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Independent Research Performed by i-Cultiver for Sanyo Chemical

Research Report (Unpublished Data)

Sanfresh GT-800 Promotes Tomato Yield (Under normal and drought conditions)

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Sanfresh GT-800 is a super-absorbent polymer developed by Sanyo Chemical. According to the manufacturer, Sanfresh GT-800 can be used to increase soil water retention. i-Cultiver, Inc. (a research organization) conducted an *independent study* of Sanfresh GT-800 with greenhouse tomatoes (determinate cultivar Microtom). Sanfresh GT-800 was mixed with soil at 0% (Control), 0.25%, 0.5%, 0.75% and 1.0% concentrations and tomato plants were subjected to regular-watering and reduced (one-fourth watering) conditions. Sanfresh GT-800 increased tomato production under both, regular and reduced watering conditions. This study suggests that Sanfresh GT-800 increases water availability (water retention) and can be used to increase plant performance under normal and drought conditions.

Water is essential for plant growth and development. Water availability and climate change are the two greatest challenges facing the future of agriculture. Increase in temperature leads to water loss through increased plant-transpiration and soil-water evaporation. **Available Water Holding Capacity** (AWC) is the amount of water soil can hold. It is the difference between **Field Capacity** (FC) and **Permanent Wilting Point** (PWP), and can be measured using infrared reflectance spectra (Blaschek et al., 2019). **Water Retention** (WR) is the actual amount of water retained in the soil.

Increasing AWS and WR are a major focus of farming practices, such as No Till or Reduced Till (limiting soil disturbance), Cover Crop (seasonal cover with grasses, legumes), Mulching (applying plant residue), and other Organic Matter Additions (Organic waste additions) (Smith, 2018). In addition, some of the more strategic practices are Forage and Biomass Planting (adaptable species or pasture, biomass production), Crop Rotation (Cycling crop sequence on same field), or Subsoiling or Deep Tilling (Tilling at greater depth to preserve topsoil) (Smith, 2018).

There is a need for new technologies to increase soil AWC and WR both in the field and for indoor growing systems, such as greenhouse production. Improving WR of potted soil systems can lead to yield increase.

SANFRESH GT-800 (Sanyo Chemical) is a new **Super-absorbent Polymer** (SAP). This study was conducted to test the performance of Sanfresh GT-800 in promoting plant productivity.

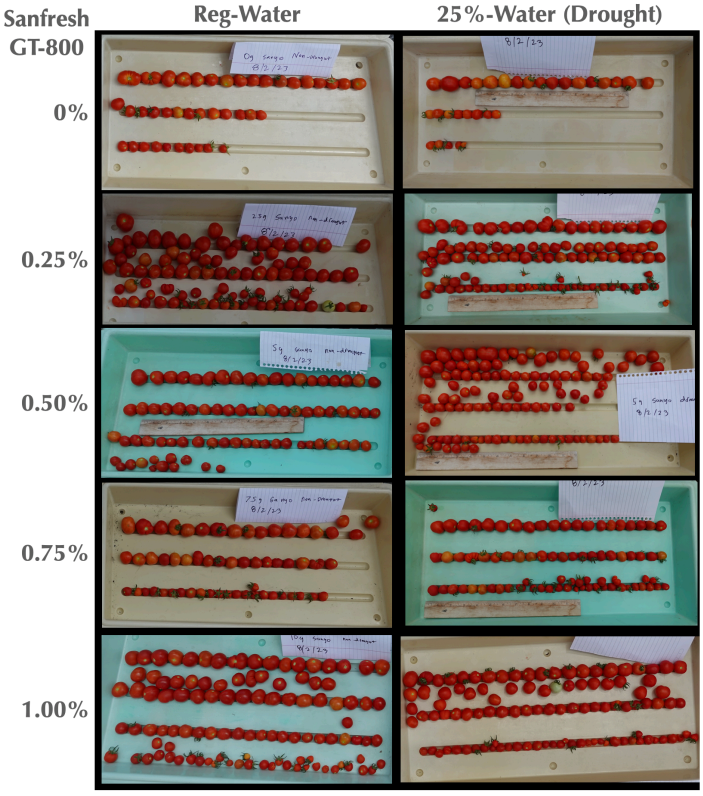

Figure 1. Inclusion of Sanfresh GT-800 in potted soil increased greenhouse tomato production. Sanfresh GT-800 was applied at various concentrations (as indicated). Tomatoes cultivar Microtom grown in the greenhouse under regular (Reg-Water) and reduced (25%-Water) conditions were harvested and photographed (as shown). Total harvest from 5 plants per treatment.

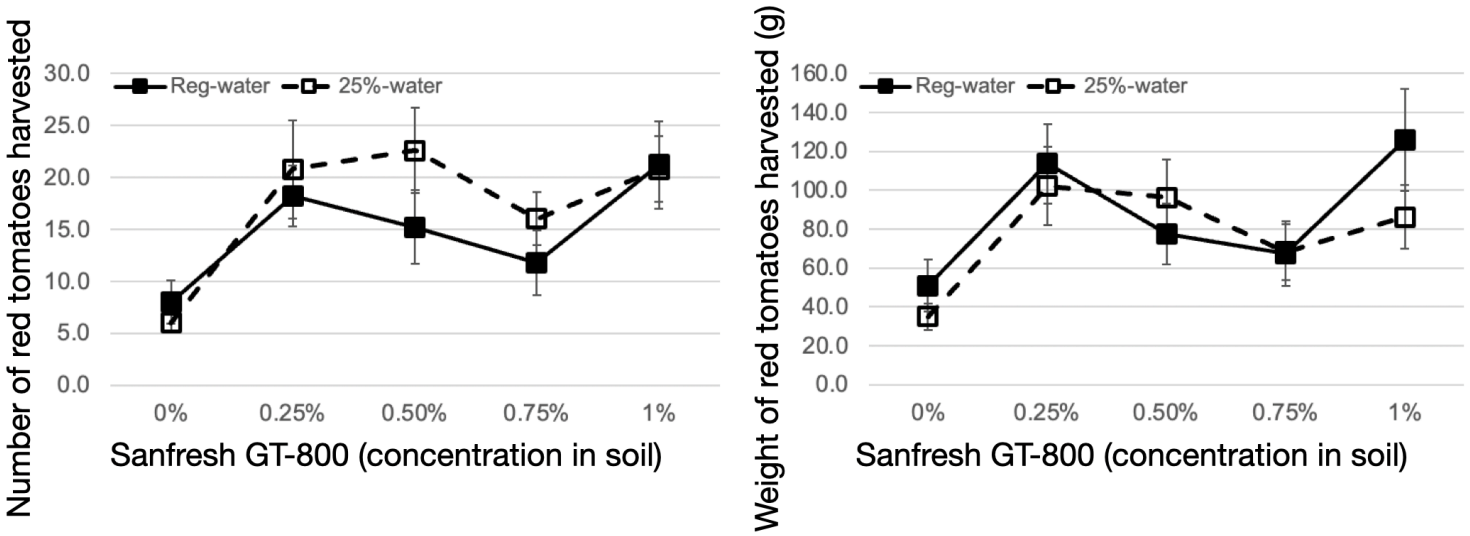

Figure 2. **Sanfresh GT-800 increased the number and weight of tomatoes produced.** Total number (left) and weight (right) of tomatoes harvested from greenhouse plants treated with various concentrations of Sanfresh GT-800 (indicated). Normal watering (Reg-Water, solid line) and reduced (25%-Water, dashed line) conditions. N=5 plants per treatment. Average values are plotted with *S.E.*

RESULTS

Tomato plants containing Sanfresh GT-800 in potted soil performed better under both normal and reduced (25%-water) conditions (Fig. 1 and 2). There was a marked increase in total number and weight of tomatoes harvested from the determinate cultivar Microtom with Sanfresh GT-800 (Fig. 2).

Increase in tomato production under regular watering conditions suggests that Sanfresh GT-800 improved the capacity of the soil to hold water (AWC), thereby promoting total fruit production to significantly more than the control (untreated plants). These data suggest that even under regular grower's conditions, Sanfresh GT-800 has the ability to increase yield in greenhouse-frown plants.

There was a notable yield increase under drought (25%-water) conditions as well (Fig. 1 and 2), suggesting that the soil water retention (WR) was increased by Sanfresh GT-800. Under reduced water conditions, the Control (untreated) plants produced fewer fruit with reduced fruit weight, whereas the Sanfresh GT-800 treated plants retained or marginally exceeded in fruit yield (Fig 2).

The differences between the different Sanfresh GT-800 concentrations applied were insignificant in this first test, suggesting that at 0.25% or 0.5% lower concentrations, the product was sufficient in increasing

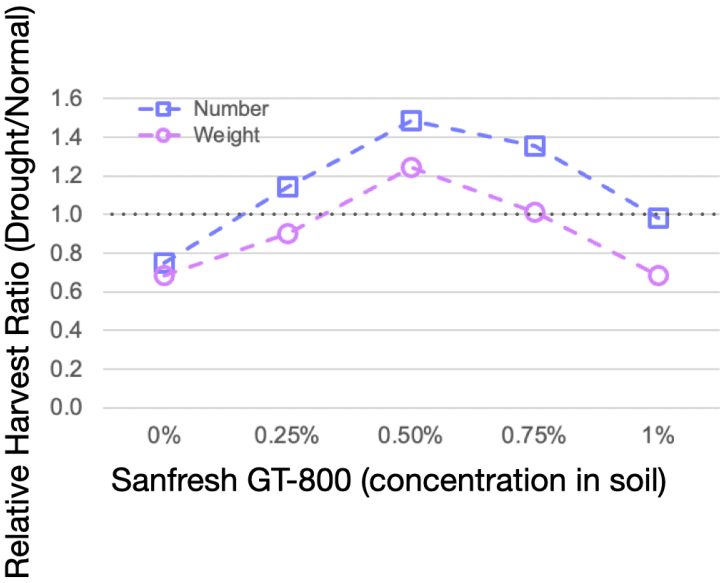

Figure 3. **Relative ratio of total fruit number and weight produced by drought/regular water plants.** Ratio (0.25%-water/Reg-water) is plotted for each treatment type. For example, the graph shows reduced (less than 0.8) relative production by Control (0% Sanfresh GT-800) plants under drought, relative to Reg-water plants. Ratio of 1.0 indicates no change in production (dotted line). All values above 1.0 represent increased performance and values below 1.0 represent reduced performance under drought vs. regular water. Ratios were calculated with the values used in Figure 2, representing the first tomato harvest.

soil AWC and WR in potted soil in the greenhouse. These results may vary in the field or with crops with higher water needs than microtom tomatoes.

Under drought (25%-water) conditions, the Control (0%) plants produced less than 80% tomatoes (in

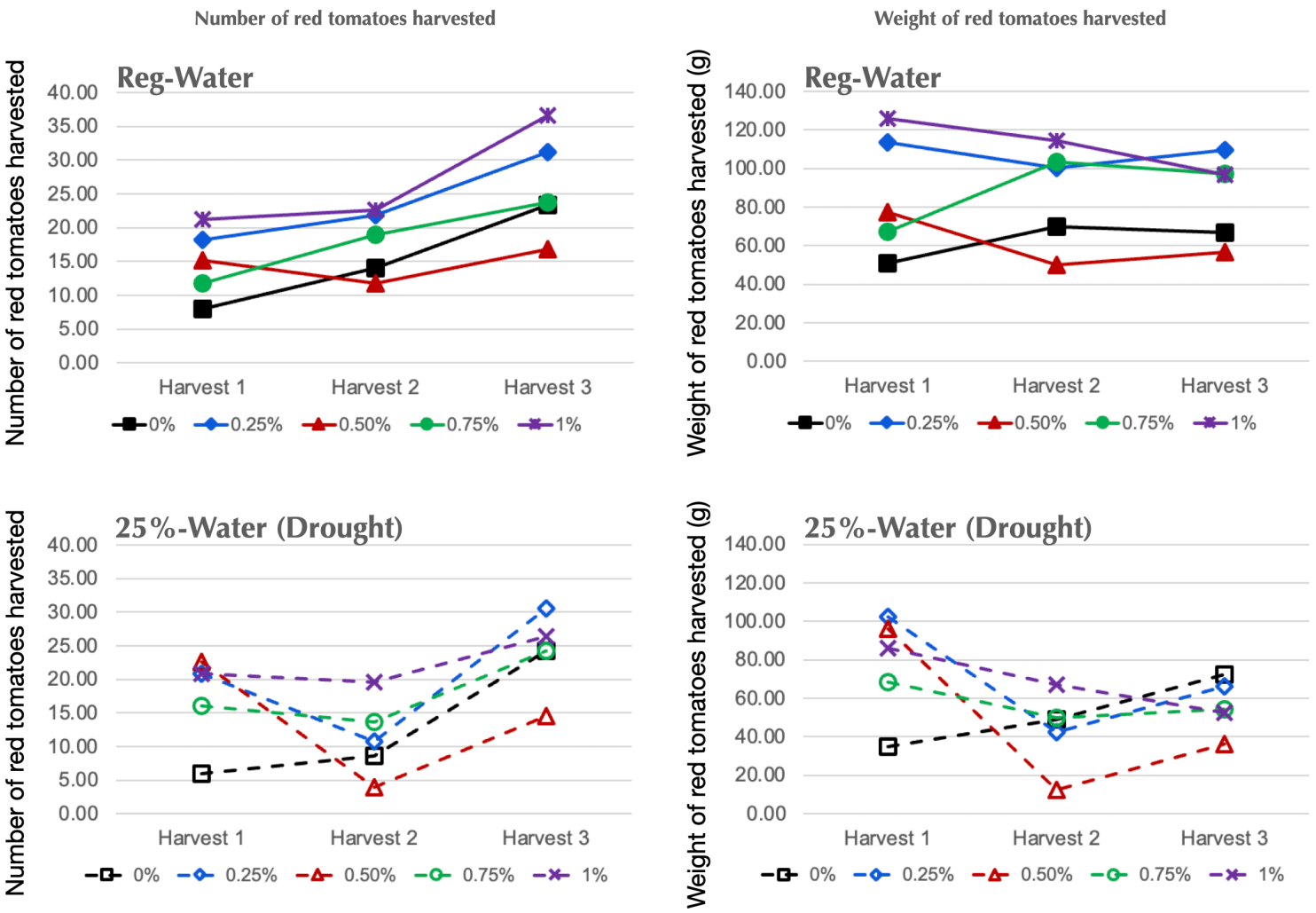

Figure 4. **Number and weight of tomatoes harvested per week over three weeks.** Total number (left) and weight (right) of tomatoes harvested weekly, over three weeks (Harvest 1, 2 and 3) from greenhouse plants treated with various concentrations of Sanfresh GT-800 (indicated). Normal watering (Reg-Water, solid line) and reduced (25%-Water, dashed line) conditions. N=5 plants per treatment. Average values from each harvest are plotted.

number and weight) compared to Reg-water (Figure 3). Plants treated with Sanfresh GT-800 produced relatively more tomatoes with higher total weight under drought compared to Reg-water (Fig. 3) at the lower product concentrations tested. These data suggested that at first harvest, the overall performance of tomato production was improved by lower concentrations of Sanfresh GT-800 under 25%-water, likely due to the increased soil WR property.

Soil AWC and WR are critical parameter that influence plant growth and performance as a major ingredient for plant health, as well as in determining the absorption and assimilation of essential nutrients through the movement of water in the plant (driven by transpiration). Different soil types exhibit a range of AWC, from lower in sandy soils to higher in clay and silt loams. Similar studies with will help in determining the optimal concentrations needed of Sanfresh GT-800 to improve crop performance in soils with different WR properties.

The determinate cultivar Microtom stops producing fruit at full maturity. In this study, plants were harvested three times (once per week) before the plants stopped producing new tomatoes. Previous figures were plotted from values obtained at Harvest 1.

Figure 4 shows the number and weight of tomatoes obtained in three consecutive harvests. Overall, the Sanfresh GT-800 treated plants produced more

tomatoes compared to Control plants. There were some variations in Harvest 2 and 3. The Control plants had slightly more red tomatoes at second and third harvest (Fig. 4) than Harvest 1. In contrast, Sanfresh GT-800 treated plants on average produced more tomatoes (number and weight) at Harvest 1 and 2 compared to Controls, with the exception of 0.5% product, which showed a slight dip at Harvest 2 (Fig. 4). 0.25% and 0.5% Sanfresh GT-800 were the best performing treatments under drought at Harvest 1 (Fig.4). These variabilities are expected within the treatment sets because the total number of plants tested per treatment was only 5 plants/ treatment (relatively smaller N). Higher number os plants per treatment and repetition of the experiment are needed to draw final conclusions.

DISCUSSION

In this first trial, Sanfresh GT-800 treated plants performed better than controls in all conditions tested, suggesting that AWC and WR can be improved even by lower (0.25% and 0.5%) concentrations of the product.

Possible Mechanisms of Activity

1. **Soil Water Retention** is improved in Sanfresh GT-800 treated pots due to the presence of the super-absorbent polymer. Increased water retention is beneficial to plants (see below). Under normal conditions, relatively higher water availability to the plant improves nutrient uptake and similar benefits, along with the soil's ability to hold more water under reduced-water conditions provides tolerance to drought, as seen in the Results.

2. **Sustaining beneficial soil microbial activity** is another possibility related to increased soil WR. Higher moisture and WR within the soil is likely to maintain a healthier microbiome in the soil, providing benefits such as in plant absorbable nutrients and protection from pathogens. These benefits can be tested by profiling the microbiomes of Control and treated soil and root endosphere.

Microtom is a small cultivar of tomato. It serves as a good crop for trials in the greenhouse. Repetition of the trials with Microtom will confirm these findings with a higher statistical confidence than the 5 plants/treatment tested here. Additional soil types ad crop tests will provide a better measure of the efficacy of the product.

RECOMMENDATIONS

Sanfresh GT-800 was easy to use in the greenhouse, it could be mixed with soil in the pots and it led to increased yield even under normal watering conditions, and it provided drought tolerance to plants. Analysis of nutrient dynamics between soil and the plant, and microbiome profiles in soil and in root endosphere will help determine its mode of activity, leading to optimizing its application in greenhouse and on the field.

The application of Sanfresh GT-800 in the field needs to be tested and developed for convenient method of its application to provide similar benefits on the field.

Properties of Sanfresh GT-800 over time, its breakdown in soil are important to test, particularly if applied on agricultural fields. Weathering and breakdown of the product in the soil and its effectiveness over multiple seasons should be tested for its impact on soil properties over longer periods. In greenhouse settings, repurposing of soil containing Sanfresh GT-800 for multiple production cycles should be tested, and based upon its breakdown products, proper disposal procedures should be developed. These studies are critical for the overall assessment of sustainability practices of Sanfresh GT-800 on agricultural fields and greenhouse production systems.

CONCLUSION

Sanfresh GT-800 significantly increased tomato yield in the greenhouse. As a SAP, it is expected to increase soil water retention, providing a continuous benefit to plants from start to harvest. Additional studies with more plants/ treatment and on the field are necessary to confirm these findings.

MATERIALS and METHODS

Plant growth and Sanfresh GT-800 application

Seeds of tomato determinate cultivar Microtom were germinated and grown for 11 weeks. Five plants per treatment were grown on benches in a single greenhouse room under controlled conditions with supplemented lights to maintain long days and fans to control high temperature fluctuations. Liquid nutrient supplementation

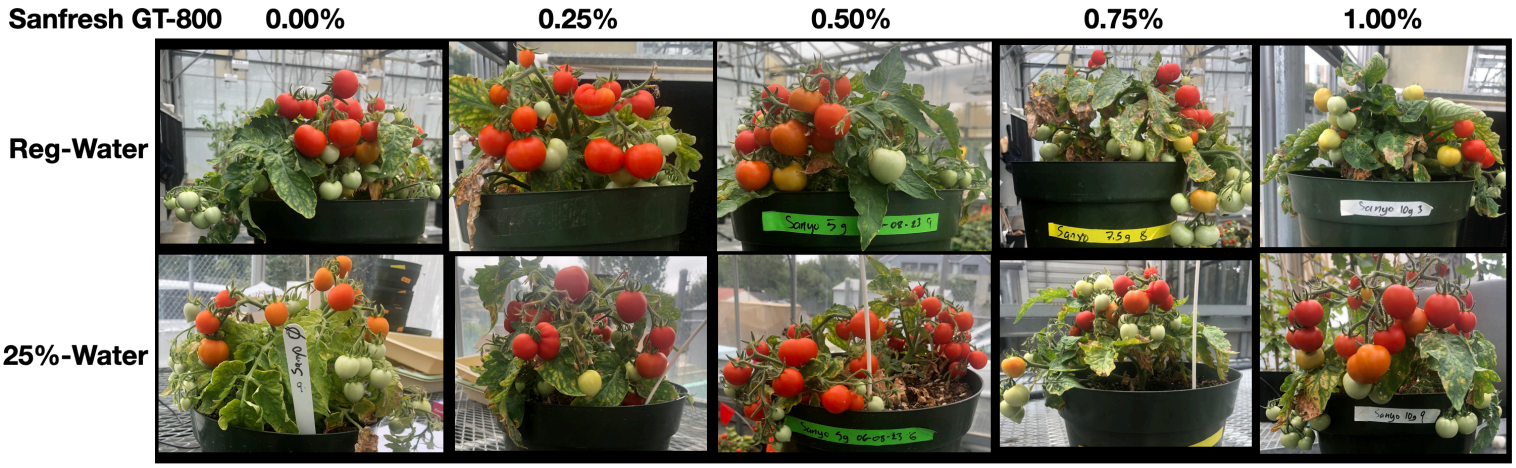

Figure 5. **Harvest 1 plants.** Images of representative plants at week 9 (Harvest 1). Total of 50 plants were grown (5 plants/treatment). On the left, the effect of 25%-Water (drought) can be seen on the Control (0.00%) plants. As shown, the Sanfresh GT-800 treated plants were drought tolerant under the conditions tested. See Figure 6 for weekly weights of pots measured throughout the duration of the experiment.

program consisting of Peters Professional 20/20/20 water soluble fertilizer was applied (1:64 ppm) once per week, as well as a disease suppression program consisting of Floramite and Decathlon at a rate of ¼ tsp per gallon of water, mixed/agitated, was applied through a controlled sprayer at the rate of 1-2 gal per 100 plants.

Sanfresh GT-800 was mixed with soil in the pots at indicated concentrations. The pots were irrigated through a drip system with 100 mL/day/pot with a total of 700 mL/week/pot. For the 25%-water conditions, the drip irrigation was reduced to 25mL/day/pot with a total of 175 mL/week/pot. 25 plants (5 plants per treatment; o%, 0.25%, 0.5%, 0.75% and 1.0%) were grown under normal (Reg-water) conditions and another similar set of 25 plants was subjected to drought (25%-water).

Weekly pot images and pot weights

Each pot (with soil and plant) was imaged and weighed every week. All images of all individual pots are available on DropBox (see References, Images of all individual pots taken weekly). Images of representative pots at Harvest 1 (week 9) are shown (Fig. 5). Pots were grown as shown (Fig. 6). The average weights of 5 pots/treatment are plotted for each week (Fig. 7).

Harvest

Red tomatoes were harvested on weeks 9 (Harvest 1), 10 (Harvest 2), and 11 (Harvest 3). Total numbers of tomatoes produced were counted and weighed per pot. Averages from these data were used to develop Figures 1, 2, 3 and 4.

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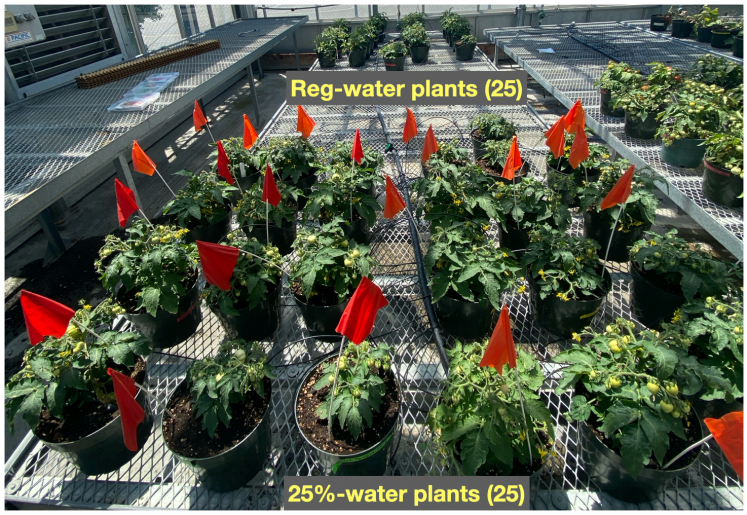

Figure 6. **Reg-water (set in the back) and 25%-water (set in the front).** Plants were grown in randomized pattern within each irrigation-set, but on the same greenhouse bench to minimize location-based variations. Irrigation volumes were set at described at week 3. Plants treated with drought were marked (red-flags).

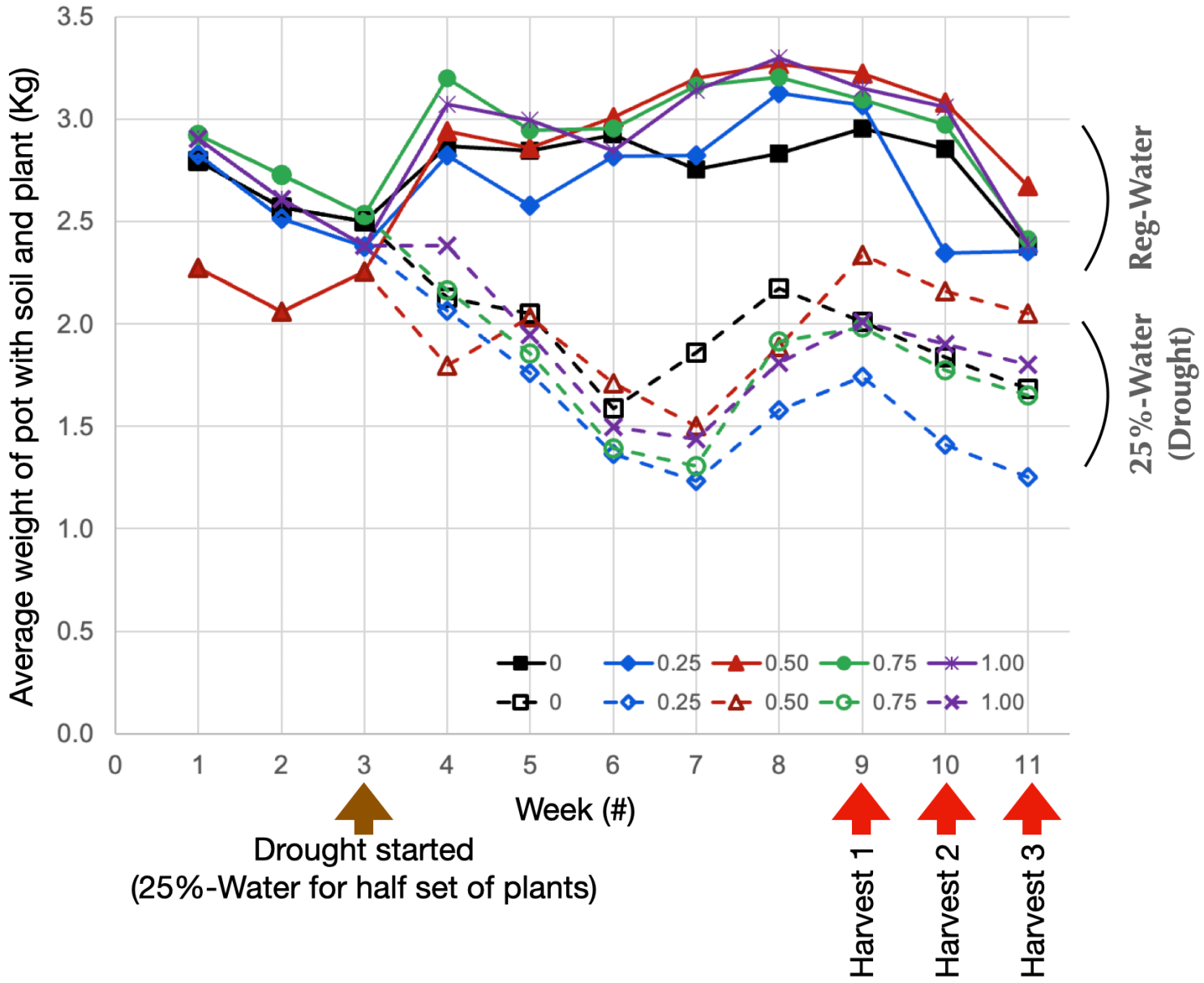

Figure 7. **Weekly average weights (in Kg) of pots.** Throughout the duration of the experiment (11 weeks), all pots (50) were weighed individually. Average pot weight is plotted for each treatment. All plants were grown under regular water conditions until week 3. Drought (25%-water) was started at week 3. Half-set (25 pots) were placed under reduced watering for the remaining duration of the experiment (week 3 to 11). 0.5% treatment plants were transplanted into pots a week after all the other treatments. The 0.5% plants were slightly smaller at start, but they caught up with the rest of the plants within a few weeks. There was a notable difference in pot weight between drought and regular-water conditions. There was no correlation between the pot weight and the concentration of Sanfresh GT-800 used, as expected, since the amounts added to soil were small. The pot-weight varied largely with soil WR and plant size with and without fruit. Only red tomatoes were harvested at Harvests 1 to 3 at weeks 9, 10 and 11.

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Conflicts of Interest

Rajnish Khanna is the founder of i-Cultiver, an independent company providing consultation and research assistance to food and agricultural industries. All aspects of this study were performed by independent researchers. i-Cultiver declares that there are no competing interests.

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