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## GENOTYPE X ENVIRONMENT ANALYSIS

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## What is Genotype x Environment (GxE) analysis?







Genotype-by-Environment (GxE) analysis examines the performance of plant genotypes across a range of environmental conditions and agricultural inputs, including soil, rainfall, and temperature. This approach enables evaluation of consistent performance across different environments for various grasses and legumes, thereby enabling stakeholders to make well-informed decisions about sowing strategies tailored to their specific needs.

Pasture Trials Network (PTN), Meat & Livestock Australia (MLA), prominent Australian seed companies, and pasture consultants have collaborated to enhance confidence in selecting appropriate forage varieties for diverse environmental conditions across Australia's temperate zones. This collaboration is underpinned by data from the Pasture Variety Trial Network (PVTN) and the Pasture Trial Network (PTN) across various species.

Complementing the MLA PTN eTool is an online resource for finding local trials across a range of forage species; the Genotype by Environment (GxE) analysis assesses varieties based on their consistent performance across seasons, years, and regions.

These evaluations consider factors like rainfall, soil pH, and temperature. For example, the graphs show that a pasture variety within a certain species might excel in cool, moist areas but underperform in warmer, drier regions—more confidence, supported by multiple datasets.

GxE analysis boosts confidence in selecting varieties tailored to specific locations, thereby improving pasture quality, yield, and farm productivity. Understanding genotype-environment interactions supports better planting choices, promoting enhanced productivity and sustainability in Australian temperate agriculture.

This new data output from the Pasture Trials Network offers a supplementary resource for the MLA PTN eTool, helping producers make informed forage choices that meet their production requirements. It also supports pasture seed companies in their breeding decisions, aiming to enhance Australian forage productivity by selecting superior varieties.

SCAN ME

+ VISIT THE MLA PTN ETOOL

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## Selecting the graph of interest

### Environments available

PTN GxE graphs depict how different varieties' (genotypes) yields vary across diverse environments. To start, PTN has created graphs for the following environmental factors:

- **Rainfall input:** based on rainfall data collected during each trial from the closest Bureau of Meteorology (BOM) weather station to the trial during its conduct.

- **Total thermal time:** based on air temperature collected throughout each trial from the closest BOM weather station. Base temperatures for each species, the minimum air temperature for growth, were selected from the scientific literature by the PTN Technical Working Group (TWG).

## Seasons

- Individual seasonal performance, with spring further separated into early and late spring.

- A combined total graph, which summarises the performance of varieties across all seasons, is also included.

## List of sites

All graphs display the sites' data sources, using red to indicate sites with higher environmental cues and blue for those with lower environmental cues.

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## Absolute vs relative

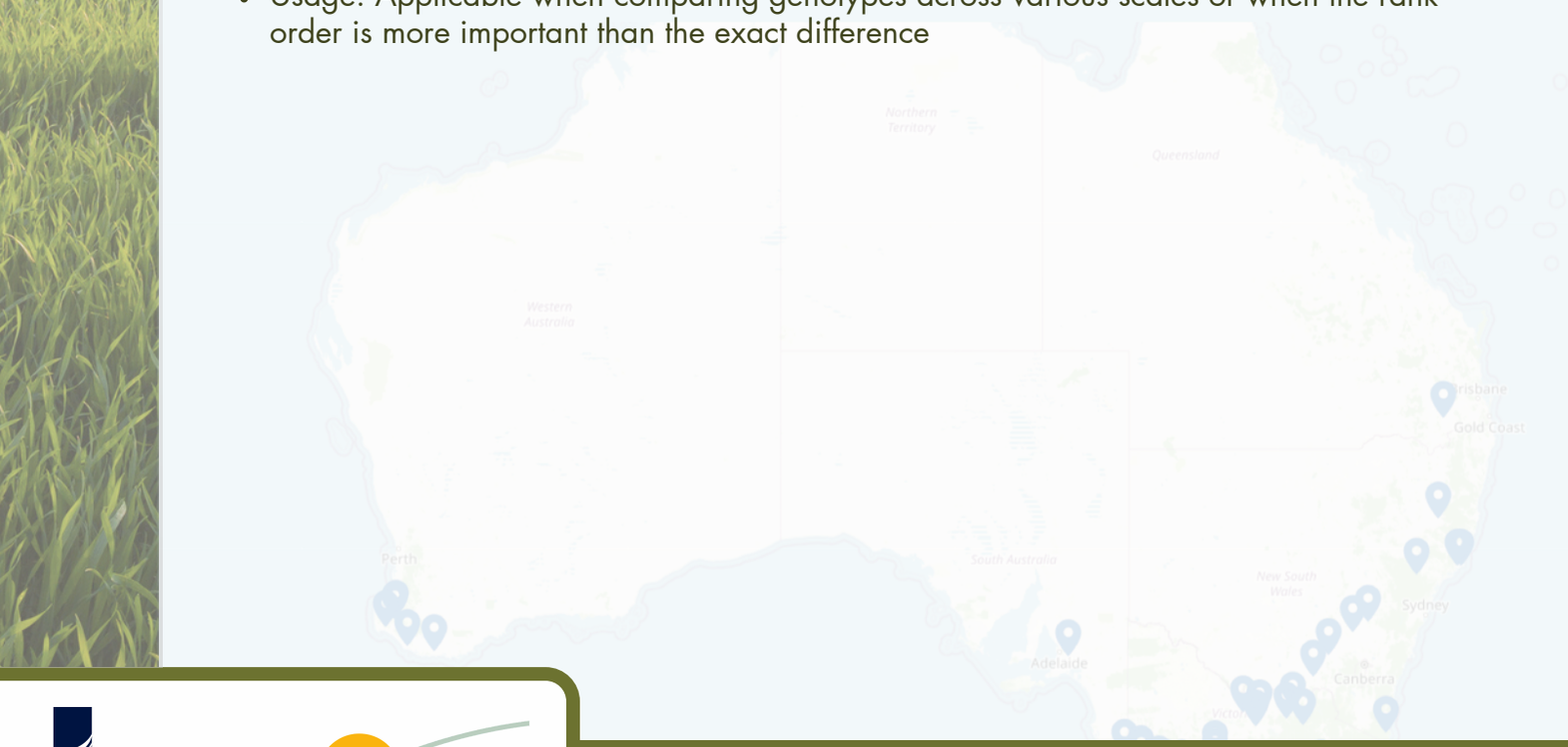
For each, there are two types of graphs for interpretation: absolute vs relative. These are best defined as:

### Absolute (Absolute Difference)

- Explanation: This is the direct, quantifiable difference in performance between varieties, expressed as yield (T/ha).
- Example: Variety "A" yields 5 tons/ha, while Variety "B" yields 8 tons/ha, when comparing rainfall inputs (an absolute change of 3 tons/ha).
- Usage: This is used for comparing the overall average yield performance of different genotypes across various environments.

### Relative (Relative/Ratio Difference)

- Explanation: This refers to comparing or ranking a genotype's performance relative to a reference point, such as pH or minimum rainfall, and expressing the result as a percentage.
- Example: One variety outperforms another by 10% in a single environment, indicating a shift in their relative rank (re-ranking).
- Usage: Applicable when comparing genotypes across various scales or when the rank order is more important than the exact difference




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## Interpreting the graphs

With numerous varieties scattered across the page, these graphs can appear complex to interpret at first glance. To assist, below explains how to read and get the best value from the graphs:

**1.Axis:**

- The x-axis (horizontal line) typically indicates the higher performance of varieties in relation to the environmental cue being evaluated, with better-performing varieties positioned to the left.
- The y-axis (vertical line) represents the lower performance of varieties for the environmental cue being assessed, with varieties further from the base of the axis performing better.

**2.Data Points:**

- Each point on the graph signifies the performance of a specific pasture variety under certain conditions. Different varieties are represented by their own data points along the axes.
- Not all varieties have been included in the PTN or the market, and sufficient data across all environments is not available; as such, some statistical assumptions have been used to determine the potential performance of some varieties in each environment. These are identified with hollow/unfilled dots.

**3.Interpreting Performance:**

- A tight cluster of points (closer together) means that varieties perform similarly across different environments.
- Each point features error bars. When data are limited, some varieties exhibit higher error, as indicated by lines extending from the data points. Overlapping lines indicate no statistical difference in performance among varieties in that environment.

**4.Included trials:**

- Trials from the data source are noted on the right-hand side of the graph, with above-median* trials coloured in red and below-median trials.
- The median value used to determine the split into the two groups is located in the centre of the list of trials and is coloured green. In the graphs, ♦ = median (middle value) of the environmental variable, which differs from the average.

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## Interpreting the graphs

In summary, a GxE graph illustrates the performance of various pasture varieties across different locations or environmental conditions, facilitating the identification of the most stable or adaptable varieties.

The proximity of data points to the top of the y-axis indicates superior performance of the respective varieties. This is presented in the graph below, where each quadrant is divided in Figure 1:

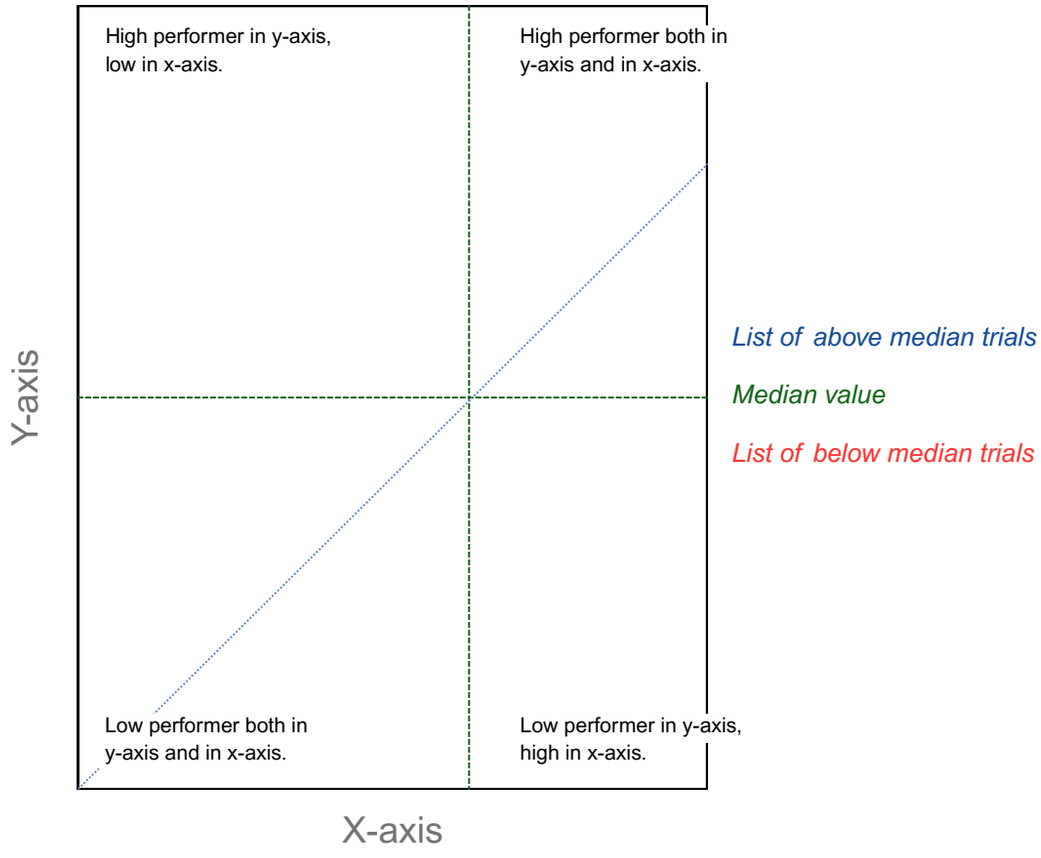



*Figure 1. A guide to interpret GxE graph outputs, with each quadrat of the graph indicating the analysed performance of the variety across multiple trials.*

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## Key explainers

***Why aren't all trials included from the PTN eTool?***

- To complete the analysis, varieties need to be consistently entered into several trials, ideally across differing environments. Some varieties have limited data in alternative environments, such as low-rainfall locations, and statistical assumptions are used to assess their performance. As such, these are indicated by a hollow data point.

- Given its legacy data, PTN is working with seed companies to improve the consistency of varieties across environments and improve future GxE outputs.

***What defines dryland wet sites?***

- Due to the number of trials and the varying environments and rainfall levels, each GxE output is tailored to the total rainfall each trial experienced. The number of trials is evenly classed into above or below, with a dynamic median, or central value, calculated for each graph.

- Rainfall data is collected from the closest BOM station during the active phase of the trial.

***What defines cool and hot sites in terms of thermal time?***

- Due to the number of trials and the varying temperature environments, each GxE output is tailored to the air temperature each trial experienced. The number of trials is evenly classed into above or below, with a dynamic median, or central value, calculated for each graph.

- Temperature data is collected from the closest BOM station during the active phase of the trial.

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## Key explainers

***What is thermal time?***

- Thermal time is the time required for a plant to accumulate the thermal units needed to reach developmental stages, with each species having a pre-determined minimum growth temperature, known as the base temperature.

- The accumulated time a plant is exposed above the base temperature of growth is known as growing degree days, and is calculated as:
  - Data can be used to determine the potential leaf regrowth rate or other factors, with plants that can tolerate higher temperatures having greater yield potential.

***Why are all varieties not present from the eTool, or missing data, or hollow data points?***

- Some varieties have limited data in alternative environments, such as low-rainfall locations, and statistical assumptions are used to assess their performance. To be assessed, a variety must be in at least three trials in both environments. Where an entry has 3 trials in only one environment, the point is plotted a hollow data point is plotted on the average line for the missing environment.

- Where varieties have insufficient data in some zones, these have been excluded. As more data becomes available, these will be included in future GxE updates.

**Acknowledgement**

**PTN acknowledges and thanks** its members, David Baird, MLA and Dairy Australia, for support and collaboration in preparing these graphs.

PTN is funded and supported by MLA, Dairy Australia, Australian Seed Federation and leading Australian seed companies.

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*The information in these graphs has been collated from a series of field trials conducted in growing regions across Australia to formulate variety performance.*

*Due to variations in production systems, weather conditions, and soil types, varietal outcomes may differ significantly by location.*

*It has been prepared without taking into account individual objectives, financial situation or needs. Due to the above growing variations, PTN can not be held liable for the performance of the variety specified in this document.*

*PTN disclaims liability, including for negligence, for any loss or injury directly or indirectly sustained by any person as a result of any reliance upon (including reading or using) the data contained in these graphs and associated data.*

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*Where quoted, past performance is not indicative of future performance.*

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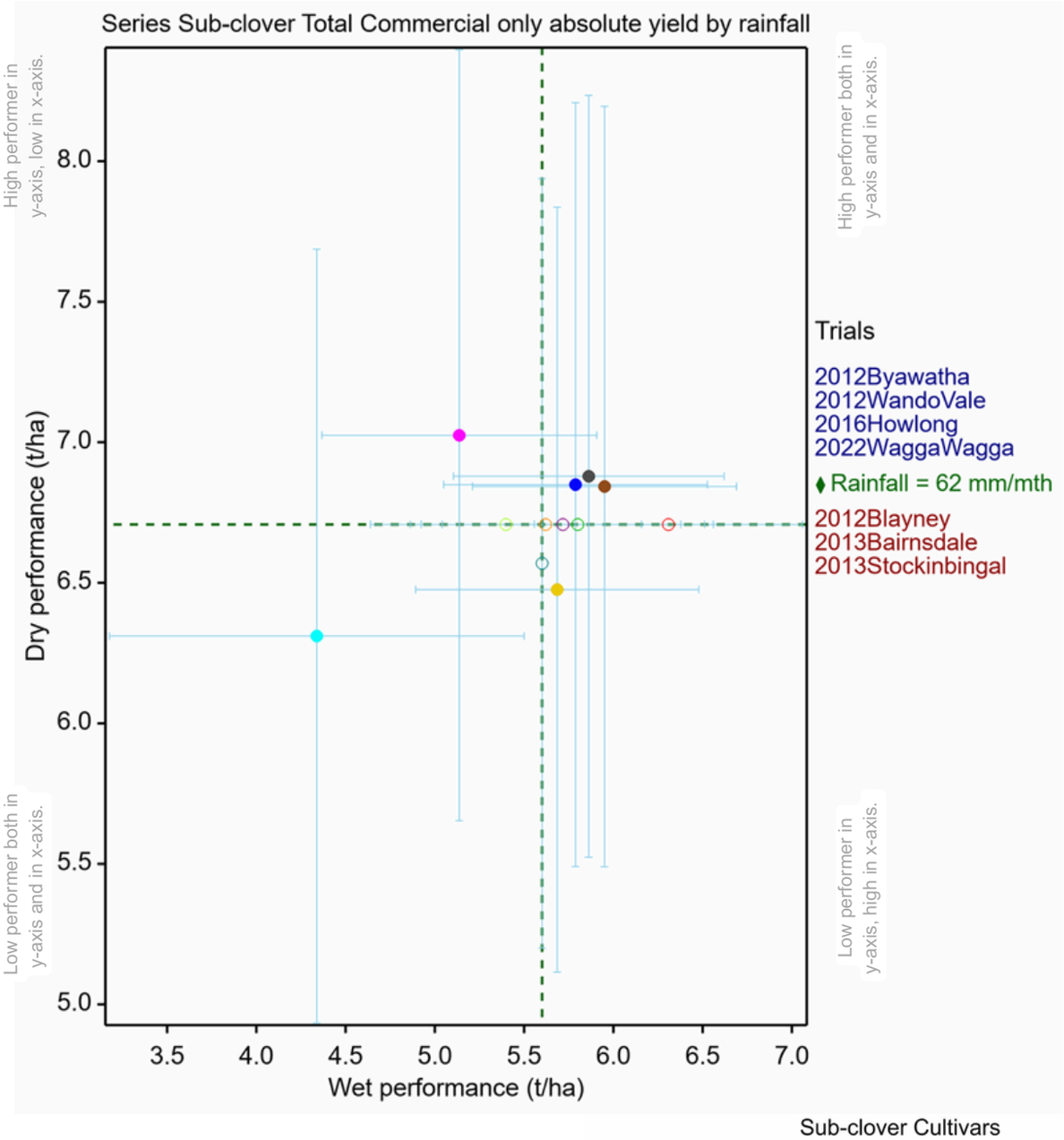
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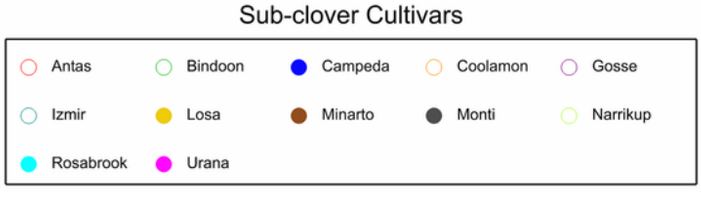
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## Absolute rainfall interaction analysis | Sub-clover | Total




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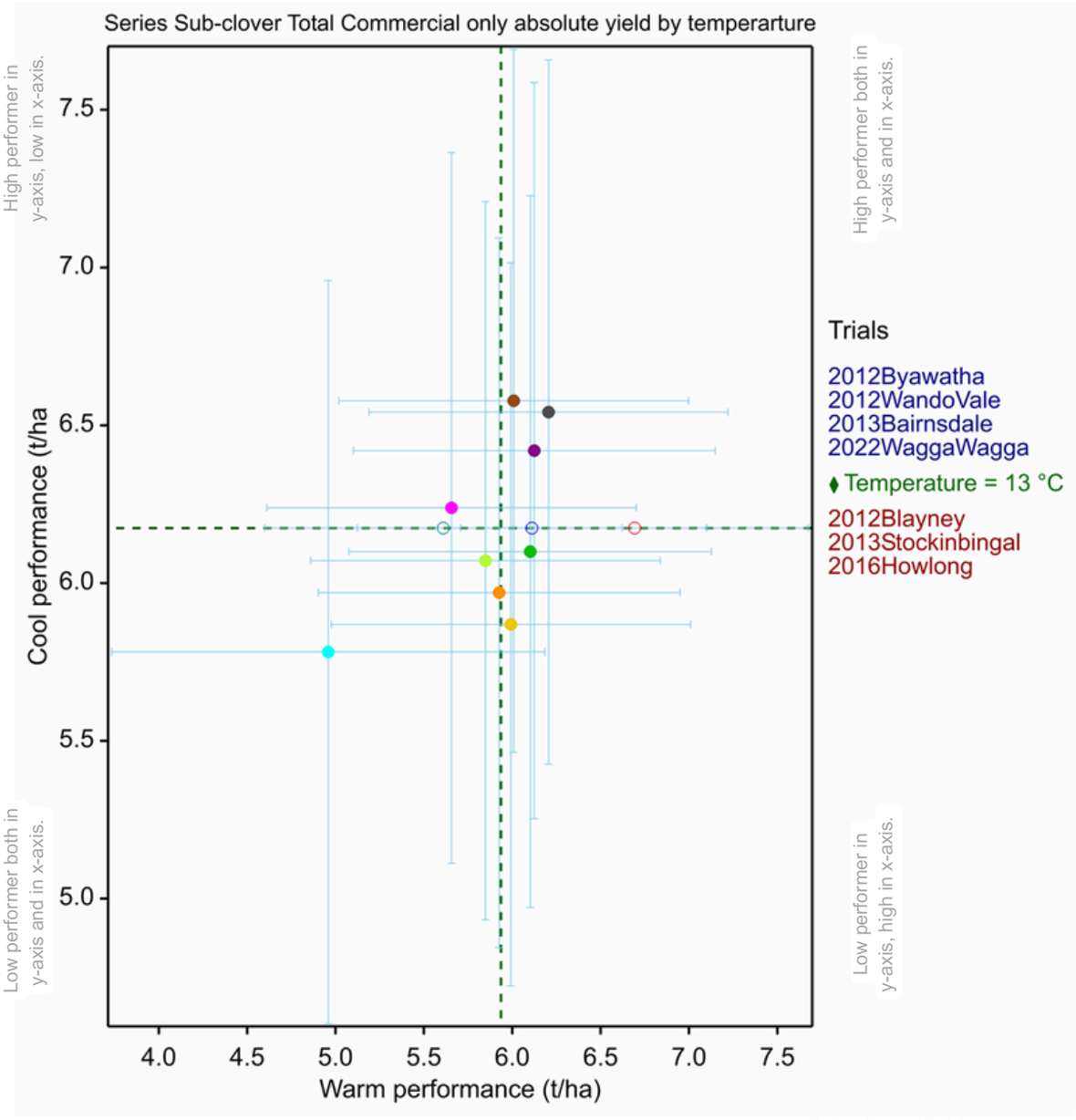
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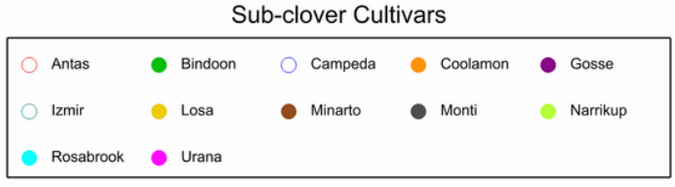
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## Absolute temperature interaction analysis | Sub-clover | Total




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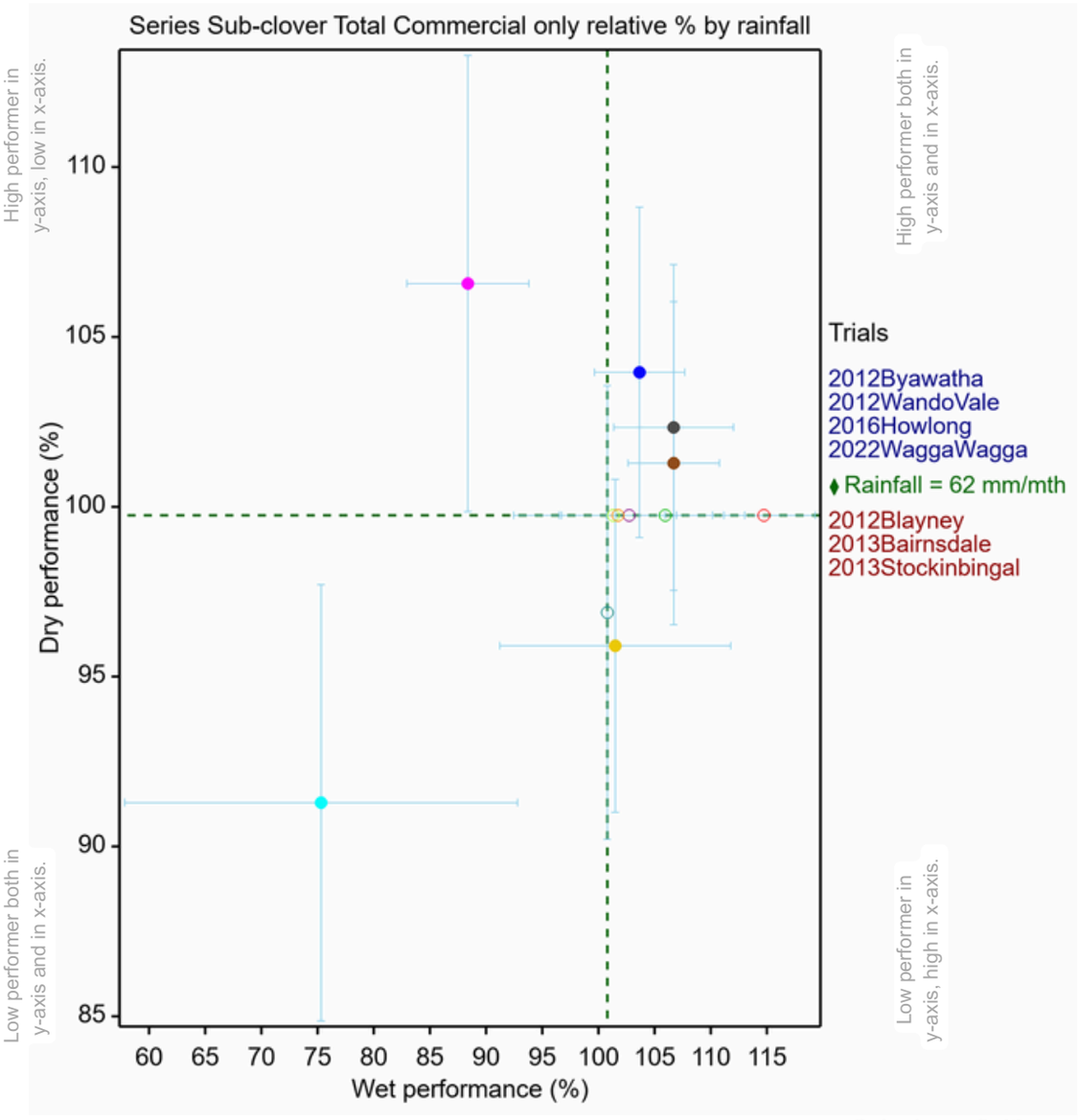
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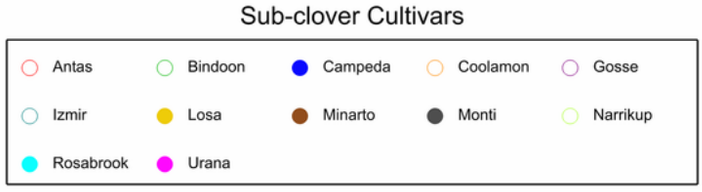
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## Relative rainfall interaction analysis | Sub-clover | Total




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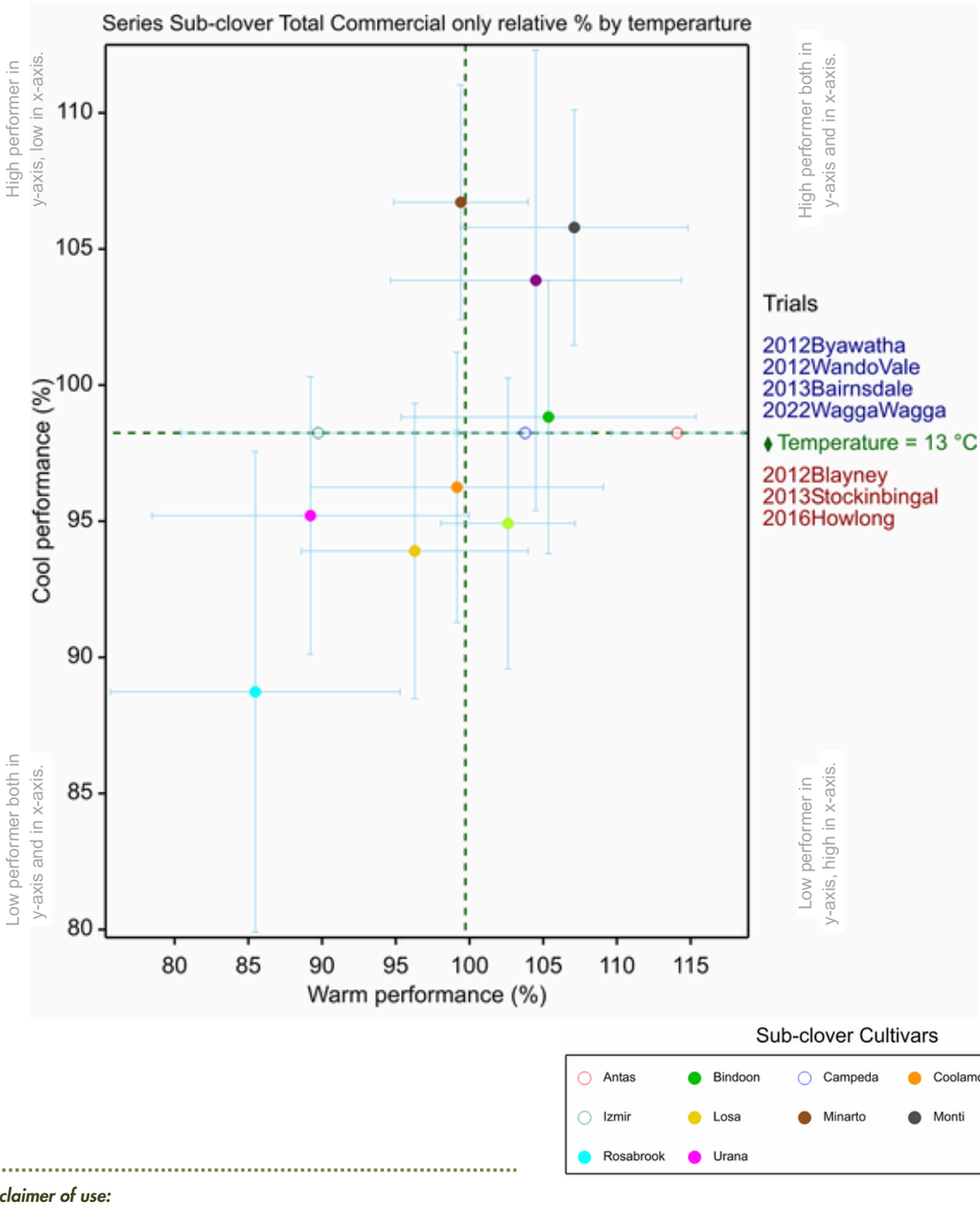
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