Assessing Genotype by Environment Interaction in a Diverse Barley Panel for Enhanced Breeding Strategies in Morocco

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INTRODUCTION

- Barley (*Hordeum vulgare*) is an important cereal crop cultivated over a wide range of environments and in diverse agro-ecologies in Morocco.
- Genotype by environment interaction (GxE) has important consequences in barley breeding. It complicates testing and selection of superior genotypes and reduces genetic progress in breeding programs.
- The use of a diversity panel is an important component in a breeding program to understand GxE, traits linkage and feed crossing-blocks with the necessary diversity.

Objective
Evaluate a barley diversity panel for morphological traits, phenology and yield components across several environments.

MATERIALS AND METHODS

Plant material:
320 barley genotypes (ICARDA elite breeding lines, cultivars, varieties, landraces…) from different origins (Africa, Latina America, Europe, India, USA, Canada, Australia and others).

Environments:
The trials installed across four locations that represent the varying agro-ecologies of the major barley growing areas of Morocco (Marchouch, Tessaout, Annaceur, Sidi El Aydi) over four years, 2017 to 2020.

Design:
- Alpha-lattice design with two replications.
- Plots of 3 m^2 with six rows measuring 2.5 m and 0.2 m between rows.

Collected data:
- Grain yield data was collected from the four central rows.
- Morphological traits (plant height, spike length), phenology (days to heading) and other yield component (thousand kernel weight, hectoliter weight) were also recorded. (Results not shown in this study)

Statistic analysis:
A semi-automatic two staged analysis for multi-environmental trials developed by ICARDA using AsREML was used to analyze the resulting data (FAGE).

Picture 1: Barley field experiment in Annaceur station

RESULTS

✓ Multi-environment trial analyses showed the existence of high genotype-by-environment interaction for yield.

✓ Heritability was calculated for all environments for grain yield but two (Tessaout in 2018 and 2019) were not included in the GxE analysis (Figure 1 left).

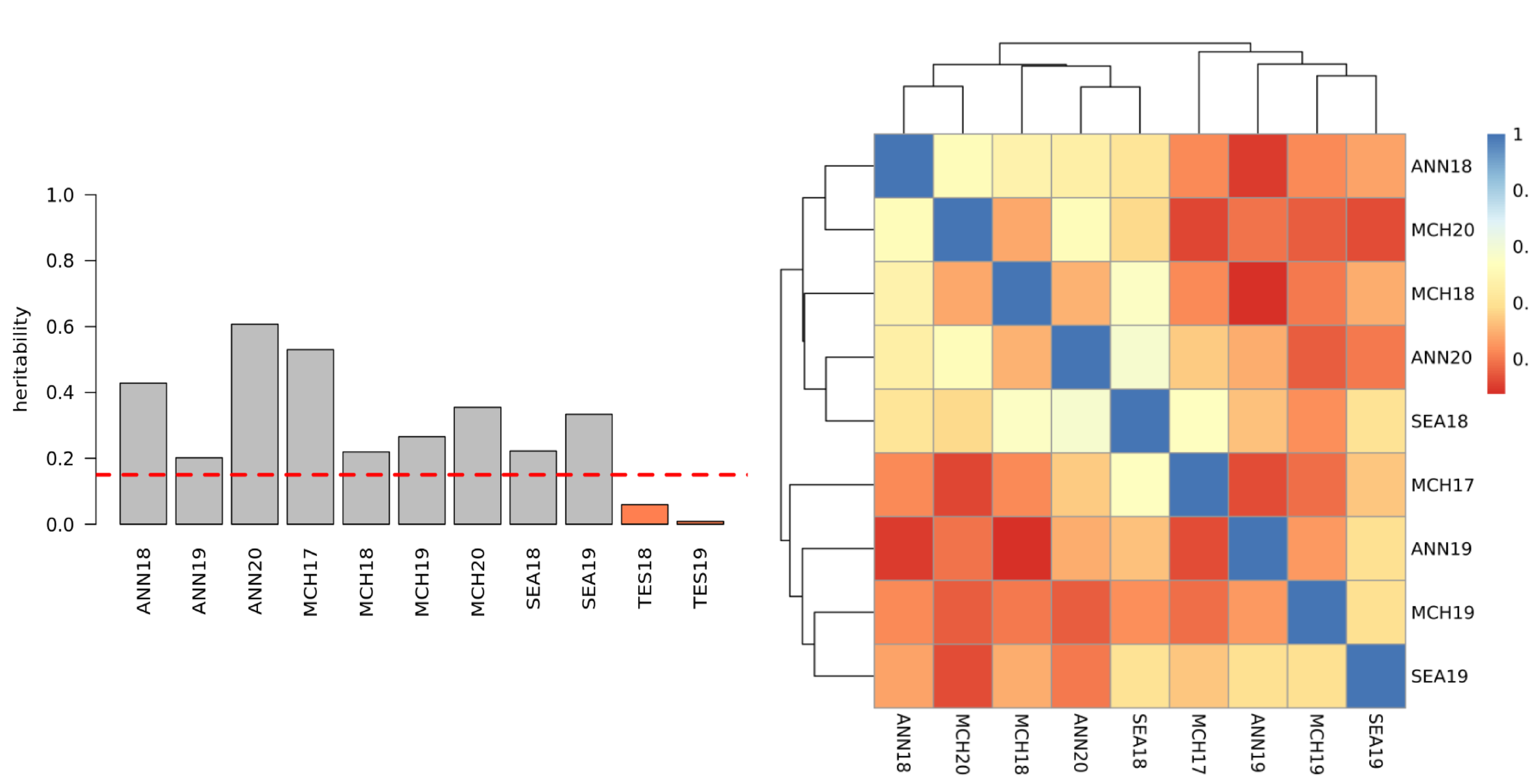

Figure 1: Heritability in multi-environmental trial analysis for grain yield (left). Heatmap of the genetic correlation between trials (right)

✓ Genetic correlation (GC) between environments for yield showed only one cluster of environments with GC of 0.4-0.5 (ANN18, ANN20, MCH18 and MCH20). (Figure 2 right).

✓ All the other environments remain uncorrelated showing the existence of high GxE (Figure 2 right).

Figure 2: Cumulative variance explained by factorial analytic model for each environment

✓ The factorial analytic model explained more than 70% of to the total variance for 4 environments, more than 50% for 8 environments and MHC19 with only 27% explained (Figure 2).

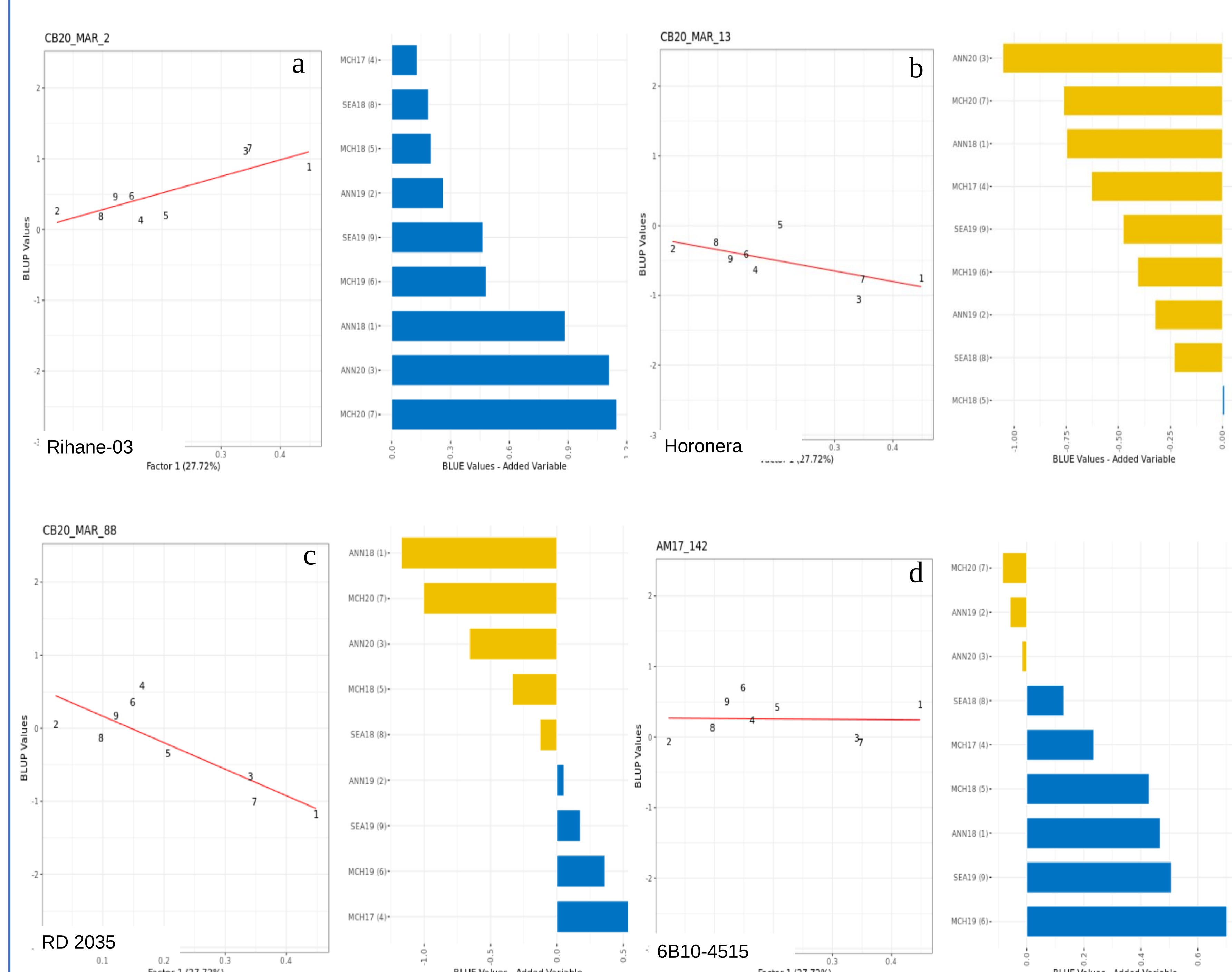

Figure 3: Genotypes performance of grain yield across environments. (a) Genotype performs better in environments 1,3, and 7; (b) Genotype below the average; (c) Genotype performs better in environment 4,6 and 9; (d) Stable genotype across environment above the average

DISSCUSSIONS

- In a study by Sanchez-Garcia et al. (2012), the research focused on the genotype-environment interaction for bread wheat yield in Spain. The study revealed a substantial GxE effect, suggesting the potential for selecting adaptable wheat genotypes across diverse environmental conditions. Multiple high-performing genotypes were identified, each excelling in different environmental settings. These superior genotypes are set to be seamlessly integrated into breeding programs, promising improved crop performance across a wider range of conditions.
- Furthermore, Bustos-Korts et al. (2019) emphasized the importance of genotype by environment interaction in crop breeding and adaptation. Their work highlights the need for breeding programs to consider GxE interactions when developing new genotypes, enabling crops to thrive in a variety of environmental conditions.
- These studies underscore the significance of GxE effects in crop yield and the potential for enhancing crop performance by selecting adaptable genotypes, ultimately contributing to improved agricultural productivity and food security, as the case of barley in our study here.

CONCLUSIONS

The study reveals a significant GxE interaction effect on barley crop yield, indicating the potential for selecting adaptable genotypes across diverse environmental conditions. Multiple high-performing genotypes have been identified, each excelling in distinct environmental conditions. These superior genotypes are set to be seamlessly integrated into the breeding program's crossing block, promising improved crop performance across a wider range of conditions.

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