THE EFFECT OF PLANT STRESS ON CHERRY TOMATO FRUIT QUALITY

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Introduction

How does stress affect plants?

- **Plant stress** is strongly associated with the **growth and production** yield of crops and fruits: past studies have shown that when plants experience a certain degree of stress they produce a **higher yield** of crops and **better quality of fruits** (Randome, Basu, and Pereira 2017; Iida 2014).
- **Jasmonic acid (JA)** is a hormone released by the plant when it is stressed or is defending itself from biotic or abiotic factors, such as water deficiency or herbivore insects (Yang, Duan, and Li 2019).

Picture 1. Japanese farmers applying "Mugifumi". *Source: Iida, Hidetoshi. 2014. "Mugifumi, a Beneficial Farm Work of Adding Mechanical Stress by Treading to Wheat and Barley Seedlings." Frontiers in Plant Science 5 (September): 453. https://doi.org /10.3389/fpls.2014.00453.*

Success story

- **"Mugifumi"** - an old custom in Japan in which farmers induce mechanical stress on the plants by treading the wheat and barley seedlings.
- By doing that, they actually strengthened the roots to grow and spread, and eventually gave a good yield. In other words, they induce JA within the plants and triggered some complex biological pathways that promote the crop's yield (Iida 2014).

Past study

- In a study by Ahnya M.Redman et al. (2001), the fruits from tomato plants ("Burpee Big Boy," or Lycopersicon esculentum) **treated with JA were significantly larger**, by an average of about 15 grams, than those in the other treatment groups (Redman, Jr., and Schultz 2001).
- Another recent study by Ipeleng Randome at the University of Pretoria in 2017 revealed that tomato plants treated with **salt stress** produced fruits **2.8 times higher in lycopene** and **2.5-2.7 times higher in beta-carotene** compared to other groups (Randome, Basu, and Pereira 2017).

Materials and Methods

Plant acquisition and growing conditions

- 20 cherry tomato plants (variety Supersweet 100) were purchased from Atlas Farm in South Deerfield, MA, all of which were in the flowering stage.
- Tomato plants were then transplanted in 2-gallon plastic pots at the University of Massachusetts CNS greenhouse.
- The plants were trimmed to 120 cm height, supported with cages, climb trellises, and stakes or ties, and were irrigated every day and supplemented with nutrients as needed.

Jasmonic Acid application

- Purified Jasmonic Acid was purchased from Sigma-Aldrich, then dissolved in 100% ethanol at three different concentrations: 0.1 mM, 1 mM, and 10 mM, while a control group was treated with ethanol solvent only.
- 3 mL of treatment solution were applied to the foliage of tomato plants weekly for 4 consecutive weeks using a mist spray bottle. The total quantity of JA applied per treatment plant is noted in Table 1.

Picture 2. Cherry tomato plants (variety Supersweet 100) were planted in the greenhouse. *Source: Lauren Ho*

Table 1. Quantity of Jasmonic Acid applied to tomato plants. The concentration of JA applied to tomato plants for each treatment and moles of JA treated per cherry tomato plant after a four-week spray is noted.

	Group 1	Group 2	Group 3
Concentration (mM)	0.1	1	10
Moles per plant for each group (mmol)	0.0012	0.012	0.12

Fruit quality assessment

- Tomato fruits were harvested throughout the treatment period and were harvested starting July 19 throughout August 16 as fruit acquired a deep red color on the vine.
- After picking the fruits, the diameter of 20 fruits from each group was taken using a vernier caliper. The weight of the fruits was then measured and recorded with a scale.

Picture 3. Example of harvested cherry tomato. *Source: Lauren Ho*

Statistical Analyses

To compare diameter and weight measures from the multiple treatment groups, (i.e. the three different concentrations of JA and the control group), we ran analyses of variance (ANOVA) with post-hoc multiple comparison test in Statistica (StatSoft, Tulsa, OK).

Abstract

- **Jasmonic acid (JA)** and the jasmonates family are essential organic compounds often produced during **plant growth and defense responses**, which can be stimulated by **biotic and abiotic stressors** such as water stress, mechanical stress, or pathogenic stress.
- Jasmonates have been associated with **enhancing the quality of some plants' fruit**. Previous studies have shown that stressed tomato plants produce fruit of better quality, although the fruit yield is lower than in non-stressed plants.
- However, it is unclear whether the application of JA during cherry tomato development influences the quality of the fruit in terms of its size.
- We hypothesized that the **application of JA enhances cherry tomato fruit quality, specifically the fruit's diameter and weight.**
- Tomato plants growing in the greenhouse at UMass Amherst were sprayed once every week during a 4-week span with three concentrations of JA (0.1mM, 1.0mM, 10mM), as well as a solvent control. The fruits' growth was then evaluated via weight and diameter. Our study will clarify the relationship between tomato stress responses and fruit quality, allowing growers to develop optimized growing practice.

Research Question

Does Jasmonic Acid application during the fruiting period affect cherry tomato fruit size?

Results

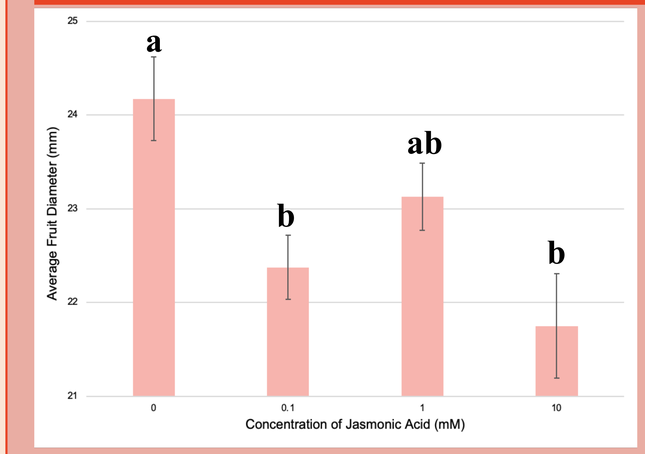
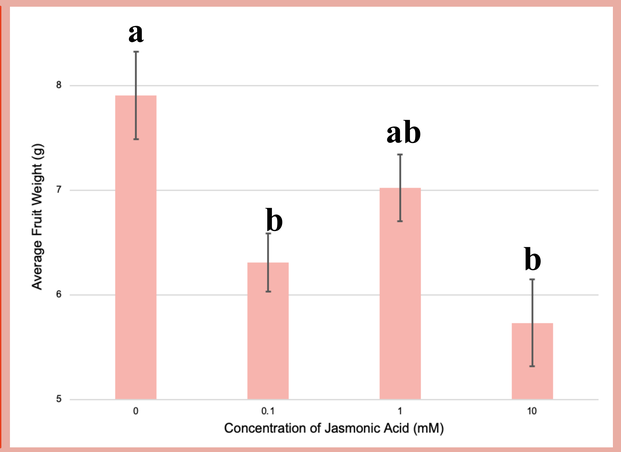


Figure 1. Diameter of cherry tomato (Supersweet 100) at harvest across different Jasmonic Acid concentrations. The fruit diameter from the control group is significantly larger than those of 0.1 mM JA and 10 mM JA groups. (ANOVA; $F_{3,76} = 5.76$, $p = 0.001$).

Figure 2. Weight of cherry tomato (Supersweet 100) at harvest across different Jasmonic Acid concentrations. The fruit weight from the control group is significantly larger than those of 0.1 mM JA and 10 mM JA groups (ANOVA; $F_{3,76} = 6.656$, $p < 0.001$).



Discussion and Conclusion

- My results showed that the application of JA exerted a **negative impact** on fruit size!
- In two out of the three treatment groups, tomatoes from **control** plants had a significantly **larger diameter and heavier weight than fruits** from JA-treated plants, with the exception of fruits from the 1mM plants.
- **Why are there differences?** The **application period and frequency** chosen in this study are different from our reference study as well. The period and frequency of our JA application may thus not be optimal for promoting fruit size.

Picture 4. Cherry tomato (variety Supersweet100). *Source: Lauren Ho*

Picture 5. Tomato (variety Burpee Big Boy). *Source: New Jersey Agricultural Experiment Station*

- Each crop species or **varieties** may have **different Jasmonic Acid concentration responses**. For example, Reyes-Díaz et al. (2016) reported that doses and application methods of methyl jasmonate in various fruit crops varies in their ability to inhibit fungal diseases.
- For the purpose of this study, we used **cherry tomato** (Supersweet 100). Therefore, it may be that concentration of JA used in this experiment, or the application methods, are simply not suitable for this variety of cherry tomatoes.

Future Research

JA application

Future study may focus on finding an optimal amount of JA applied, application methods, and frequency of application (Yang, Duan, and Li, 2019) since several studies have shown that while the quality of the fruits may be better, the marketable yield is reduced (Nuruddin, Madramootoo, and Dodds 2003; Redman, Jr., and Schultz 2001).

Nutritional value and sensory aspect

It is important to also consider the nutritional value of the tomato, such as vitamin C, lycopene, and beta carotene, and the sensory aspects, such as sugar-acid ratio (Nuruddin, Madramootoo, and Dodds 2003; Randome, Basu, and Pereira 2017).

Reduce cost

There is a need to investigate pathways to either extract the compound inexpensively from plants or find alternative stressors, such as water, salt, or mechanical stress (Randome, Basu, and Pereira 2017; Van Moerkercke et al. 2019).

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