Sciences, 305-8602 Tsukuba, Japan;
Architecture, Leibniz Institute of Plant Genetics and Crop Plant Research, 06466 Gatersleben, Germany; [c]F
Tottori, Japan; [d]The Robert H. Smith Institute of Plant Sciences and Genetics in Agriculture, The Hebrew
[e]Institute of Agrobiological Sciences, National Agriculture and Food Research Organization, 305-8518 Ts
Agriculture and Food Research Organization, 305-8518 Tsukuba, Japan; [g]Research Group Experimental T
Crop Plant Research, 06466 Gatersleben, Germany; [h]Independent Research Group Domestication Genom
Plant Research, 06466 Gatersleben, Germany; [i]German Centre for Integrative Biodiversity Research Halle
Group Plant Reproductive Biology, Leibniz Institute of Plant Genetics and Crop Plant Research, 06466 Ga
Experiment Station, Hokkaido Research Organization, 099-1496 Kunneppu, Japan; [l]Central Agricultural
Organization, 069-1395 Naganuma, Japan; and [m]Institute of Agricultural and Nutritional Sciences, Facult
Halle-Wittenberg, 06120 Halle, Germany

Peso de granos en arroz

nature COMMUNICATIONS

ARTICLE

DOI: 10.1038/s41467-017-01501-8 OPEN

NOG1 increases grain production in rice

Xing Huo[1], Shuang Wu[1], Zuofeng Zhu[1], Fengxia Liu[1], Yongcai Fu[1], Hongwei Cai[1], Xianyou Sun[1], Ping Gu[1], Daoxin Xie[2], Lubin Tan[1] & Chuanqing Sun[1]

Peso de granos en trigo sin mostrar rendimiento

Mol Breeding (2017) 37: 78
DOI 10.1007/s11032-017-0676-y

CrossMark

Cloning of *TaTPP-6AL1* associated with grain weight in bread wheat and development of functional marker

Pengfei Zhang · Zhonghu He · Xiuling Tian · Fengmei Gao · Dengan Xu · Jindong Liu · Weie Wen · Luping Fu · Genying Li · Xinxia Sui · Xianchun Xia · Chunping Wang · Shuanghe Cao

Actividades actuales y futuras

Proyecto FONDECYT Regular 2021

Agencia Nacional de Investigación y Desarrollo
Ministerio de Ciencia, Tecnología, Conocimiento e Innovación

CONVENIO FINANCIAMIENTO PROYECTO FONDECYT REGULAR 2021

AGENCIA NACIONAL DE INVESTIGACIÓN Y DESARROLLO-FONDECYT/INVESTIGADOR(A) RESPONSABLE/INSTITUCIÓN(ES) PATROCINANTE(S)

En Santiago de Chile, a 05 de marzo de 2021, comparecen, por una parte, la Subdirectora de Proyectos de Investigación de la Agencia Nacional de Investigación y Desarrollo, en adelante la Agencia, que se individualiza al final del presente instrumento, en representación de esta entidad domiciliada para estos efectos en calle Moneda 1375, comuna de Santiago, y, por la otra parte, el(la)Investigador(a) Responsable y la(s) Institución(es) Patrocinante(s) que se individualizan al final del presente convenio, quienes acuerdan lo siguiente:

PRIMERO: ANTECEDENTES DEL PROYECTO

La Agencia declara que en el Concurso Nacional de Proyectos FONDECYT Regular 2021 ha sido aprobado el proyecto **Nº1211040** (Anexo Nº1), titulado: **"UNRAVELLING THE MECHANISMS CONTROLLING THE TRADE-OFF BETWEEN KERNEL WEIGHT AND GRAIN NUMBER TO IMPROVE YIELD AND CROP ADAPTATION OF WHEAT",** con una duración de **4** años, por un monto total de **$240.900.000,** como se indica a continuación:

Convenio Bioceres – UACh – Universty of York - NIAB

MUTUAL NONDISCLOSURE AGREEMENT

THIS MUTUAL NONDISCLOSURE AGREEMENT ("Agreement") is entered into on the day the last Party to sign it signs it, ("Effective Date"), by and between (i) Bioceres Crop Solutions Corp. (BCP), a Cayman Islands exempted company, having offices at Ocampo 210bis, 2000, Rosario, Santa Fe, Argentina; (ii) Universidad Austral de Chile (UACh), a nonprofit educational corporation having offices at Independencia 631, Valdivia, Chile; (iii) University of York (UYork) a body incorporated in England and Wales by Royal Charter with registration number RC000679, whose principal offices are at Heslington, York, YO10 5DD, United Kingdom; and (iv) and NIAB 93, Lawrence Weaver Road, Cambridge, CB3 0LE, United Kingdom. Collectively BCP, UACh, UYork and NIAB may also be referred to as the "Parties" and individually as a "Party."

RECITALS:

WHEREAS, BCP, UACh, UYork and NIAB are each engaged in research and development of wheats that overexpress expansion only in grains using a promoter such as that used in Calderini et al. (2020)[1] by genetic engineering or by gene editing to increase grain weight and crop yield;

WHEREAS, BCP, UACh, UYork and NIAB each have expertise and information in their respective research areas which they each desire to retain as confidential and proprietary; and

WHEREAS, the Parties desire to enter into discussions and possibly a business arrangement to carry out research activities;

NOW, THEREFORE, in consideration of the promises and covenants hereinafter contained and other good and valuable consideration the receipt of which is acknowledged, the Parties agree as follows:

1. "Purpose" shall mean the disclosure between the Parties of their respective Confidential Information under terms that will protect the confidential and proprietary nature of such information, and thereby allowing the Parties to discuss possibly entering into and actually carrying out business and research activities in the area of increasing grain weight and yield inwheat .

Estudio de resiliencia en trigo y raps

Specie	Expt.	Treatment	GN		TGW		Grain protein	
			(10^3 m^{-2})	Change (%)	(g)	Change (%)	(%)	Change (%)
Wheat	Va	C	**21** ± 2 a	-	**64.2** ± 2.1 a	-	**10.5** ± 0.2 a	-
		S	**20** ± 1 a	-5.7	**59.1** ± 0.8 a	-7.9	**10.6** ± 0.2 a	0.4
		HT	**24** ± 1 a	13.6	**60.6** ± 0.4 a	-5.6	**11.0** ± 0.2 a	4.3
		S+HT	**23** ± 1 a	6.9	**59.0** ± 1.3 a	-8.0	**10.8** ± 0.2 a	2.1
	BA	C	**19** ± 3 a	-	**56.6** ± 0.7 a	-	**12.8** ± 0.5 a	-
		S	**16** ± 1 a	-19.7	**50.0** ± 1.0 b	-11.6	**14.4** ± 1.4 a	12.7
		HT	**15** ± 1 a	-23.8	**49.7** ± 2.6 b	-12.1	**13.0** ± 0.4 a	1.7
		S+HT	**13** ± 1 a	-32.9	**42.9** ± 0.9 c	-24.2	**14.7** ± 1.0 a	15.0

Mean ± standard error of mean. Different letters indicate significant differences between treatments within each experiment ($p<0.05$)

Specie	Expt.	Treatment	GN		TGW		Grain oil		Grain protein	
			(10^3 m^{-2})	Change (%)	(g)	Change (%)	(%)	Change (%)	(%)	Change (%)
Rapeseed	Va	C	**313** ± 17 a	-	**2.9** ± 0.1 a	-	**48.2** ± 0.2 a	-	**17.9** ± 0.5 a	-
		S	**219** ± 19 b	-31.6	**3.6** ± 0.1 bc	24.4	**48.2** ± 0.3 a	0.0	**18.9** ± 0.3 a	5.5
		HT	**270** ± 24 ab	-14.2	**3.3** ± 0.1 b	12.2	**48.4** ± 0.1 a	0.4	**18.8** ± 0.3 a	5.1
		S+HT	**194** ± 24 b	-39.5	**4.2** ± 0.1 c	42.7	**48.1** ± 0.3 a	-0.1	**19.6** ± 0.5 a	9.5
	BA	C	**151** ± 11 a	-	**3.2** ± 0.1 a	-	**43.9** ± 0.7 a	-	**21.9** ± 0.6 c	-
		S	**97** ± 10 b	-36.1	**3.7** ± 0.1 a	13.5	**40.8** ± 1.1 a	-7.1	**24.4** ± 0.7 ab	11.2
		HT	**125** ± 15 ab	-17.1	**3.2** ± 0.1 a	0.4	**43.5** ± 1.5 a	-0.9	**22.6** ± 1.2 bc	3.1
		S+HT	**116** ± 11 ab	-23.2	**2.4** ± 0.3 b	-24.6	**40.4** ± 1.0 a	-8.1	**25.1** ± 0.8 a	14.7

Mean ± standard error of mean. Different letters indicate significant differences between treatments within each experiment ($p<0.05$)

Gonzalo Rivelli (datos no publicados)

CONCLUSIONES

- La seguridad alimentaria, el cambio climático y la sustentabilidad son los mayores desafíos de la agricultura del siglo 21
- Para incrementar el rendimiento de trigo existen *trade-offs* que no son simples de quebrar y no los conocemos en profundidad
- La superposición en la determinación del número y el peso de los granos entre bota y 10 DDA podría ser clave para romperá el *trade-off*
- Puede haber algunas alternativas para incrementar los rendimientos complementando e integrando conocimientos de distintos niveles de organización (biología molecular, genética, fisiología y agronomía)
- La comprensión de la resiliencia que experimentan diversos cultivos en el sur de Chile nos podría proveer herramientas para lograr la adaptación de los cultivos al cambio climático

Agradecimientos

A la Academia Chilena de Ciencias Agronómicas, sus presidentes y miembros

A Gustavo Slafer, Roxana Savin, Gabriela Abeldo, Daniel Miralles, Carolina Lizana, Patricio Sandaña, Alejandro Quintero, Francisca Castillo, Jaime Herrera, Daniela Bustos-Kort, Gonzalo Rivelli, Déborah Rondanini, el personal del campo experimental de la FA-UBA y de la EEAA.

A todas/os,

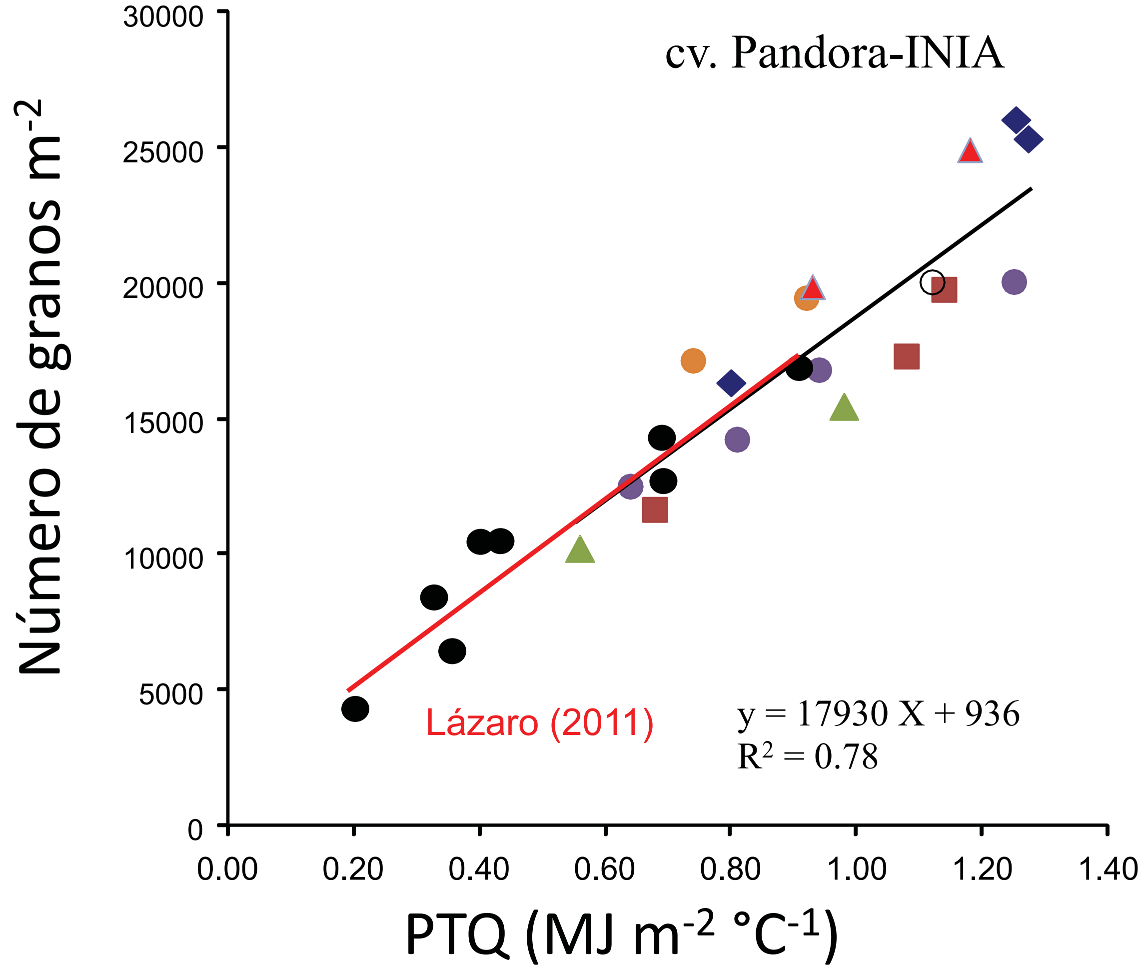
¡MUCHAS GRACIAS!

Estrategias para incrementar el rendimiento de trigo quebrando el *trade-off* entre el peso y el número de granos

Daniel F. Calderini
Universidad Austral de Chile

Academia Chilena de Ciencias Agronómicas
Diciembre 2021

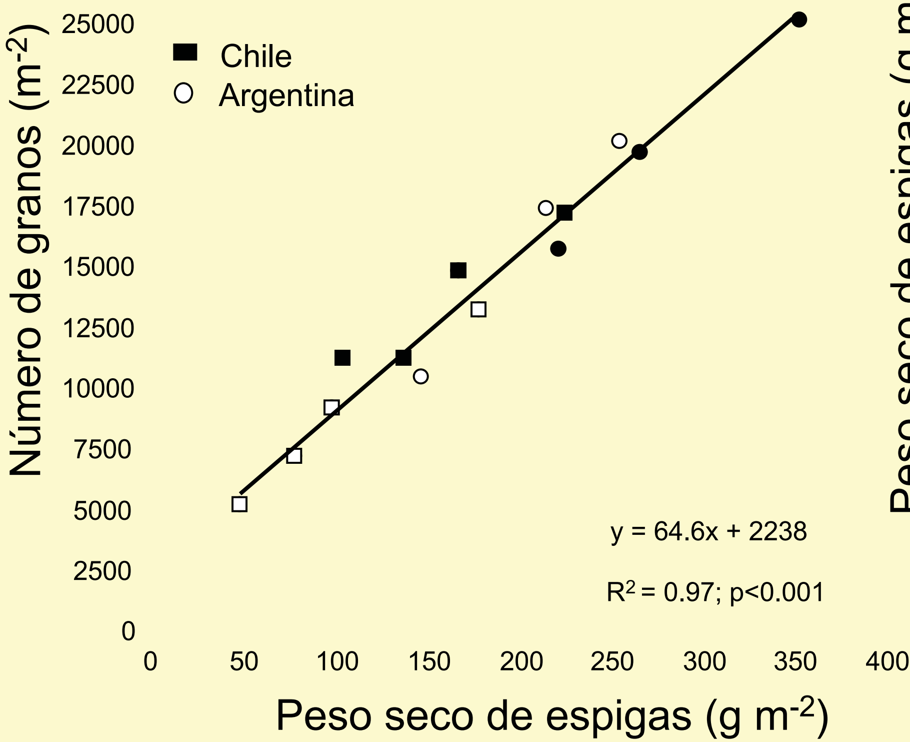
Relación entre el número de granos y el cociente fototermal en trigo

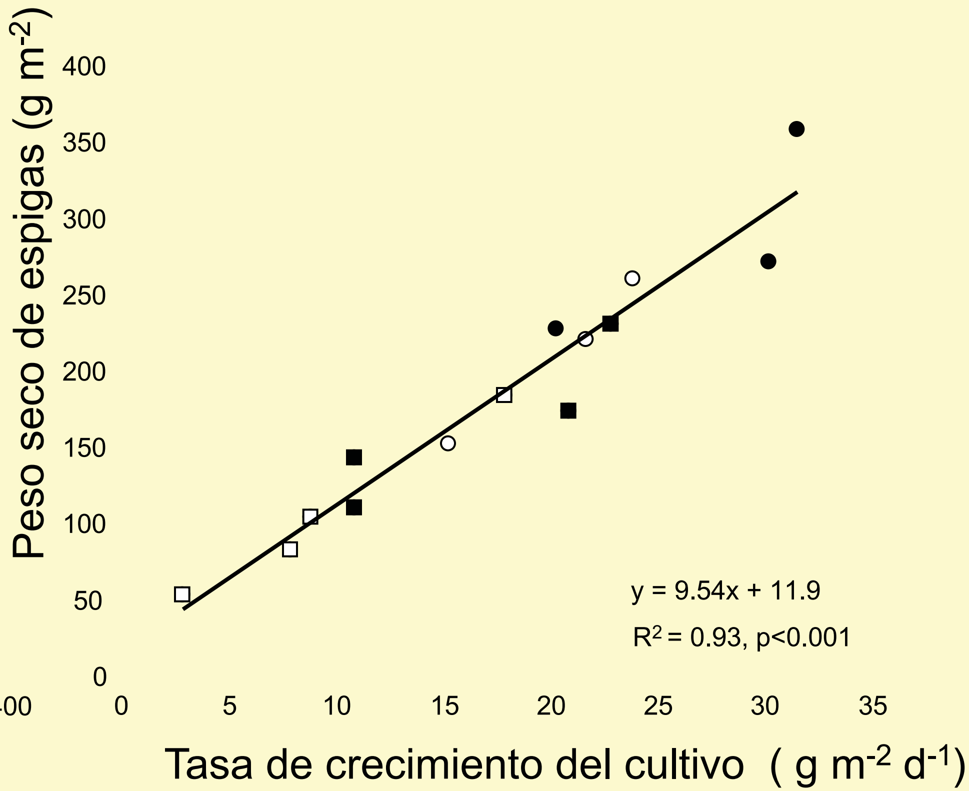


PTQ calculado para 8 ambientes con radiación PAR interceptada y T° base= 4,5°C

Sandaña (2013)

Relaciones Funcionales con el Número de Granos en Trigo





Lázaro et al. (2009)
Field Crops Research

Sandaña & Pinochet (2011)
Field Crops Research

Cambio de Hábitos Alimentarios