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Estimation of determinate varieties of tomatoes (*Solanum lycopersicum* L.) in irrigating conditions of the Absheron region

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The research conducted at Genetics Resources Institute focused on the cultivation of determinate tomato varieties in the irrigating conditions of the Absheron Region. In this area, tomato growers encounter challenges related to water scarcity and mismanagement, which significantly impact their income and the local ecosystem. Given the vital role of water in tomato cultivation, the study investigated the impact of irrigation on the quality of determinate tomatoes intended for processing. The experiment, conducted between 2017 and 2018 in Absheron's experimental fields, involved treating different determinate tomato varieties with various irrigation regimes, which varied based on water quantity and the interval between irrigations. Eight standard varieties with varying stem lengths were selected from the gene pool of determinate tomatoes for the experiment. The primary objectives were to analyze the morphological and biological traits of these varieties and identify potential donors with economically beneficial characteristics for future tomato breeding efforts. Additionally, the study aimed to determine the optimal irrigation schedule for determinate tomato varieties to strike a balance between yield and water usage efficiency. Two experiments were carried out, each monitoring variables related to determinate tomato production, including plant height, stem diameter, fruits per plant and overall yield. The findings indicated that the quantity of water applied had a more significant impact on fruit quality and production than the frequency of irrigation.

Keywords: *Water dosage, irrigation frequency, tomato quality, tomato production, water use efficiency*

INTRODUCTION

Plant breeders have extensively utilized determinate tomatoes in recent years to enhance yield levels in various cross-pollinated crops (Huseynzade et al., 2020). The process of domesticating and improving crops through breeding has proven highly effective in concentrating allelic variation that imparts useful characteristics for both cultivation and consumption (Osborn, Chad, Elaine and Carl, 2007). Tomato occupies a special place among vegetable crops. The nutritional properties of fruits, which are used fresh and pickled in the canning industry for the manufacture of ketchup, juice, mashed tomatoes, and other products, contribute to their widespread use. The quality and yield of tomatoes depend on their variety (Albert et al, 2016a). Determinate varieties of tomatoes have a compact bush, which allows long-term inter-row cultivation. They can be grown with seedlings 2 times thicker than ordinary varieties, and therefore the cost of growing seedlings per 1 ha is 2 times cheaper. In the determinate varieties, the fruit is in less contact with the soil than in ordinary varieties (Avdeev, 2006). In connection with the value of determinate varieties, the study of their biological properties is of great importance. In the selection and collection of the gene pool of tomatoes, we selected determinate samples that differ in stem length. It is of interest to study their differences in

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other biological and economic characteristics.

The primary aim of the experiment was to examine the morphological and biological attributes of determinate tomato varieties, particularly focusing on those grown under irrigating conditions in the Absheron Region.

This study also aimed to identify individuals possessing economically beneficial traits, thus contributing to the broader goal of utilizing these selected varieties in future tomato breeding programs.

Many studies have assessed plant responses to different watering regimes in several species and shown the negative impact of water shortages on plant growth and yield. Reviews of the different morphological, physiological, and molecular changes induced by water limitation are available (Chaves et al., 2003; Hirayama and Shinozaki 2010; Farooq et al., 2012; Silva et al., 2013).

Irrigation mismanagement affects water storage in reservoirs (Irmak et al., 2016) and can be improved if the water dose and frequency of irrigation is correctly determined (Wang et al., 2006).

MATERIALS AND METHODS

The experiment took place in the experimental fields of the Absheron region at the Genetic Resources Institute during 2017-2018. Determinate tomatoes were initially planted in the greenhouse in the first decade of March, and then transplanted as seedlings into the open experimental field in the last decade of April. Seedling care included watering, weeding, and loosening of the soil. Plants were fertilized with mineral fertilizers at a rate of N10P20K15 per 10 liters of water, which were applied to plants in the open area, followed by irrigation. Tomatoes were planted using a scheme of 150 x 35 cm spacing. Throughout the growing season, three inter-row cultivations were conducted at a rate of 210-270 m^3/ha, and weeding was carried out three times manually. Additionally, nine irrigation sessions were performed. Eight types of determinate tomatoes were studied: Volqaqrad-5\95, Ordubad, Krosnodar, Ilkin, Shahin, Varonej, Utro and Azerbaijan.

Geography and climate. Azerbaijan, positioned in SW Asia or the far SE of Europe, covers an area of 86,600 km^2 between 38º25’ and 41º5’N and 50º-50º51’E, bordered by the Caspian Sea to the east. In the Greater Caucasus mountains, temperatures average 14-16ºC at 2,000 m elevation and remain above 8-10ºC at 3,000 m.

Absheron, partly on a peninsula and partly inland, lies along the west coast of the Caspian Sea of Baku.

Absheron soils are typically influenced by the semi-desert to dry-desert climate of the area and are characterized by their arid conditions. Absheron soils may vary but often exhibit characteristics such as low organic matter content, high salinity levels, and poor fertility. Due to these conditions, agriculture in the region often requires careful irrigation and soil management practices to support plant growth. Additionally, the presence of salt lakes in the area can contribute to soil salinization, further impacting agricultural productivity.

Experimental design. The present study is focused on finding the optimal irrigation schedule for determinate tomato crops that balances yield and quality. Thus, several doses of water and the frequency of irrigation were evaluated. In the first experiment, two watering frequencies were controlled: two waterings per day (F1) and one watering per day (F2), as well as four water doses: 80% (L1), 100% (L2), 120% (L3) and 140% (L4) dose-control. In the second experiment, four watering frequencies were evaluated: two waterings per day (F1), one watering per day (F2), one watering every two days (F3), and one watering every three days (F4), as well as two doses of water (the best of the first experiment): 100% (L1) and 120% (L2). In the first experiment, a factorial arrangement (2 × 4) was performed on divided plots in a fully randomized four-replication block design. In the second experiment, a factorial design (2 × 4) was performed in a completely randomized block design with four repetitions.

Measurements. The study tracked field agronomic variables, fruit quality parameters, and water use efficiency. Agronomic and fruit quality variables were measured over a sampling area that was representative of the site; thus, in the first and second experiments, 10 and 12 plants were selected (located in the center of the plot), respectively.

Agronomic variables. The selected agronomic variables were plant height, stem diameter, number of fruits per plant, and productivity. These variables were measured in all plants in the sampling area. A measuring tape was used for the height of the plant, and measurements were made from under the trunk to the entry point of the last truss. At the end of each experiment, the total and marketable products are calculated. In terms of fruit weight and taking into account the parameters set by the Ibarra Wholesale Market (Imbabura Province), the fruits were divided into four categories, ie <70 g (very small fruit), 70-100 g (small fruit), 100-150 g (medium size fruit) and> 150 g (large fruit). Very small, deformed and cracked fruits were considered unsold.

Quality parameters. Quality indicators were monitored in two and three samples for each experimental site, and each sample was analyzed separately. In the first experiment, samples were taken 119 and 130 days after sowing, and in the second experiment, 135 and 160 days after sowing. For each sample, three fruits were selected (same in size, degree of maturity, without external defects).

RESULTS AND DISCUSSION

Determination of tomato production and quality. Table 1 describes the outcomes from the ANOVA and Duncan's Multiple Range test tests of the first experiment. The effect of water dose on plant height was more considerable than the effect of irrigation frequency in the first experiment. The irrigation dose applied (140%) and the 120% resulted in plants with the greatest heights: 129.90 and 116.43 cm, respectively. The smallest height corresponded to 102.59. In the second experiment, the effect of water dose and irrigation density was not significant.

All parameters are given in charts (Fig. 1-6). The first figure illustrates how different water doses affect the plant height of determinate tomato plants. It shows the trend of plant height increasing or decreasing with varying water doses.

The second figure depicts the correlation between water doses and the number of fruits produced per determinate tomato plant. It shows how changes in water doses influence the fruit yield per plant.

Table 1. Analysis of variance and Duncan's multiple range test of the average plant height, stem diameter, fruits per plant, total yield, marketable yield, total water use efficiency and marketable water use regulation for the first experiment

Factor	Plant height (cm)	Stem diameter (mm)	Fruits Plant (-)	Total Yield (kg plant^{-1})	Marketable yield (kg plant^{-1})	Total WUE (kg m^{-3})	Marketable WUE (kg m^{-3})
Irrigation frequency							
F1	106.08	13.56	47.63	11.05	10.08	49.83	46.50
F2	105.33	13.73	47.50	11.81	11.08	54.39	51.48
Water doses							
L1-80%	102.59	10.44	47.39	10.92	8.89	57.32	53.68
L2-100%	114.13	10.62	48.66	12.00	11.12	53.26	50.32
L3-120%	116.43	12.18	48.53	12.95	12.15	49.89	45.56
L4-140 %	129.90	13.35	49.79	14.27	13.36	45.97	43.81
Anova							
F	ns	Ns	ns	Ns	ns	ns	ns
L	**	***	ns	***	***	***	*
F × L	ns	Ns	ns	Ns	ns	ns	ns

F and L represent irrigation frequency and water height, respectively. F1: one irrigation per day; F2: two irrigations per day; L1: 80%; L2: 100%; L3: 120% ; L4: 140% ETc ; WUE: water use efficiency;*: significant at $p < 0.05$; **: significant at $p < 0.01$; ***: significant at $p < 0.001$; ns: no significant at $p < 0.05$

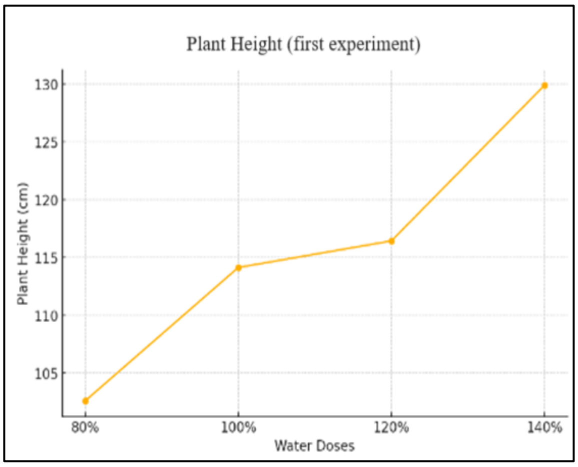

Fig.1. The relationship between water doses and plant height

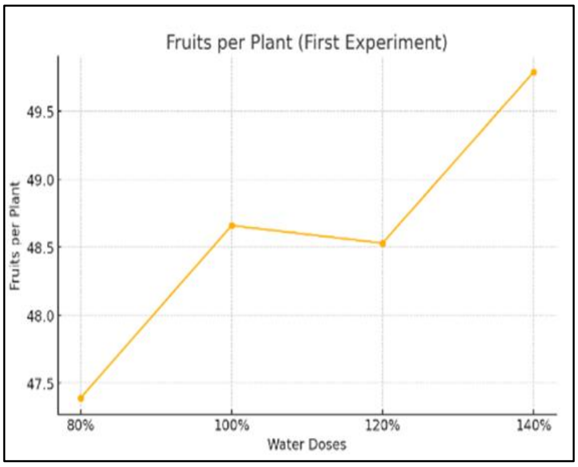

Fig. 2. The relationship between water doses and fruits per plant

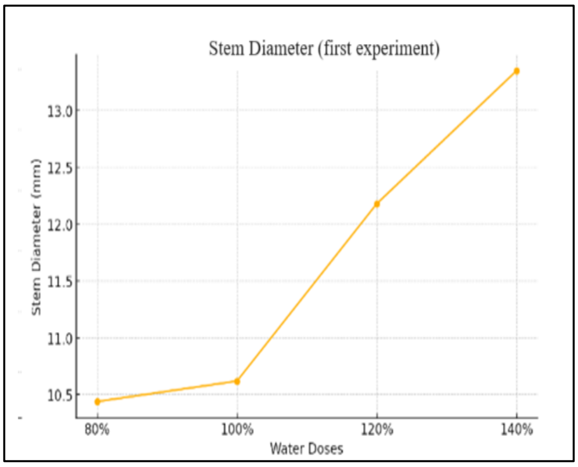

Fig. 3. The relationship between water doses and stem diameter

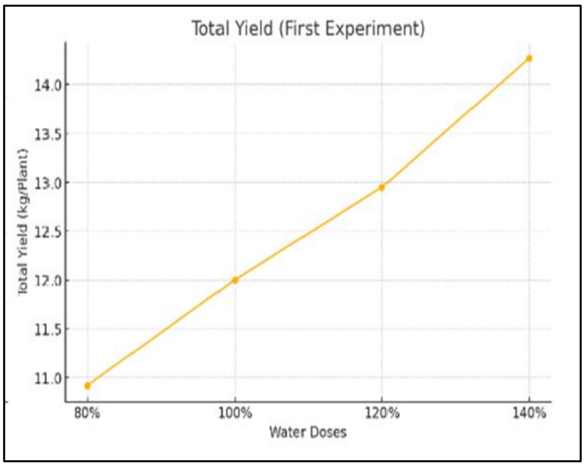

Fig. 4. The relationship between water doses and total yield

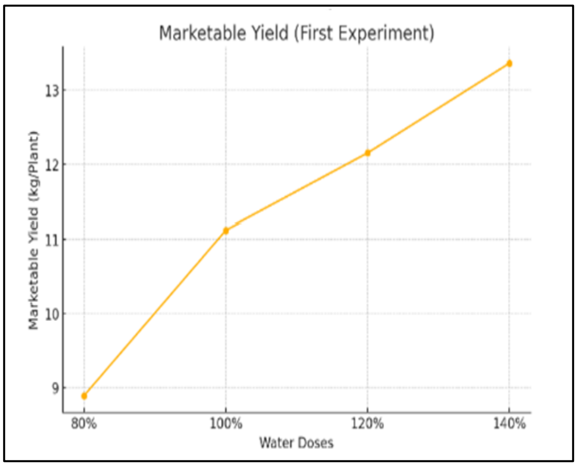

Fig. 5. The relationship between water doses and marketable yield

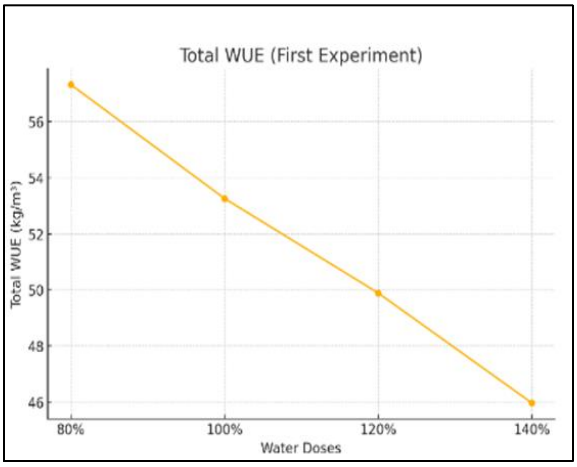

Fig. 6. The relationship between water doses and marketable yield

The third figure demonstrates the impact of different water doses on the stem diameter of determinate tomato plants. It visualizes how water availability affects the thickness of the plant stems. The forth figure shows the relationship between water doses and the total yield of determinate tomatoes. It presents how variations in water doses contribute to changes in the overall yield of the tomato plants.

The fifth figure displays how different water doses influence the marketable yield of determinate tomatoes. It highlights the relationship between water availability and the yield of tomatoes suitable for the market.

The sixth figure likely provides additional information or a different perspective on the relationship between water doses and marketable yield compared to the fifth figure. It may offer insights into the marketable yield under varying irrigation conditions.

The effect of water dosage on stem diameter was prominent, but the effect of irrigation frequency was not noticeable in the first experiment. The water doses L4 and L3 resulted in the highest stem diameters, whereas the L1 dosage produced the smallest diameter (10.44 mm). In the second experiment, the effect of both water dose and irrigation frequency was significant. Thus, the L3 resulted in the highest stem diameter, and it coincides with the first experiment.

So, one and two irrigations per day presented the highest stem diameters, whereas one irrigation every three days showed the lowest. Similar results were noticed in the first experiment.

Number of Fruits per Plant. As provided in Tables 1 and 2, the effect of water dosage and irrigation density on the number of fruits per plant was not important in both experiments.

Yield. In the first experiment, no significant disparities in irrigation frequencies were observed, but they were detected in the second experiment. Both total and marketable yields raised at irrigation frequency increased. In both experiments, the highest water doses resulted in the highest yields (Tables 1, 2). In the first experiment, irrigation frequency did not have an effect on yield. In the second experiment, the frequencies of one and two irrigations per day resulted in a greater total yield and together with one irrigation every three days, it resulted in the highest marketable yield.

Water Use Efficiency. In the first experiment, no significant differences in irrigation frequencies were noted, but water doses significantly differed. In the second experiment, no significant differences were detected in water doses, but irrigation frequencies differed.

Table 2. Analysis of variance and Duncan's multiple range test of the average plant height, stem diameter, fruits per plant, total yield, marketable yield, total water use efficiency and marketable water use efficiency after the second experiment

Factor	Plant height (cm) (135)	Plant height (cm) (after 160)	Stem diameter (mm)	Fruits plant (-)	Total Yield (kg plant^{-1})	Marketable yield (kg plant^{-1})	Total WUE (kg m^{-3})	Marketable WUE (kg m^{-3})
Water doses								
L1	108.39	101.39	10.93	85.44	6.99	6.36	44.59	36.51
L2	108.52	102.29	12.44	87.31	8.25	7.68	44.46	37.92
Irrigation frequency								
F1	107.83	104.55	12.56	97.00	9.32	7.77	47.69	40.55
F2	109.00	103.05	12.16	95.75	8.68	7.13	44.73	47.71
F3	107.95	98.74	12.37	97.25	8.08	6.34	42.22	44.26
F4	109.23	99.14	10.63	95.50	8.39	6.84	43.45	46.34
ANOVA								
L	ns	ns	***	Ns	***	***	ns	ns
F	ns	ns	**	Ns	*	*	*	*
L × F	ns	ns	ns	Ns	ns	ns	ns	ns

L and F represent water height and irrigation frequency, respectively. L1: 100% ETc; L2: 120% ETc; F1: two irrigations per day; F2: one irrigation per day; F3: one irrigation every two days; F4: one irrigation every three days; WUE: water use efficiency; *: significant at $p < 0.05$; **: significant at $p < 0.01$; ***: significant at $p < 0.001$; ns: no significant at $p < 0.05$.

As shown in Table 1, the 80% and 100% doses resulted in the highest WUE and 40%, the lowest in the first experiment. Overall, two and one irrigations per day achieved the highest total WUE in the second experiment. Likewise, the highest marketable WUE was attained for the frequencies: one and two irrigations per day, and one irrigation every three days.

Discussions. This study examined the impact of varying water doses and irrigation frequencies on crop production, crop quality, and water use efficiency. The results showed that reduced water doses led to decreases in plant height, stem diameter, and tomato yield. These findings are consistent with previous studies by Biel et al. (2021) and Agbna et al. (2017), which reported a reduction in vegetative growth and fruit yield under deficit irrigation conditions. Similarly, a 2020 study found that water stress negatively affected plant height and stem diameter. However, neither water doses nor irrigation frequencies influenced the number of fruits per plant. This aligns with Shabbir et al. (2020), who observed a consistent number of fruits per plant at both 100% and 75% irrigation levels, although other research indicated that water dose can affect fruit number. Tomato plants are highly sensitive to water stress during flowering and fruiting, which can lead to flower abortion and reduced fruit numbers (Zegbe et al., 2006). Despite this, our study did not observe a decrease in fruit number due to water stress.

Water doses had a significant effect on tomato yield, corroborating previous studies that found small water doses negatively impact fruit yield (Giuliani et al., 2017; Liu et al., 2019). Sezen et al. (2010) reported the highest tomato yield with the highest water dosage (150%), which is consistent with our findings. Conversely, Neto et al. (2017) found that weekly irrigation frequencies resulted in the highest yields, while daily irrigation led to the lowest yields. Similarly, Fara et al. (2019) noted that frequent irrigations increased nutrient leaching from the root zone and reduced root system development.

Our study showed only slight differences between total and marketable yields. In terms of marketable yield, one irrigation every three days and one to two irrigations per day produced similar results. However, for total yield, one irrigation per day and every two days resulted in the highest values. The best water use efficiency (WUE) was observed with the lowest irrigation dose, aligning with findings from Wang et al. (2017), Silva et al. (2019), and Mendoça et al. (2020). The highest WUE was achieved with the highest irrigation frequency, which is in line with Oke et al. (2020), who noted that increased irrigation frequency boosts fruit number and yield, thereby improving WUE. However, in our study, the number of fruits per plant was not influenced by either irrigation frequency or water dose. The highest yields and WUE were observed with two irrigations per day, which also produced over 10% more large-sized fruits compared to other frequencies. Conversely, the lowest WUE was recorded with irrigation every other day, resulting in a higher percentage (10% to 21%) of unmarketable fruits.

CONCLUSIONS

Daily irrigation schedules are advisable to better adjust to the variable climatic conditions in the region.

Water scarcity and mismanagement significantly impact tomato growers' income and the local ecosystem. The quantity of water applied has a more significant impact on fruit quality and production than the frequency of irrigation. Water doses significantly affect tomato yield, with small water doses negatively impacting fruit yield. The highest marketable water use efficiency was achieved with one or two irrigations per day and one irrigation every three days. The highest total water use efficiency was observed with two irrigations per day (L1 and L2) in the second experiment. Water dose and irrigation frequency play crucial roles in determining plant height, stem diameter, and tomato yield. Frequent irrigation may result in higher nutrient leaching and less developed root systems. The number of fruits per plant was not significantly affected by irrigation frequency or water dose in the study.

Optimal irrigation schedules can help strike a balance between yield and water usage efficiency in determining tomato cultivation. These conclusions highlight the importance of efficient irrigation practices and water management strategies in enhancing tomato production and quality in regions facing water scarcity challenges. Both total and marketable yields showed a proportional relationship with water doses.

REFERENCES

Albert E., Gricourt J., Bertin N., Bonnefoi J., Pateyron S., Tamby J.P., Bitton F., Causse M. (2016) Genotype by watering regime interaction in cultivated tomato: lessons from linkage mapping and gene expression. *Theoretical and Applied Genetics,* **129(2):** 395-418; doi: 10.1007/s00122-015-2635-5

Avdeev, A.Y., Ivanova, L.M. (2007) Breeding tomatoes for conditions in the Lower Volga region. Russ. Agricult. Sci. **33**,367-368; doi: 10.3103/S1068367407060055

Biel C., Camprubí A. Lovato E., Calvet C. (2021) On-farm reduced irrigation and fertilizer doses, and arbuscular mycorrhizal fungal inoculation improve water productivity in tomato production. *Sci. Hortic*., **288:** 110337.

Chand J., Hewa G., Hassanli A., Myers B. (2020) Evaluation of deficit ırrigation and water quality on production and water productivity of tomato in greenhouse. agriculture. **10:** 297; https://www.mdpi.com/2077-0472/10/7/297

Chaves M.M., Maroco J.P., Pereira J.S. (2003) Understanding plant responses to drought - from genes to the whole plant. *Functional Plant Biology (FPB),* **30(3):** 239-264; doi: 10.1071/FP02076.

Fara S.J., Delazari F.T., Gomes R.S., Araújo W.L., da Silva D.J. (2019) Stomata opening and productiveness response of fresh market tomato under different irrigation intervals. *Sci. Hortic*., **255:** 86-95.

Gamareldawla A., She D., Zhipeng L., Nazar E., Shao G., Timm L.C. (2017) Effects of deficit irrigation and biochar addition on the growth, yield, and quality of tomato. *Scientia Horticulturae*, **222:** 90-101.

Giuliani M., Nardella E., Gagliardi A., Gatta G. (2017) Deficit ırrigation and partial root-zone drying techniques in processing tomato cultivated under Mediterranean climate conditions. Sustainability. **9**, 2197.

https://escipub.com/ajar-2020-01-0901

https://link.springer.com/article/10.1007/s00271-005-0018

https://www.mdpi.com/2071-1050/9/12

https://www.nature.com/articles/s41598

https://www.researchgate.net

https://www.researchgate.net/publication

https://www.researchgate.net/publication/316914624

https://www.scihub.ru/10.1016/j.scienta.2019.05.025

Huseynzade G.A., Akperov Z.I., Hasanov S.R. (2020) Combining ability and gene action of tomato hybrids (*Lycopersicum Esculantum* L.) genotypes in Azerbaijan. *American Journal of Agricultural Research,* **5:** 80.

Liu H., Li H.H., Ning H.F., Zhang X.X., Li S., Pang J., Wang G.S., Sun J.S. (2019) Optimizing irrigation frequency and amount to balance yield, fruit quality and water use efficiency of greenhouse tomato. *Agric. Water Manag.*, **226**, 105787.

Mendonça T.G., Da Silva M.B., Pires R.C.D.M., Souza C.F. (2020) Deficit irrigation of subsurface drip-irrigated grape tomato. *Eng. Agrícola*, **40**, 453–461.

Neto M.D. Azevedo B.M., De Araújo T.V.V., DeVasconcelos D.V., Fernandes C.N. (2017) Irrigation frequency on economic performance and productivity of tomato in the coast of Ceará, Brazil. *Rev. Caatinga*, **30:** 971-979.

Oke A.M., Osilaechuu A.P., Aremu T.E., Ojediran J.O. (2020) Effect of drip irrigation regime on plant height and stem girth of tomato (*Lycopersicon esculentum* Mill). *IOP Conference Series Earth and Environmental Science*, **445:** 012016.

Osborn T.C., Chad K., Elaine G., Carl J.B. (2007) Insight and Innovations from wide crosses: Ex-amples from canola and tomato. *Crop Science Society of America, Madison*. **47:** 3228-3237.

Sezen S.M., Yazar A., Tekin S., Kapur B. (2010) Effect of irrigation management on yield and quality of tomatoes grown in diferent soilless media in a glasshouse. *Scientific Research and Essay,* **5(1):** 041-048

Shabbir A., Mao H., Ullah I., Buttar N.A., Ajmal M., Lakhiar I.A. (2020) Effects of drip ırrigation emitter density with various ırrigation levels on physiological parameters, root, yield, and quality of cherry tomato. *Agronomy*, **10:** 1685.

Silva C.J., Frizzone J.A., da Silva C.A., Golynski A., da Silva F.M., Megguer C.A. (2019) Tomato yield as a function of water depths and irrigation suspension periods. *Rev. Bras. De Eng. Agrícola E Ambient*., **23:** 591–597.

Wang X., Xing Y. (2017) Evaluation of the effects of irrigation and fertilization on tomato fruit yield and quality: A principal component analysis. *Sci. Rep*., **7:** 350.

Zegbe J.A., Behboudian M.H., Clothier B.E. (2006) Responses of 'Petopride' processing tomato to partial rootzone drying at diferent phenological stages. *Irrig. Sci*., **24:** 203-210.

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