

# 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 be a proxy for determining final grain yield. It has a direct implication on grain filling behavior of a plant. Ideally, the contribution of pre-anthesis photosynthetic reserves to the final grain yield has been found to stall around 5% to 10% (Sharma 1992). A major fraction of total yield, therefore, is dependent upon the photosynthesis that occurs post-anthesis. Terminal leaves, particularly the flag leaf and the one directly below it, have significant contribution to genotypic variation in yield (Aslam and Hunt 1978) with respect to provisioning of assimilate to functionally active parts of plants including the storage organ (grain). Similarly, it is well known that various biotic agents, primarily diseases, sustain reduction in yield with pathways that relate to the effective photosynthetic surface area (Lopes and Reynolds 2012).

Current study aims to make use of “augmented row-column design for a small number of checks” for estimation of genotypes’ effect under a mixed modeling framework to uncovering association of wheat crops’ yield with the traits characterizing its leaf health.

# Materials and methods

Test material consisted of 104 diverse lines representing advanced genotypes screened for resistance to various diseases. Four check varieties – Aditya, Bhrikuti, Gautam and Tilottama – released by NARC and adapted to a wide range of environmental conditions of Nepal were included alongside. Observations were kept for final yield and associated as well as morpho-phenological traits, that were potentially prolonging the leaf health during post-anthesis period.

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<sup>2</sup> in the grid. Standard interculture operations were followed with none pesticidal sprays.

At least four plant hills per plot were sampled for observations except when visually scoring, in which case more than 50% canopy coverage was examined. Features like soil temperature and soil moisture formed basis for environmental covariate adjustment.

Observational traits were categorized into three underlying features:

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.

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

L106	3	1	L79	L92	1	1	2	3	L12	4	L98	L17	3	L37	4	2	4	L95	L88
1	4	L33	L24	3	L58	L43	3	L13	2	L4	2	L10	1	2	3	L38	L49	4	1
3	L89	2	2	L57	4	4	L94	3	L46	L53	1	4	L82	2	L62	1	3	3	L40
2	L7	4	L108	L32	L85	1	1	L5	3	1	L83	4	L41	L28	2	4	L76	2	3
L99	1	L101	3	2	4	L34	L96	L67	L77	3	4	2	L9	L66	3	1	1	L91	L44
1	L6	2	4	3	3	L72	L15	2	L18	L87	1	L84	1	4	2	L21	L29	4	2
L45	2	L8	1	L65	2	4	3	L103	2	L69	3	3	L48	4	4	L70	L19	1	4
4	L63	1	L80	1	L42	3	4	L105	3	L23	2	2	2	L14	L52	3	4	L90	L36
3	4	L93	2	1	L71	2	L16	4	L51	1	4	L102	L74	3	1	3	L11	L104	2
2	L64	4	L31	2	L73	3	L78	1	1	3	L39	1	L27	3	L3	1	2	L30	4
L107	1	L61	4	L47	L97	2	1	L35	L59	2	3	3	4	1	L68	4	L81	L2	3
L20	2	3	1	4	1	L1	L56	2	4	L55	L60	L54	4	L22	2	L86	3	1	L26

(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

The model with both genotypes (checks and entries) outperformed in comparison to the one without in predicting the real yield ( $\chi^2 = 14.4$  with  $df = 4$ ).

Pairwise comparison of fixed effects estimate indicate that check variety Aditya has the lowest yield amongst all varieties while other have similar yields. Average yield of the lowest yielder is  $3.02 \text{ tons ha}^{-1}$  ( $\pm 0.60$ ) and Bhrikuti yields the highest with average yield of  $3.54 \text{ tons ha}^{-1}$  ( $\pm 0.60$ ).

Genotypes show highly significant differences for the disease resistance trait. LRT shows that both checks and entries possess significant heritable variation. 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. Although, no distinction could be made on the severity scale of the disease (All check varieties exhibited similarly less affected ( $2.5$ - $5.0$ ) symptom at the time of scoring). Entry genotypes also show considerable amount of heritable variation.

Genotypes showed highly significant differences in the greenness score measured at Zadok's stages 75 and 85. LRT shows that both checks and entries possess significant heritable variation. Pairwise comparison of fixed effect estimates for both growth stages implicate check variety Aditya for retaining maximum greenness of the flag leaf followed by Bhrikuti and Gautam (both have similar greenness scores) and Tilottama. Noteworthy variation was also found among the entry genotypes (significant at  $p < 0.01$ ). Check variety Aditya suffered largest reduction in greenness ( $93.03 (\pm 19.70)$ ), while Tilottama had the least ( $77.35 (\pm 19.71)$ ) loss of all check varieties.

Highly significant difference exist among the genotypes for Plant height trait. However, the random effects estimates of plant height showed no difference among entry genotypes. No significant difference was discovered among the genotypes for flag leaf surface area trait, either. In contrast, entry genotypes' chlorophyll content at Zadok's stage 65 showed considerable variation, while the it is not true for check genotypes.

Significant differences were detected among the check genotypes but not among entries for the SPAD measured at Zadok's stage 85. Likewise, genotypes have significant differences for the Canopy temperature depression (CTD) measured near anthesis stage. Fixed effect estimates shows that canopy structure of check variety Bhrikuti favors greater reduction in temperature than check variety Aditya ( $9.08^{\circ}\text{C} (\pm 0.79)$ ). Other varieties were at par with both of the check varieties. Highly significant difference were detected among the genotypes were found for days to heading trait. All check varieties differ from one another except for Aditya (late heading type) (with mean of  $67.79 (\pm 2.40)$  days) and Gautam, which require similar days for heading. 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 levels also exhibited high variation for the trait.

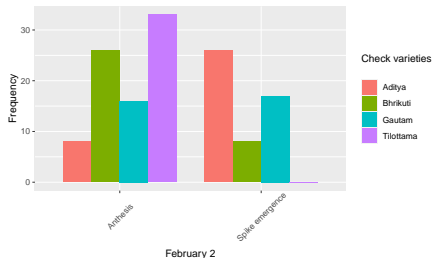
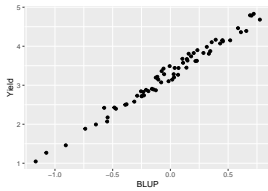
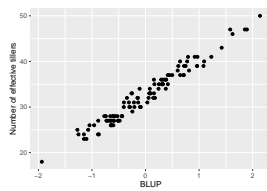


Figure 2: Number of checks at different growth stages on February 2, 2017. Time point comparison of different stages of reproductive periods of growth reaffirms that Tilottama variety flowers the earliest amongst the check varieties and Aditya reaches to the flowering relatively late.

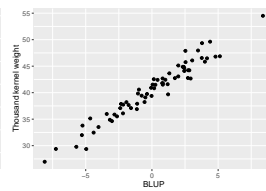




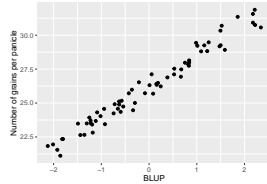
(a) Yield



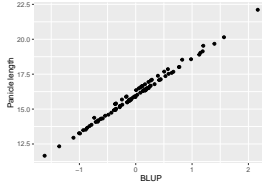
(b) Number of effective tillers



(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 (one having both blocking and leaf health components). This reveals that augmenting leaf health traits with structured blocking factors leads to improved yield estimates. Apart from the check variety Aditya, which gave the lowest yield ( $3.02 \pm 0.61$  t/ha), all other check varieties were similar (3.54 t/ha, 3.33 t/ha, 3.42 t/ha). However, they had more contrasting differences in Number of tillers /m<sup>2</sup>. Findings based on block adjusted random effect estimates suggest for inclusion of some entry genotypes, those having leaf traits characterizing good health and with high yielding characters, 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

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- 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.
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