Lettuce field data summary and explanation for leaf count measurement

Source file: 9.5.25 control leaf count.xlsx (for example purpose)

Background

1. What is an Agrivoltaic System?

An **agrivoltaic system (AGV)** combines:

- 🌞 Solar photovoltaic panels (electricity production)
- 🌱 Agricultural crops (food production)

The idea is to use the same land for both energy and agriculture.

In this study:

- Solar panels are mounted on poles.
- Lettuce is planted underneath and around the panels.
- We compare plant performance under different light environments.

2. Why Study Lettuce Under Solar Panels?

Solar panels change:

- Light intensity

- Light duration
- Soil temperature
- Soil moisture
- Microclimate (wind, evapotranspiration)

Lettuce is a good test crop because:

- It is sensitive to light and temperature.
- It has a short growth cycle.
- Yield metrics are easy to measure.

We are studying whether partial shading from panels:

- Reduces stress?
- Changes growth rate?
- Improves or reduces yield?
- Affects morphology (leaf number)?

3. Experimental Design Structure

The field is organized into:

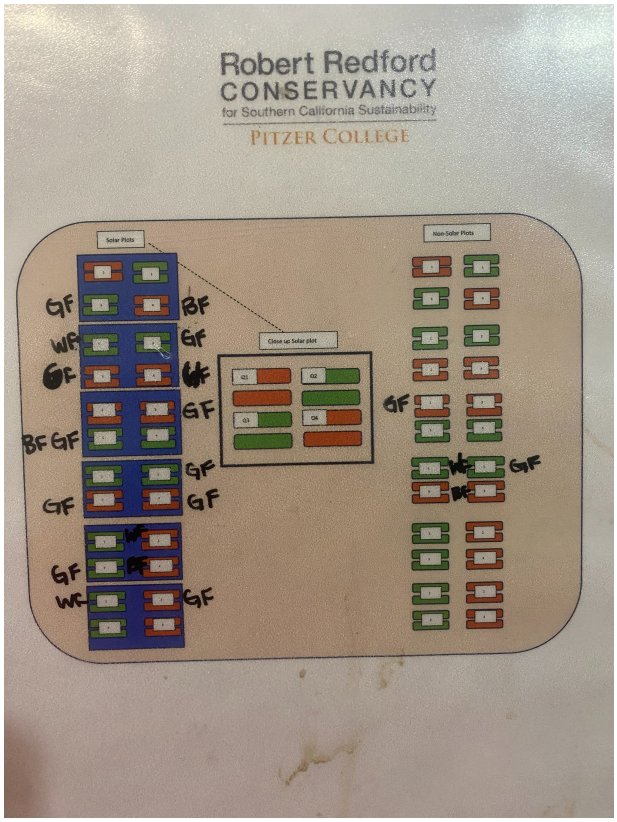
- **Panels (P)** → e.g., P1, P2, etc.
- Each panel has **4 quadrants (Q1–Q4)**.
- Each quadrant contains:
    - **Subplot A**
    - **Subplot B**

So a column name like: P1Q3A

Means:

- Panel 1
- Quadrant 3
- Subplot A

Each subplot contains multiple lettuce plants (typically 14 or 28 depending on cycle). – Ignore the marked sharpie text. You can refer the rest.



Purpose

1. Control Case (Non-Solar)

The **control treatment** consists of lettuce plants grown under normal field conditions without shading from solar panels.

These plants:

- Receive full ambient sunlight.
- Experience standard field temperature and wind exposure.
- Serve as the baseline reference group.

Control plots allow us to answer:

What would plant growth look like under conventional farming conditions?

2. Solar Case (Agrivoltaic Treatment)

The **solar treatment** consists of lettuce plants grown underneath photovoltaic panels.

These plants:

- Experience partial shading.
- Have altered light intensity and light duration.
- May have modified microclimate (cooler soil, reduced evapotranspiration, altered humidity).

This treatment allows us to test:

Does growing lettuce under solar panels significantly change plant growth compared to full sun?

For each measurement date:

- Control and Solar plants were measured at approximately the same time.
- The response variable is **leaf count per plant**.
- Subplots are spatially organized by panel and quadrant.

This is a **parallel comparison**, not a time-series study.

We are comparing treatments at the same time point or within a week of each other since sometimes it takes time to do the measurements across the full field

Purpose

This report summarizes the dataset:

File: *9.5.25 control leaf count.xlsx*
Sheet: *9-5-25 CONTROL (Non Solar)*

The objective is to prepare the data for categorical and statistical analysis by:

1. Explaining the structure of the experimental design.
2. Clarifying variable definitions used in the Excel sheet.
3. Quantifying planting density per subplot.
4. Identifying inferred border plant positions.
5. Providing structured summary metrics for each subplot column.

This document ensures that the dataset can be correctly interpreted prior to computational modeling or categorical analysis.

Legend / Terminology

Columns: Columns are subplot columns such as P1Q1A, P1Q1B, ..., where P = Panel number, Q = Quadrant, A/B = subplot within quadrant.

Rows: L1..L28 are plant (lettuce) index positions used in the template. Depending on planting density, not all L1..L28 positions may have been planted.

Cell values: Numeric = lettuce leaf count for that plant. 'X' = plant died (no leaf count). Blank = either border plant excluded or no plant existed at that position.

Border rule (inferred): The code infers how many positions were planted per column and then marks border positions accordingly (e.g., row ends). Border positions are outlined in blue in the schematic.

Rows (L1–L28)

Rows labeled **L1–L28** represent plant index positions within a subplot template.

However:

- Not every subplot contains all 28 plant positions.
- Planting density varied between cycles.
- Some positions may not have been planted.

- Some positions were excluded as border plants.

Therefore, L1–L28 should be interpreted as potential plant slots, not guaranteed plants.

Cell Values

Each cell in the Excel sheet represents a single plant position.

Possible values:

- **Numeric value** → Leaf count for that plant (primary response variable).
- **"X"** → Plant died (no leaf count recorded).
- **Blank cell** → Either:
    - Border plant excluded from analysis, or
    - No plant existed at that position (due to planting density adjustments).

Definition of Variables in Summary Table

Variable	**Meaning**
Panel and Quadrant	Subplot identifier (e.g., P2Q3B).
InferredK	Estimated number of planted positions in that subplot (inferred from last non-blank index).
Measured	Number of plants with numeric leaf count values.
DeadX	Number of plants marked as "X" (died).
Blank	Number of empty cells (either border-excluded or unplanted positions).
BorderPositions	Number of inferred border plant positions based on row-end exclusion rule.
BorderBlank	Number of inferred border positions that are blank.
BorderNonBlank	Number of inferred border positions that contain data (should typically be excluded in analysis).

Important

Why Border Plants Are Excluded from Analysis

Border plants are typically excluded in agricultural experiments because they experience systematically different growing conditions compared to interior plants.

Specifically, border plants may:

- Receive more light exposure (less competition from neighboring plants).
- Experience different airflow and temperature.
- Have reduced root competition.
- Have different soil moisture conditions.
- Be influenced by adjacent open space or pathways.

Because of these differences, border plants can:

- Grow larger or smaller than interior plants.
- Exhibit higher variability.
- Bias average growth estimates.

Including border plants in statistical analysis can therefore:

- Artificially inflate or deflate treatment effects.
- Increase variance unrelated to the experimental factor.
- Reduce internal validity of comparisons.

In this agrivoltaic study, the goal is to compare growth conditions (e.g., solar vs. control treatment) under comparable microenvironmental conditions. Removing border plants helps ensure that:

- Observations reflect interior plot conditions.
- Comparisons between treatments are not confounded by edge effects.
- Statistical assumptions of independence and homogeneity are better approximated.

For categorical analysis, border plants should generally be removed prior to modeling unless the research question specifically investigates edge effects.

Summary table (per subplot column)

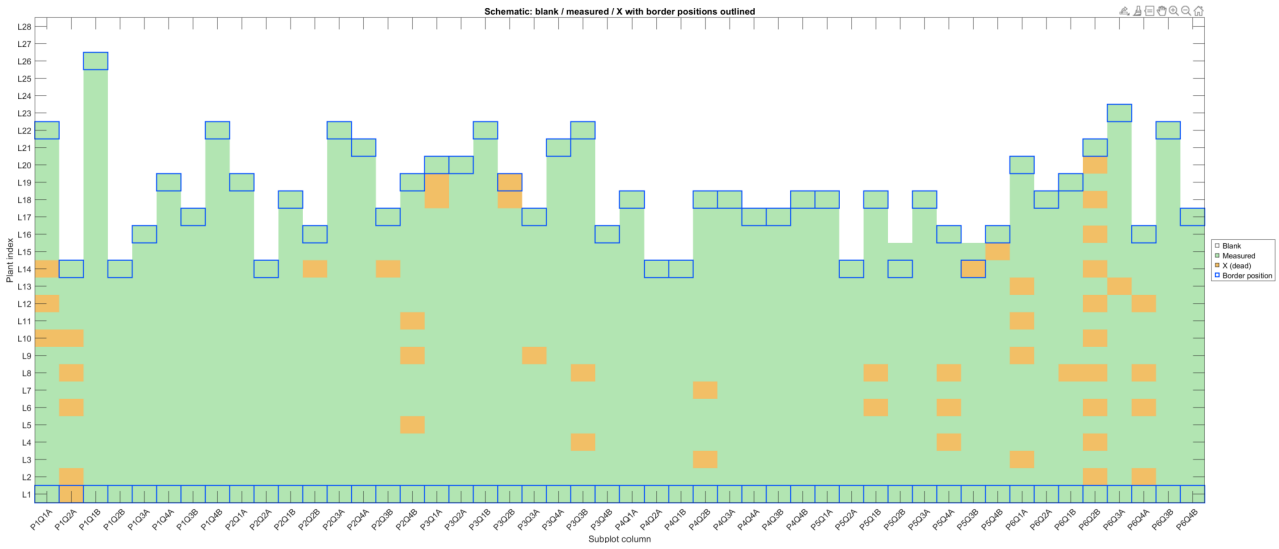
Panel and Quadrant	InferredK (number of	Measured	Dead (X)	Blank	Border plants

	plants per row)				
P1Q1A	22	19	3	6	2
P1Q2A	14	9	5	14	2
P1Q1B	26	26	0	2	2
P1Q2B	14	14	0	14	2
P1Q3A	16	16	0	12	2
P1Q4A	19	19	0	9	2
P1Q3B	17	17	0	11	2
P1Q4B	22	22	0	6	2
P2Q1A	19	19	0	9	2
P2Q2A	14	14	0	14	2
P2Q1B	18	18	0	10	2
P2Q2B	16	15	1	12	2
P2Q3A	22	22	0	6	2
P2Q4A	21	21	0	7	2
P2Q3B	17	16	1	11	2
P2Q4B	19	16	3	9	2
P3Q1A	20	18	2	8	2
P3Q2A	20	20	0	8	2
P3Q1B	22	22	0	6	2
P3Q2B	19	17	2	9	2
P3Q3A	17	16	1	11	2
P3Q4A	21	21	0	7	2
P3Q3B	22	20	2	6	2
P3Q4B	16	16	0	12	2
P4Q1A	18	18	0	10	2
P4Q2A	14	14	0	14	2
P4Q1B	14	14	0	14	2
P4Q2B	18	16	2	10	2
P4Q3A	18	18	0	10	2
P4Q4A	17	17	0	11	2
P4Q3B	17	17	0	11	2
P4Q4B	18	18	0	10	2
P5Q1A	18	18	0	10	2
P5Q2A	14	14	0	14	2
P5Q1B	18	16	2	10	2
P5Q2B	14	15	0	13	2
P5Q3A	18	18	0	10	2
P5Q4A	16	13	3	12	2
P5Q3B	14	14	1	13	2
P5Q4B	16	15	1	12	2
P6Q1A	20	16	4	8	2
P6Q2A	18	18	0	10	2

P6Q1B	19	18	1	9	2
P6Q2B	21	11	10	7	2
P6Q3A	23	22	1	5	2
P6Q4A	16	12	4	12	2
P6Q3B	22	22	0	6	2
P6Q4B	17	17	0	11	2

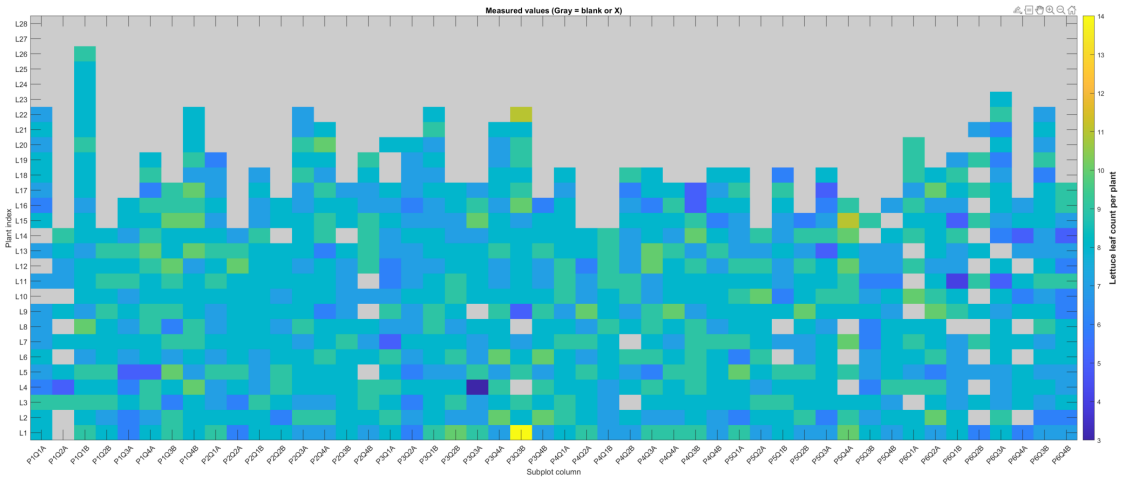
Schematic (Blank / Measured / X with border overlay)

Explanation: White = blank (no data); Green = numeric measurement; Orange = 'X' (dead). Blue rectangles indicate inferred border positions that would be excluded under the chosen border rule.



Measured values heatmap

Explanation: Color scale shows lettuce leaf count per plant. Gray = blank or 'X'. Colorbar label: 'Lettuce leaf count per plant'. Use this plot to see distribution of leaf counts across subplot columns and plant positions.



Notes

1. Treat Blank and 'X' differently: 'X' means plant existed but died; blank may mean the site wasn't planted or was excluded as border. Decide how to code blanks for categorical analysis (usually exclude).

2. Planting density varied between cycles; check inferred 'InferredK' in the summary table for each subplot before aggregating across dates.

3. The schematic overlay shows inferred border positions; if field notes say a different border rule was used, update the code parameters (preferTwoRowsWhen28, endDrop) and re-run.

4. If you want automatic CSV outputs restructuring data into tidy long format (one row per plant with metadata columns), ask and I will add that export step.

5. A MATLAB Code is attached for every sheet for the excel sheets in each cycle.

6.