Effect of temperature during grain filling on the amylose/starch ratio in maize hybrids with different grain hardness

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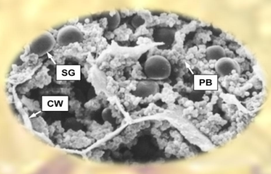
Introduction

Maize dry-milling industry demands high grain hardness in order to maximize the yield of coarse fractions during grinding (1)

Maize grain hardness is an intrinsic property of the genotype (2), but it is modulated by the crop growing conditions (3)

In the hard endosperm, starch granules and proteins are more strongly bound than in the starchy endosperm (4). Endosperms with high proportion of amylose would be more compressible and therefore, more dense and harder than an endosperm with a high proportion of amylopectin (5).



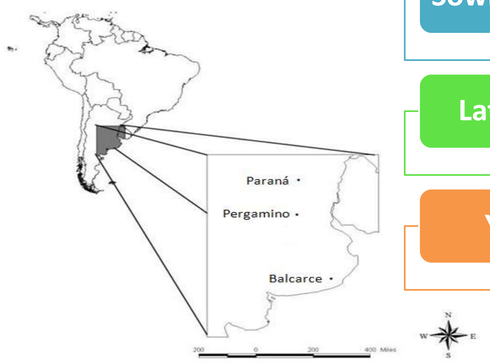
PB: Protein bodies
SG: Starch granules
CW: Cell wall

Actis (6) observed changes in amylose/starch ratio in maize grains from different environments. In that work, grains from late sowing dates presented less amylose concentration than those from early dates.

Changes in the amylose/starch ratio between environments could be explained by the direct effect of temperature on the Starch branching enzyme (7).

The aim of this work was to evaluate the effect of temperature during grain filling on the grain amylose/starch ratio in three maize hybrids differing in grain hardness (i.e, flint, semi-flint and semi-dent).

Materials and methods



Sowing dates — 2 — Early, Late

Latitudes — 3 — 31◦43 S longitude 60◦32 W; 33◦53 S longitude 60◦34 W; 37◦50 S longitude 58◦15 W

Years — 2 — 2009-10; 2010-11

Hybrid — 3 — Semi-dent: AW 190; Semi-flint: Cóndor; Flint: M522

At each location, treatments were arranged in a split-plot design with three replicates:
- Main plots: Sowing date
- Sub-plots: Hybrids

At harvest time total grain yield, grain number, weight per grain, starch and amylose concentration were determined.

Starch and amylose content and concentration: Grain amylose concentration was determined by Knutson (8) method with modifications from Robutti *et al.* (9), and the starch concentration by the method of Dubois *et al.* (10). Starch and amylose content were obtained by multiplying their concentration by weight per grain.

Results and discussion

Positive and lineal relationships between mean temperature during grain filling and amylose/starch ratio were detected for the semi-flint and the semi-dent hybrids (Figure 1). Amylose/starch ratio variations were not asociated with mean temperature for the flint hybrid (p = 0.7584).
These trends are supported by data from wheat trials, in which increases in postanthesis temperature increased the amylose percentage and reduced grain starch percentage (11).

Table I: Mean temperature during grain-filling (from silking to physiological maturity) of three hybrids grown at three locations with two sowing dates during 2009–2010 and 2010–2011 growing seasons.

Location	Year	Sowing Date	Mean Temperature (°C)
Balcarce	2009-10	Early	20.51
		Late	16.43
	2010-11	Early	21.02
		Late	18.29
Pergamino	2009-10	Early	23.83
		Late	20.16
	2010-11	Early	21.57
		Late	18.44
Paraná	2009-10	Early	25.22
		Late	22.47
	2010-11	Early	25.20
		Late	21.22

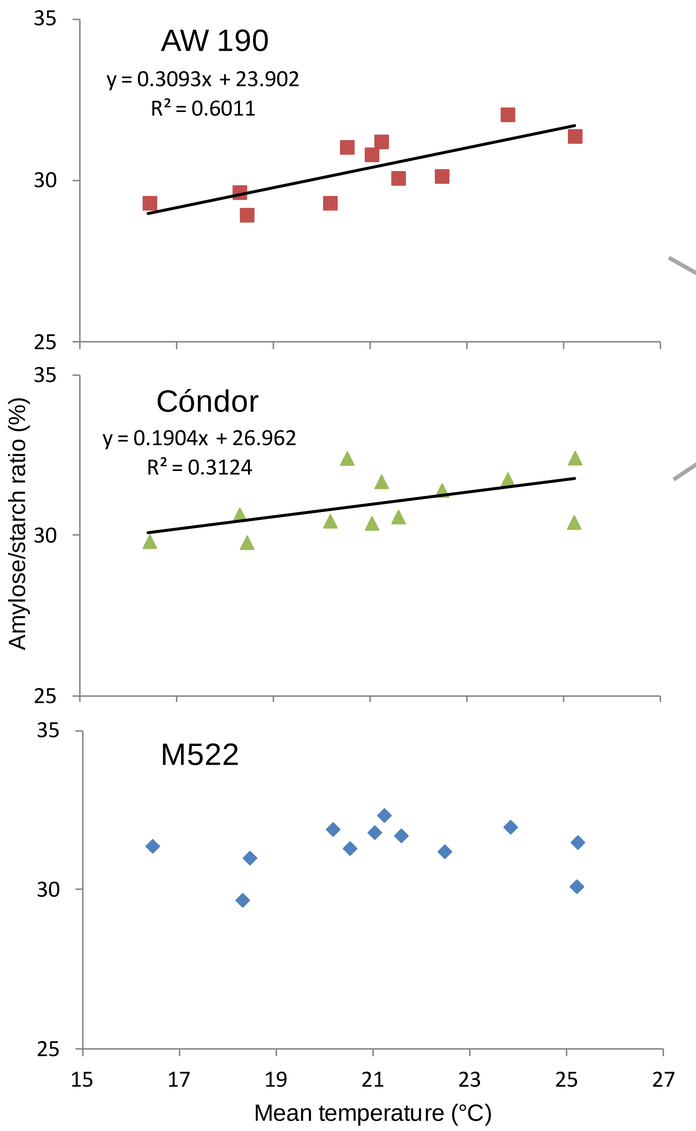


Fig. 1. Amylose/starch ratio (as percentage) as a function of mean temperature during grain filling for three maize hybrids: Semi-dent hybrid AW 190 (squares), Semi-flint hybrid Condor (triangles) and flint hybrid M522 (diamonds). Each symbol corresponds to the mean of three replications (p value ≤ 0.0589).

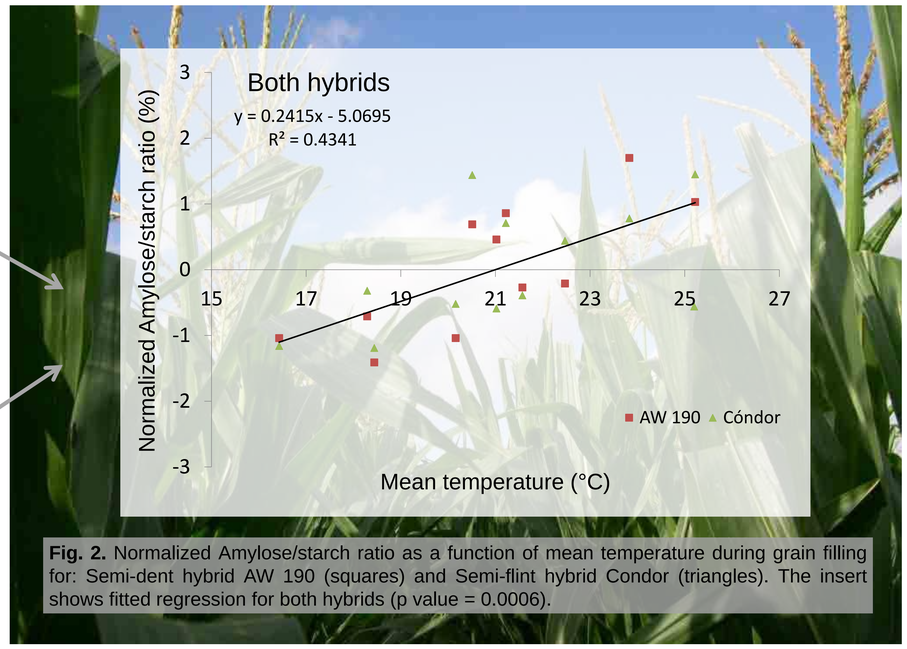


Fig. 2. Normalized Amylose/starch ratio as a function of mean temperature during grain filling for: Semi-dent hybrid AW 190 (squares) and Semi-flint hybrid Condor (triangles). The insert shows fitted regression for both hybrids (p value = 0.0006).

The results in non flint hybrids could be explained by the model proposed by Lenihan et al. (8), which hypothesizes that temperature affects chain branching on the step catalyzed by the starch branching enzyme, reducing amylopectin synthesis.

Concluding remarks

In the non flint hybrids analyzed, as latitude was increased or sowing date was delayed the amylose/starch ratio was reduced. This is in accordance with the cooler condition during the grain filling period for these environments.
The flint hybrid did not show a relationship between mean temperature during grain filling and grain amylose/starch ratio.
These findings would be useful for maize production for dry milling industry and other uses.

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