Development of out-of-season mango production under the extreme desert conditions of the Israeli Dead Sea and Arava regions

Yuval Cohen

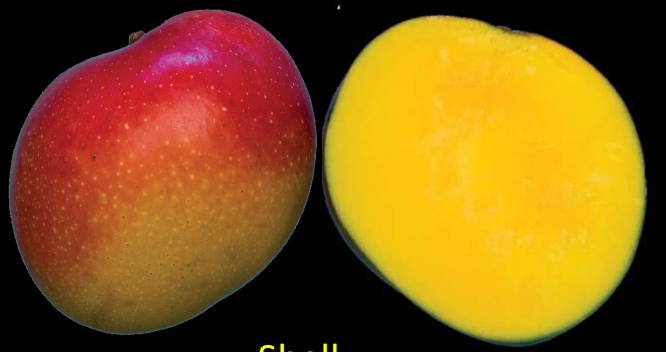
Department of Fruit Tree Sciences
Agricultural Research Organization – Volcani Institute

Email: vhyuvalc@volcani.agri.gov.il

Mango cultivation areas in Israel

- Cultivation on approximately 3,000 Ha.
- Currently, more then 90% of mango cultivation is in the Northern Valleys region.
- Commercial success result in renewed interest in mango cultivation in arid regions of Israel, and especially near the Dead Sea and at the Arava desert.

Mango cultivars of the Israeli breeding project



Shelly

Omer

Agam

Tango

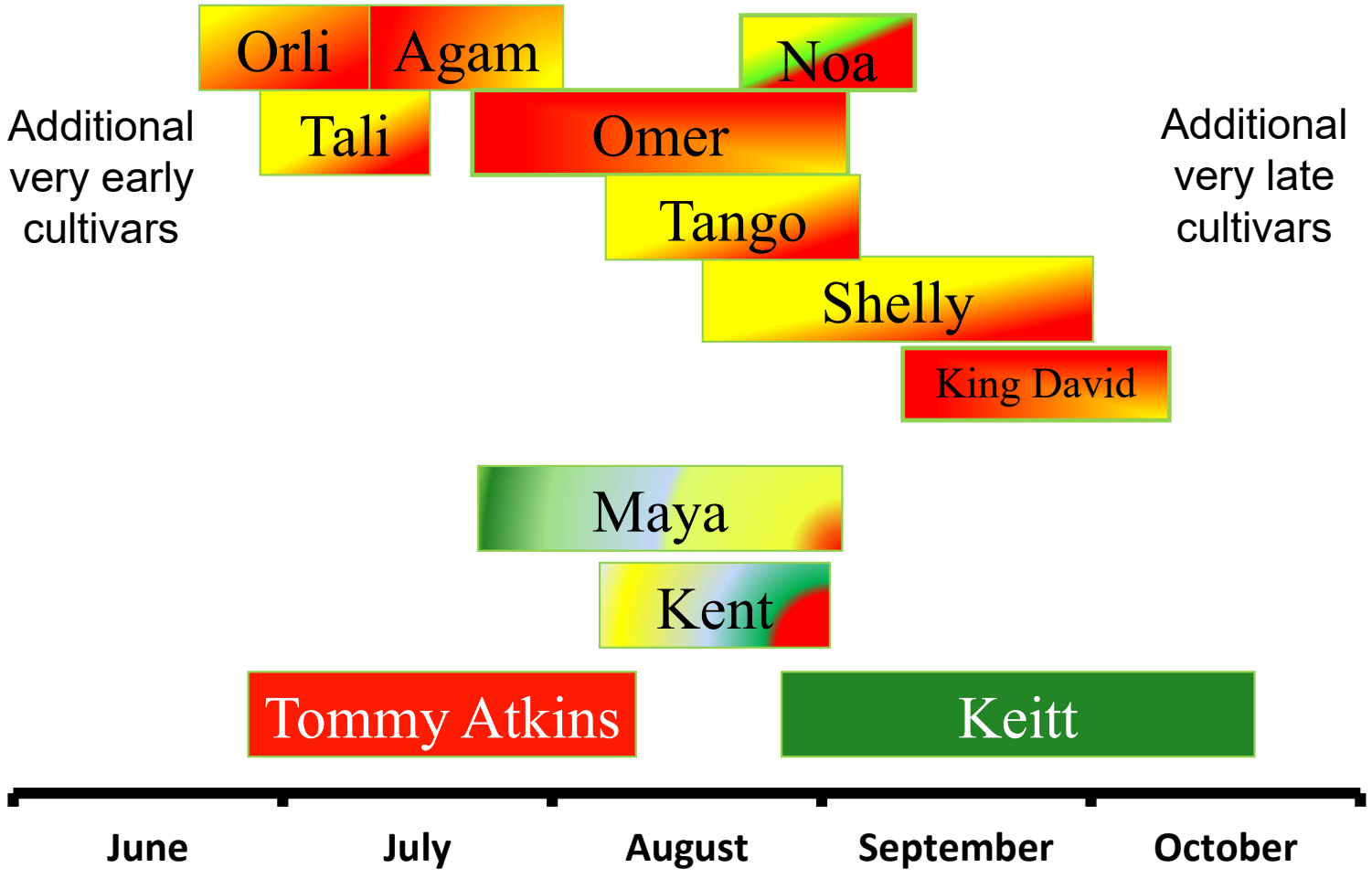
Tali

Noa

Orli

King David

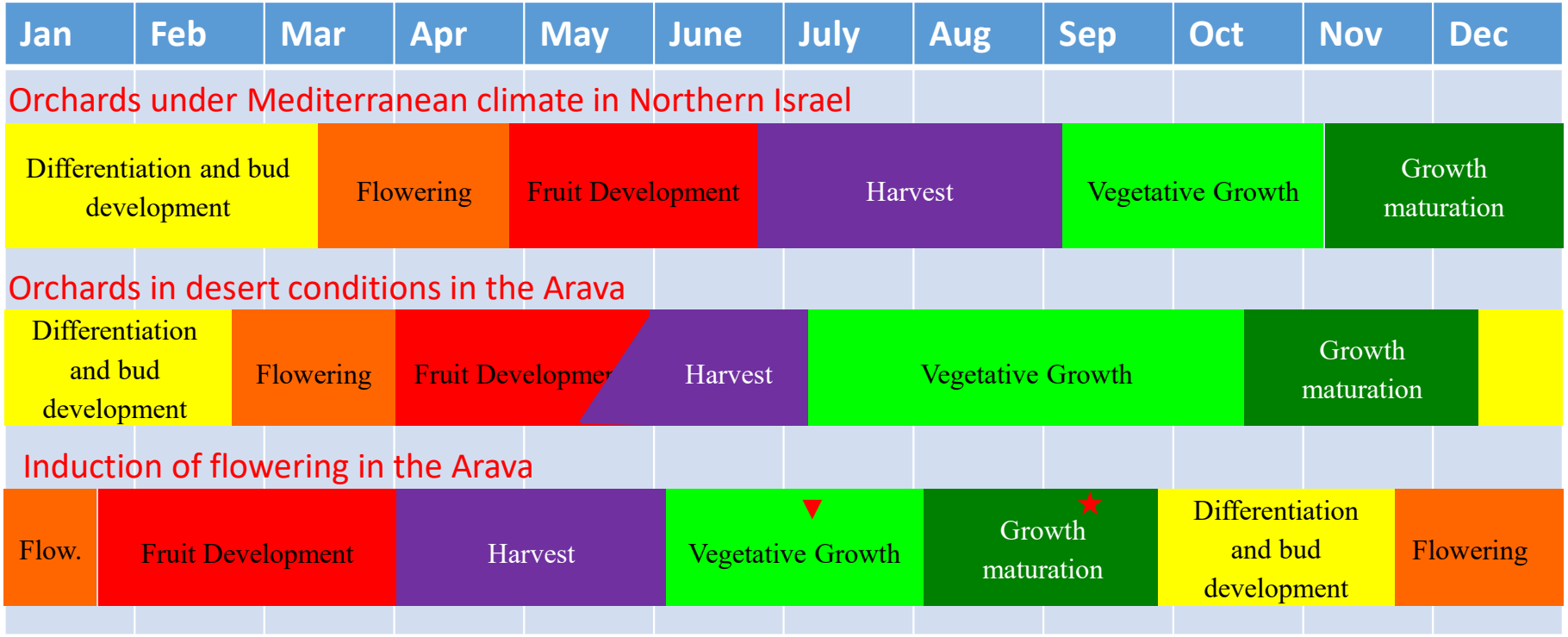
Ripening calendar for Israeli cultivars



Out of Season mango production in arid regions

- The Arava region is already the early season producer of mango to the Israeli market.
- The warm and dry desert conditions near the Dead Sea and the Arava valley provide an opportunity for out-of-season production in either open orchards or in green houses.
- Induction of flowering by external application of paclobutrazol (PBZ, Cultar), or by drought is a common practice in tropical regions, but is not used in Israel due to the natural induction by the cool winter.

Effects of flower induction on life cycle and productivity of mangoes in the Israeli Arava

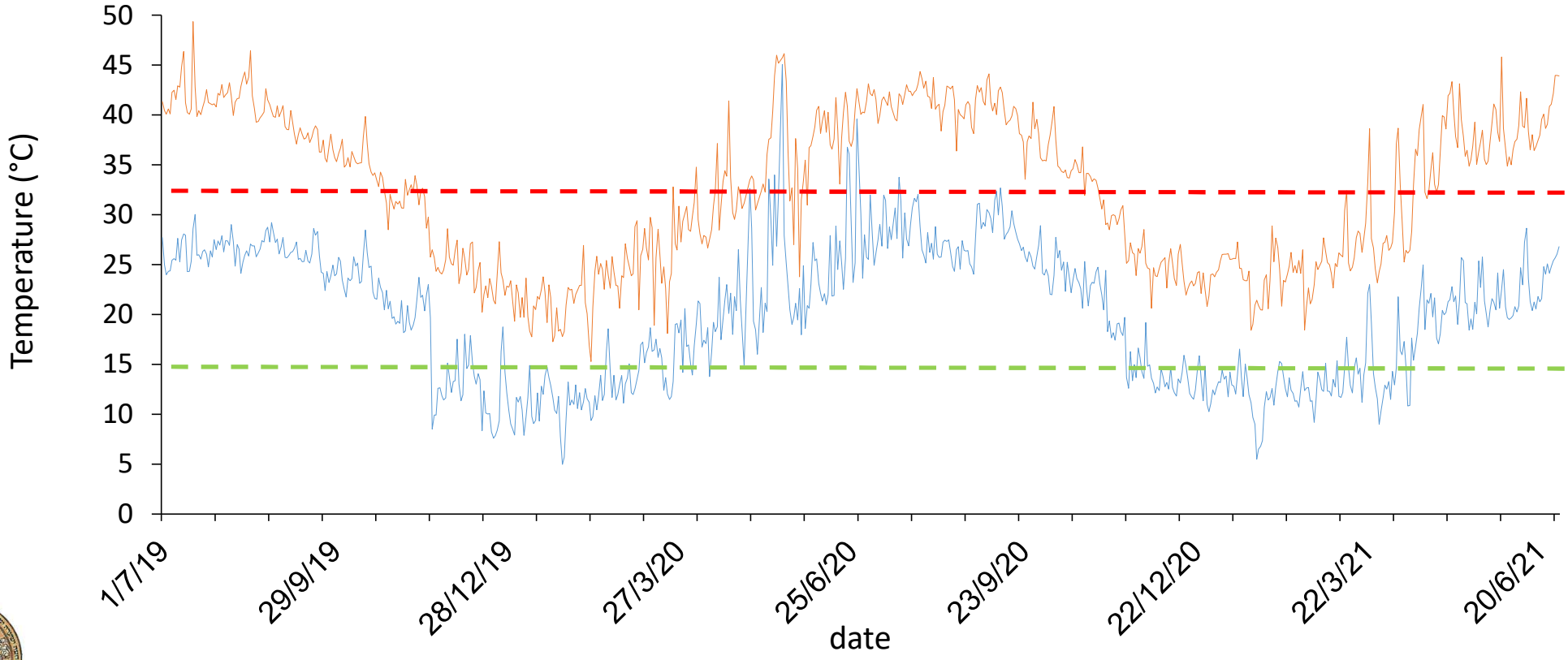


▼ - Application of growth retardant

★ - Application of KNO_3

Minimum and maximum temperatures at the Arava region

(Ein Tamar, 7/2019-7/2021)



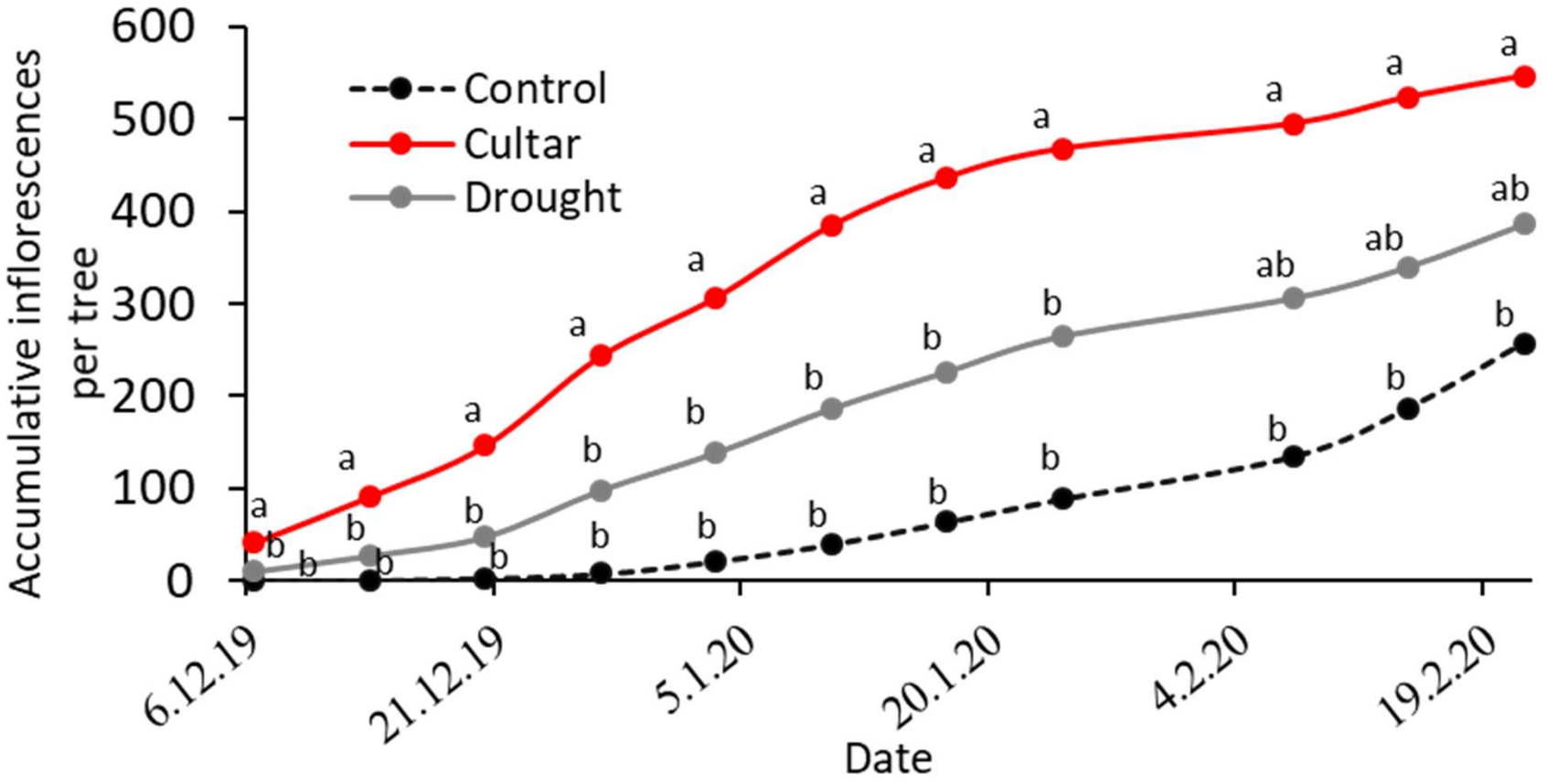
Constrains for out-of-season production of mango in the Arava desert

- Out of season flower induction and fruit production will happen only against the natural environmental conditions.
- Very warm conditions from the spring till the fall (April-November) induce strong vegetative growth.
- Flower induction under very warm conditions competes with vegetative growth.
- Temperatures may be too high for fall or early winter flower development
- Temperatures may be too low for insect pollination, fertrilization, fruit setting and development under winter conditions

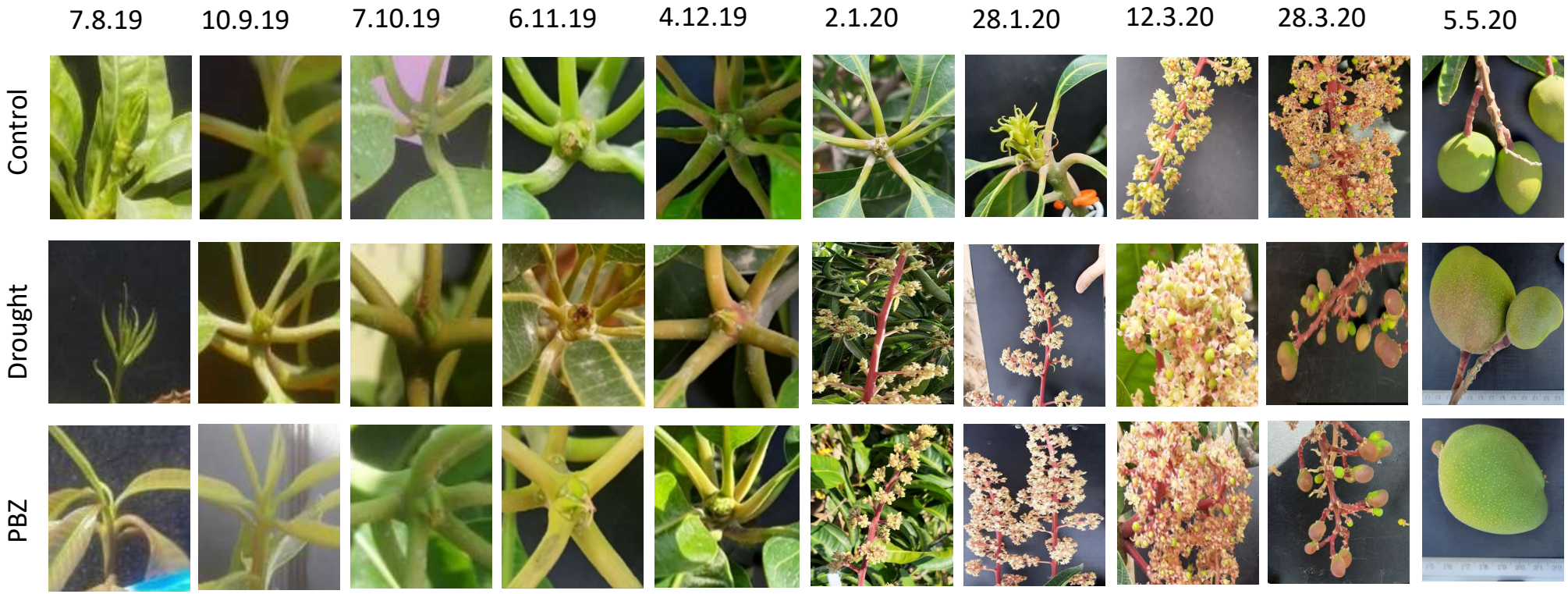
Research aims

- To explore the effectivity of out of-season flower induction treatments in different mango cultivars under the very warm Arava climate.
- To understand the natural and induced flower induction processes in different cultivars under warm conditions.
- To develop horticultural treatments in the summer to enable fall and early winter flower induction.
- To develop protocols and tools for efficient flowering, fruit setting and development during the cool winter.

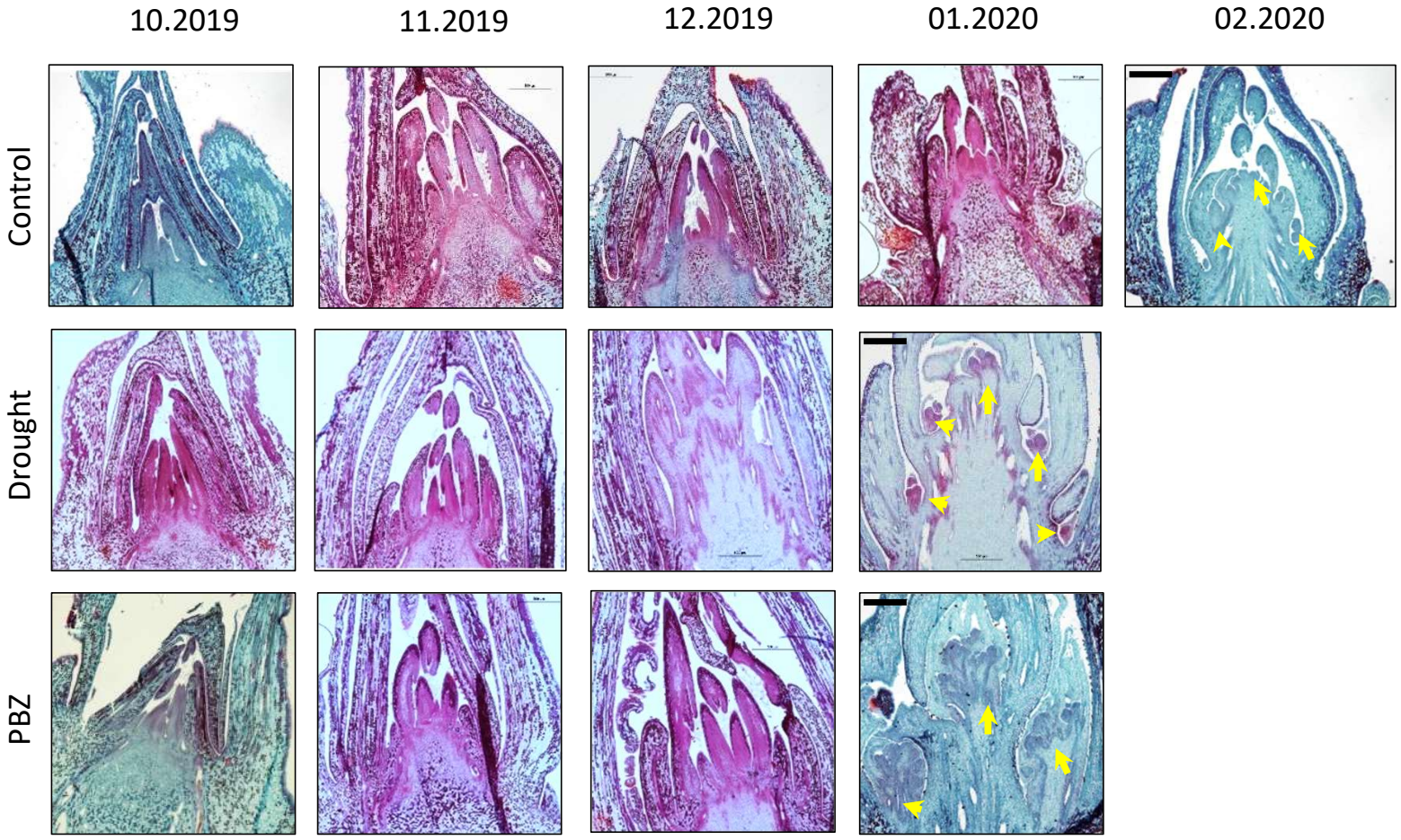
Induction of early flowering of ‘Shelly’ mangoes by drought or PBZ application



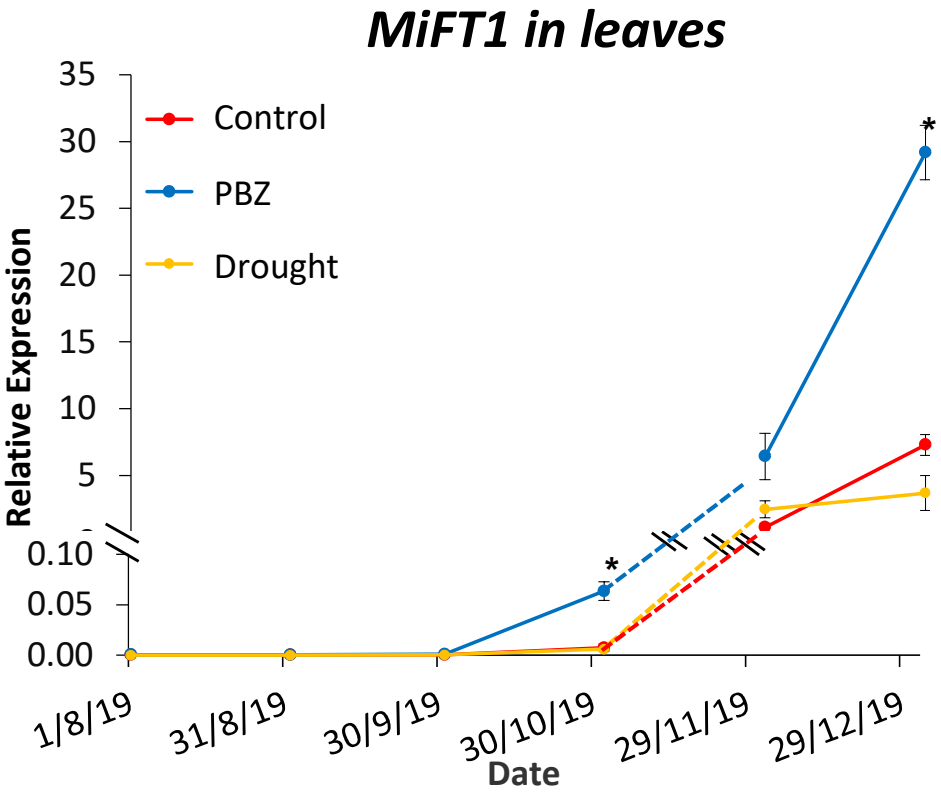
Induction of early flowering of ‘Shelly’ mangoes in the Arava by drought or PBZ application

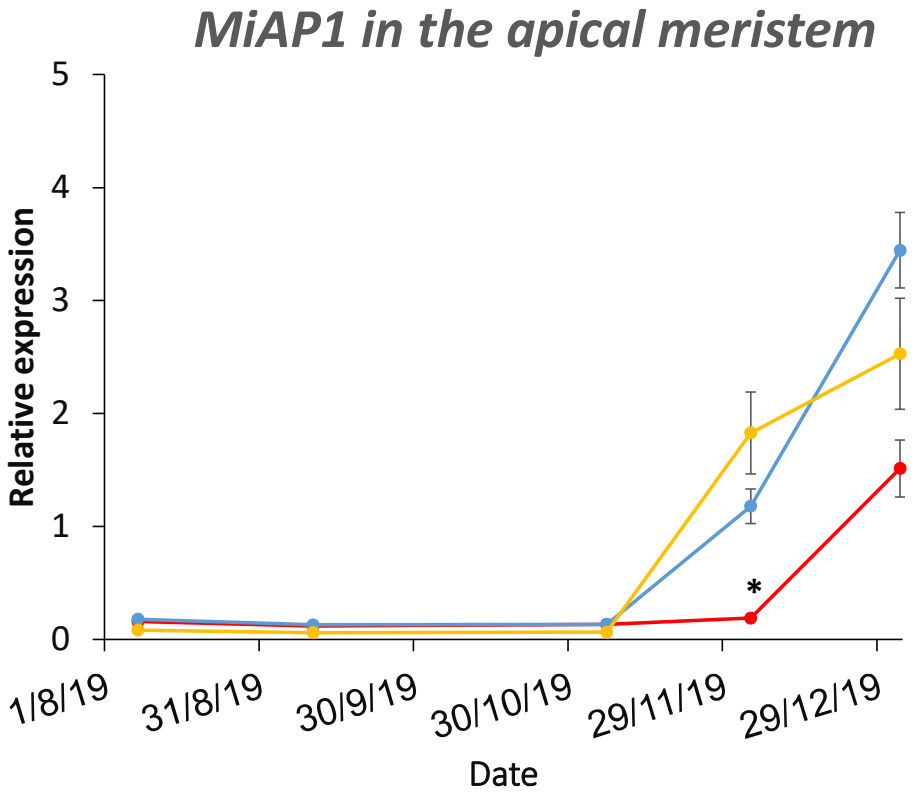


Induction of early flowering of ‘Shelly’ mangoes in the Arava by drought or PBZ application

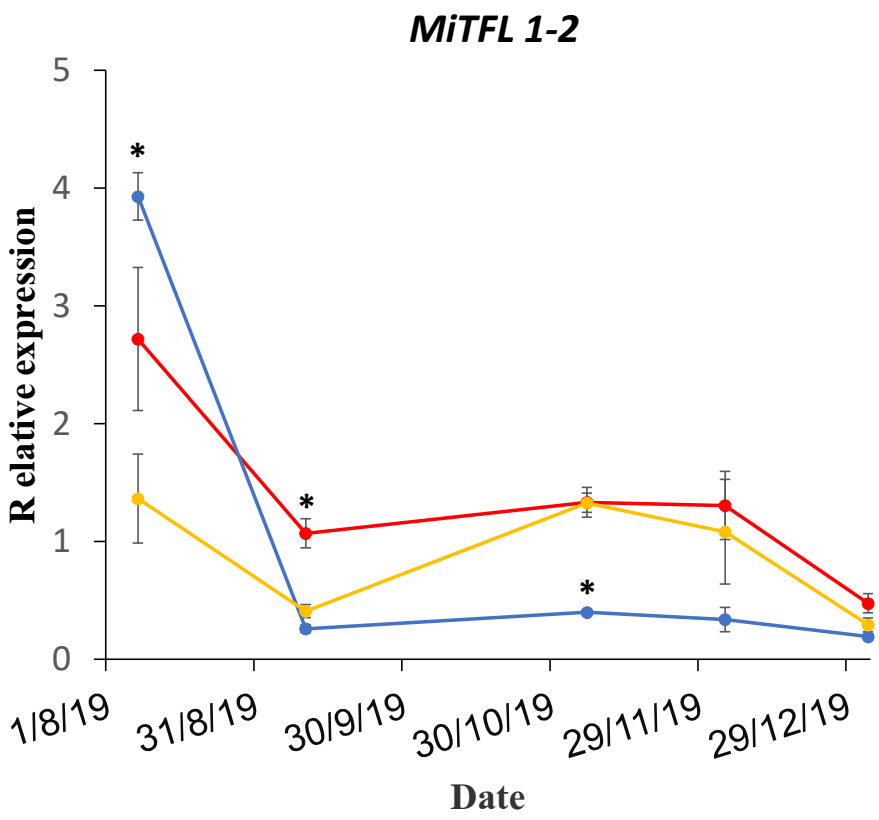


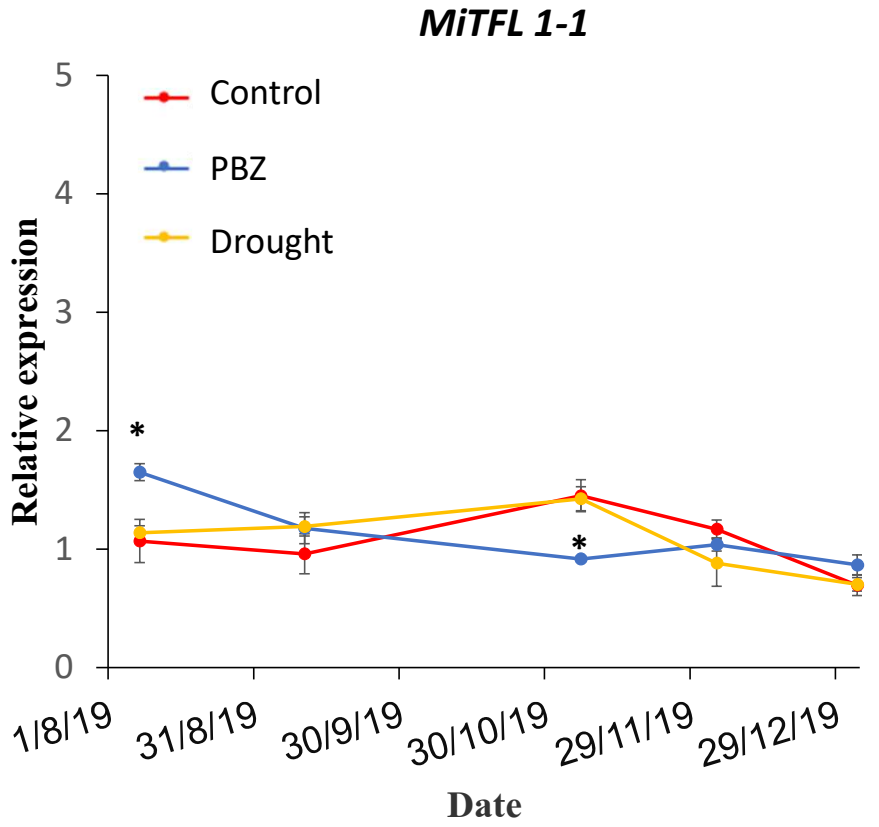
Effect of PBZ treatment on induction of *MiFT1* in the leaves and *MiAP1 in the apical meristem*



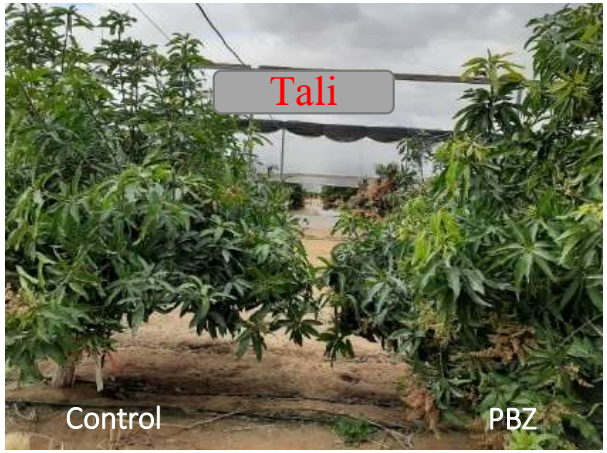


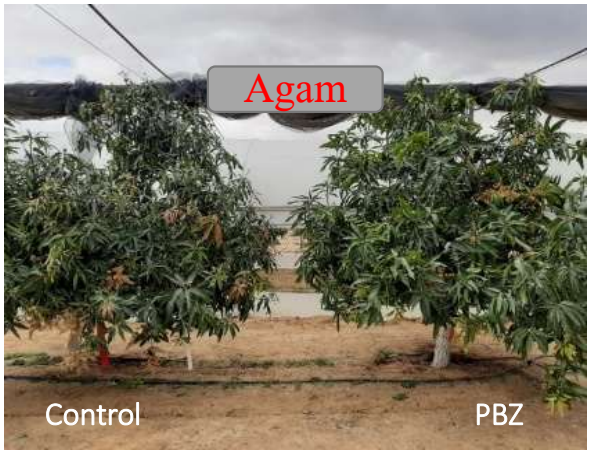
Effect of PBZ treatment on the expression of *MiTFL1-1 and MiTFL1-2 in apical buds*

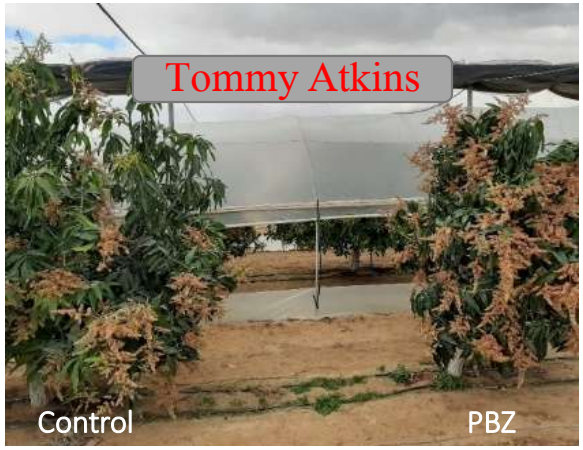




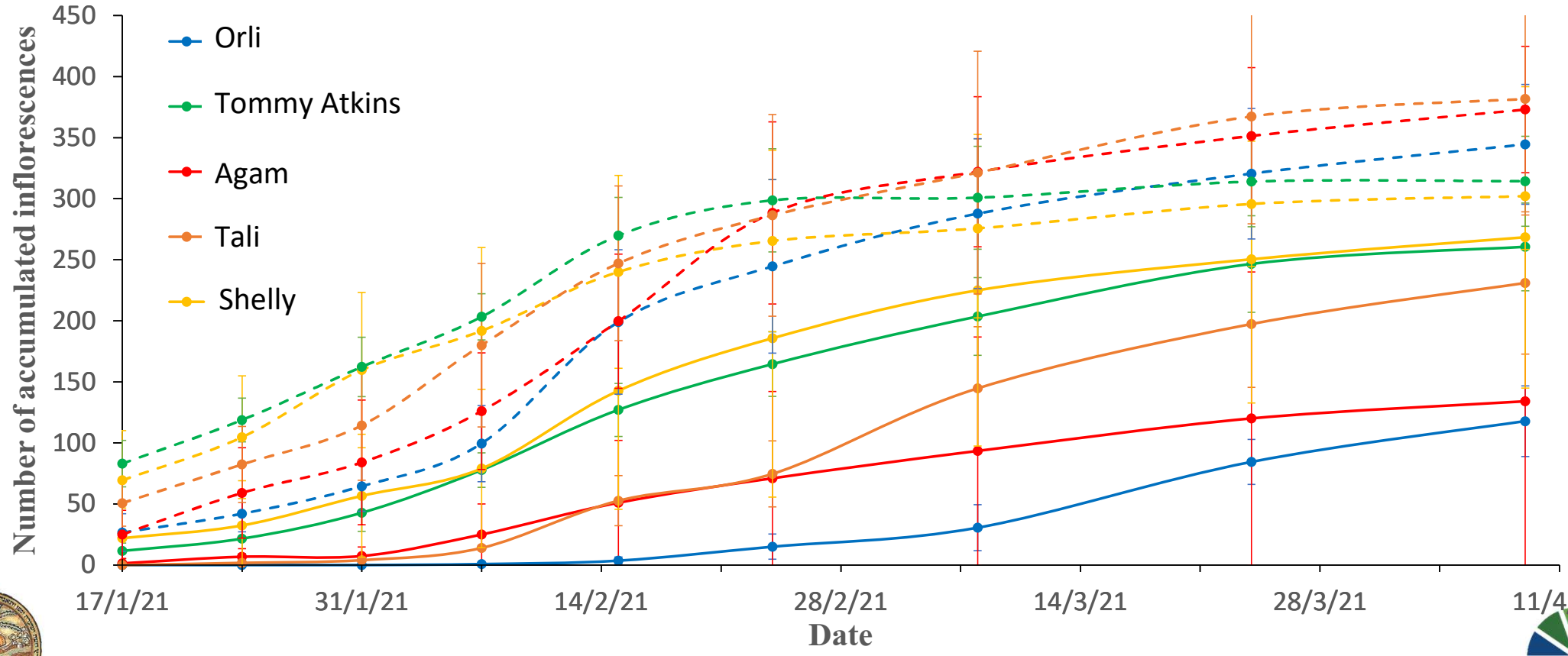
Effects of summer PBZ treatment on flower induction of five mango cultivars in the Arava region



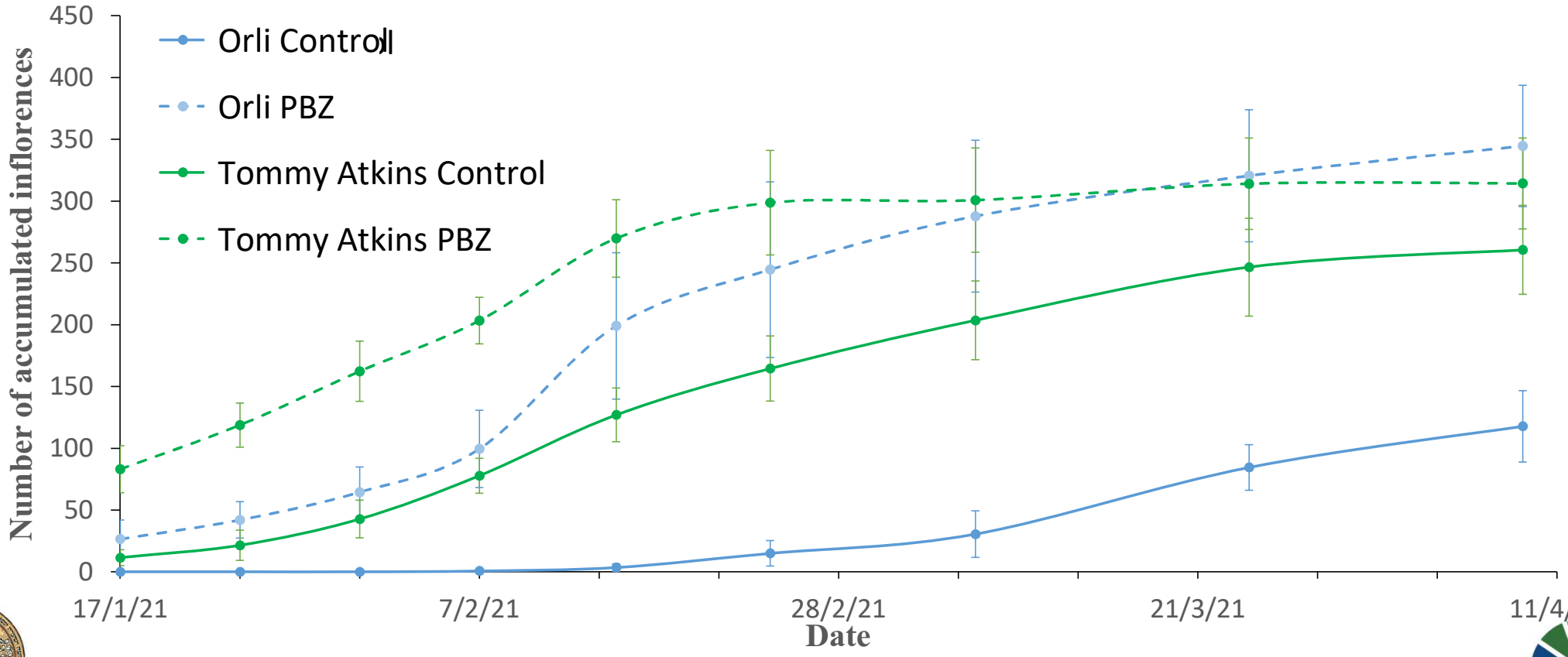




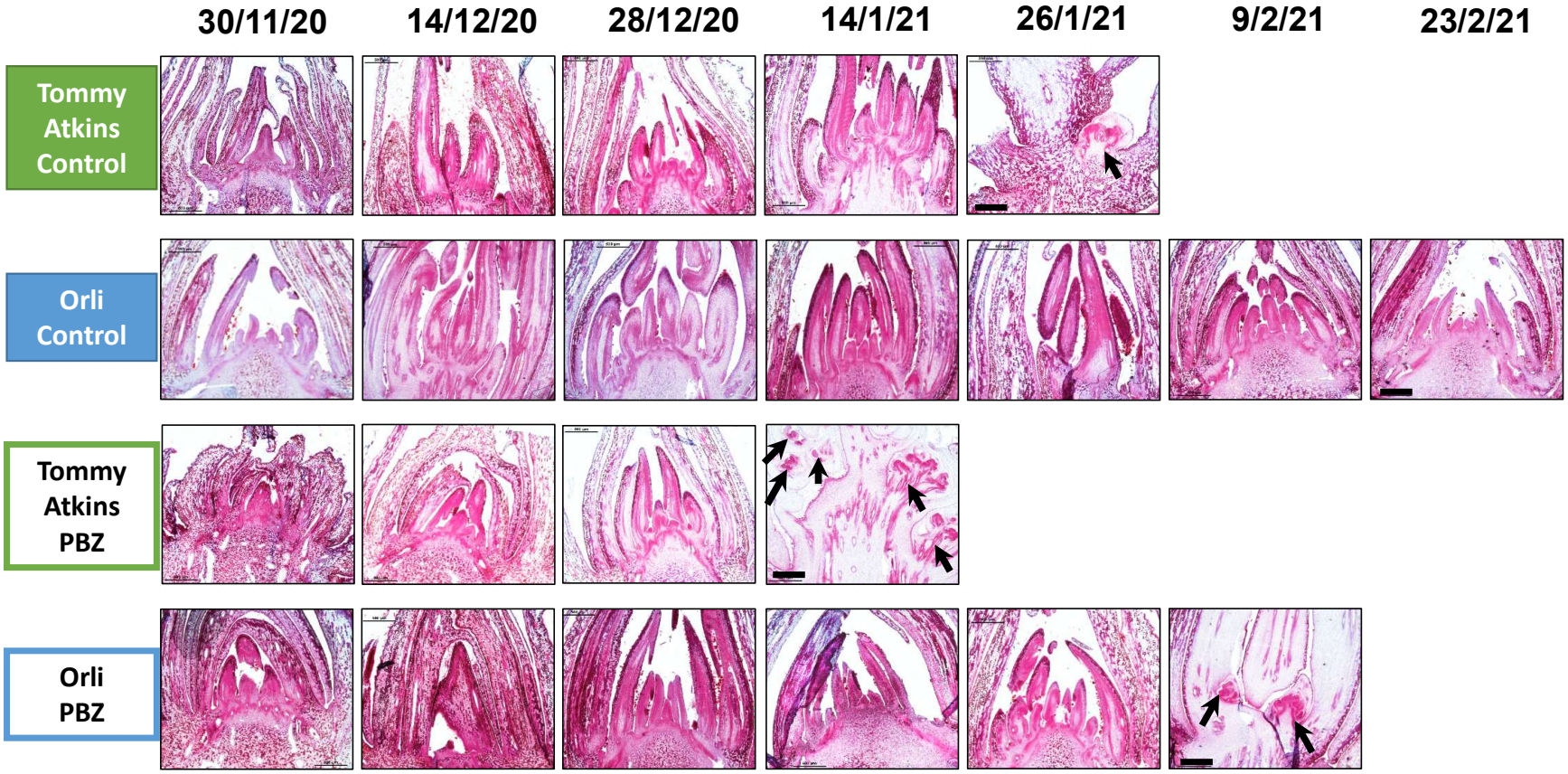
Characterization of inflorescence emergence in different cultivars in Ein Tamar, 2021



Characterization of inflorescence emergence in ‘Tommy Atkins’ and ‘Orli’ in Ein Tamar, 2021



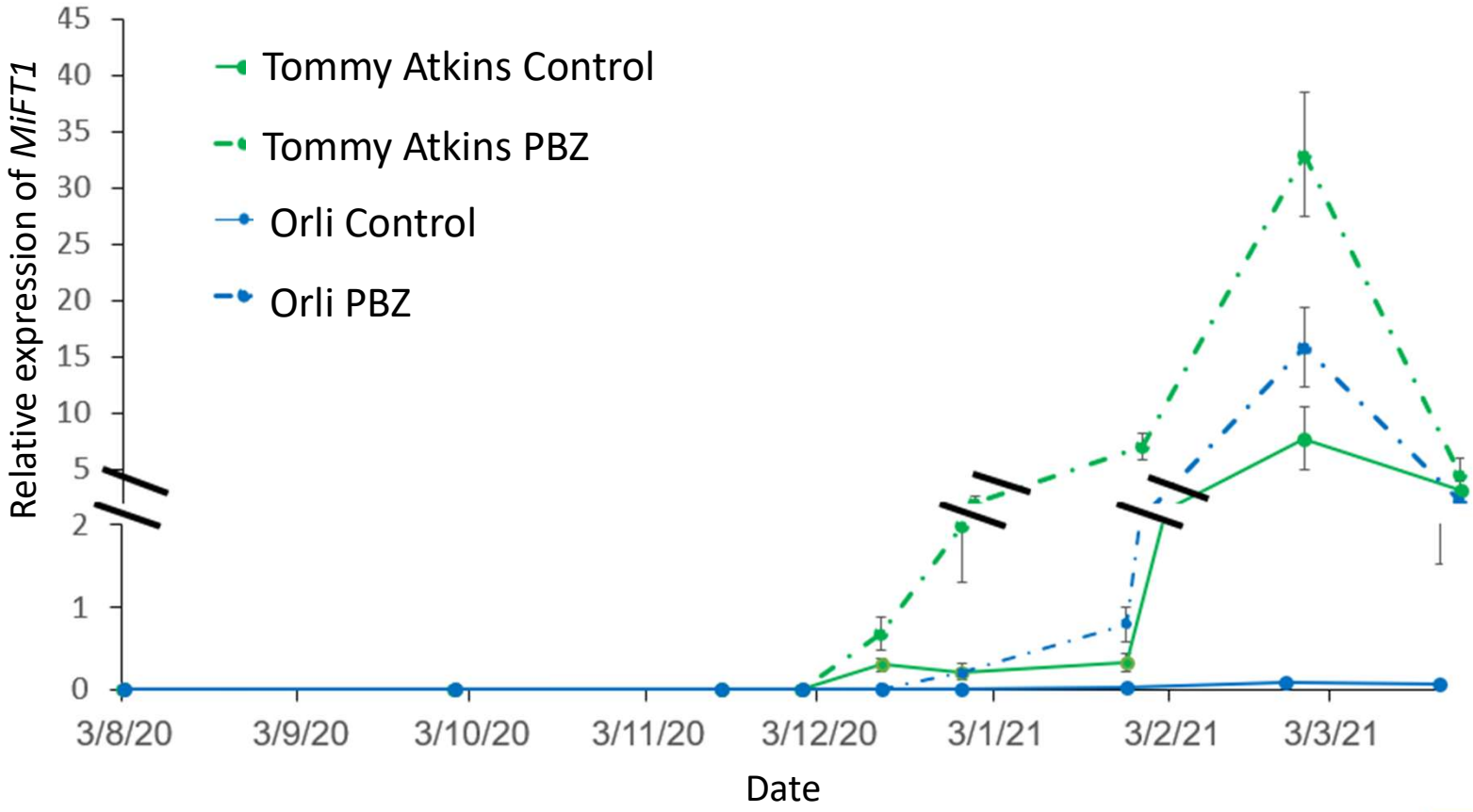
Effects of summer PBZ treatment on flower induction of ‘Tommy Atkins’ and ‘Orli’ in the Arava region



Effects of summer PBZ treatment on flower induction of ‘Tommy Atkins’ and ‘Orli’ in the Arava region

Tommy Atkins

Orli



Summary

- In warm seasons, **cultivars in the Arava differ in their flowering habits**. Some cultivars do not flower naturally.
- **Autumn PBZ treatments followed by potassium nitrate sprays** stimulate early flowering in winter.
- **Winter temperatures are unsuitable for fruit set**, resulting in the development of manyparthenocarpic fruits.
- Studying the control of flower induction and specifically the genes affecting *MiFT1* in different cultivars may be important for generation of heat tolerant cultivars.
- Further calibration of protocols and development of tools for efficient flowering, fruit setting and fruit development are required to enable out-of-season production.

Proposed treatment combinations to optimize the protocol:

- Adjusting the timing of the PBZ application
- Passive heating of trees by polyethylene coverage in greenhouses or tunnels during winter and spring
- Active heating of trees in greenhouses during winter and spring
- Evaporative cooling of trees in autumn or summer for more effective off-season induction

Horticultural treatments to Improve flower induction in the summer, fruit setting and development in the winter

Sprinklers for leaf cooling during warm days

Green house “active heating” in the night

Polyethylene tunnel coverage for “passive heating” during the day

Semi-commercial experiment to characterize the effect of PBZ and polyethylene coverage




- Three commercial cultivars in the Arava – Shelly, Omer and Agam
- PBZ application in early September.
- Polyethylene coverage before flowering (December).
- Replacement of polyethylene by shade nets (April)
- Selective harvesting (May-June)

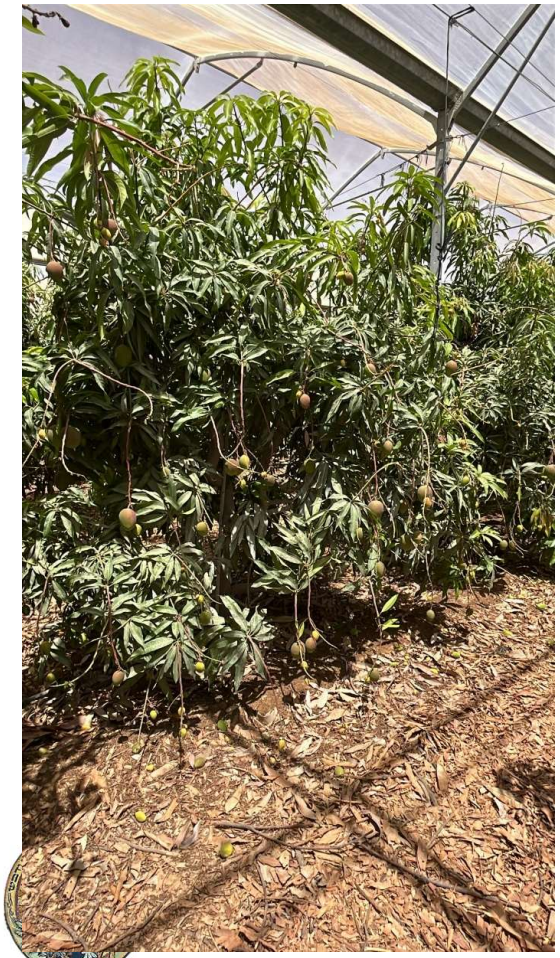
Effect of PBZ and polyethylene coverage on flowering on Omer (semi commercial)

Control

PBZ

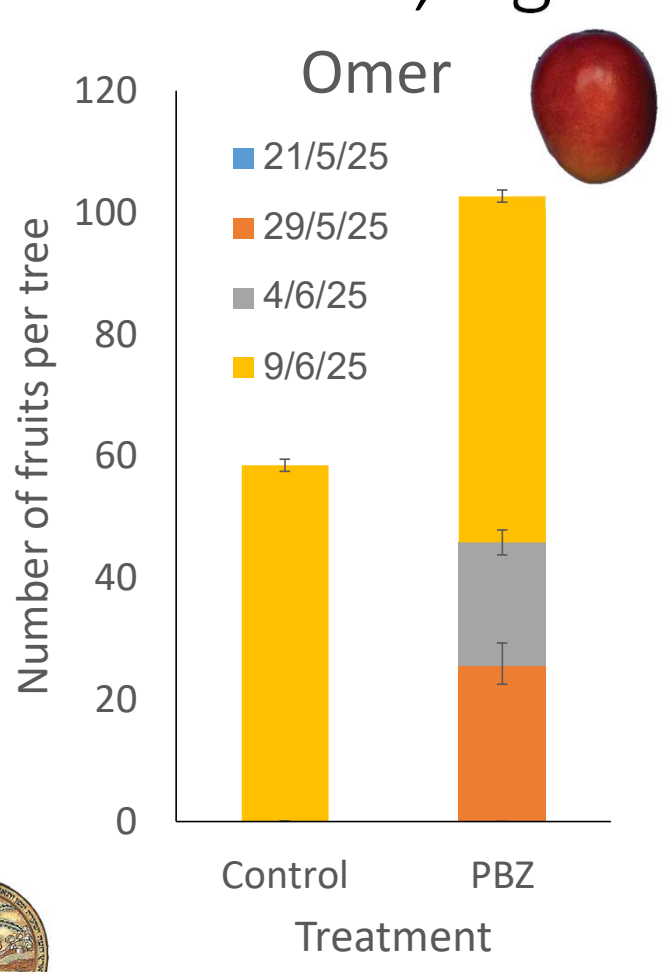
Effect of PBZ and polyethylene coverage on fruiting on Omer (semi commercial)

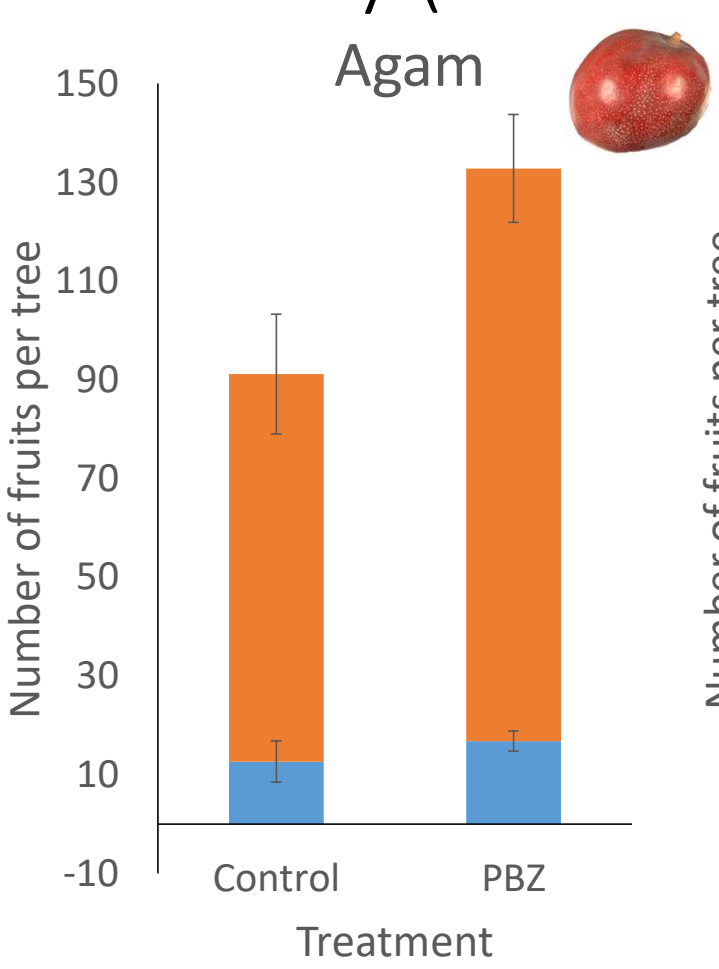
Control

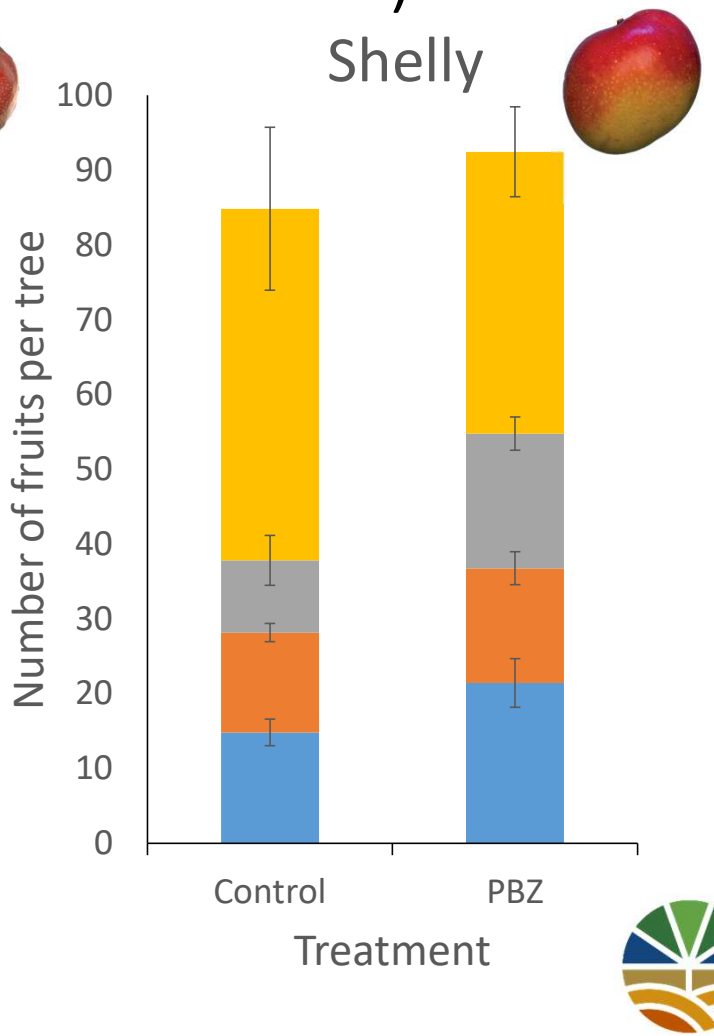


PBZ

Effect of PBZ and polyethylene coverage on harvest on Omer, Agam and Shelly (semi commercial)



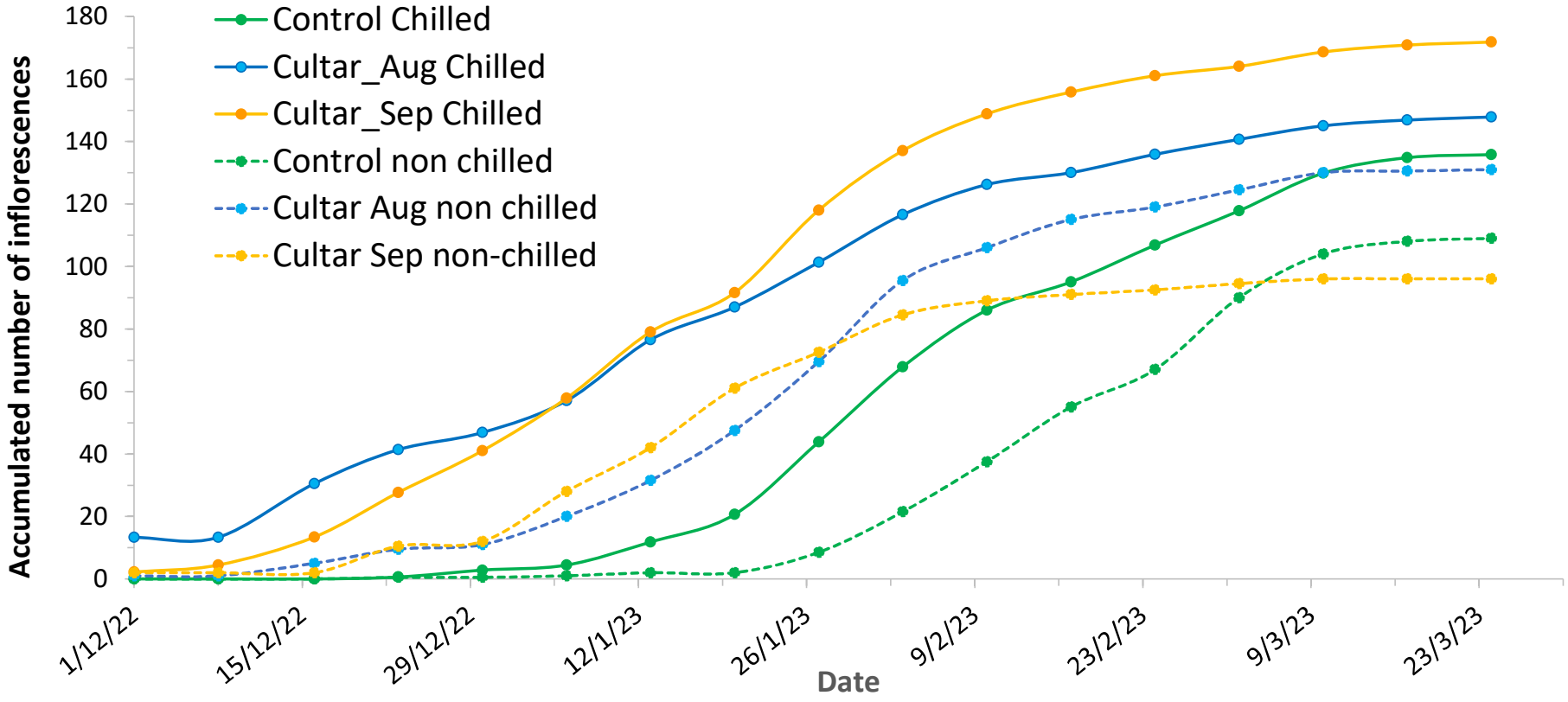




Effect of PBZ, autumn evaporative cooling and active winter heating on the 'Shelly' cultivar in a controlled greenhouse

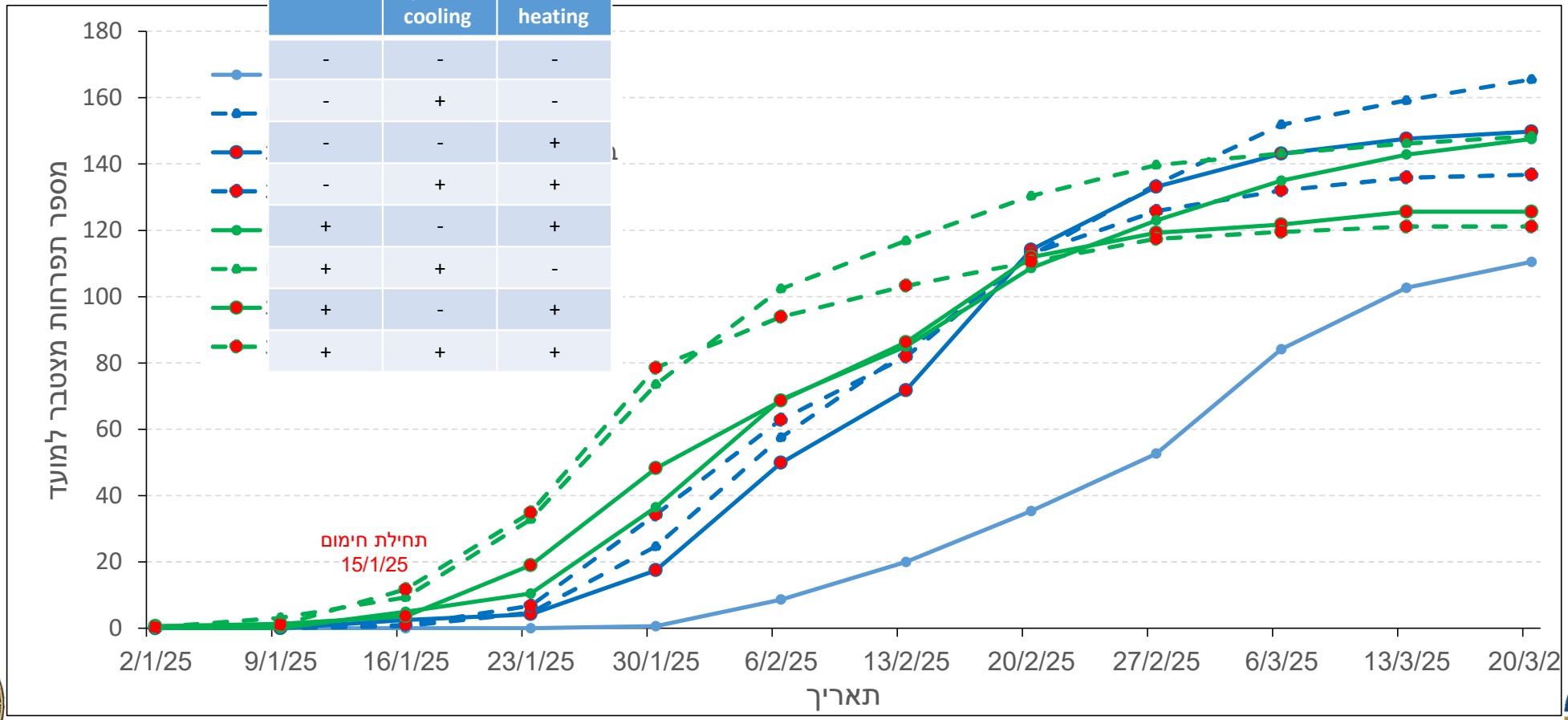
- **Soil drenching with PBZ** in September applied to half of the trees.
- **Evaporative cooling** applied to half of the trees during October and November using overhead pulsed spraying above the canopy.
- **Greenhouse heating** for a subset of the trees to maintain a minimum temperature of 15°C.

Sprinkler cooling improves out-of-season flower induction in the summer - 2023

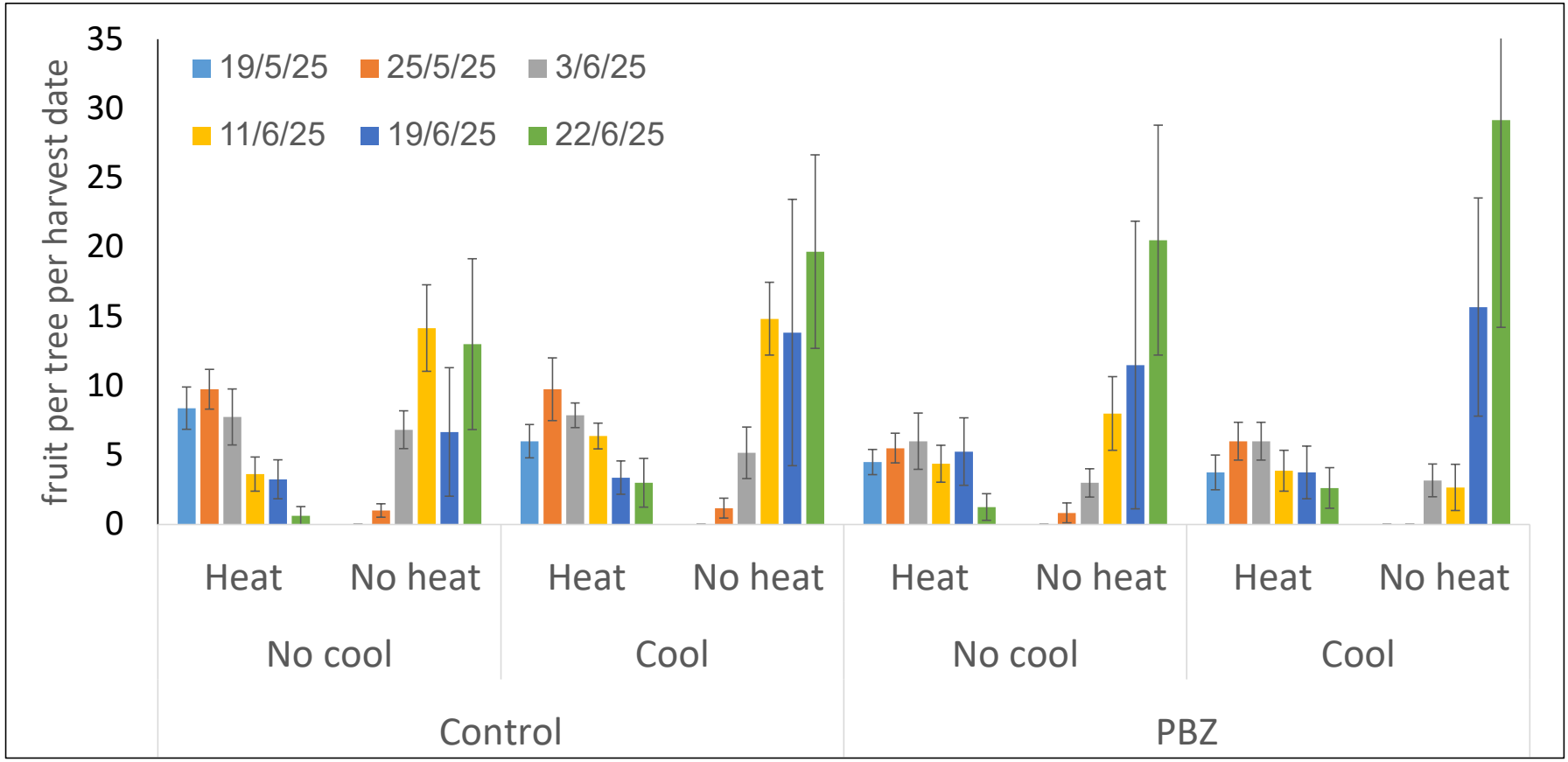


Sprinkler cooling improves out-of-season flower induction in the summer - 2025

PBZ	Sprinkle cooling	Winter heating
-	-	-
-	+	-
-	-	+
-	+	+
+	-	+
+	+	-
+	-	+
+	+	+



Effects of summer PBZ application, autumn sprinkle cooling, and winter heating on fruit harvest



Summary of controlled greenhouse experiment

- PBZ and autumn cooling treatments has synergistic effects advance flowering by up to 5 weeks.
- Winter heating promotes earlier fruit development.
- Earlier heating may enable fruit set in earlier inflorescences within the PBZ and cooled-PBZ treatments.
- Heating negatively impacts late inflorescence development, reducing the total number of inflorescences per tree.
- Cooling treatment increases total fruit yield per tree, whereas heating treatment decreases it.

Out of season flowering – the challenge of overcoming the natural climatic effects

- Attempting to create out-of-season production demands the overcoming of climatic challenges. In the arid Arava these include
  - Warm summer, favoring vegetative work over flower induction
  - Cold winter, preventing fertilization, fruit settings and development
  - Warm spring causing sun burns and reducing fruit qualities
- The use of horticultural treatments can overcome these effects for earlier yield
  - PBZ application
  - Sprinkler cooling
  - Active heating
  - Polyethylene coverage
  - Shade net coverage

Acknowledgments

Agricultural Research Organization - Volcani Institute

- Shacham Megidish
- Avinash Chandra Rai
- Mazal Ish Shalom
- Noga Daniel
- Meir Amram
- Yam Shimoni
- Adi Doron-Feigenboim
- Vered Irihimovitch
- Amir Sherman

Ministry of Agriculture extension services

- Shai Tsaidi
- Dov Nir

Central and Northern Arava R&D

- Dafna Harari
- Tovia Strijker
- Hadas Pereg
- Dudi Kadosh
- Shlomi Vacart
- Noah Martinsen

Moshav Hazeva

- Erez Lichtenstein

Funding:

Israeli Ministry of Agriculture

ICA -Jewish Charitable Association Fund

National Mango Board