Effects of Salt, Sugar, and Tap Water on Growth Physiology and Root Competition in Vicia faba

Research Questions:

1. Which treatment is best for growth physiology and root competition: salt water, sugar water, or tap water (control)?

2. How does root competition in the same container affect root growth?

3. Can optimal planting distance be determined based on which plant "wins" the root competition?

4. Can fava beans contribute to solving world hunger?

Background:

I believe fava beans can support efforts to address world hunger. Fava beans are cultivated in over 66 countries across nearly every continent, primarily in temperate and subtropical regions. As a cool-season crop, they are grown during different months depending on local climate to avoid extreme summer heat (above 27°C).

Major Growing Regions:

- Asia: China (largest global producer), India, Bangladesh, Iran, Syria
- Europe: United Kingdom, France, Germany, Italy, Spain, Denmark
- Africa: Ethiopia (2nd largest globally), Egypt, Sudan, Libya, Tunisia
- Americas: Canada, Mexico, Peru, Bolivia, United States
- Oceania: Australia (top exporter)

Planting Seasons by Climate:

Climate Type	Planting Time	Typical Harvest
Mild Winters (Mediterranean)	Fall/Early Winter (Oct–Dec)	Late Spring (April–May)
Cold Winters	Early Spring (March–April)	Summer (July–August)
Hot/Tropical (high elevations)	Winter Months (Dec–Feb)	Late Spring
Southern Hemisphere	Autumn (April–May)	Late Spring (Oct–Nov)

Key Environmental Factors:

- In tropical countries, fava beans struggle at sea level due to heat but can grow at high elevations with cooler temperatures

- In regions where ground doesn't freeze solid, fall-planted fava beans can "overwinter" and produce early spring crops

- Spring-sown crops: 90–100 days to mature

- Fall-sown overwintering crops: up to 240 days

Fava beans are planted in many countries and serve as a food source for millions. Sudan is experiencing one of the worst famines in history. Ethiopia, Syria, and Egypt also rely heavily on this crop. In Egypt, fava beans are a staple breakfast food across all economic classes.

Materials:

- Same glass of water for every plant

- Same teaspoon for salt and sugar measurements

- Same soil and same size pots for Phase 1 (second week: same container for all three)

- Tap water used throughout

Observations Recorded Daily (Weeks 1–2):

- Height of every plant

- Number of leaves on every plant

Protocol:

- Beans not pre-sprouted

- Measurements taken before watering at approximately 10:55 AM

- Watering time: 11:00 AM daily

Day 1 — March 22

Placed soil in pots. Planted beans at 11:00 AM. Will water daily at this time. Beans not pre-sprouted.

Day 2 — March 23

Nothing has appeared yet. I should have pre-sprouted them; this would have accelerated the experiment. I will extend Phase 1 (individual pots) by one extra week. I will also extend Phase 2 (shared container) by one week if the root competition lasts that long.

Day 3 — March 24

Still nothing appearing. It rained heavily today. I am unsure if any rain reached the pots, but due to the intensity of the rainfall, I will not water them today.

Day 4 — March 25

Forgot to water them—woke up late. Rain was expected today, though yesterday it rained heavily five times, which is rare for Egypt. It did not rain today. I also discovered that I have exams approaching, so I may forget watering due to academic stress.

Day 5 — March 26

Still nothing. I accidentally spilled approximately one-quarter of the water from the salt solution pot. This was due to dizziness from waking up to my alarm; I felt disoriented.

Day 6 — March 27

Did not water today—had a tutoring session. I dug up the salt-treated plant to check for root development. It had rooted, indicating that all three seeds have likely germinated. I then dug up the sugar-treated plant and found the longest root, but I accidentally cut the tip. I also disturbed the control plant but did not cut it. I may have replanted them incorrectly, potentially damaging them. Results will be visible tomorrow.

Day 7 — March 28

Nothing visible above soil. Watered at approximately 12:30–12:45 PM. It rained heavily today; I arrived one hour late to school, which is typically a 20–30 minute drive.

Day 8 — March 29

Significant progress: stems are emerging from both the sugar-treated and control plants, despite the sugar plant's root tip having been cut. The salt-treated plant has not yet produced a stem. I dug slightly to verify and found upward stem growth. I forgot to water today.

Day 9 — March 30

Watered at 2:20 PM. Had a ministry exam today.

Status:

- Salt: no stem visible above soil
- Sugar: stem emerged
- Control: stem emerged

⚠ Note: I will not dig up plants again. Yesterday (March 30) was the final excavation. ⚠

⚠ All times recorded in Egypt/Cairo local time. ⚠

⚠ Photos will be taken weekly, not daily. Next photo will be taken in 5 days, marking the end of Phase 1. ⚠

Day 10 — March 31

Ten days into the experiment. Real-life conditions were challenging due to heavy rainfall. Watered at 10:57 AM. Two insects were observed on the sugar solution pot; they were removed. I suspect they were attracted by undissolved sugar in the water. I am unsure whether to use pesticide or maintain a clean environment, as this is a balcony we use regularly. Insects may also damage the plants. The control stem appears to be growing longer.

Current ranking:

1. Control (water)

2. Sugar solution

3. Salt solution

⚠ Stem measurements will be taken weekly, not daily, starting at the beginning of Phase 2. Leaf counts will be recorded daily after watering. ⚠

Day 11 — April 1

Two risks identified today:

1. Sandstorm (affected plants at 10:25 AM; likely ongoing for extended period)

2. My cat, who consumes everything

Watered at 11:00–11:05 AM. Allowed salt and sugar to dissolve fully before application to deter insects. No stem visible on the salt-treated plant. Considering extending the timeline or excavating the salt plant next week to assess viability. If dead, I will proceed to Phase 2 without it.

Day 12 — April 2

Slept through my alarm and did not water the plants.

Day 13 — April 3

Watered at 11:05–11:15 AM.

Significant finding: the sugar-treated plant is now the tallest, exceeding the pot height. It remains visible from side angles, unlike the control, though the control is still relatively tall. Leaves are present but not yet fully distinguishable; I will count them when clearly separated.

Moved pots outdoors at approximately 11:14–11:16 AM for direct sunlight exposure.

I believe I observed a small stem on the salt-treated plant during watering; it may have been planted upside down.

Hypothesis

I believe the sugar-treated plant achieved superior growth because supplemental glucose provides an energy source that bypasses the need for extensive photosynthetic carbon fixation. Plants typically require sunlight to produce energy through photosynthesis, generating glucose as a simple sugar. The sugar-treated plant receives exogenous glucose in addition to sunlight and minerals, providing a metabolic advantage and stronger initial growth compared to the other treatments.

I am extending the experiment by approximately one week or three additional days, depending on travel plans during spring break.

Day 14 — April 4

The salt-treated plant has finally emerged. I discovered that it was planted upside down, which, combined with salt stress, delayed emergence.

Watered at 11:40–11:50 AM.

Phase 1 will conclude tomorrow between 11:00 AM and 12:00 PM.

Current height ranking:

1. Sugar + water
2. Water (control)
3. Salt

Day 1 (Phase 2) — April 5

All three plants transferred to shared container at 3:17 PM.

Watered at 10:30 PM.

Day 2 (Phase 2) — April 6

The petiole (structure connecting stem and leaf) detached from the control plant. Fortunately, the plant has two stems, and the main stem remains intact.

Day 3 (Phase 2) — April 7

Watered between 11:30 PM and 12:00 AM. Exact time not logged.

Day 4 (Phase 2) — April 8

Forgot to water. Remembered but did not act.

Day 5 (Phase 2) — April 9

Measurements taken with ruler:

- Salt: 8 cm
- Control: 9 cm
- Sugar: 14 cm

Day Unknown — April 14

Forgot to water for an extended period; start date of this experimental phase is unclear.

Watered at 6:35–6:36 PM.

The salt plant appears healthy, as does the control. The control has two stems. The sugar plant has grown taller, now exceeding 15 cm.

April 17

Watered at 4:10–4:15 PM.

Added support for the salt plant stem. Sandstorm forecasted; moved pot indoors. Accidentally crunched the salt plant stem during relocation. The salt plant is compromised and should likely be removed.

Options Considered:

1. Remove salt plant from Phase 2; continue with sugar vs. control for root competition data.

2. Replace salt plant with new seedling; this would delay the experiment and introduce age disparity.

I will select Option 1, as replacing the salt plant would allow the control and sugar plants to dominate the shared container and initiate root competition. I will wait briefly to see if the wound heals, though this is unlikely. The salt plant was an underdog I had hoped would succeed.

April 21

Watered with plain water today. Considering ending the experiment or waiting 1–3 days until the next watering cycle.

April 22 — Final Harvest

Watered at 3:40–3:47 PM. Waited 20 minutes before excavation. Planned to start with the salt plant due to its complex history. Delayed excavation to prepare a meal.

Sugar plant excavated at 5:50 PM:

- Roots: approximately 19 cm (7+ inches)

- Stem: 30 cm (approximately 1 foot)
- Total plant length: approximately 50 cm
- Leaves: 14

Control plant:

- Roots: 14 cm
- Stem: 20 cm
- Root width: approximately 15 cm (not measured for sugar plant; re-excavation avoided to prevent root damage)
- Leaves: 20 (open and closed leaves counted for all plants)
- Two separate stems from single seed

Salt plant:

- Minimal root width
- Roots: 18 cm
- Stem: 21 cm
- Total: 39 cm
- Leaves: 11

Final Data Summary:

Plant	Roots (cm)	Stem (cm)	Total (cm)	Leaves
Sugar	19	30	49	14
Salt	18	21	39	11
Control	14	20	34	20

Question Responses:

Q1: Which treatment is best?

Sugar is the most effective treatment. Plants utilize water and sunlight to synthesize energy through photosynthesis, producing simple sugars. When exogenous sugar is provided, plants can allocate more energy toward growth and expansion rather than primary carbon fixation. However, sugar supplementation attracts insects, requiring pest management.

Q2: Root competition status?

The root competition phase is ongoing. I plan to continue this experiment for one year to determine a definitive winner and document the duration of competition. This may require several months. I will record which plant dominates and the time required, though regular data logging may not be maintained.

Q3: Optimal planting distance?

Determination will follow the one-year observation period. However, I may terminate the experiment due to entering Grade 11, which demands significant academic focus at my school. I may also need to prioritize convincing my parents to allow me to change schools.

Q4: Can fava beans solve world hunger?

Potentially, if agricultural implementation is optimized. This would require accessible pest control measures for both soil-dwelling and aerial insects.

Conclusion

I am proud to have completed this project. I acknowledge that my attention span as a teenager presented challenges; this manuscript was written while viewing online content. This experiment is not definitive—accurate determination of optimal treatment would require farm-scale testing, which is not feasible given resource limitations. Thank you for reading this thesis.

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