Crop Trait Optimization via Precision Agriculture

Bridging Machine Learning and Food Security

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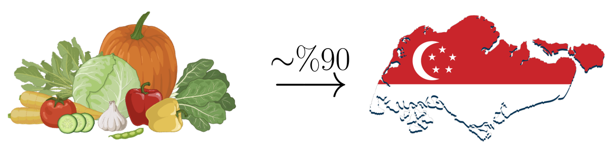
1. Problem



1. Singapore imports about 90% of its food demand.
2. National goal: meet 30% of nutritional needs by 2030.
3. For local farming to be sustainable it needs to be economically viable.
4. Proposal: synergistic effort including in-situ and remote sensing; and plant, materials, and statistical sciences to boost Singapore agriculture and make it viable.

2. Research Question

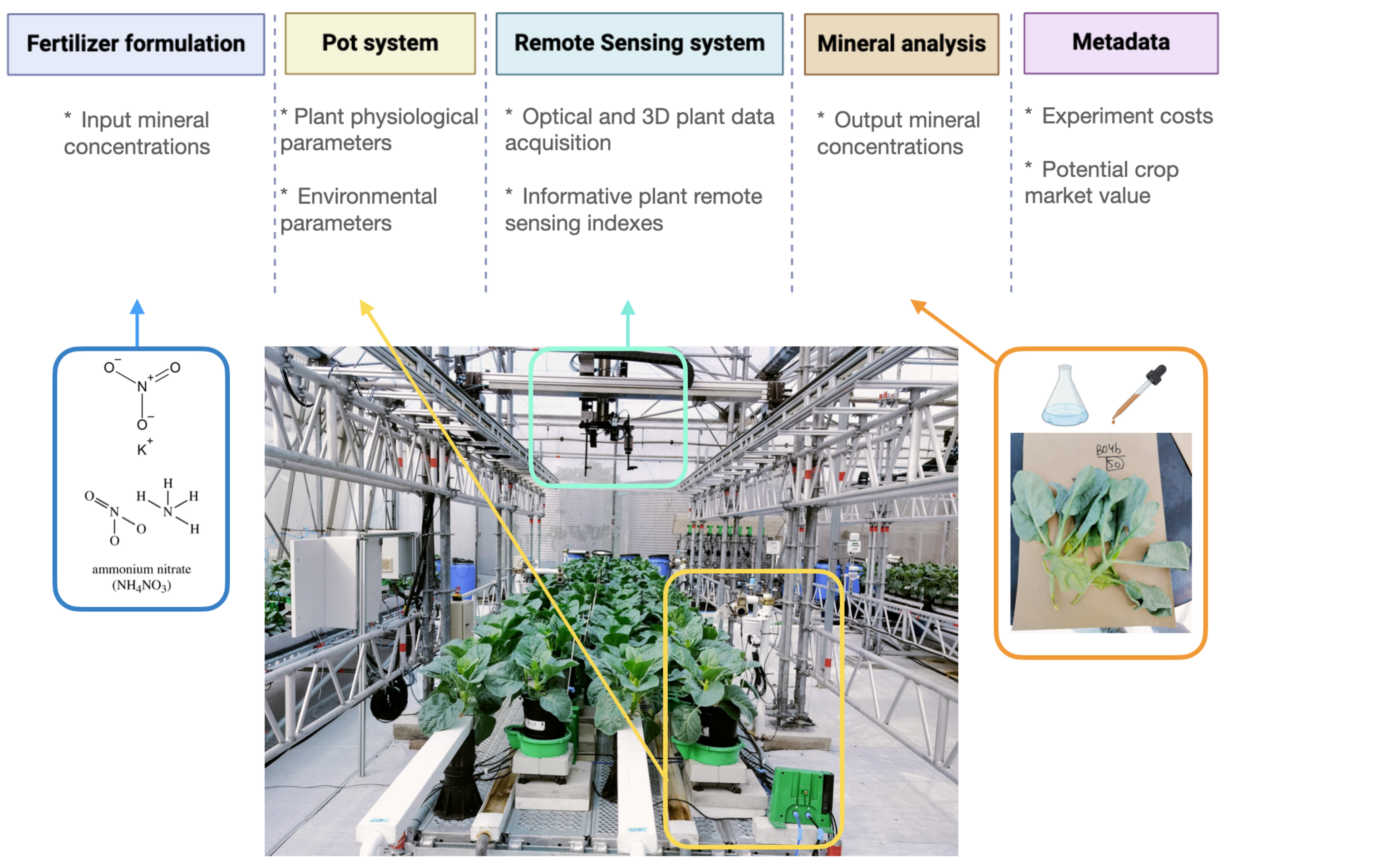
How to improve yield and nutritional content, and how to be maximally optimal in this process.

We identify we need:

1. Efficient and affordable **monitoring** of crop growth and environmental conditions.
2. Models for continuous **intervention** to optimize multiple traits.

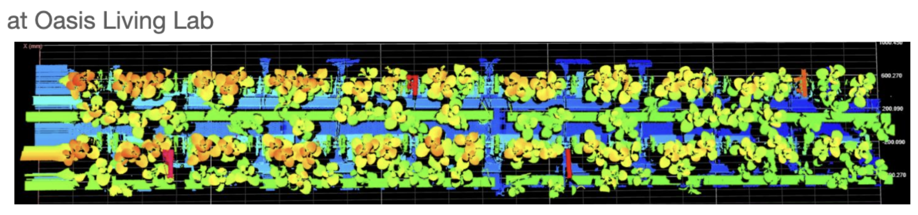
3. Plant Phenotyping (monitoring)

- Multimodal data from 84 block-randomized plants (subjected to 8 treatments or mineral concentrations) and environment are consolidated in a unified database.
- E.g. weight, transpiration, leaf stomatal conductance, radiation, temperature, etc.



Greenhouse at Oasis Living Lab

E.g. Hyperspectral data capture:

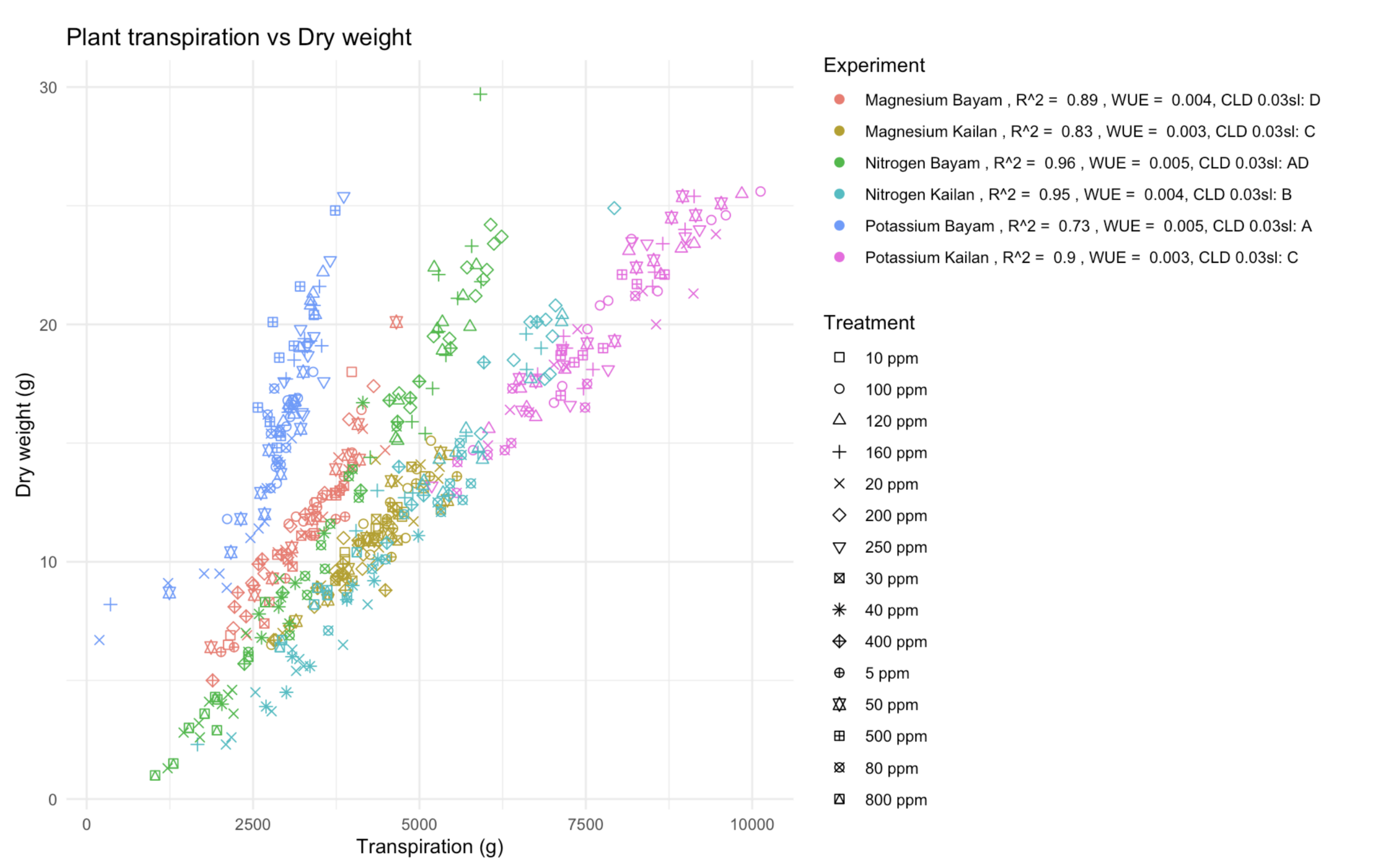


- A Bayesian model identifies the optimal treatment for a given set of traits and their ideal outcomes (Pebes et al., 2024; `arxiv.org/abs/2410.17604`)

4. Crop Improvement via Reinforcement Learning (intervention)

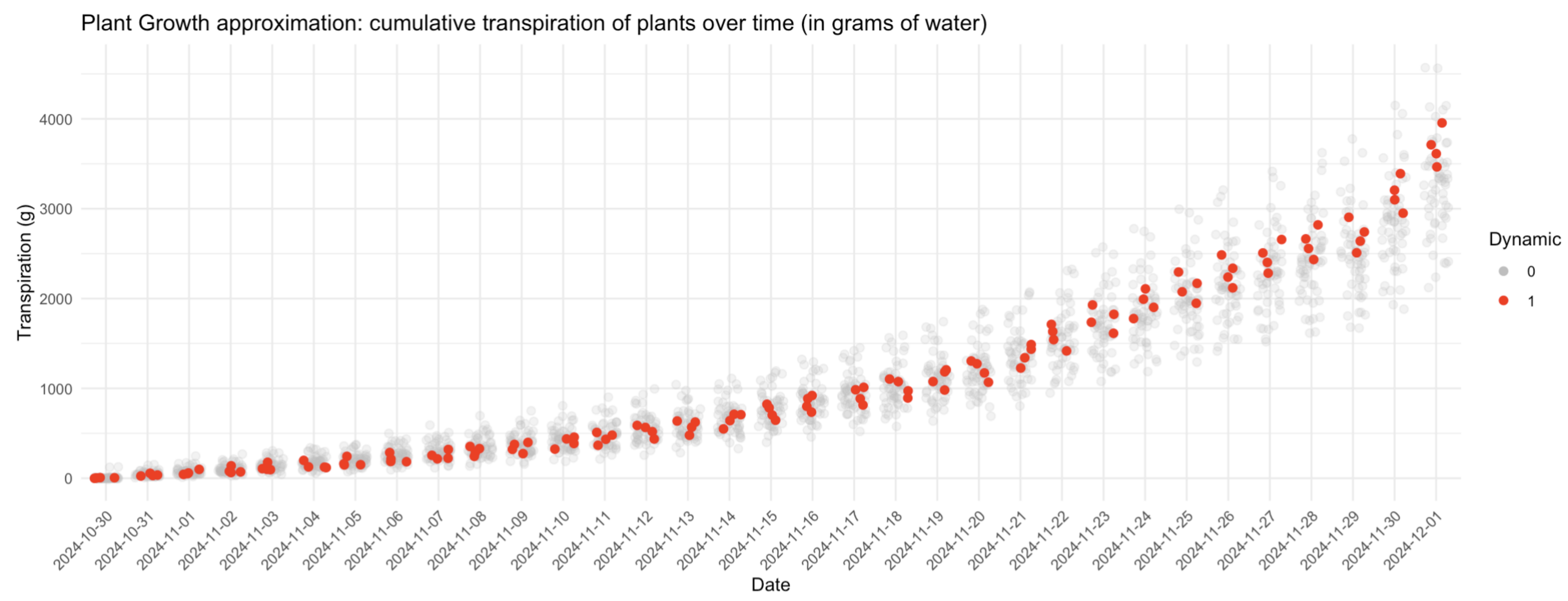
Step 1: Find continuously available predictors for desired traits.

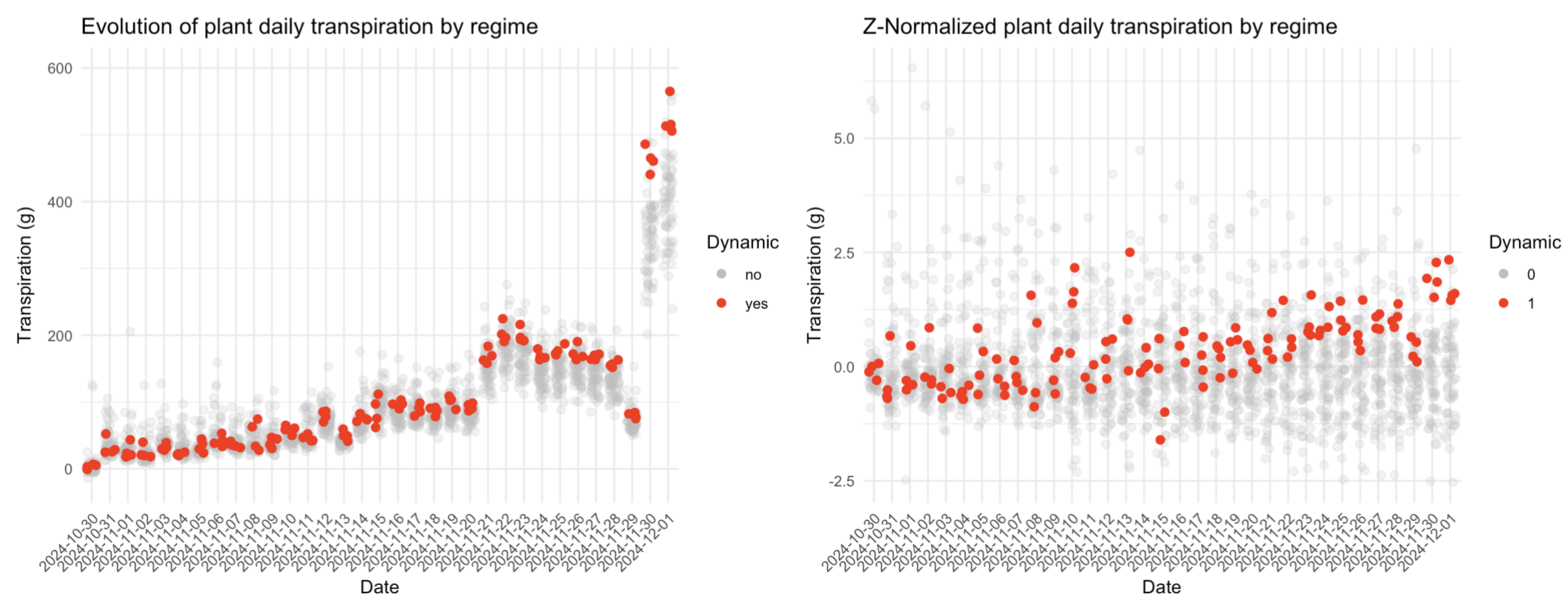
- E.g. plant yield (g) is linear on cumulative plant transpiration (g of water).
- While yield is measured after harvest as plant dry weight (destructive procedure), plant transpiration is continuously collected through a non-invasive process.

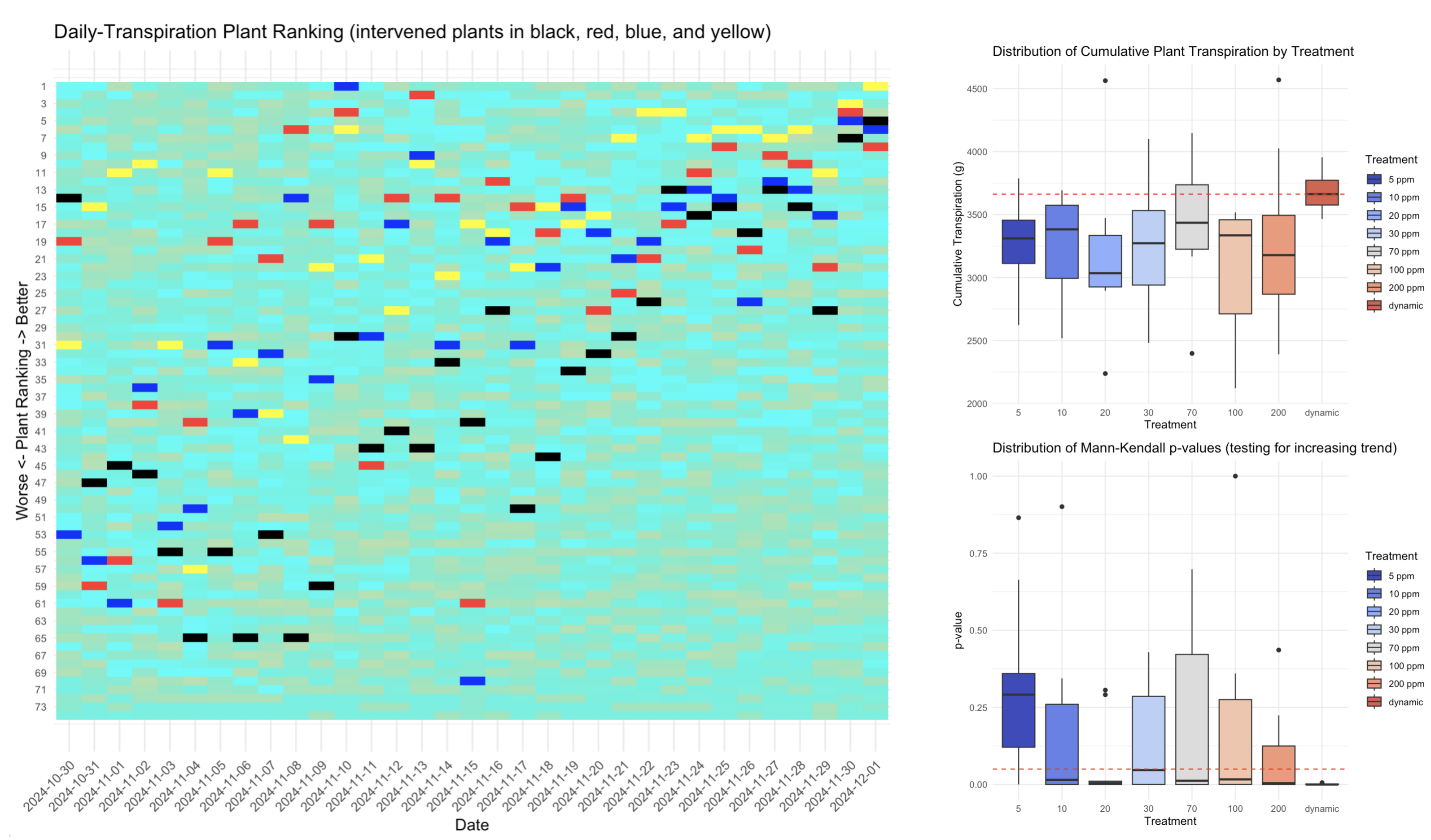


Step 2: Application of our model over time using the continuous predictors

- Every day, our model evaluates the performance of fertilizers based on predictor measurements and decides which one to apply the following day.
- We showcase crop yield maximization using plant transpiration.
- Intervened plants (dynamic) improve continuously achieving the highest median performance at harvest (Experiment on Kailan or Chinese broccoli varying Iron).







6. Conclusions and Forthcoming Research

- Our proposed model is effective for both evaluation and intervention tasks.
- It offers two-fold benefits: (1) increased yield and (2) recovery of stressed plants.
- We anticipate improved efficiency by tailoring our model to weather predictions.
- We are developing new remote sensing indexes as predictors for other traits.

References

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