Plant Phenome

AI Accelerating Variety Breeding

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What is Plant Phenome?

Plant Phenome refers to a set of plant characteristics or traits that result from the plant genes expression within the environment. These traits include plant morphology, physiology, development, and response to different environmental conditions such as climate, soil type, water availability, and nutrition.

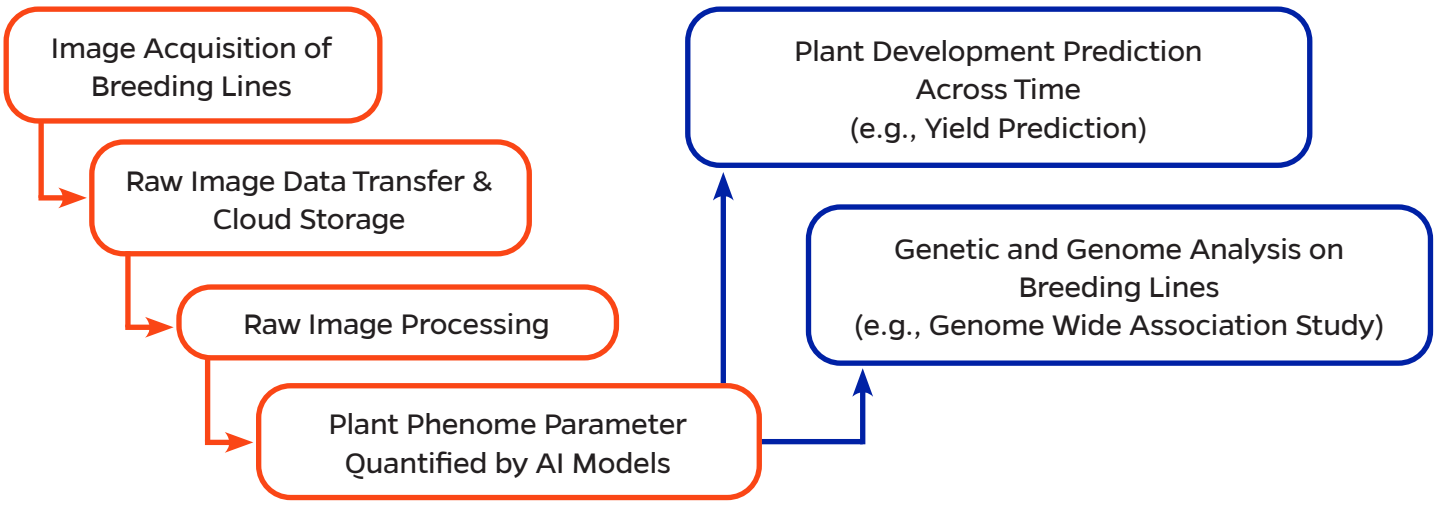
Traditional Breeding:

Breeding lines' selection goes through various quantitative and qualitative evaluation protocols. With traditional breeding methods, evaluation protocols are usually destructive sampling methods to measure characteristics such as plant canopy biomass, and fruit weight. This may require multiple sampling times throughout the crop growth stage. With these traditional time-consuming and labor-intensive methods, more plants are required from each breeding line to provide the evaluation parameters investigated. With the need for more plants, more acreage and monetary investments are also required for breeding trials. Another limitation of traditional selection is its subjectivity, as trait measurements often depend on human judgment. This can lead to variability, with different individuals assigning inconsistent scores for the same trait. Moreover, maintaining consistency by having the same person assess traits throughout an entire season can be challenging, further contributing to potential bias in selection.

Artificial Intelligence (AI) in Breeding:

AI has been employed in a variety of methods to assist crop breeding. One particularly beneficial way is the use of complex AI models to regularly analyze enormous amounts of imaging data from trial plants to develop quantitative growth profiles for each breeding line. This reduces the need for traditional destructive sampling and evaluation methods. Aerial or ground-based imaging of breeding trials can be completed regularly in a fraction of the time used for sampling with limited labor involved (Fig 1). Imaging data is analyzed to develop an accurate quantifiable phenome profile for the tested breeds with much easier repeatability throughout the season without the penalties of destructive sampling (Fig 2).

AI-Assisted Breeding Pathway:



AI-Assisted Breeding Savings:

By integrating AI models into breeding, we can achieve the following savings/reductions:
1-Number of plants needed to evaluate each breeding line.
2-Acreage needed for breeding lines, thus increasing the ability to test lines.
3-Labor needed to manually harvest and measure various plant phenome parameters.
4-Time needed for traditional manual quantifications. For example, new strawberry varieties can potentially be developed within 5-6 years with AI-assisted models compared to 7-9 years with traditional methods.

Ongoing Research:

AI models are constantly being improved and enhanced to boost efficiency and increase functionality. For example, evaluating plant stresses in the field through enhanced imaging or analysis may also assist in developing disease and pest susceptibility or resistance levels profile for various crops which can also be tremendously valuable in the cultivars' selection process. Additionally, this could potentially assist in early detection and/or differentiation of diseases, pests, and other plant stressors.

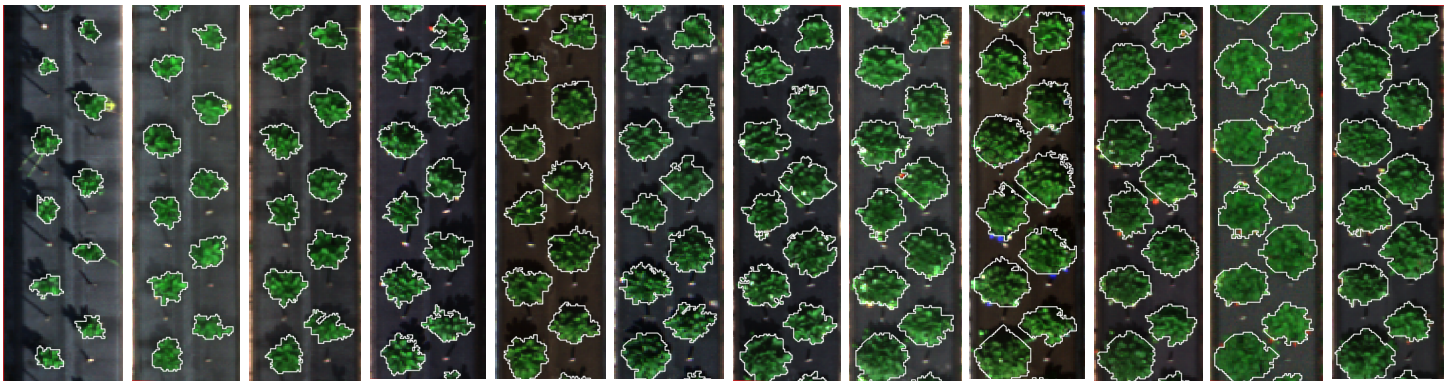


Figure 1: Strawberry breeding research plots' imaging during the 2021 season. Weekly imaging shows the growth and development of the individual plants from left to right. AI-analyzed images can detect and track certain phenome traits over time such as biomass.

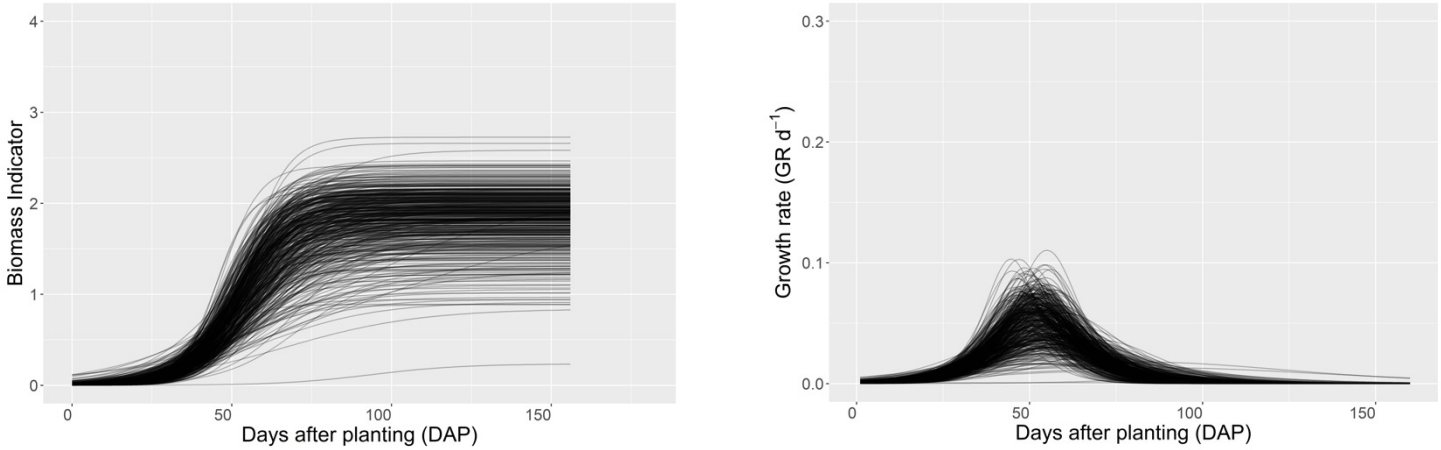


Figure 2: AI calculated biomass of strawberry breeding lines using research plots' imaging during the 2021 season (left). The growth rate calculated over time shows plant development shifts during the season (right).

References:
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