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Effect of Water Stress at Fruit Maturity Stage on Production and Skin Separation Phenomenon of Date Palm cv. Medjool

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Abstract:

Water scarcity and skin separation of the fruits are two major problems in most date palm growing regions in the world. This study aims to evaluate the effect of water stress on date palm productivity and the phenomenon of skin separation in date fruits during the years of 2018 and 2019. The experiment consists of six treatments (S_1: 0% water stress as a control, S_2: 10% water stress, S_3: 20% water stress, S_4: 30% water stress, S_5: 40% water stress, S_6: 50% water stress).The highest significant fruit yield (kg/tree) was recorded in the treatments S_1, S_2 and S_3 during the year of 2018 and S_1 and S_2 during the year of 2019. The lowest significant Balah fruit percentage was recorded in the treatments S_3, S_4, S_5 and S_6 during the year of 2018 and S_2, S_3, S_4, S_5 and S_6 during the year of 2019. No

significant differences between the treatments were recorded in fruit weight (g), percentage of fruit with and without stalk and skin separation of the fruits, except for the year of 2018 which recorded a significantly lower percentage of skin separation with the treatments S_2, S_3, S_4, S_5 and S_6. It can be concluded from this study that water stress at the fruit ripening stage had a limited effect on the yield of the tree (kg/tree), stimulated the ripening of the fruits, and had a minor effect on the skin separation of the date fruits.

Key words: Date palm, *Phoenix dactylifera*, Medjool, water stress, skin separation.

تأثيرالإجهاد المائي في مرحلة نضج الثمارعلى إلإنتاج وظاهرة فصل جلد الثمار في نخيل التمر صنف مجول

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الملخص

تعد ندرة المياه وظاهرة فصل جلد ثمار التمر مشكلتين رئيستين في معظم مناطق زراعة نخيل التمر في العالم. تم القيام بهذه الدراسة لتقييم تأثير الإجهاد المائي على إنتاجية نخيل التمر وظاهرة فصل جلد ثمار التمر خلال عامي 2018 و2019. تألفت التجربة من ست معاملات (S_1: 0٪ إجهاد مائي معاملة الشاهد، S_2: 10٪ إجهاد مائي، S_3: 20٪ إجهاد مائي، S_4: 30٪ إجهاد مائي، S_5: 40٪ إجهاد مائي، S_6: 50٪ إجهاد مائي).

تم تسجيل أعلى إنتاجية (كغم/ شجرة) في المعاملات S_1 و S_2 و S_3 خلال عام 2018 و S_1 و S_2 خلال عام 2019. وسجلت أقل نسبة مئوية من ثمار البلح في المعاملات S_3 و S_4 و S_5 و S_6 خلال عام 2018 وS_2 و S_3 و S_4 و S_5 و S_6 خلال عام 2019. لم تسجل فروق ذات دلالة إحصائية بين المعاملات في وزن الثمرة (غرام)، النسبة المئوية للثمار مع أو بدون حامل ثمري وفصل الجلد عن الثمار، باستثناء عام 2018حيث سجلت وبفارق معنوي أقل نسبة لفصل الجلد عن الثمار في المعاملات S_2 و S_3 و S_4 و S_5 و S_6. يمكن الاستنتاج من هذه الدراسة أن الإجهاد المائي في مرحلة نضج الثمار أدى الى تأثير محدود على إنتاجية الشجرة (كغم/ شجرة)، والى تحفيز نضج واستواء الثمار، إضافة الى تأثير ثانوي على فصل جلد ثمار التمر.

الكلمات المفتاحية: نخيل التمر، *Phoenix dactylifera*، مجول، الإجهاد المائي، فصل الجلد عن الثمار

INTRODUCTION

Water scarcity is a major limiting factor in modern date palm cultivation in Jericho and Jordan valley (Abu-Qaoud, 2015) and the gap between irrigation supply and demand is increasing from year to year (Ali, 2013).Therefore, availability of good quality water resources for irrigation is considered as the main challenge facing date palm development and sustainability (Abu-Jaish, 2018). Further, the limited water resources force the researchers and scientists to maximize date palm productivity and to improve fruit quality by reducing its irrigation water consumption (Abderrahman and Al-Nabulsi, 2001). Improving fruit quality of date palm by water stress can be considered to be one of the most important benefits of water stress (Al-Yahyai and Al-Kharusi, 2012).Thus, proper irrigation of date palm should follow their actual water demands and allow sufficient quantity of water at the critical periods (Kassem, 2007). However, the response to water stress depends upon the stage of fruit growth, intensity, rate, and duration of exposure (Osakabe et al., 2014). Reducing water supply of date palm to 50% produced a similar yield with high quality; however, water requirement varied according to climate, tree age and location (Mohebi, 2005). Application of 133, 164, 182 and 199 m^3 per tree per season produced 33.5, 36.0, 37.8 and 42.5 kg per date palm tree respectively (Mazahrih et al., 2012).

Ismail et al. (2014) suggested that supplying 34 m^3 yr^1 per tree for date palms grown under the conditions of the western part of Saudi Arabia is enough to maximize irrigation water use (IWU), yield and quality of the ’Nabbut-Saif’ date palm cultivar.

Skin separation or loose skin (aka puffy skin and blistering) is considered one of the most important physiological disorders that reduce the fruit quality of Medjool date palm (Cohen and Glanser, 2015). In this phenomenon, the skin of the date fruit becomes loose, dry, hard, brittle, and is separated from the flesh parts (Kader and Hussein, 2009). This phenomenon develops during fruit ripening and drying of soft date cultivars, which vary in susceptibility (Lobo et al., 2013). Skin separation is caused partly by high diurnal, cyclic stresses of turgor pressure fluctuations before the ripening stage of the fruit and is affected by high humidity at the pre-ripening stage. Skin separation is also associated with anatomical (skin elasticity) and physiological (fruit turgor) properties of the fruits (Gophen, 2014).

Skin separation of ripped date fruits is considered an unpleasant property as it significantly diminishes their market value and causes financial loss to the growers (Lustig et al., 2014). Several approaches have been suggested for reducing skin separation, such as reducing the differences of the vapor pressures of the fruit skin and the environment, increasing the air flow around the fruit, altering the mechanical properties of the fruit skin or restricting the water flow from the tree to the fruits (Lustig et al., 2014). Irrigation regime, irrigation timing and mineral fertilization are also suggested as possible treatments to reduce this phenomenon (Al-Hajjaj and Ayad, 2018; Al-Hajjaj et al., 2020).

Because of climate change and water scarcity, irrigation problem is becoming a more and more limiting factor in most date-growing regions, including Palestine. Consequently, it is necessary to develop new technologies for sustainable usage of limited water resources throughout optimizing water use efficiency during specific or critical periods without

crop yield reduction, thus, matching irrigation to actual date palm water requirements as much as possible (Khan and Prathapar, 2012; Nikolaou et al., 2020). Therefore, in the present study, it is hypothesized that water stress at maturity stage may decrease the skin separation in Medjool date palm fruits. In addition, this study aims to improve fruit quality by water stress without affecting the production of date palm.

MATERIALS AND METHODS

This study was carried out at Nakheel Palestine Farm in Jericho-Palestine over the years of 2018 and 2019. Located at 31°52′16″N latitude and 35°26′39″E longitude, the farm, or the site of the experiment, is situated in an elevated plain at an altitude of 360 meters below the sea level, an area with an average annual rainfall of 166 mm (PMD, 2020). The climatic conditions at the site are characterized by very hot dry summers and warm winters, while the soil is characterized by having silt texture with high pH and high salts content (Dudeen et al., 2001). The experiment was conducted on six-year-old Medjool date palm trees, spaced at 8×9 meter grown under drip irrigation system.

The experimental design was randomized complete block design (RCBD). The blocks of experimental units were uniform as much as possible. The number of replicates was five and each replicate was randomized separately. The experimental unit or plot size was one date palm tree. Trees were selected for their uniformity in vigor and size and were subjected to the same usual horticultural practices. There were six treatments of water stress, each of which was adjusted by controlling the number of drippers per tree (one dripper discharge 8 L/h): S_1: 0% water stress as a control 10 drippers/tree, S_2: 10% water stress 9 drippers/tree,

S_3: 20% water stress 8 drippers/tree, S_4: 30% water stress 7 drippers/tree, S_5: 40% water stress 6 drippers/tree, S_6: 50% water stress 5 drippers/tree.

During maturity, ripening, and drying stages of the fruits, the trees were subjected to water stress treatments for three months: July, August, and September in the two seasons of 2018 and 2019. Table (1) shows normal irrigation schedule during the two seasons of 2018 and 2019.

Table 1: Normal irrigation (m^3 of water/tree of date palm cv. Medjool) schedule without water stress during the two seasons of 2018 and 2019

Season	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
2018	3.6	4.4	8.6	11.6	12.1	12.1	9.0	6.8	5.4	7.2	6.3	3.9	**90.9**
2019	4.0	5.0	9.5	12.5	13.0	13.0	10.0	7.5	6.0	8.0	7.0	4.5	**100.0**

At harvest time, the yield (kg/tree) was weighed, and the average fruit weight (g) was measured by collecting 25 fruits randomly from each tree. The value obtained for the 25 fruits was divided by 25 to obtain the average fruit weight in gram. Balah fruits (%) referring to the yellow fruits (khalal stage) were computed by weighing the yellow fruits on the tree to the total weight (yield /tree) and expressed in percentage. Fruits with stalk were those with calyx or cap and fruits without stalk were those with detached calyx or cap. Fruits with stalk (%) were computed by weighing the fruit with stalk on the tree to the total weight (yield /tree) and expressed in percentage, whereas fruits without stalk (%) were computed by weighing the fruit without stalk on the tree to the total weight (yield /tree) and expressed in percentage. Skin separation (loose skin) refers to air content between skin and the fleshy parts of the fruit. It was categorized from 0-5%, 6-30% and >30% according to air content in the fruit. Air content (%) in the fruits was computed by weighing the fruit for

each category (0-5%, 6-30% and >30%) on the tree to the total weight (yield/tree) and expressed in percentage.

All the data were statistically analyzed and the significant difference of the treatment means was separated according to LSD test at 5% level (SAS software, 1990).

RESULTS

The results for the first (2018) and second (2019) seasons are presented in Tables 2, 3 and 4. The highest significant fruit yield (kg/tree) was recorded in the treatments S_1, S_2 and S_3 during the season of 2018 and S_1 and S_2 during the season of 2019 (Table 2). No significant difference was recorded in the water stress treatments for fruit weight in both seasons as compared to the control (Table 2).

Table 2: Effect of water stress at fruit maturity stage on yield (kg/tree) and fruit weight (g) of date palm cv. Medjool, in 2018 and 2019

Treatment	Yield (kg/tree)		Fruit weight (g/fruit)	
	2018	**2019**	**2018**	**2019**
S_1 (control)	52.20 a*	60.11 a	19.15 a	25.69 a
S_2	50.40 a	58.82 ab	17.77 a	25.80 a
S_3	50.00 ab	56.26 bc	18.70 a	24.68 a
S_4	47.00 bc	55.10 c	17.26 a	24.16 a
S_5	46.40 c	54.54 c	18.73 a	25.41 a
S_6	45.80 c	54.04 c	18.32 a	24.39 a
LSD 0.05	**3.35**	**2.82**	**5.30**	**3.70**

*Means followed by similar letters in each column are not significantly different according to the Fisher LSD at $p \leq 0.05$.

The lowest significant Balah fruit percentage (the less % is the better) was recorded in the treatments S_3, S_4, S_5 and S_6 during the season of 2018 and S_2, S_3, S_4, S_5 and S_6 during the season of 2019 (Table 3). No significant differences were recorded in the treatments for the percentage of fruit with and without stalk and skin separation of the fruits, except for the season of

2018 which recorded the lowest significant skin separation with the treatments S_6 which was on par with the treatments S_2, S_3, S_4 and S_5 (Tables 3 and 4).

Table 3: Effect of water stress at fruit maturity stage on Balah fruits (%) and fruit with and without stalk(%) of date palm cv. Medjool, in 2018 and 2019

Treatment	Balah fruits (%)		Fruit with stalk (%)		Fruit without stalk (%)	
	2018	2019	2018	2019	2018	2019
S_1 (control)	5.50 a*	4.65 a	43.96 a	30.83 a	56.89 a	69.53 a
S_2	4.59 ab	3.06 ab	44.80 a	29.31 a	55.54 a	69.31 a
S_3	2.69 bc	3.05 ab	46.03 a	32.54 a	54.04 a	67.03 a
S_4	1.97 c	2.64 ab	47.02 a	36.23 a	52.98 a	64.70 a
S_5	1.54 c	1.30 b	46.88 a	34.25 a	53.57 a	66.63 a
S_6	1.62 c	1.79 b	47.74 a	35.49 a	52.66 a	64.42 a
LSD 0.05	**2.56**	**2.25**	**12.51**	**28.74**	**8.20**	**29.08**

*Means followed by similar letters in each column are not significantly different according to the Fisher LSD at $p \leq 0.05$.

Table 4: Effect of water stress at fruit maturity stage on air content (%) in fruit of date palm cv. Medjool, in 2018 and 2019

Treatment	Air content (%) in fruit					
	0-5 (%)		6-30 (%)		>30 (%)	
	2018	2019	2018	2019	2018	2019
S_1 (control)	49.18 b*	62.09 a	23.81 a	18.75 a	27.56 a	19.11 a
S_2	50.61 ab	61.43 a	23.69 a	21.39 a	25.92 a	17.27 a
S_3	50.56 ab	59.43 a	23.48 a	18.75 a	26.52 a	21.71 a
S_4	51.65 ab	64.70 a	23.25 a	19.23 a	25.24 a	16.29 a
S_5	52.65 ab	63.24 a	24.38 a	20.49 a	23.21 a	15.64 a
S_6	56.68 a	66.93 a	20.55 a	22.64 a	23.27 a	9.95 a
LSD 0.05	**7.36**	**22.49**	**4.26**	**12.10**	**7.60**	**12.34**

*Means followed by similar letters in each column are not significantly different according to the Fisher LSD at $p \leq 0.05$.

DISCUSSION

Date palm is known to survive and withstand harsh environment, especially under scarce water availability and extreme dry conditions (Elshibli et al., 2016). Most of date palm cultivars, including Medjool,

achieve an acceptable yield when grown under water stress (Alihouri and Torahi, 2013; Al-Qurashi et al., 2016). Furthermore, a fundamental goal of commercial growers in modern date palm cultivation is to produce a large crop of high quality fruit free from pesticide residues with the least amount of irrigation water (Ismail et al., 2014).

In the present study, the yield (kg/tree) was reduced by water stress (Table 2). Water deficit is one of the most environmental stresses affecting agricultural productivity around the world and may result in yield reduction. However, most research related to date palm's response to water availability has concentrated on the effects on yield performance and productivity (Khan and Prathapar, 2012).

In the present study, fruit weight was not affected significantly by water stress as compared to control (Table 2). This result could be explained by the fact that water stress during maturation stage may not affect cell division and cell enlargement. Beyond this stage, no dramatic changes in fruit weight could be expected (Alikhani-Koupaei et al., 2018). Similar results were observed by Gribaa et al., (2013) who reported no significant change in fresh weight of "Degletnour" fruits, but the water content of the pulp decreased dramatically by two different water irrigation regimes. Date palm fruits are smaller and have lower water content and higher soluble solids. Water stress had an effect on the fruit size and mass of date palm (Al-Yahyai and Al- Kharusi, 2012). The fruit water content was the highest in the Kimri and Khalal stages and fruits tended to lose moisture during the Rutab and Tamar stages. Moisture content did not differ between the irrigation treatments at the Tamar stage. During the harvestable stage of Rutab, water stress reduced dry weight while no

difference in dry matter was observed at the final harvest stage of Tamar (Al-Yahyai and Kharusi, 2012).

In this study, water stress reduces the percentage of Balah fruits (Table 3). This result may be attributed to the fact that water stress enhances the maturation and ripening process of the fruit, so the percentage of Balah fruits (yellow fruits or khalal fruits) decreased by water stress as compared to the control. In date palm, fruit ripening induces a decrease of water content and an increase of soluble sugar content (mostly glucose and fructose) as observed in other varieties (Gribaa et al., 2013). Date palm trees under water stress showed significantly high dry matter, total soluble solids (TSS) and pectin, whereas sucrose, tannin and pH were not significantly different between the irrigation treatments (Al-Yahyai and Kharusi, 2012).

There were no significant differences in the percentage of fruit with and without stalk (Table 3). It is well known that fruits with stalk are better than without stalk due to their good appearance and extended shelf life. In addition, such fruits cannot be easily penetrated by microbes as they have a comparatively low number of openings on the surface of the fruits.

The air content (skin separation) between the skin and the fleshy parts of the fruit was not significantly affected by water stress treatments, except for the year of 2018 which recorded the lowest significant skin separation (the less air content in fruit means the better fruit quality) with the treatments S_6 (50% water stress) which was on par with the treatments S_2, S_3, S_4 and S_5 (Table 4). One of the suggested explanation of the less air content in the fruits of category 0-5% in 2018 season may be due to 50% water stress treatment which resulted in a less moisture content in the soil

after irrigation. This situation provided indirectly less air humidity in the canopy of the tree and around the fruits, which may explain the reason for the lowest level of skin separation. Therefore, good agricultural practices management to remove excess air humidity from the field especially from around the fruit clusters may be effective in reducing skin separation in the fruits. Good ventilation and air circulation in the canopy of the tree and around the fruit clusters may be reached through proper planting distance (9*9 meters), pruning, fruit clusters thinning, and proper irrigation.

The mechanical properties of the fruit skin affect primarily the skin separation. As the phenomenon of skin separation occurs in the fruits of many date palm cultivars, it is extremely important in Medjool (Gophen, 2014). Fruits with skin separation are disqualified from export (Lustig et al., 2014) and their price is only one-half of those without skin separation (Cohen and Glanser, 2015). Thus, improving the quality of the fruits is extremely important, and the elimination of skin separation in 'Medjool' fruits is a significant concern for date producers and the economy of this variety (Kader and Hussein, 2009). Finally, we must confirm that early fruit ripening can reduce the skin separation phenomenon. Therefore, good management of date palm plantation by avoiding the practices that delay fruit ripening (excessive application of nitrogen and heavy irrigation) and following the practices which lead to early and faster fruit ripening (pollen grains) may be a useful approach to reduce skin separation in date palm fruits.

CONCLUSIONS

The present study attempts to decrease the skin separation in Medjool fruits by using different water stress treatments at the maturity stage, but

the results are not satisfactory. Therefore, a long-term thorough study to find highly effective and practical methods to overcome skin separation phenomenon is necessary, especially in Medjool fruits.

The results of this two-season experiment show that it is possible to conclude that

water stress at maturity stage has slightly decreased crop yield per tree, enhanced

maturation and ripening of the fruits, and a minor effect on skin separation.

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REFERENCES

Abderrahman, W.A., & Al-Nabulsi, Y. (2001). Irrigation water use of date palm. Paper presented at Fourth Date Palm Symposium: Alhassa, Saudi Arabia 5-8 May.

Abu-Jaish, A.A. (2018). Determinants of the expansion of palm growing within the natural resources (land, water) available for the development of the agricultural sector in the Jordan Valley region. M.Sc. Thesis in Sustainable Rural Development, Al-Quds University in Abu Dees, Jerusalem, Palestine.

Abu-Qaoud, H. (2015). Date palm status and perspective in Palestine. In J. M. Al-Khayri, S. M. Jain, and D. V. Johnson. *Date Palm Genetic Resources and Utilization*, eds.: Volume 2: Asia and Europe, (Springer Press), p.423-439.

Al-hajjaj, H.S., & Ayad, J.Y. (2018). Effect of foliar boron applications on yield and quality of Medjool date palm. *Journal of Applied Horticulture*, 20(3),181-188.

Al-Hajjaj, H.S., Ayad, J.Y., Othman, Y.A., & Abu-Rayyan, A. (2020). Foliar potassium application improves fruits yield and quality of 'Medjool' date palm. *Fresenius Environmental Bulletin,* 29(3), 1436–1442.

Alihouri, M., & Torahi, A. (2013). Effects of water stress on quantitative and qualitative fruit characteristics of date palm (*Phoenix dactylifera* L.). *Acta Horticulturae*, 975, 287-292.

Ali, E. (2013). Study on stability and vegetative growth of date palm in the different irrigation treatments. *Intl. J. Agri. Crop Sci.*, 5(3), 241-248.

Alikhani-Koupaei, M., Fatahi, R., Zamani, Z., & Salimi, S. (2018). Effects of deficit irrigation on some physiological traits, production and fruit quality of 'Mazafati'date palm and the fruit wilting and dropping disorder. *Agricultural Water Management*, 209, 219-227

Al-Qurashi, A.D., Ismail, S.M., & Awad, M.A. (2016). Effect of water regimes and palm coefficient on growth parameters, date yield and irrigation water use of tissue culture-regenerated 'Barhee' date palms grown in a newly established orchard. *Irrigation and Drainage*, 65, 491–501.

Al-Yahyai, R., & Al-Kharusi, L. (2012). Sub-optimal irrigation affects chemical quality attributes of dates during fruit development. *African Journal of Agricultural Research*, 7, 1498–1503.

Cohen, Y., & Glanser, B.A.B. (2015). Date palm status and perspective in Israel. In J.M. Al-Khayri, S.M. Jain and D.V. Johnson. *Date Palm Genetic Resources and Utilization*, eds.: Volume 2: Asia and Europe, (Springer Press), p.265-298.

Dudeen, B., Lacirignola, C., Montanarella, L., Steduto, P., & Zdruli, P. (2001). The soils of Palestine (The West Bank and Gaza Strip) current status and future perspectives. *Soil Resources of Southern and Eastern Mediterranean Countries*, 203-233.

Elshibli, S., Elshibli, M.E., & Korpelainen, H. (2016). Growth and photosynthetic CO_2 responses of date palm plants to water

availability. *Emirates Journal of Food and Agriculture*, 28(1), 58-65.

Gophen, M. (2014). Skin separation in date fruits. *International Journal of Plant Research*,4(1), 11-16.

Gribaa, A., Dardelle, F., Lehner, A., Rihouey, C., Burel, C., Ferchichi, A., Driouich, A., & Mollet, J. (2013). Effect of water deficit on the cell wall of the date palm (*Phoenix dactylifera* 'Degletnour', Arecales) fruit during development. *Plant Cell and Environment*, 36, 1056–1070.

Ismail, S.M., Al-Qurashi, A.D., & Awad, M.A. (2014). Optimizing of irrigation water use, yield and quality of Nabbutsaif date palm under dry land conditions. *Irrig. Drain.* 63, 29–37.

Kader, A.A., & Hussein, A.M. (2009). Harvesting and postharvest handling of dates, ICARDA, Aleppo, Syria, 15p

Kassem, M.A. (2007). Water requirements and crop coefficient of date palm trees "Sukariah CV". *Misr J. Ag. Eng.*, 24(2), 339-359.

Khan, M.M., & Prathapar, S.A. (2012).Water management in date palm groves. In A. Manickavasagan, M.M. Essa, and E. Sukumar. *Dates Production, Processing, Food, and Medicinal Values*, eds. (CRC Press), p.45-66.

Lobo, M.G, Yahia, E.M., & Kader, A.A. (2013). Biology and postharvest physiology of date fruit.InM. Siddiq, S.M. Aleid, and A.A. Kader. *Dates: Postharvest Science, Processing Technology and Health Benefits*, eds. (John Wiley & Sons, Ltd), p.57-80.

Lustig, I., Bernstein, Z., & Gophen, M. (2014). Skin separation in Majhul fruits. *International Journal of Plant Research*, 4(1), 29-35.

Mazahrih, N.T., AL-Zu'bi, Y., Ghnaim, H., Lababdeh, L., Ghananeem, M., & Abu-Ahmadeh H. (2012). Determination actual evapotranspiration and crop coefficients of date palm trees (*Phoenix dactylifera*) in the Jordan Valley. *American-Eurasian Journal of Agricultural and Environmental Sciences*, 12, 434–443.

Mohebi, A.H. (2005). Effects of water use in drip irrigation and surface irrigation methods on yield and vegetative characteristics on date palm. In Proceedings of the International Conference on Mango and Date Palm: Culture and Export, 20–23 June, University of Agriculture, Faisalabad, Pakistan.

Nikolaou, G., Neocleous, D., Christou, A., Kitta, E., & Katsoulas, N. (2020). Implementing sustainable irrigation in water-scarce regions under the impact of climate change. *Agronomy*, 10(8),1120.

Osakabe, Y., Osakabe, K., Shinozaki, K., & Tran. L.S. (2014). Response of plants to water stress. *Front Plant Sci*., 5, 86–94.

Palestinian Meteorological Department (2020). Climatic data for Jericho. https://www.pmd.ps/en

SAS Institute (1990). User's guide. Statistics. Ver. 6.4th ed. SAS Inst. Cary. N. C, 956.