Environmental characterization facilitate G × E interaction to highlight the role of stay-green traits for genetic gain

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Introduction

Environmental characterization (EC) one influential approach for understanding the performance of genotypes in different environments. Sometimes interactions between environment and genotype limit the genetic gain for complex traits in breeding programs, especially drought. Stay green lines are able to retain green leaf area longer than standard lines leading to superior adaptation under water-limitation.

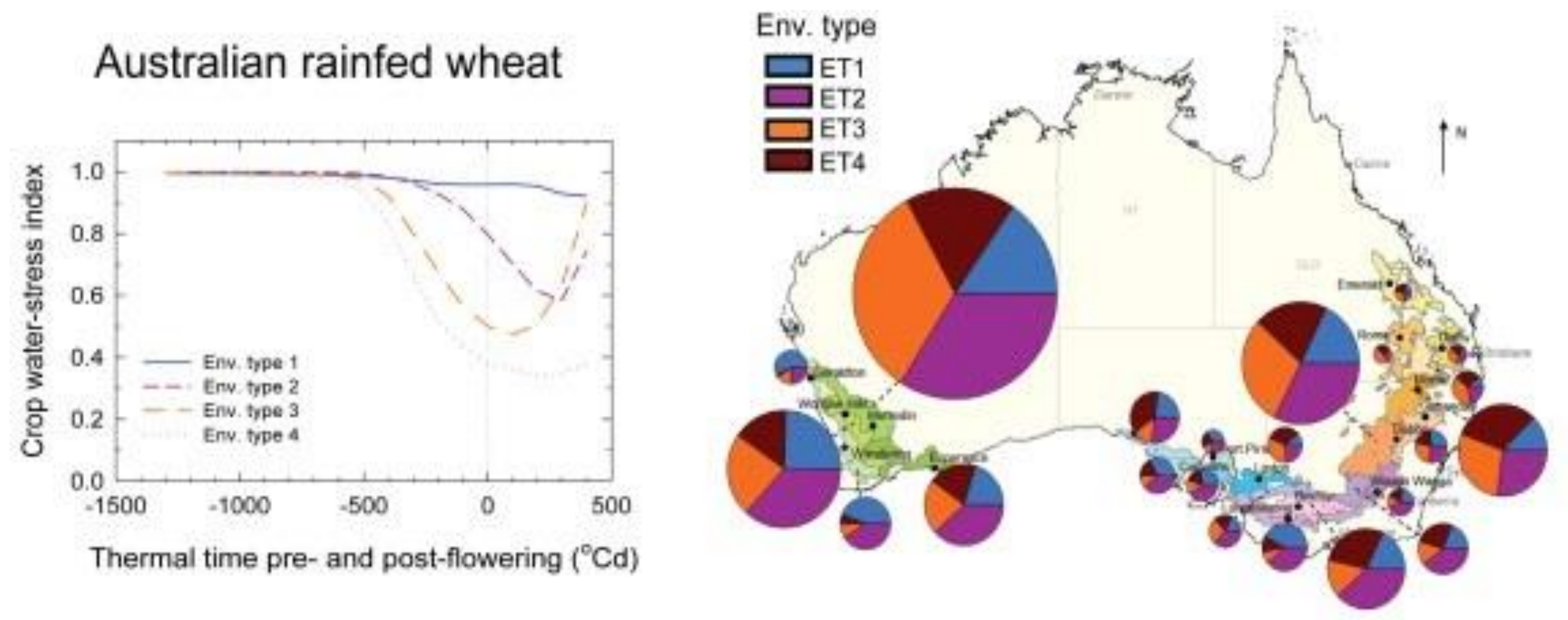


Figure 1: Drought environmental characterization for rain-fed wheat belt in Australia [1].

Problem

- Studies identified that in different conditions yield primarily arises from the environment (E) (48 – 93 %) , secondly from the (G ×E) (4 – 35 %) interactions and, finally, from the genotype (G) (1 – 16 %) , i.e. E > G × E > G
- However, the resources invested to deal with these factors varied with the rank in the opposite order: G > G × E > E
- This approach effect the selection decision during each cycle in breeding

Aims

Modelling framework has been used analytically in breeding to dissect complex traits, such as yield under water limitation, into critical trait components (e.g. stay-green, flowering time, root architecture). Characterization can help to select more heritable genotypes that can be subjected to high throughout phenotyping, and make more sensible targets for genomic selection by the following search aims:

- Characterise stressed environments (accounting for climate and soil characteristics, management practices, and crop development) to characterise the timing and severity of the stress and non-stress
- Identify the potentially adaptive cultivars and traits in each specific environment
- Determine the correlation between stay-green traits and yield in the different environment types

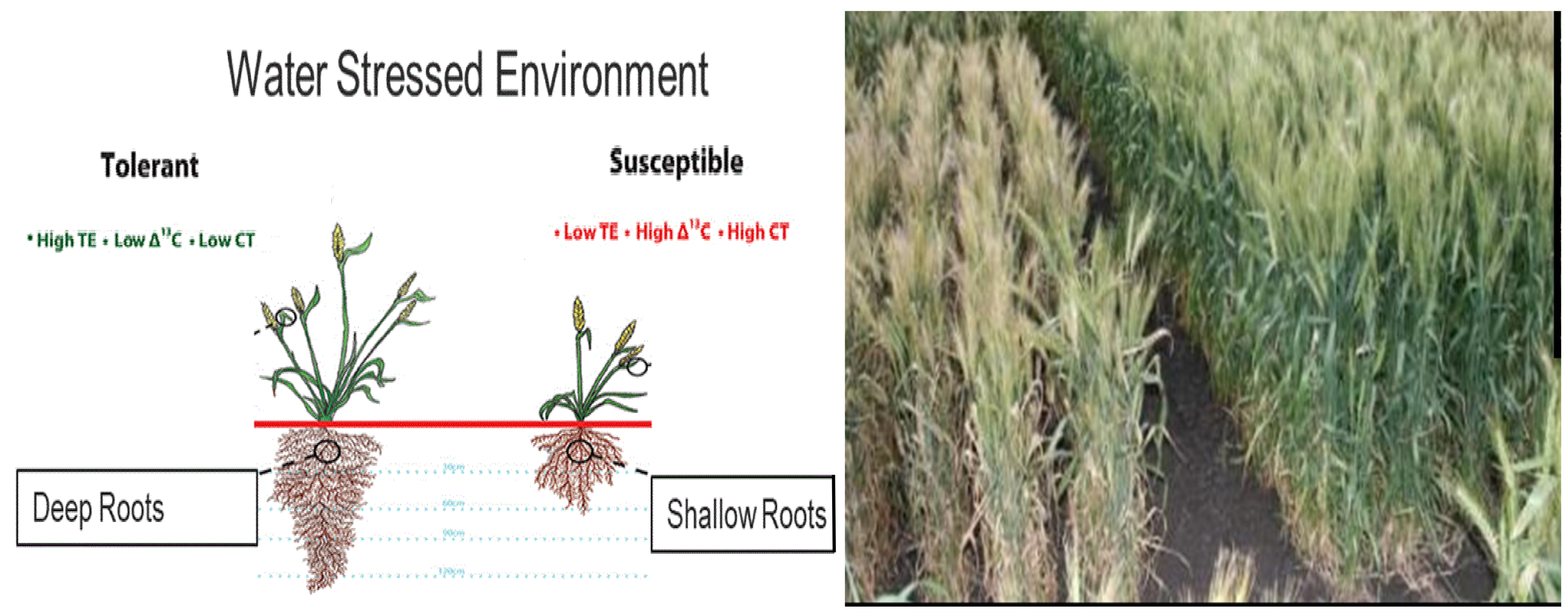


Figure 2: Different genotypes with different root traits [2] and stay-green traits [3].

References

1. Chenu, K., et al.(2013). Large-scale characterization of drought pattern: a continent-wide modelling approach applied to the Australian wheat belt – spatial and temporal trends. *New Phytologist, 198*(3), 801-820.
2. Kulkarni, M, et al. (2017). Drought Response in Wheat: Key Genes and Regulatory Mechanisms Controlling Root System Architecture and Transpiration Efficiency. *Frontiers in Chemistry, 5*(106).
3. Christopher, J. T., et al (2016). Stay-green traits to improve wheat adaptation in well-watered and water-limited environments. *Journal Of Experimental Botany, 67*(17), 5159-5172.

Material and methods

A modelling approach is proposed here to characterize the experimental trials with respect to different factors (geographic area, climate, soil and year of sowing) to understand the response of different genotypes. Water stress patterns in different soil types with climate variations were examined using the APSIM crop model for drought-prone regions in Australian wheat belt. Sources of data for the model included the following.

- **Data from 11 wheat trials**
- **Phenotypic data** for developmental stages (# of days) in accordance with the Zadoks growth stages, with a focus on yield; stay-green traits and agronomic traits.
- **Post-harvest traits:** Yield (all trials) , and Biomass (selected trials) of all the genotypes
- **BLUPs for stay-green traits:** Best linear unbiased predictors for stay-green traits
- **Historical weather and soil data** from the online APSIM data bases plus soil parameters were measured during the field trials

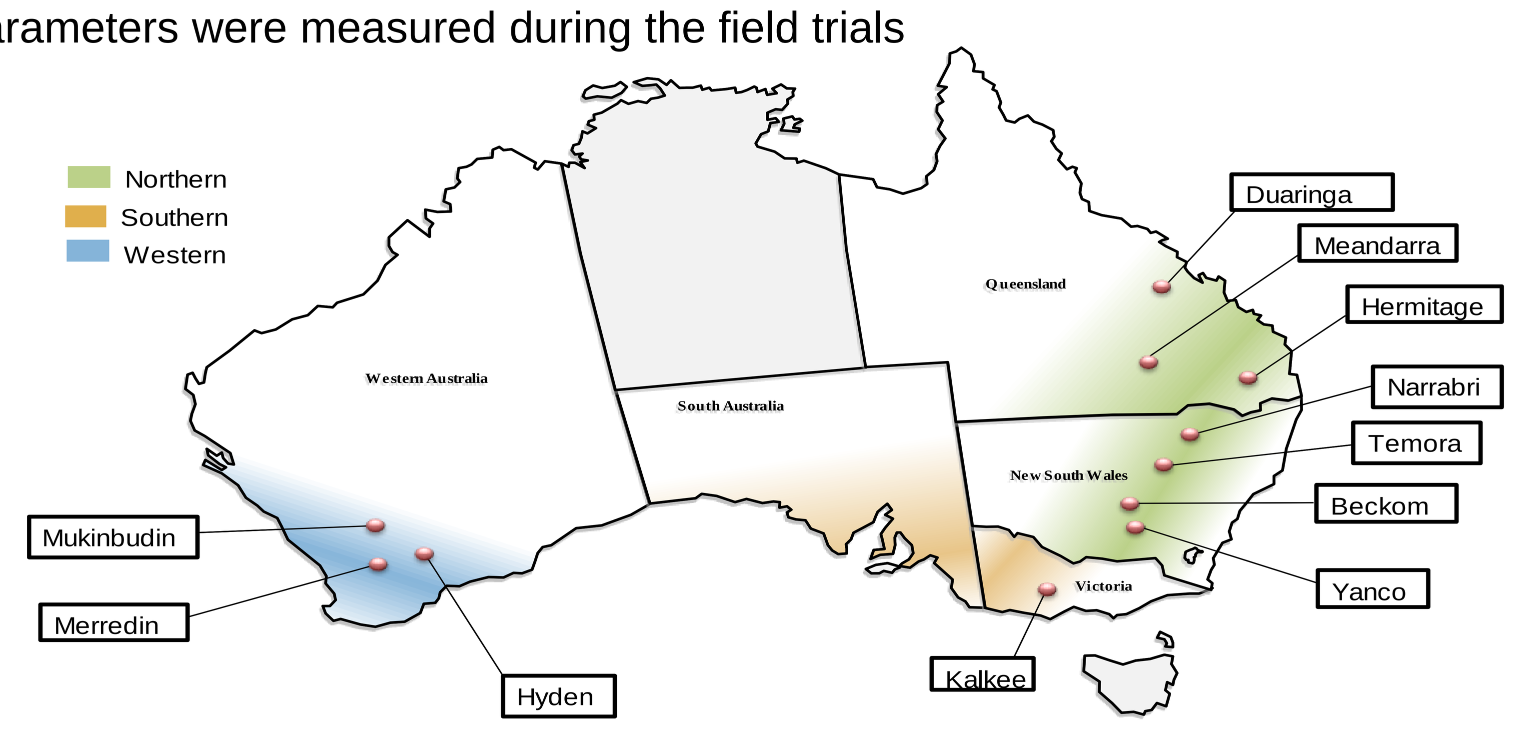
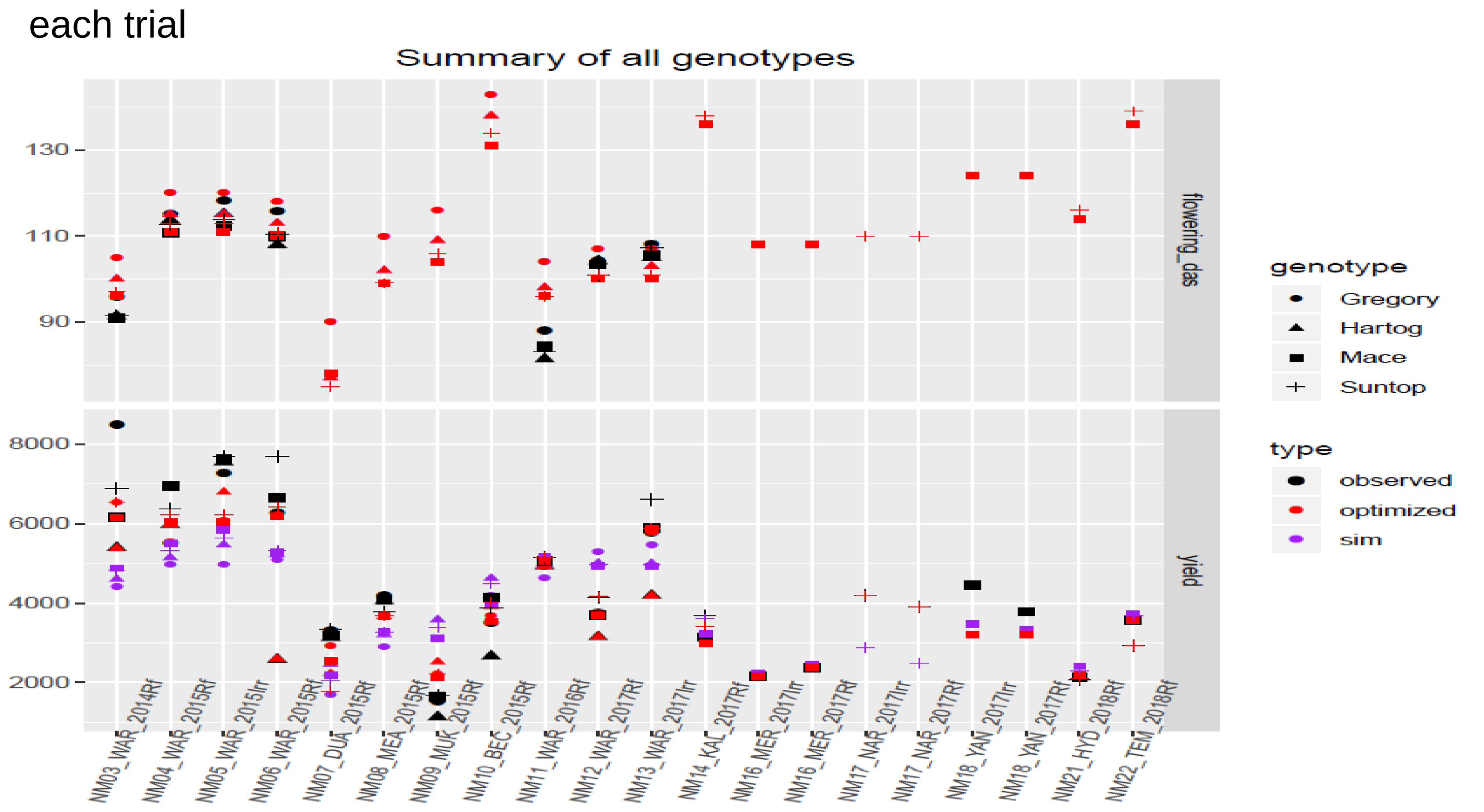
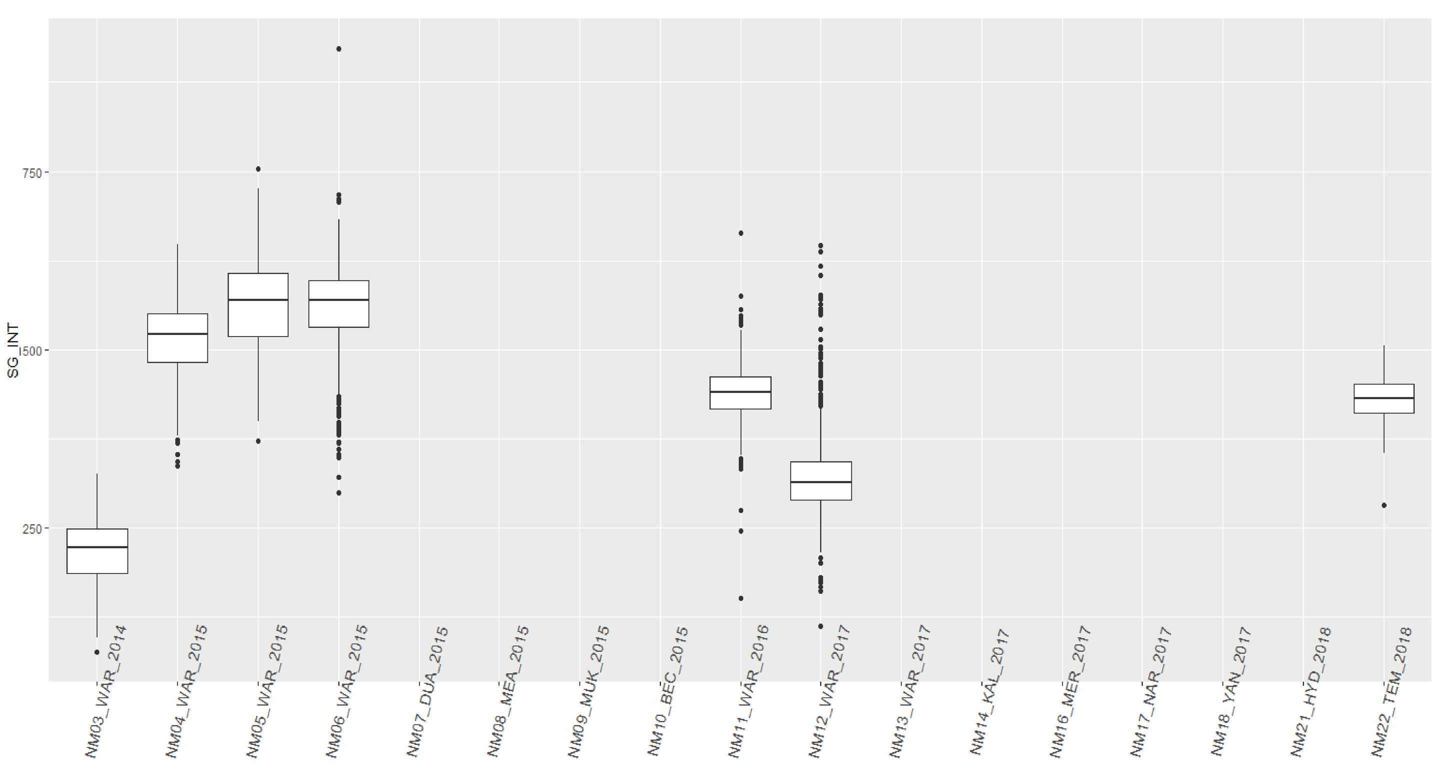


Figure 3: Trials across the Australian wheat belt.

Expected outcomes

- Initial results of the optimization highlights yield variations and importance of EC across the Australian wheat belt
- Subgrouping of the trials will reduce G x E
- High correlation found between the different environments for yield
- SG-INT (stay-green trait) highly correlated with yield stability
- Highlight genotypes with significant stay-green traits response to genetic gain in each trial





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