Model-estimated photoperiod sensitivity of spring wheat and barley

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Introduction

Photoperiod sensitivity is of primordial importance in setting time to anthesis in most spring wheat and barley varieties, regulating the adaptation to a range of planting dates. Traditional methods utilized in the determination of photoperiod sensitivity include reciprocal transfer experiments, where plants are exposed to long and short day periods. Alternatively to this approach, data from field trials can be assimilated into a model to estimate photoperiod sensitivity.

Results

Only eleven wheat and three barley cultivars showed to be insensitive to photoperiod. The remaining had some degree of photoperiod sensitivity, with a clear predominance of highly sensitive cultivars among those with the largest emergence-flowering period. Cultivars showed a continuum of responses and it was not possible to identify groupings. Barley photoperiod sensitivity extended over a wider range of values and higher sensitivities than wheat, while per-se temperature sensitivity was concentrated within a smaller range of values with similar mean.

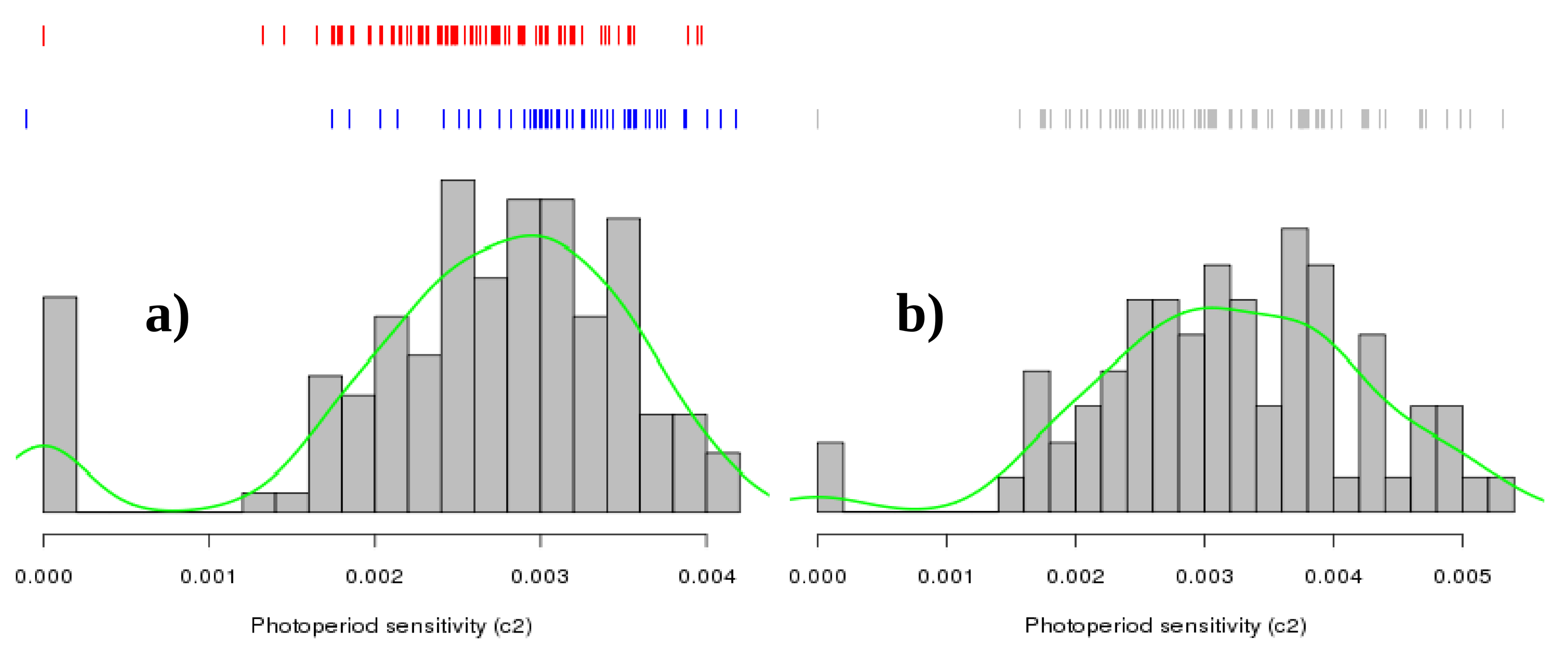


Figure 1. Photoperiod sensitivity of wheat (a) and barley (b). Red, gray and blue lines correspond to cultivars classified as early-intermediate, intermediate and late maturing.

Figure 2. Temperature sensitivity of wheat (a) and barley (b).

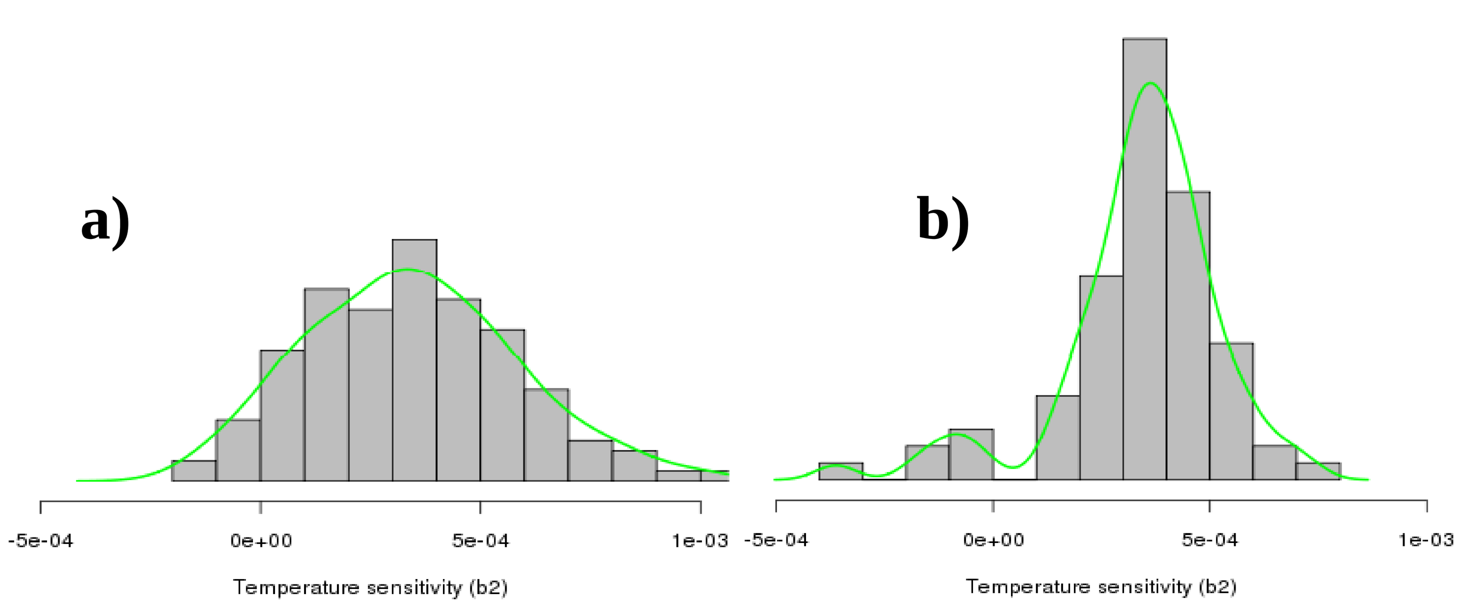
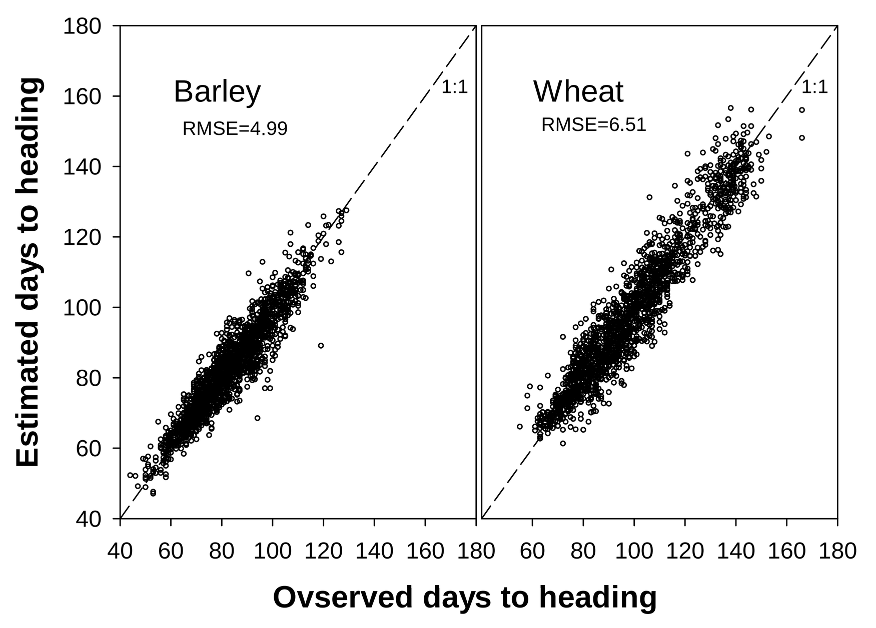


Figure 3. Observed vs. estimated days to heading for wheat and barley.



Results are in agreement with prior knowledge of photoperiod response observed in differential planting time trials for a set of well characterized genotypes, indicating that the model captures the observed photoperiod response. The present method appears as a high benefit to cost approach to achieve continuous estimates of photoperiod sensitivity for genetic and modeling analyses utilizing ancillary data from field trials.

Materials and methods

In this study, data collected from field variety trials conducted at two locations (Young, 32°43' S, 57°39' W and La Estanzuela, 34°20' S, 57°41' W) between 1991 y 2008 was used to fit the model. A total of 3754 records for 145 spring wheat, and 1806 records for 77 spring barley cultivars representative of the germplasm planted in southern Brazil, Uruguay and Argentina were utilized, assuring a minimum of 11 records per cultivar distributed from early planting (May) to late planting (August) dates. The model used is similar to Rodmod (Watkinson, AR et al. 1994) and fits a three plane surface in the 3D space defined by mean temperature, mean photoperiod and 1/days to heading ($1/f$).

- Plane B, daylenght longer than critical photoperiod
  $\rightarrow 1/f = a_1 + b_1 *$ temperature
- Plane C, daylenght shorter than critical photoperiod
  $\rightarrow 1/f = a_2 + b_2 *$ temperature $+ c_2 *$ photoperiod
- Plane D, minimum development rate
  $\rightarrow 1/f = a_3$

For normal planting dates most of the data lays on plane C and parameters b_2 and c_2 become the effective sensitivity to photoperiod and temperature respectively.

Conclusions

■ Model estimates of time to heading agreed with observed values ($RMSE_{barley}$=4.99, $RMSE_{wheat}$=6.51) demonstrating that the model is robust across cultivars, locations and planting times.

■ Wheat and barley photoperiod sensitivity proved to be distributed continuously for the set of cultivars tested, showing large association with the length of time between emergence and anthesis.

■ Per-se temperature sensitivity of wheat and barley varied continuously for the set of cultivars tested, within a similar range on wheat and barley.

■ The parameters derived synthesize the response of wheat and barley to photoperiod and temperature across locations and years, and can be utilized in for example QTL analyses, achieving presumably more robust results than traditional single experiment analyses.