Wheat Ppd-1 allelic combination modulates photoperiod sensitivity

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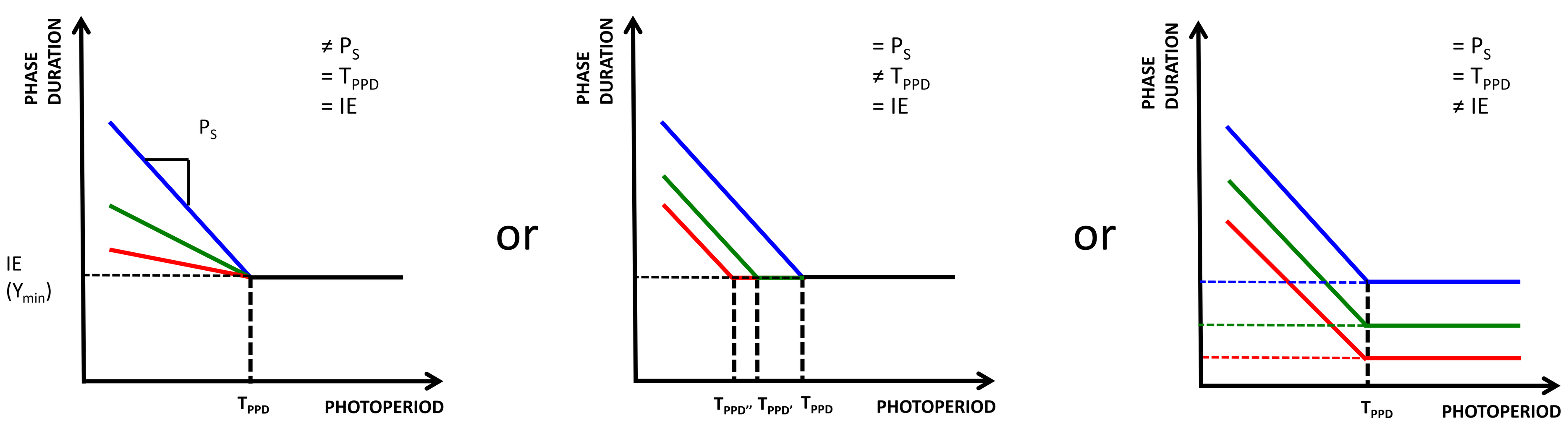
ABSTRACT: a model linking *Ppd-1* allelic composition to photoperiod response curve would allow replacing expensive and time-consuming phenologic trials. In *Ppd-1* near isogenic lines grown under different photoperiods we observed that *Ppd-1a* "insensitivity" alleles decreased photoperiod sensitivity for the whole cycle to anthesis, with negligible effect on threshold photoperiod or intrinsic earliness. Photoperiod sensitivity for the first half of the cycle (emergence to onset of stem elongation) responded similarly. Photoperiod response for the second half (onset of stem elongation to anthesis) was milder. After validation, this model would allow to predict photoperiod response of any genotype, given its *Ppd-1* allelic combination.

INTRODUCTION

Photoperiod is one of the environmental factors that determine wheat **development** and, with it, the possibility of any genotype to flower within the recommended dates for a given environment. ***Ppd-1*** major genes modulate crop's **response** to it, but it is yet to be confirmed which parameters of the response model they have an effect on:



Objective: To asses the effect of three different insensitivity alleles *(i.e. Ppd-1a)* and their combination on parameter of wheat's photoperiod response curve:

- ✓ Photoperiod sensitivity (slope, P_S),
- ✓ Threshold photoperiod (point of change in slope, T_{PPD}),
- ✓ Intrinsic earliness (Y_{min}, IE).

MATERIALS AND METHODS

A photoperiod-sensitive cultivar, Paragon, and four near-isogenic lines carrying single *Ppd-1a* insensitivity alleles and their triple combination were tested under a range of natural and extended photoperiod during four years.

NIL	Genome D	Genome B	Genome A	*Ppd-1a* donor
Paragon				-
P(S64-2D)	*			Sonora 64
P(CS-2B)		*		Chinese Spring
P(GS-100-2A)			*	GS-100
Triple Insensitive	*	*	*	All of the above

: Ppd-1a allele at the indicated genome

Timing of phenologic stages were recorded, including leaf appearance. Durations of i) the whole cycle – emergence (EM) through anthesis (AN)–, ii) EM through onset of stem elongation (OSE), and iii) OSE to AN, were related to mean photoperiod by fitting and testing multivariate, hierarchical models using *brms* package with R.

RESULTS

1. PHOTOPERIOD RESPONSE FOR THE WHOLE CYCLE TO ANTHESIS

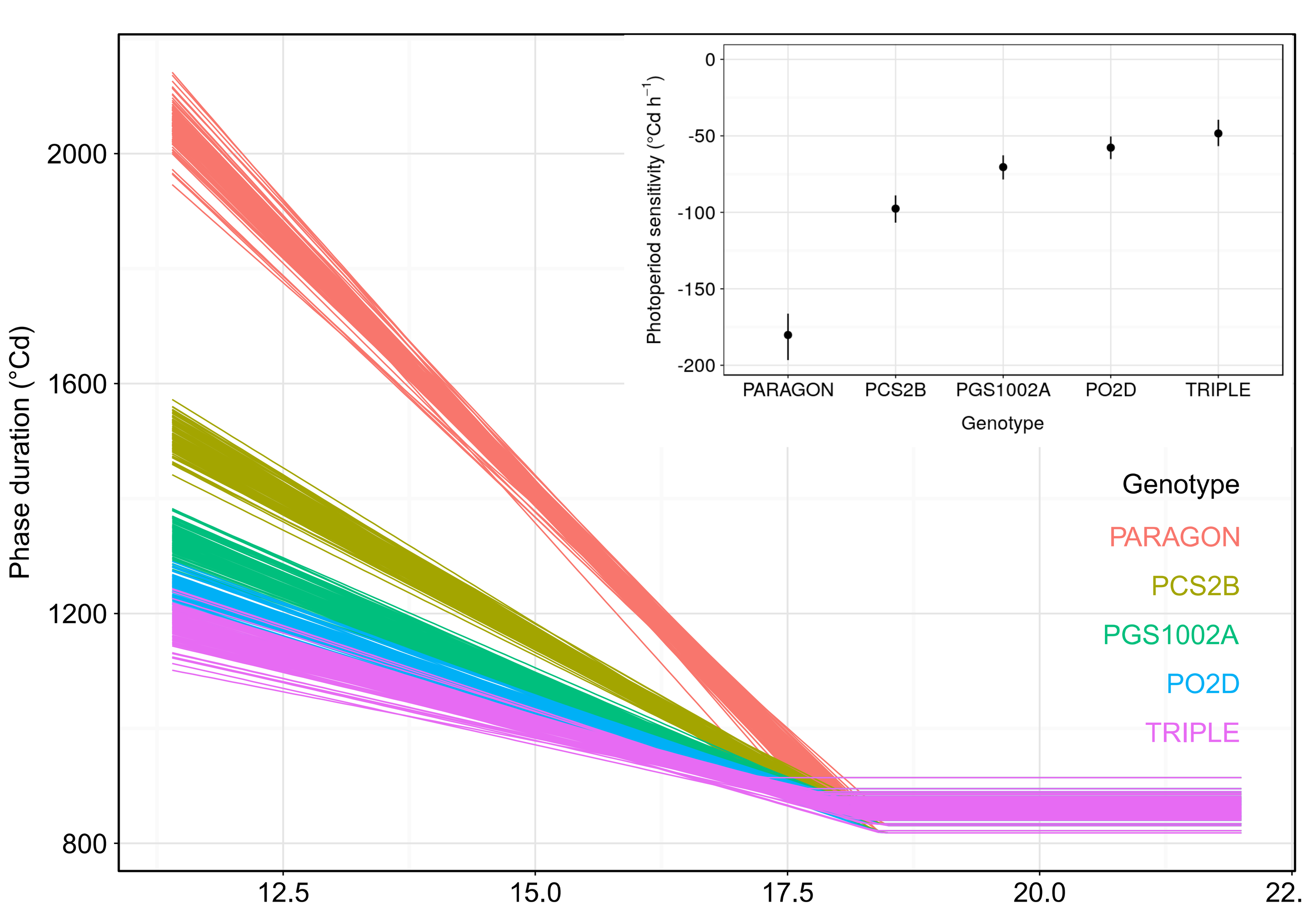


*Figure 1: A hundred posterior samples of the final model [Y = A - B * X (X < C) - (B*C (X >= C))] relating thermal time from emergence to anthesis to mean photoperiod during that phase for each genotype tested.*

The best model was that with alleles affecting only photoperiod sensitivity, a common threshold photoperiod and intrinsic earliness.

2. PHOTOPERIOD RESPONSE IN SUBPHASES

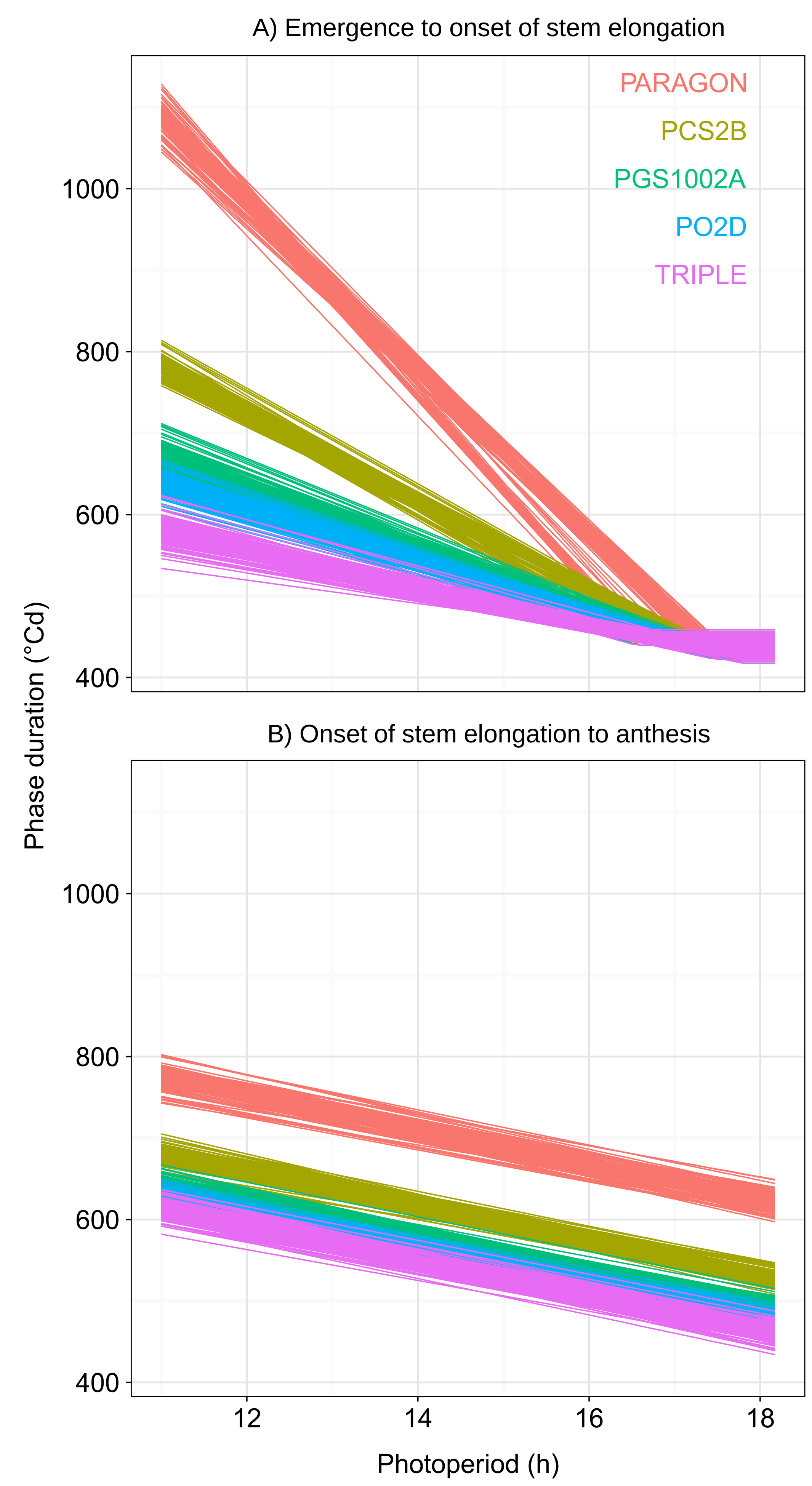


Figure 2: A hundred posterior samples of the final model for each sub-phase.

When modelling the response to photoperiod of each particular sub-phase we found two different response models. (Fig. 2)

Until the beginning of stem elongation, the response was also bi-linear and alleles reduced photoperiod sensitivity, with no tangible effect on threshold photoperiod or intrinsic earliness (Fig. 2A).

During stem elongation, a single and lower photoperiod sensitivity described the behaviour of all genotypes (Fig. 2B).

However, duration of the second phase was found to be highly correlated to photoperiod sensitivity during the first one (Fig. 3), which may be consequence of memory effects associated to number of leaves to be appeared during that phase (Fig. 4)

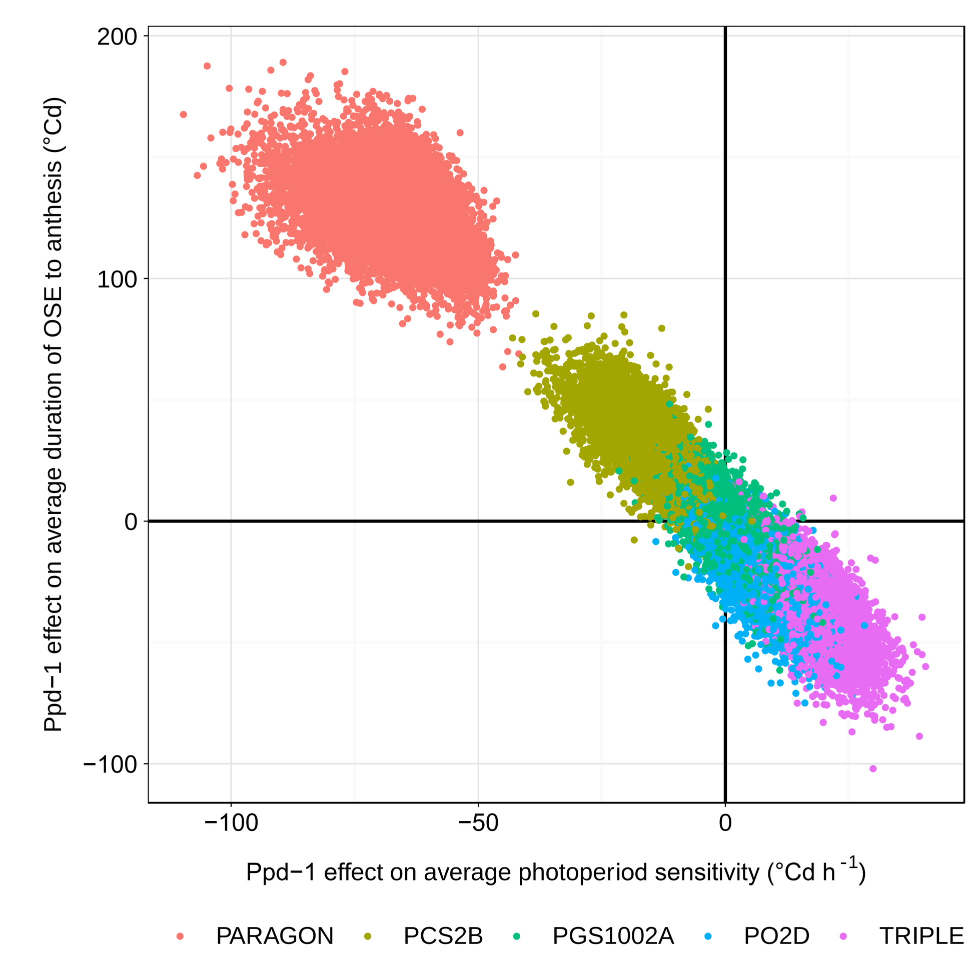


Figure 3: Correlation between the intercept of the second sub-phase and the adjusted slope for the first sub-phase.

3. MEMORY EFFECT THROUGH NUMBER OF LEAVES TO BE APPEARED

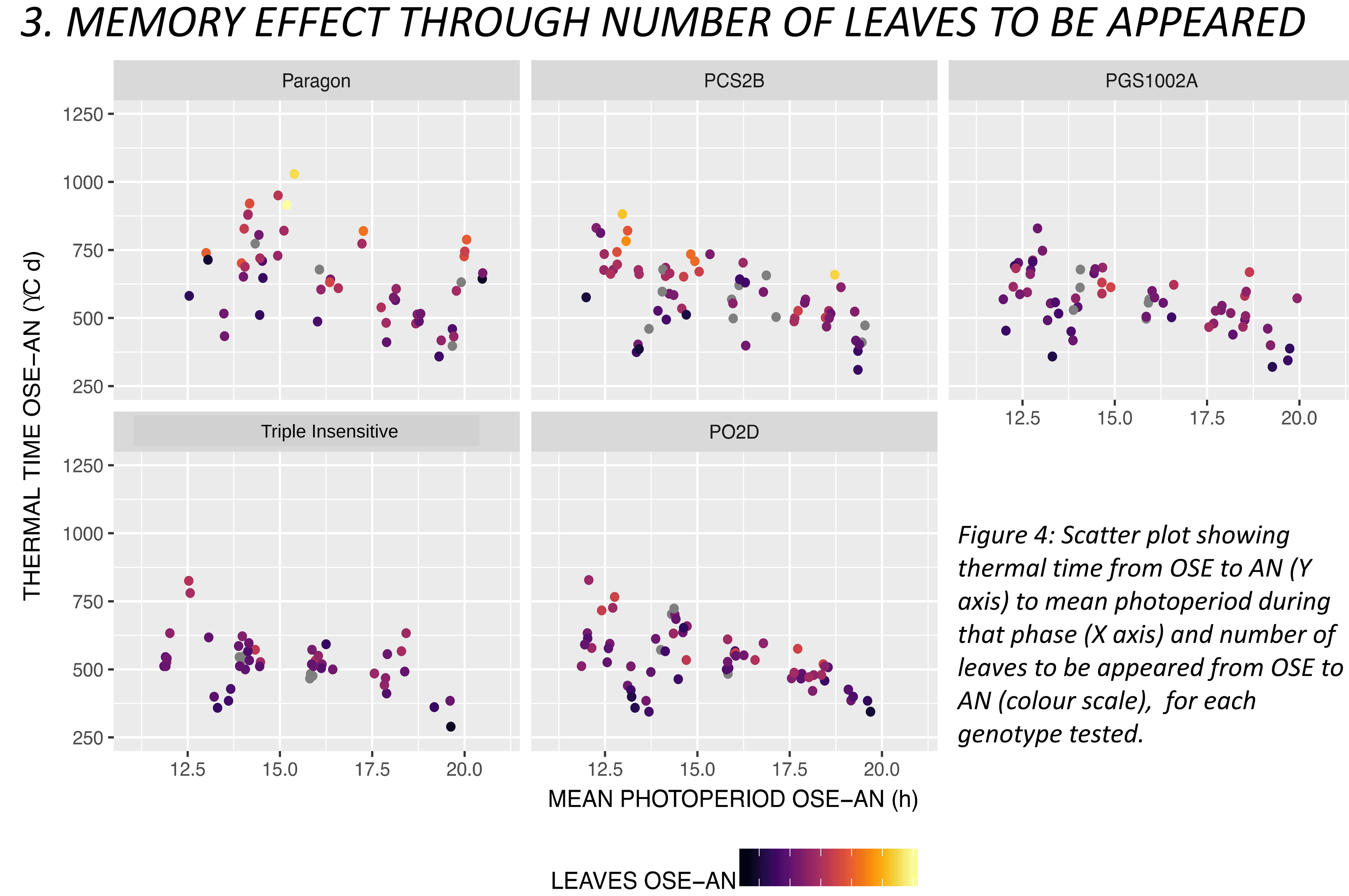


Figure 4: Scatter plot showing thermal time from OSE to AN (Y axis) to mean photoperiod during that phase (X axis) and number of leaves to be appeared from OSE to AN (colour scale), for each genotype tested.

CONCLUSIONS

- ✓ *Ppd-1a* alleles modulated photoperiod response chiefly by reducing photoperiod sensitivity (P_S)
- ✓ Both other parameters of photoperiod response (T_{PPD}, IE) remained unaffected by *Ppd-1a* alleles
- ✓ Alleles' effects were not found to be cumulative beyond a certain minimum insensitivity: response in photoperiod sensitivity terms saturated around -50º C d h⁻¹.
- ✓ The first and second sub-phases' durations showed different response curves to photoperiod.

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