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Araştırma Makalesi/Research Article

Responses of Different Stresses on Tomato

Domates Üzerinde Farklı Streslerin Tepkileri

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ABSTRACT

Tomato is one of the products with the highest production and consumption in the world, and it is among the sine quanon of human nutrition because of its high trade. In terms of plant yield, water deficiency is an important factor. In addition, salt stress in plants is an important limiting environmental factor affecting production. During the study period, the temperature values of the growing room were kept at 23 / 17 ±2 °C (day/night), 55–60% humidity, and under 8000 lux light intensity. In practice, irrigations of 25%, 50%, 75%, 100%, 125%, 150%, 175%, 200%, salt 50 mM, salt 100 mM, and salt 150 mM were performed. It was determined that the control plants under drought and salt stress gave poor and negative results in terms of plant growth. In our application, it was determined that tomato plants under drought, salt, and water stress (excessive water level) had a higher chlorophyll content than plants not exposed to drought. It was observed that the potassium ratio (%) of the tomato plant in the green and root parts of the tomato plant was higher in the control plants exposed to salt stress. It was determined that the potassium ratio (%) in the green and root parts of the tomato plant accumulated more in the control plants at irrigation levels of 100%, 125%, and 150%. In the study, it was determined that water and salt stress applications affect the growth and development of plants negatively, as seen in plants under stress (salt stress, water deficiency and excess). In addition, water plays a vital role for plants in the world.

Keywords- Tomato, Salt, Stress, Irrigation

ÖZ

Dünyada sebzelerde üretim ve insanların tüketim açısından domates en çok kullanılan ürünlerde ilk sırada yer almaktadır. Ayrıca ticaret konusunda ve insan beslenmesinde ise en önemli sebzelerindendir. Genel olarak abyotik stres faktörleri bitkilerde, özellikle tuz stresi, su noksanlığı ve fazlalığı bitki büyümesini olumsuz etkilemektedir. Deneme Bahçe bitkileri bitki yetiştirme kontrolü odasında sıcaklık (gündüz/gece) 24 / 18 ±2 ºC, ortalama nem % 60 ve 8000 lüks ışık şiddeti altında yetiştirilmiştir. Denemede farklı stresler (tuz stresi, su noksanlığı ve fazlalığı) uygulanmıştır. Uygulamalar; %25, %50, %75, %100, %125, %150, %175, %200, tuz 50 mM, tuz 100 mM ve tuz 150 mM şeklinde yapılmıştır. Stres altındaki bitkilerde (tuz stresi, su noksanlığı ve fazlalığı) kontrole göre bitki

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gelişimi açısından daha az gelişim gözlemlenmiştir. Bitkilerde klorofil açısından kurak stres altındaki bitkiler Tuz ve su stresi (fazla su düzeyi) göre daha yüksek oranda belirlenmiştir. Domates bitkisinin, potasyum oranı (%) kök ve yeşil aksamında tuz stresinde, kontrol ve su fazlalığına göre yüksek değer olarak tespit edilmiştir. Uygulamalar arasında ise potasyum içeriğinin kontrol (%100), %125 ve %150 sulama yeşil aksam ve kök kısmında daha yüksek oranda elde edilmiştir. Çalışmada stres (tuz stresi, su noksanlığı ve fazlalığı) altında olan bitkilerde görüldüğü gibi su ve tuz stres faktörlerinde bitkilerde büyüme ve gelişimi negatif yönde etkilediği belirlenmiştir. Ayrıca su dünyada bitkiler için hayati rol oynamaktadır.

Anahtar Kelimeler- Domates, Tuz, Stres, Sulama

I. INTRODUCTION

Tomato is one of the products with the highest production and consumption in the world, and it is one of the most important consumption sources of human nutrition because of its high trade. In addition to the fresh consumption of tomatoes, it is of great importance when it has many uses in the food industry, such as tomato paste, ketchup, sauce, tomato juice, tomato pickles, peeled tomatoes, tomato puree, diced tomatoes, sliced tomatoes, canned tomatoes, and dried tomatoes [1,2]. According to FAO 2020 data, tomato production ranks third after China and India with 186.821.220 tons in a 5.0511.983 ha area in the world and 13.204.010 tons in our country [3]. Drought stress is one of the abiotic stresses that negatively affects some of the morphological and physiological characteristics of plants. Especially when plants are exposed to drought for a long time, leaf water potential and stomatal opening slow down, resulting in decreases in the level of photosynthesis, and it has been reported that photosynthetic pigments and thylakoid membranes are damaged due to drought [4-7]. The tomato plant gives better results with low to moderate rainfall and monthly average temperatures of 21 to 23°C. Tomato plants are not frost tolerant. Long periods of dehydration or excessive watering should be avoided. It has been observed that open irrigation increases the water use efficiency in tomatoes, but there is an inconsistent decrease in yield. However, not all stages of growth in tomatoes are equally susceptible to soil moisture deficits, and low watering will be more beneficial during non-critical stages. The flowering and fruiting stages are very sensitive to water deficits [8]. Drought stress is considered one of the most repetitive and limiting environmental conditions for plant growth and good yield. Plant hormones under drought work together to achieve resource optimization [9]. Many of the high yielding plants are sensitive to salt stress. It is difficult for these plants to survive in salty environments. This causes great losses in yield. It is reported that due to the increase in salinity, it is estimated that agricultural lands may disappear by 50% in the next 25-30 years, for the continuity of agriculture [10-12].The aim of this study is to investigate the effects of different salt concentrations and water stress on tomatoes at the young plant stage.

II. MATERIAL AND METHOD

This study was carried out in the cultivation and growth room (climate room) of the Department of Horticulture, Faculty of Agriculture, Sirnak University. The size of the growing room is around $20m^2$. Tomato seeds were sown in viols on February 29. It was also planted in pots on March 30, 2020 after 3 leaves. The tomato seed used as the material was used as M-19 F1. A total of 3/1 ratio was used in the preparation of Peat + Perlite. Concentrations of elements in the nutrient solution of tomato plants used for cultivation in substrate culture (N 177.2 mg L^{-1} -P 52.70 mg L^{-1} - K 240.44 mg L^{-1} - Mg 53.46 mg L^{-1} - Ca 120.30 mg L^{-1} - Fe 3.36 mg L^{-1} - Mn mg L^{-1} – B 0.45 mg L^{-1} - Zn 0.50 mg L^{-1} - Cu 0.10 mg L^{-1} - Mo 0.05 mg L^{-1}) were used. In practice; different irrigations were applied as 25%, 50%, 75%, 100%, 125%, 150%, 175%, 200%, 50 mM, 100 mM and150 mM salt. Plants to be exposed to water stress and salt stress were equally irrigated with standard nutrient solution until they reached the stage with 3-4 true leaves (Figure 1).

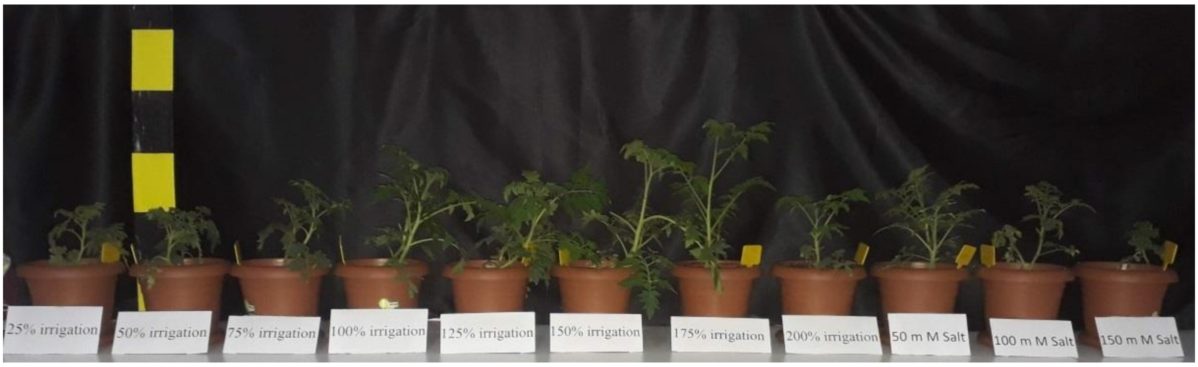

Figure 1. An image from 3 different applications

In the experiment, leaf temperature, chlorophyll in leaves and relative leaf water content [13], leaf area is measured by CI BIO-Science CI 202 model leaf area and Mineral Element Analysis [14] used according to methods.

A.Statistical analysis

All data presented for different nutrient levels, average of at least four replicates of each treatment. Data were numerically obtained using one-way analysis of variance (ANOVA) and tested for treatment with significant ($P \leq 0.05$) differences using the Tukey test.

B.Recording of climate values

Temperature and humidity values in the experimental growth and cultivation room were recorded every day and their averages were calculated (Figure 2).

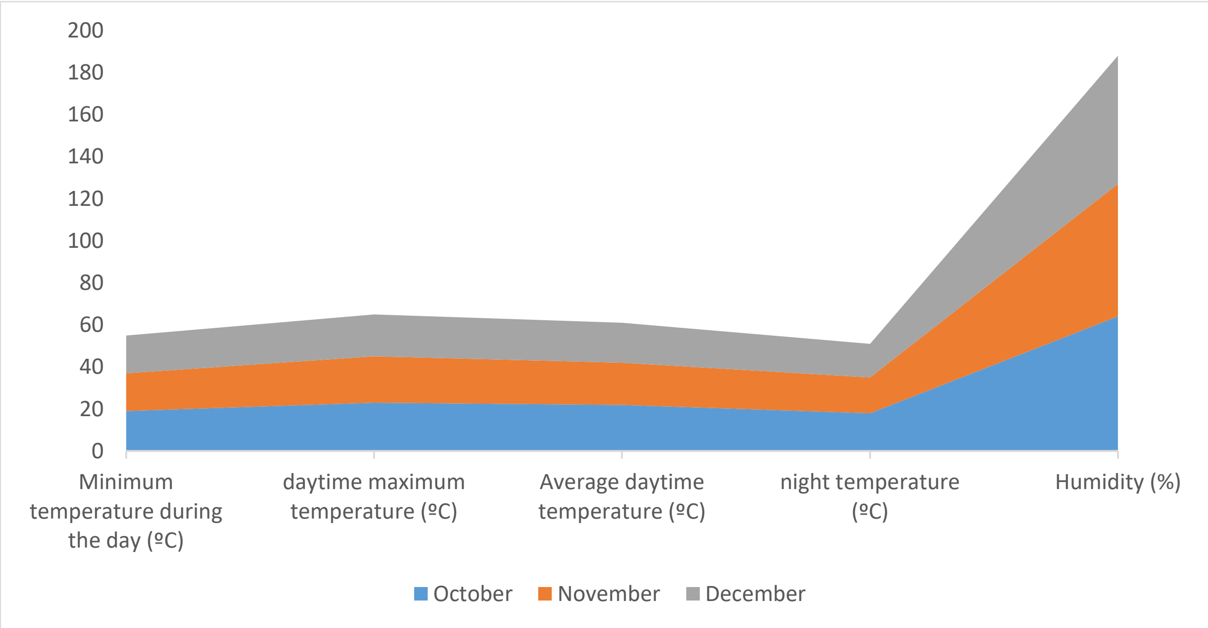

Figure 2. Climatic data of the study area

III. RESULTS AND DISCUSSION

A.Values of chlorophyll (SPAD) amount in leaves

1. 2. Chlorophyll measurements were carried out on the 15th and 30th days of seedling planting. In the first measurements, it was determined that the chlorophyll amount in the 75% irrigation application (59.33) had the highest average value, while the chlorophyll amount in the 125% irrigation application (51.63) had a lower effect compared to the other measurements. In the first measurements, the mean amount of chlorophyll (SPAD) was measured at 56.08 in the control group and all doses. These values are 50% irrigation (55.13), 100% irrigation (65.63), 125% irrigation (51.63), 150% irrigation (55.73), 175% irrigation (55.66), salt stress 100 (52.33) and salt stress 150 mM (55.63) applications were below the average in the amount of chlorophyll (SPAD) doses. In the second measurement, it was seen that the 25% irrigation (61.50) dose was numerically higher in the amount of chlorophyll (SPAD) compared to the control and other dose applications, while the 200% irrigation (36.57) dose was on the chlorophyll (SPAD) amount in the measurements compared to other measurements was found to have a lower effect. After the second measurements, depending on the effect of the doses, the average amount of chlorophyll (SPAD) was measured at (49.10). These values are 125% irrigation (49.08), 175% irrigation (39.01) 200% irrigation (36.57), salt stress 50 mM (45.01), salt stress 150 mM (47.50), It has been determined that the effects of doses on the amount of chlorophyll (SPAD) were below average and gave similar responses in terms of numerical data (Table 1). In our application, it was determined that the chlorophyll content of tomato plants under drought, salt, and water stress (excessive water level) and plants exposed to drought. It has been determined that there is an increase in the total chlorophyll density in the leaves due to the reduction of the transpiration area in order to minimize the amount of water caused by the reduction in the leaf surface. They reported that the decrease

in the amount of chlorophyll caused by drought stress applications generally causes damage to the chloroplast membrane, and drought stress causes the decrease in chlorophyll a and chlorophyll b content [15-18].

Table 1. Average values of leaf chlorophyll amount

Different stresses (%)	1 Chlorophyll measurement	2 Chlorophyll measurement
% 25 irrigation	59.06 a	61.50 a
% 50 irrigation	55.13 a	57.75 ab
% 75 irrigation	59.33 a	53.20 ac
% 100 irrigation	55.63 a	51.95 ac
% 125 irrigation	51.63 a	49.08 ac
% 150 irrigation	55.73 a	49.53 ac
% 175 irrigation	55.66 a	39.01 c
% 200 irrigation	58.93 a	36.57 c
Salt stress 50 mM	57.86 a	45.01 bc
Salt stress 100 mM	52.33 a	49.41 ac
Salt stress 150 mM	55.63 a	47.50 ac
Mean	56.08	49.10
LSD	9.48	14.88
P	0.6807	0.1172

*There is no difference between the averages shown with the same letter in the same column.
* Significant at $p \leq 0.05$. ** Significant at $p \leq 0.01$

B.Determination of values of leaf temperature measurement (ºC)

Average values of temperature measurements of tomato plant applications used in the experiment and multiple comparisons are given in Table 2. In the leaf temperature measurements, 50% irrigation (18.10 ºC) had the highest average values in temperature measurements, while salt had a lower effect on 150 mM irrigation (16.53 ºC) measurements compared to other measurements. In the leaf temperature measurements, the average of the temperature gauges of the control group and all doses was 17.27 ºC. These values are: 100% irrigation (17.26 ºC), 150% irrigation (17.06 ºC), 175% irrigation (17 ºC), 200% irrigation (16.56 ºC), Salt 100 mM irrigation (17.26 ºC), Salt 150 mM irrigation (16.53 ºC), doses below the average of the temperature meter (Table 2).

In their study of heat and drought stress separately on three tomato plants (Arvento, LA1994 and LA2093), it was found that exposure to a combination of heat and drought stress of tomato plant varieties gave the same reactions, and fresh and dry weight, leaf area and relative water yield in three tomato cultivars reported a significant decrease in content [19].

Table 2. Average values of leaf temperature measurement (ºC)

Different stresses (%)	leaf temperature
% 25 irrigation	17.73 ab
% 50 irrigation	18.10 a
% 75 irrigation	17.83 a
% 100 irrigation	17.26 c
% 125 irrigation	17.30 c
% 150 irrigation	17.06 c
% 175 irrigation	17.00 c
% 200 irrigation	16.56 d
Salt stress 50 mM	17.36 bc
Salt stress 100 mM	17.26 c
Salt stress 150 mM	16.53 d
Mean	17.27
LSD	0.41
P	<.0001*

*There is no difference between the averages shown with the same letter in the same column.
* Significant at $p \leq 0.05$. ** Significant at $p \leq 0.01$

C.Average and relative leaf water content values (%) for the measurement of plant leaf areas (cm²)

The highest value in leaf area was 121 cm² at 125% irrigation level, and the lowest value was 58 cm² at salt 150 mM (control) irrigation level. When the values of the averages of plant leaf areas are examined, it is stated in Table 3 that the differences between the values are significant ($p<0.05$) in terms of the numerical data (Table 3). In our drought, salt and water stress (excess water level) applications, it was determined that the leaf area was narrow in the measurements on leaf areas, remaining below the average at all irrigation levels in drought and salt applications. It has been determined that they have the largest leaf area in all measurements at 100% and 125% irrigation levels, and decreases in leaf area occur as water stress (excessive water level) and salt intensity increase. In our application, it was calculated that the width of the leaf area is directly proportional to the irrigation level, as in the previous measurements. Steiner et al. [20], in their study, drought stress caused a significant decrease in leaf area compared to control plants. Leaf area measurements among the test plants were found to be high in Artvin Hopa (80.01 cm^2 $plant^{-1}$) and Kemer (52.44 $cm^2 plant^{-1}$) genotypes. Dasgan et al. [21], It has been observed that tomato plants exposed to drought, salt, and water stress have relatively less leaf area and a decrease in leaf proportional water content compared to control plants. During the experiment, the root weight of the tomato plant; The effects of different salt concentrations and water stress on tomatoes were measured by considering the vertical distance between the top of the plant and the soil surface. As a result of the calculations of the fresh weight of the leaf, the weight of the turgor water ratio, and the dry weight content of the leaf after the harvest, it was concluded about the proportional water ratio in the leaf. They stated that there was a positive correlation between the relative water content of the leaf and the proportional growth value as a result of the low level of drought stress used in tomato genotypes, but there was a negative correlation in terms of lipid peroxidation (MDA), H_2O_2, phenolic content, and proline content [22].

After the experiment was completed, the fresh leaf weights of the plant were recorded from each application at the harvest time, they were kept in water for 4 hours, taking the turgor weight, and then dried in an oven at 65 ºC, and the dry weights were recorded by weighing. Average values of leaf dry matter amount (Table 3) given with statistical calculations. The effect of different applications on the wet and dry weight of the leaf was found to be significant. According to these measurement results, the highest relative leaf water content was reached at 75% irrigation (91.96%) levels. The lowest relative leaf water content value was determined at a salt 150 mM irrigation (76.84%) irrigation level. Leaf proportional water content average was measured as (83.75). These values are 25% irrigation (77.53%), 50% irrigation (77.79%), 125% irrigation (83.46), 200% irrigation (84.44%), salt 50 mM irrigation (78.08%), salt 150 mM irrigation (76.84%) doses of leaf proportional water content. found to be below average. relative leaf water content (%). Avcu et al. [23] the application was made on tomato plants with the addition of salt. As a result of the experiment, salt stress decreased the leaf stomatal conductivity and the relative leaf water content of the leaves in the plants compared to the control application. Abeer et al. [24], similar to our study, reported that 200 mM salt application significantly reduced the relative content of leaves compared to control plants.

Table 3. Average values of plant leaf area (cm^2) and relative leaf water content (%)

Different Stresses (%)	leaf area index (cm^2)	relative leaf water content
% 25 irrigation	72.33 f	77.53 ef
% 50 irrigation	76 e f	77.79 df
% 75 irrigation	81 d e	91.96 a
% 100 irrigation	116.33 a	83.78 cd
% 125 irrigation	121 a	83.46 ce
% 150 irrigation	108.33 b	91.36 ab
% 175 irrigation	91 c	90.59 ab
% 200 irrigation	82 d	84.44 c
Salt stress 50 mM	76.33 def	78.06 df
Salt stress 100 mM	73.33 f	85.45 bc
Salt stress 150 mM	58 g	76.84 f
Mean	80.21	83.75
LSD	5.68	6.12
P	<.0001	<.0001*

*There is no difference between the averages shown with the same letter in the same column.
* Significant at $p \leq 0.05$. ** Significant at $p \leq 0.01$

D.Effect of drought, salt and water stress (excessive water level) on potassium (K) accumulation in tomato plants

The difference between the averages in K studies, which is one of the plant nutrients in the green and root parts of the plants, was found to be statistically significant ($p<0.05$). While this rate was found to be (4.43%) at 25% irrigation level, where drought and water stress were the most severe in the plant's green parts, this rate was determined as (5.66%) at 100% irrigation level. While this rate at 25% irrigation level, where drought and water stress are most severe in plant root parts, was determined as (0.77%), this rate was determined as (2.38%) at 100% irrigation level (Table 4). According to the results obtained in the study on potassium (K), the highest rate of salt mM 150 was found to be (7.51%) in the tomato plant exposed to salt stress in the green parts of the plant. The closest ratio to this was determined at (6.71 %) at the salt 100 irrigation (control) irrigation level and remained above the average and took place in the same group (Table 4). Ullah et al. [25] reported that water stress, which is the most important factor in plant growth, weakens root movement in plants and adversely affects water and nutrients taken from the soil. Ali and Rab reported that drought stress reduces K concentrations in tomatoes under drought and salinity conditions [26].

In the studies of Ca, one of the plant nutrients in the green and root parts of the plants, the difference between the averages was found to be statistically significant (P<0.05). While this rate was (1.04%) at 25% irrigation level, where drought and water stress were most severe in plant's green parts, this rate was (2.38) at 100% irrigation level. While this rate was determined as (0.63%) at 25% irrigation level, where drought and water stress were the most severe in plant root parts, this rate was determined as (0.96%) at 100% irrigation level. It has been identified (Table 4). While calcium (Ca) was the most abundant in plant green parts (2.38%), this rate was found at 100% (control) irrigation level (2.38%) (Table 4). Considering the Ca results in the root parts of the plants, the highest rate (0.96%) was reached, while this rate was stated as (0.96%) at 100% (control) irrigation level (Table 4). In the studies of Günes et al. [27] on chickpea plants, it was reported that N, K, P, and Ca minerals accumulate more in the tissues of drought-sensitive plants during drought stress applications and that growth inhibition gradually decreases. Aktaş [28], Daşgan et al. [29] in their study, it was stated that plants showed different defense and sensitivity levels in K, Ca, and Na ion contents under drought conditions.

Table 4. Average values of potassium (K), calcium (Ca) ratio (%) in green and root parts of tomato plant

Different stresses (%)	Amount of potassium in the leaf	Amount of potassium in the root	Amount of calcium in the leaf	Amount of calcium in the root
% 25 irrigation	4.43 de	0.77 cde	1.04 e	0.63 dg
% 50 irrigation	3.56 g	0.61 f	0.88 ef	0.55 fg
% 75 irrigation	3.38 g	0.65 ef	0.74 f	0.51 g
% 100 irrigation	5.66 c	2.38 a	2.38 a	0.96 a
% 125 irrigation	4.74 d	1.07 b	2.22 a	0.88 ab
% 150 irrigation	4.45 de	1.11 b	1.93 b	0.70 cf
% 175 irrigation	4.13 ef	0.81 cd	1.69 c	0.73 be
% 200 irrigation	3.60 fg	0.79 cde	1.37 d	0.60 eg
Salt stress 50 mM	6.32 b	0.74 def	1.35 d	0.74 be
Salt stress 100 mM	6.71 b	0.89 c	1.39 d	0.76 bd
Salt stress 150 mM	7.51 a	0.89 c	1.40 d	0.83 ac
Mean	4.95	0.97	1.49	0.71
LSD	0.53	0.14	0.16	0.15
P	<.0001	<.0001	<.0001	0.0002

*There is no difference between the averages shown with the same letter in the same column.
* Significant at p≤0.05. ** Significant at p≤0.01

IV. CONCLUSION

Drought stress, salt stress, and water stress (excessive water level) caused a decrease in both the green parts and the mineral nutrient contents of potassium and calcium examined in the leaves of the tomato genotype. In the root region, it was determined that potassium and calcium increased in the green parts and root region due to salt accumulation. Among the stresses applied in general, drought stress, salt stress, and water stress (excess water level) are among the most effective stress levels, water stress (excess water level) is 125% irrigation, drought stress is 75% irrigation, and salt stress is more positive in 50 mM applications.

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KAYNAKLAR

[1] Sönmez, K., & Ellialtıoğlu, Ş. Ş. (2014). Domates, karotenoidler ve bunları etkileyen faktörler üzerine bir inceleme. *Derim*, 31(2),107-130.

[2] Ertürk, Y.E., & Çirka, M. (2015). Türkiye’de ve Kuzey Doğu Anadolu Bölgesi (KDAB)’nde Domates Üretimi ve Pazarlaması. *Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi,* 25(1), 84-97.

[3] FAO, (2020). https://www.google.com/search?q=fao+stat+2020&oq=fao+stat+2020&aqs=chrome.69i57j0i13i512j0i22i30l6j0i22i30i625.6702j0j15&sourceid=chrome&ie=UTF-8http://www.fao.org/faostat/en/#data/QC

[4] Fahad, S., Bajwa, A. A., Nazir, U., Anjum, S. A., Farooq, A., Zohaib, A., Sadia, S., Nasim, W., Adkins, S., Saud, S., Ihsan, M. Z., Alharby, H., Wu, C., Wang, D., & Huang, J. (2017). Crop production under drought and heat stress: plant responses and management options. *Frontiers in Plant Science*, 8, 1147. doi:10.3389/fpls.2017.01147.

[5] Ghahremani, Z., Mikaealzadeh, M., Barzegar, T., & Ranjbar, M. E. (2021). Foliar application of ascorbic acid and gamma aminobutyric acid can improve important properties of deficit irrigated cucumber plants (*Cucumis sativus cv. Us*). *Gesunde Pflanzen*, 73(1), 77-84.

[6] Kalaji, H. M., Jajoo, A., Oukarroum, A., Brestic, M., Zivcak, M., Samborska, I. A., Cetner, M. D., Łukasik, I., Goltsev, V., & Ladle, R. J. (2016). Chlorophyll a fluorescence as a toolto monitor physiological status of plants under abiotic stress conditions. *Acta Physiologiae Plantarum*; 38(4), 102.
[7] Nadali, F., Asghari, H. R., Abbasdokht, H., Dorostkar, V.,& Bagheri, M. (2021). Improved quinoa growth, physiological response, and yield by hydropriming under drought stress conditions. *Gesunde Pflanzen*, 73(1), 53-66.
[8] Liu, J., Hu, T., Feng, P., Wangand, L., & Yang, S. (2018).Tomato yield and water use efficiency change with various soil moisture and potassium levels during different growth stages. *PLoS ONE*, 14(3), e0213643. https://doi.org/ 10.1371/journal.pone.0213643.
[9] Christmann, A., Moes, D., Himmelbach, A., Yang, Y., Tang, Y., & Grill, E. (2006). Integration of abscisic acid signalling in to plant responses. *Plant Biology*, 8, 314– 325.
[10] Ahmadi, A., Emam, Y., & Pessaraklı, M. (2009). Response of various cultivars of wheat and maize to salinity stress. *Journal of Food, Agriculture Environment*, 7, 123-128.
[11] Bonilla, P., Dvořák, J., Mackill, D., Deal, K., & Gregorio, G. (2002). RFLP and SSLP mapping of salinity tolerance genes in chromosome 1 of rice (*Oryzasativa L.*) using recombinant in bredlines. *Philippine Agricultural Scientist*, 85, 68–76.
[12] Munns, R. (2002). Comparative physiology of salt and water stress. *Plant, Cell and Environment*, 25, 239–250. https://doi.org/10.1046/j.0016-8025.2001.00808.x.
[13] Birgin Ö., Akhoundnejad Y., & Dasgan H. Y. (2021). The effect of foliar calcium application in tomato (*Solanum lycopersicum* l.) under drought stress in greenhouse conditions. *Applied Ecology and Environmental Research*, 19 (4), 2971–2982. doi: 10.15666/aeer/1904_29712982.
[14] Jones, J.B. (2001). Laboratory guide for conducting soil tests and plant analysis. *CRC Press*. pp, 384.
[15] Ahmed, H. G. M., Zeng, Y., Yang, X., Anwaar, H. A., Mansha, M. Z., Hanif, C. M. S., İkram, K., Ullah, A., & Alghanem, S.M.S. (2020). Conferring drought-tolerant wheat genotypes through morpho-physiological and chlorophyll indices at seedling stage. *Saudi Journal of Biological Sciences*, 27(8), 2116-2123. https://doi.org/10.1016/j.sjbs.2020.06.019.
[16] Arslan, Ö. (2018). Su kıtlığına maruz bırakılmış C3 ve C4 bitkilerinin fotosentetik aktivitelerinin belirlenmesi. *Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi,* 8(4), 47-54.
[17] Kıran, S., Özkay, F., Kuşvuran, Ş., & Ellialtıoğlu, Ş. Ş. (2014). Tuz stresine tolerans seviyesi farklı domates genotiplerinin kuraklık stresi koşullarında bazı özelliklerinde meydana gelen değişimler. *Journal of Agricultural Faculty of Gaziosmanpasa University*, 31(3),41-48
[18] Yıldırım, E. D., & Güneş, H. (2021). Tuz ve kuraklık stresi altında yetiştirilen buğday bitkisine (triticum aestivum l.) silikon uygulamalarının bazı stres parametreleri üzerine etkisi. *Journal of the Institute of Science and Technology*, 11(4), 2559-2572. DOI: 10.21597/jist.915426.
[19] Zhou, R., Yu, X., Ottosen, C., Rosenqvist, E., Zhao, L., Wang, Y., Yu, W., Zhao, T., & Wu, Z. (2017). Drought stress had a pre dominant effect over heat stress on three tomato cultivars subjected to combined stress. *BMC Plant Biology*, 17, 24.
[20] Steiner, F., Zuffo, A. M., da Silva Oliveira, C. E., Ardon, H. J. V., de Oliveira Sousa, T., & Aguilera, J. G. (2022). Can potassium fertilization alleviate the adverse effects of drought stress on soybean plants?. *Revista em Agronegócio e Meio Ambiente*, 15(1), 1-17. DOI:10.17765/2176-9168.2022v15n1e8240.
[21] Daşgan, H. Y., Bayram, M., Kuşvuran, Ş., Çoban, G. A., & Akhoundnejad, Y. (2018). Screening of Tomatoes for Their Resistance to Salinity and Drought Stress. *Journal of Biology, Agriculture and Healthcare*, 8(24), 2018.
[22] Sanchez-Rodriguez, E., Rubio-Wilhelmi, M., Cervilla, L. M., Blasco, B., Rios, J. J., Rosales, M. A., & Ruiz, J. M. (2010). Genotypic differences in some physiological parameters symptomatic for oxidative stress under moderate drought in tomato plants. *Plant Science*, 178, 30-40. doi:10.1016/j.plantsci.2009.10.001.
[23] Avcu, S., Akhoundnejad, Y., & Daşgan, H. Y. (2013). Domateste tuz stresi üzerine selenyum ve silikon uygulamalarının etkileri. *Tarım Bilimleri Araştırma Dergisi*, 6(1), 183-188. ISSN: 1308-3945, E-ISSN: 1308-027X.
[24] Abeer, H., Abd-Allah, E. F., Alqarawi, A. A., & Egamberdieva, D. (2015). Induction of salt stress tolerance in cowpea (*Vigna unguiculata L.*) Walp.] by arbuscular mycorrhizal fungi. *Legume Research*, 38(5), 579 - 588. Print ISSN:0250-5371 / Online ISSN:0976-0571.
[25] Ullah, H., Santiago-Arenos, R., Ferdous, Z., Attia, A., & Datta, A. (2019). Chapter Two – Improving water use efficiency, nitrogen use efficiency, and radiation use efficiency in field crops under drought stress: A review. *Advances in Agronomy,* (156), 109-157. https://doi.org/10.1016/bs.agron.2019.02.002.
[26] Ali, S. G., & Rab, A. (2017). The Influence of salinity and drought stress on sodium, potassium and proline content of *Solanum Lycopersicum L*. Cv. Rıo Grande. *Pakistan Journal of Botany*, 49(1), 1-9.
[27] Günes, A., Çiçek, N., İnal, A., Alpaslan, M., Eraslan, F., Güneri, E., & Güzelordu, T. (2006). Genotypic response of chickpea (*Cicer arietinum L.*) cultivars to drought stress implemented at pre-and post-anthesisstages and its relations with nutrient. *Plant Soil Environonment*, 52(8), 368- 376.

[28] Aktaş, H. (2002). *Biberde Tuza Dayanıklılığın Fizyolojik Karakterizasyonu ve Kalıtımı.* (Doktora tezi). *Çukurova Üniversitesi Fen Bilimleri Enstitüsü,* Adana.

[29] Daşgan, H. Y., Aktaş, H., & Abak, K. (2007). Tuzgölü Çevresinden Toplanan Bazı Kavun Genotiplerin In Tuzluluğa Tolerans Düzeylerinin Erken Bitki Gelişme Aşamasında Incelenmesi. *VI. Sebze Tarımı Sempozyumu Bildirileri*, 19-22 Eylül 2006, 408-413, Kahramanmaraş.