Phenomics Tools in Raspberry Breeding: Color Perception and AI-Driven Strategies for Enhancing Breeder Adoption

Roslyn Willoughby, Sindhuja Sankaran, and Lisa DeVetter

[1] Washington State University, Pullman, WA
[2] Washington State University, Northwestern Washington Research & Extension Center, Mount Vernon, WA

Summer 2024 Research Experience for Undergraduates on Phenomics Big Data Management
Research and Extension Experiences for Undergraduates (REEU) Project: 1021788

roslyn.willoughby@wsu.edu

INTRODUCTION & PROBLEM STATEMENT

- Field phenomics offers a promising avenue for accelerating the development of high-performing raspberry genotypes.
- Numerous studies provide valuable insights into improved crop performance through selective breeding techniques and advanced sensing methods.
- Challenges and limited acceptability due to a lack of understanding.
- Need coordinated effort to develop dynamic strategies and open-access platforms.

OBJECTIVES

- Contribute to improved adoption of field phenomic technologies by enhancing raspberry breeders' understanding of these tools.
- Evaluate differences in RGB values among 8 raspberry genotypes.
- Compare color evaluation skills between breeders and non-breeders.
- Raspberry color to tartness correlations with pH and sugar content.
- Benchmarking GPT chatbot on educating on phenomic tools.
- Assess breeders' attitudes towards advanced phenomic tools.

METHODOLOGY – DATA ANALYSIS

RGB color differences across different genotypes:

1. Image collection and processing: Image 50 raspberries from eight genotypes.

2. RGB extraction: A digital image is typically stored as a two-dimensional array of pixels, where each pixel contains information about its color. Each pixel's RGB values can be accessed by iterating over the pixel array.

3. Data analysis: Multiple exploratory data analysis (python) employed to find RGB color-phenomic similarities across all eight genotypes. The algorithm extracted mean RGB values for each genotype, stored in csv. An Analysis of Variance (ANOVA) was conducted to determine if there are any significant differences in the mean RGB values across the genotypes.

4. Post-hoc analysis: Post-hoc pairwise comparisons were made using an HSD test to identify which specific pairs of genotypes differ significantly (α=0.05).

LAB WORK

1. Sugar and pH measurement: Seven genotype samples.
2. Technique: Macerated fruit to extract juice. Refractometer and pH meter used to measure sugar content (as %SSC) and pH, respectively.
3. Analysis: Correlation coefficient test to determine sugar-pH-RGB value relationship.

RESULTS

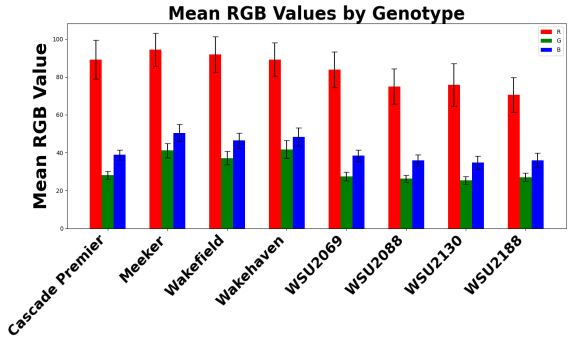

Figure 1: Mean RGB values across eight genotypes of fresh raspberries. ANOVA and Tukey's HSD tests indicate statistically significant color differences across eight raspberry genotypes. Bars represent standard error.

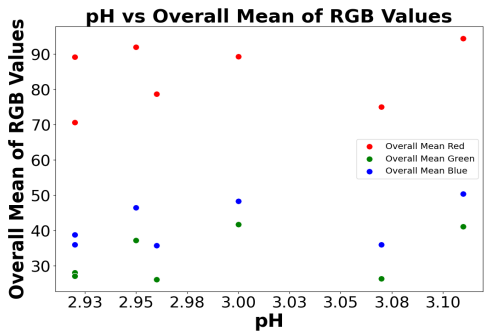

Figure 2: Scatter plot showing RGB values' relation to pH across cultivars. Lack of statistical significance indicates no strong relationship between measured pH and color, with an average p-value above 0.34.

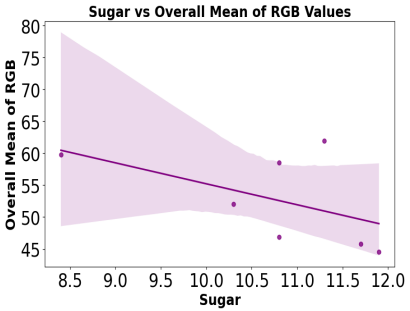

Figure 3: The scatter plot shows the relationship between sugar content (*in SSC(%)*) and the RGB_{mean}. ***Outcome:*** No statistical significance, (p=0.22).

CONCLUSION

Considerations

• Genotype WSU2069 was unavailable for sugar and pH analysis. No relationship was detected between sugar, pH, and color.

Preliminary results

- The Phenomics Guide chatbot project needs more raspberry breeders to assess attitudes and evaluate the chatbot's knowledge transfer effectiveness. This work is in progress.
- More breeders are needed to compare color assessment in the Breeder Insights survey.
- Out of 15 total participants, the overall average accuracy for the non-breeders is approximately 32.2%. The breeder had a low overall accuracy in assessing color (11.1%). More participants are needed for accurate comparison.

Main takeaways

RGB color analysis reveals significant differences among the eight genotypes, highlighting phenomics' ability to successfully discern color variations and its potential usefulness for breeding programs.

FUTURE WORK

- Finetune LLM for Phenomic Guide
- Increasing sample size for the questionnaire
- Extending methodologies to different fruits

ACKNOWLEDGMENTS

Thanks to Will Bieker for providing the initial code and images. Special appreciation to the Washington Red Raspberry Commission for hosting the raspberry field day. Gratitude to Wendy Hoashi-Erhardt for sample collection assistance and to Brian Maupin for demonstrating the pH and sugar measurement techniques. Funding for this project was provided by USDA-NIFA REEU (Project #…).