An alternative system for classifying earliness in maize varieties in Sweden

Halling M.A.
Department of Crop Production Ecology, Swedish University of Agricultural Sciences, Ulls väg 16, 756 51 Uppsala, Sweden; magnus.halling@slu.se

Abstract

Classifying earliness, or adaptation to a certain climate, is very important in varieties of maize (*Zea mays* L.). The most common classification system is the Food and Agriculture Organization (FAO) maturity class. This study systematically explored the response of maize varieties with different earliness in the maize-growing area in Sweden and examined possible alternatives to the FAO system for classifying earliness in maize varieties in Sweden. Based on differences in maturation rate according to the FAO index, four maize varieties were selected from variety trials in Sweden 2009-2011. At four sites (56°02-59°71N), the development of these varieties was determined on four occasions, when the standard variety Avenir was at silking, milk, dough and dent. Aboveground dry matter (DM) yield, DM content and starch content were measured on the latter three occasions and at final harvest of Avenir. Ontario Corn Heat Units (CHU) were calculated for all sites. DM and starch content in the varieties Avenir and Jasmic showed a significant high linear correlation with CHU (R^2=0.79 and 0.75, respectively). It was concluded that an index based on the correlation between DM or starch concentration and CHU could be an alternative to the FAO maturity class system for ranking earliness in maize varieties in the Nordic countries.

Keywords: maize, DM-yield, starch, classification system

Introduction

Earliness, or adaptation to a certain climate, is very important in maize varieties. Earliness is most commonly categorised using the Food and Agriculture Organization (FAO) maturity class system (Zscheischler *et al.*, 1990). This gives a three-digit index, the first digit of which is the maturity class (from 1 to 9), the second the earliness and the third grain colour. A difference in index of 10 units is equal to a 1-2 day difference in earliness or a 1-2% difference in dry matter (DM) content. All varieties are compared against a group of standard varieties but characteristics can vary over time, so FAO scores are not absolute and therefore alternatives are needed, especially in marginal areas for maize growing. The aim of this study was to systematically explore the response of maize varieties with different FAO earliness scores in the maize-growing area in Sweden and suggest possible alternatives to the FAO maturity class system for classifying the earliness of maize varieties in Sweden.

Methods

Using data from variety trials in Sweden 2009-2011, four maize varieties were selected based on differences in maturation rate according to the FAO index (180, 190, 210 and 240 for Avenir, Isberi, Jasmic and Nerissa, respectively). The development of the varieties was determined on four occasions, i.e. when the standard variety Avenir was at the stages R1 (silking), R3 (milk), R4 (dough), R5 (dent) at final harvest according the MAO (Ministry of Agriculture Ontario) (2002) scale. Aboveground DM yield, DM content and starch content were measured when Avenir was at R3, R4, R5 and final harvest. This was done at four locations in 2009 and three locations in 2010 and 2011, i.e. 10 field trials in total (sites located between 56°02N and 59°71N). Only Avenir and Jasmic were represented at all 10 sites. On each sampling occasion, three plants were randomly harvested from the border rows and subdivided into cobs and leaves plus stems. Immediately after harvest, a sub-sample was dried (110°C, 10 hours) and DM

content (%) was determined. The starch content (%) in the whole aboveground biomass was measured by an enzymatic method (Bengtsson and Larsson, 1990). At the last (final) harvest, the biomass in the whole plot (1.5×12 m) was cut and weighed and the aboveground biomass (g m^{-2}), DM content and starch content were measured. Starch was determined using near-infrared spectrometry. Ontario Corn Heat Units (CHU) were calculated according to the equation:

$$CHU = (9/5(T_{min} - 4.4C)+(3.33(T_{max} - 10.0) - 0.084(T_{max} - 10.0)^2))/2$$

using daily weather data from the nearest weather station (MAO, 1997).

Results and discussion

There was a clear linear regression between maize variety development and CHU. Figure 1 shows examples for two sites in 2009. The slope of the regression line was higher at the northern site Örsundsbro (56°02N) than at the southern site Kristianstad (59°71N) and the initial recording started at a higher CHU level. This means that the maize required more CHU at the northern site to reach flowering (R1), but thereafter development was faster than at the southern site. Similarly, Mussadiq *et al.* (2012) demonstrated a site effect on the development of maize varieties with different FAO maturity classes, but the ranking in earliness between the varieties in their trials was the same as between the sites. Our linear regressions for 2009 (Figure 1) showed a significant fit, with R^2 values between 0.87 and 0.99. For Avenir to reach dough stage (R4) in 2009, it required 2,244 CHU in Örsundsbro, but 2,296 CHU in Kristianstad.

The DM and starch content in the varieties Avenir and Jasmic showed a significant high linear correlation with CHU (Figure 2). Nonlinear models were also tested, but they had lower R^2 values. The difference in slope between the varieties in terms of DM content (Figure 2a) was mainly an effect of outliers in Västerås in 2010. Jasmic had the highest correlation (R^2=0.79). To reach 30% DM, Avenir needed 2,230 CHU and Jasmic 2,408 CHU. For the starch content in Figure 2b, the slope and fit between the varieties were rather equal. To reach 300 g starch g^{-1} DM, Avenir needed 2,304 CHU and Jasmic 2,480 CHU. Because of the high correlations obtained, an earliness index based on the data in Figure 2 could be an alternative to the FAO maturity class system. However, the CHU equation, which was developed in eastern Canada, has not been fully validated for Nordic conditions. Although, as seen from the results, CHU seems to be a useful tool to relate changes in DM- and starch content in varieties with earliness.

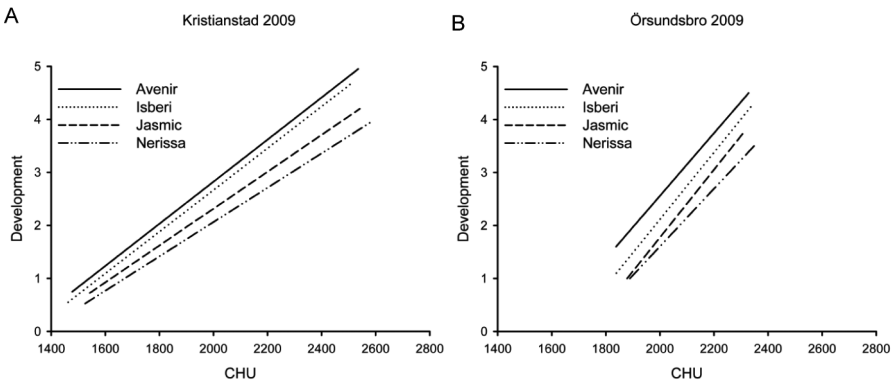

Figure 1. Linear regression between Corn Heat Units (CHU) and development stage R1-R5 (MAO, 2002) for four maize varieties grown in 2009 in (a) Kristianstad (R^2=0.99, n=10) and (b) Örsundsbro (R^2=0.87, n=9).

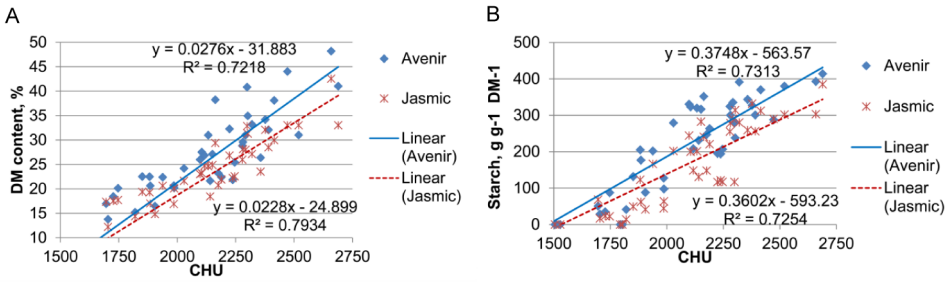

Figure 2. Linear regression between Corn Heat Units (CHU) and (a) dry matter (DM) content and (b) starch content, in all 10 trials carried out in Sweden.

Conclusions

An index based on the correlation between DM or starch content (%) and CHU could be an alternative to the FAO maturity class system when ranking earliness in maize varieties in the Nordic countries.

Acknowledgements

The project was funded by The Swedish Farmers' Foundation for Agricultural Research (grant number H0841015).

References

Bengtsson S. and Larsson K. (1990) Determination of starch in a flow-injection system with immobilized enzymes. *Swedish Journal of Agricultural Research* 20, 27-29.

MAO (1997) Corn Heat Units for corn and other warm season crops in Ontario. *Publication 93-119: Fact sheet*. Ministry of Agriculture Ontario, Canada.

MAO (2002) Corn development (chapter 1.4). In: *Agronomy Guide for Field Crops. Publication 811*. Ministry of Agriculture Ontario, Canada. Available at: http://tinyurl.com/o3l2yl6.

Mussadiq Z., Hetta M., Swensson C. and Gustavsson A.-M. (2012) Plant development, agronomic performance and nutritive value of forage maize depending on hybrid and marginal site conditions at high latitudes. *Acta Agriculturae Scandinavica Section B – Soil and Plant Science* 62(5), 420-430.

Zscheischler J., Estler M., Staudacher W., Gross F., Burgstaller G. and Rechmann T. (1990) *Handbuch Mais*. Umweltgerechter Anbau Wirtschaftliche Verwertung. DLGVerlag Frankfurt (Main), Germany, pp. 108-109.