Post anthesis leaf health as potential determinant of yield in early evaluation trial of wheat genotypes

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Introduction

Post-anthesis foliar health could serve as a proxy for determining final grain yield, as the role of terminal leaves has been well described for having implications in grain fill. A major fraction of total yield is dependent upon the photosynthesis that occurs post-anthesis. Similarly, it is well known that biotic agents such as diseases sustain reduction in yield via pathways that relate to the reduction of effective photosynthetic surface area (Lopes and Reynolds 2012).

Materials and methods

Test material consisted of 104 diverse lines representing advanced genotypes screened for moderate resistance to various diseases and four NARC, Nepal released check varieties – Aditya, Bhrikuti, Gautam and Tilottama.

Field was sown in Nov 24, 2016. Seeds were continuously sown within a row while maintaining standard 25 cm row-row distance. Field was divided into rectangular grid to assign genotypes into rows, columns, rowgroups and columngroup. Each plot occupied 1 m^2 in the grid. Standard interculture operations were followed with none pesticidal sprays.

Observed traits were categorized into three categories:

1. Leaf health was defined as complex state characterized by resistance to foliar disease, flag leaf greenness, leaf area under greenness (LAUG) and flag leaf relative chlorophyll content.
2. Yield and yield components traits comprise number of grains panicle, number of effective tillers, thousand kernel weight, and
3. Morpho-phenology were described by features like plant height, flag leaf area, canopy temperature depression, days to heading and days to anthesis.

At least four plant hills per plot were sampled for observations except when visually scoring, in which case more than 50

$$(y|\mathcal{B}) \approx \mathcal{N}(X\beta + Zb, \sigma^2 W^{-1}) \qquad (1)$$

(a) Randomized layout of the row-column experimental design

(b) Wheat crop plot at Jan 9, 2017 (46 days after sowing

Figure 1: Study design and crop canopy shown during recording of observation

Results

- Pairwise comparison of fixed effects estimate indicate that check variety Aditya 3.02 *tons* ha^{-1} ($\pm$ 0.60) has the lowest yield amongst all varieties. Bhrikuti gave the highest yield among checks (3.54 *tons* ha^{-1} ($\pm$ 0.60)), although not significantly different from other check varieties.
- Genotypes show highly significant differences for the disease resistance trait. LRT shows that both checks and entries possess significant heritable variation. With respect to severity, check variety Gautam is relatively asymptomatic (2.51 ($\pm$ 1.30)) than Bhrikuti(3.32 ($\pm$ 1.30)) and Tilottama (3.35 ($\pm$ 1.30)) to foliar pathogen. Check variety Aditya exhibited maximum greenness of the flag leaf followed by Bhrikuti and Gautam (scores for both were at par) and then Tilottama. Likewise, Significant differences were detected among the check genotypes but not among entries for the SPAD measured at Zadok's stage 85.

- As for phenology and architecture traits, genotypes showed significant differences for the Canopy temperature depression (CTD) measured near anthesis stage. Canopy structure of check variety Bhrikuti favors greater reduction in temperature than check variety Aditya ($9.08^{\circ}C$ ($\pm$ 0.79)). Other varieties were at par with both of the check varieties. Of difference among genotypes for days to heading trait, check varieties differed from one another except for Aditya (with mean of 67.79 ($\pm$ 2.40) days) and Gautam, both of which initiate heading late. Mean number of days taken for head to develop in half of the population was lowest in Tilottama (62.71 ($\pm$ 2.40) days) variety.
- Similarly, entry genotype also exhibited variation for the trait yield and yield components as well most of leaf health and phenology attributes. The model with both genotypes (checks and entries) and leaf health attributes outperformed, the one without in predicting the real yield ($\chi^2 = 14.4$ with $df = 4$).

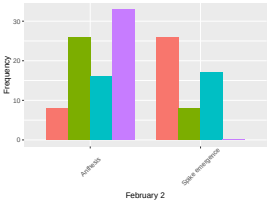
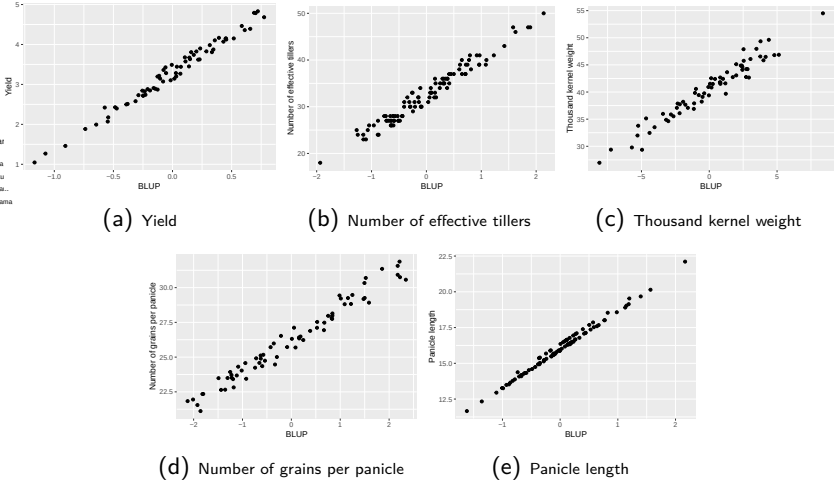


Figure 2: Number of checks at different growth stages on February 2, 2017. Time point comparison of different stages of reproductive periods of growth reaffirms that Tilottama variety flowers the earliest amongst the check varieties and Aditya reaches to the flowering relatively late.



(a) Yield (b) Number of effective tillers (c) Thousand kernel weight

(d) Number of grains per panicle (e) Panicle length

Figure 3: Scatterplot of observed versus BLUP values of yield and yield component traits

The coefficient of determination, between the observed and fitted values of random effects model are 0.61, 0.36, 0.71, 0.55, 0.48, respectively for the Yield, Number of effective tillers, Thousand kernel weight, Number of grains per panicle and Panicle length.

Conclusion

Major leaf health traits that influenced yield were the leaf greenness and relative chlorophyll content. BLUP estimation and adjustment for fixed effects dictate that 68.9% of the genotypic variation of entry genotypes in yield was explained by the full model. This reveals that augmenting leaf health traits with structured blocking factors leads to improved yield estimates. Although, for yield, all other check varieties were similar (3.54 t/ha, 3.33 t/ha, 3.42 t/ha) except Aditya (which gave lesser yield), checks showed marked difference in the number of tillers counted /m^2. Block adjusted random effect estimates suggest for inclusion of some entry genotypes, those of which yield better despite disease in advanced evaluation trials. Top ranking high yielding entry genotypes were: TRCH/SRTU//KACHU/3/KINGBIRD#1, WHEAR/SOKOLL/4/PASTOR// MILAN/KAUZ/3/B ... and MUNAL #1*2/4/HUW234+ LR34/PRINIA//PBW3 ....

References

Lopes, Marta S, and Matthew P Reynolds. 2012. "Stay-Green in Spring Wheat Can Be Determined by Spectral Reflectance Measurements (Normalized Difference Vegetation Index) Independently from Phenology." *Journal of Experimental Botany* 63 (10): 3789–98.