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Article

Influence of Water Stress and Spraying With Eucalyptus Leaves Extract on Growth and Yield of Eggplant Solanum melongena L.

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Abstract: A field experiment was conducted at the Research Station of the Northern Technical University / Polytechnic college - Hawija during the spring season of 2024. The experiment was designed according to the randomized complete block design (RCBD). This study included two factors : the first factor was water stress at two levels (irrigation for 30 minutes W1, irrigation for 15 minutes W2) and the second factor was spraying with eucalyptus leaves extract at three levels (without spraying, spraying at a concentration of 1 ml L-1, spraying at a concentration of 2 ml L-1). planted the seeds of the eggplant variety Thuraya, in cork plates (209) a plate was designated and using a growing medium for seedlings from the Dabana Agricultural Company. It is considered which is a prolific variety and is used in open cultivation. Plant seeds were planted on the date 15 / 7 /2024 when it reached the appropriate stage for planting in greenhouses and then was transferred to the field on the date 8 /10 / 2024 . the show results that first level of irrigation (W1) It achieved significant differences in most of the studied parameters (Plant height , chlorophyll content and Total yield) and its rate were (67.08 cm , 63.76 and 7.51 ton ha-1) respectively , While the level of eucalyptus leaves extract (1 ml L-1) gave the highest rates for the above parameters compared the others levels and reached (67.00 cm , 69.52 and 8.65 ton ha-1) respectively.

Keywords: Water Stress , Eucalyptus extract, Eggplant , Irrigation Levels.

Introduction

Water scarcity is a critical issue in arid and semi-arid regions, given the role of water in plant life, its scarcity, and its insufficient availability to meet plant needs and growth, it has become necessary to pay attention to the mechanism of water stress and its effect on plants. Water stress is one of the most important environmental stresses affecting agricultural production in arid and semi-arid regions of the world. Losses due to drought stress are estimated at about 17% of agricultural production (Ashraf et al.2008). Water is considered one of the most important and necessary inputs in agricultural production, locally and globally, as agricultural systems appear to be the largest consumers of available water, as they deplete approximately 80% of the available water. Water scarcity is one of the environmental determinants of plant production. The loss in crop production resulting from water stress exceeds the loss resulting from all other environmental influences. Irrigation is one of the environmental factors that has priority in influencing the characteristics and quality of the crop through its impact on the stages of emergence, formation and growth of plant organs, in addition to its role in increasing the readiness and absorption of nutrients, cell growth and division, and the regularity of the photosynthesis process. It is also a solvent and a medium that transports these materials to the different parts of the plant (Alsahookie et al,2009). While water is the most determining environmental factor for the growth and production of crops in the arid and semi-arid regions of the world, including Iraq (Al-Muaini, 2004; Amer, 2004), losses resulting from drought stress amount to about 17% of agricultural production. This stress results in various other physiological effects, including decreased absorption and transport of water and nutrients, damage to cell membranes, decreased efficiency of photosynthesis, increased rates of respiration, enzymatic and hormonal imbalance, and increased production of reactive oxygen species (ROS), which negatively affects the growth and production of plants (Farouk et al, 2009). The results obtained (Ibrahim et al,2023) indicated that water-deficient plants experienced a decrease in plant fresh weight, plant height, leaf area, total yield, chlorophyll content, and relative water content.

Plant extracts are concentrated preparations, with a liquid, solid, or viscous consistency. they are generally obtained by maceration (extraction until equilibrium with water or alcohol) or filtration (extraction until depletion of water or alcohol). Eucalyptus leave oil has been used in pharmaceutical and medicinal preparations, as well as as an ornamental plant and windbreak(Chakravarty,1976). Explain the study conducted by (Gleadow and Woodrow ,2002) Eucalyptus plant contains a large amount of toxicity inside it. because of the concentration of toxic glycosides, this toxicity increases as the plant grows, especially in hot weather compared to areas with abundant rainfall. The inhibitory effects of some plants on other plants by giving off substances with a clearly known chemical toxicity are called "allelopathy" (Djanaguiraman et al , 2005). In studies conducted by (Gliessman,2007), it was found that eucalyptus species have allelopathic activity among the strong plants that were examined. research also indicated that a large area of the soil surface planted with eucalyptus trees remains bare and the growth of lower plants is restricted to it (El-Darier,2002). they found (Dejam et al,2014) that the higher concentration of eucalyptus leaf extract lead to the lower the germination percentage, germination rate (number per day), root length (mm), shoot height (mm), fresh seed weight (mg), and dry seed weight (mg) of eggplant.

Eggplant is an economically important vegetable crop in Iraq belonging to the (Solanaceae) family. The nutritional importance of eggplant lies in the fact that its fruits contain carbohydrates, calcium salts, phosphorus, iron, and a little amounts of vitamins (A,B,C) (Hameed et al,2015). It grows in fertile soils and is well known for its drought tolerance, but the quality and quantity of the plant suffers from severe water shortage. Eggplant production in Iraq in 2012 was estimated at 3,422 thousand tons.(Iraqi Ministry of Planning,2013). Therefore this research aims to know the role of water stress and spraying with eucalyptus leaf extract levels on the growth and yield of eggplant..

Materials and Methods

Preparation of eucalyptus plant leaves extract : Fresh eucalyptus leaf samples were collected from the the university field during 2021-2022. The samples were air-dried in the shade and then

ground using an electric grinder (morter), the powder was stored in clean plastic bags at room temperature until use, to prepare the extracts solvent (methanol) the solvent was used at a concentration of 70 % methanol (Lubbad et al, 2015) and in the ratio of (1:5) weight /volume (W/V) from leave powder ,it means that 1 gram of ground sample is expressed in 5 milliliters of the prepared solven, was shaken for (2-5) hours, leave for an hours and then kept at 4°C for 2 hours. The prepared extract mixture was filtered using type (Whatman No.1) filter paper, and the extract was dried using a rotary evaporator model RV. different concentrations of the prepared extract in(0 , 1, 2) g L^{-1}.

Field experiment : The field experiment was carried out at the research station of the College of Agriculture, University of Northern Technical University /Technical Institute --Hawija during the spring season of 2024, to study the effect of water stress and spraying with eucalyptus leaf extract on the growth and yield of eggplant. A factorial experiment was conducted according to a randomized completely block design (RCBD) with a split-plot system and three replicates, the experiment included two factors: the first factor is two levels of water stress (irrigation for 30 minutes, symbolized by the symbol W1, irrigation for 15 minutes, symbolized by the symbol W2) and irrigation equivalent for (72 , 36) liter per day respectively, the second factor is spraying with eucalyptus leaves extract at three levels (the first without spraying S0", spraying at a concentration of 1 ml L^{-1} S1", spraying at a concentration of 2 ml L^{-1} S2").The greenhouse soil was prepared and some physical and chemical properties were analyzed before the experiment was carried out (table 1). the irrigation method used in the experiment is the drip irrigation system. and its type T-Tape, the treatments were distributed in six lines (three for each terrace), with a lock installed to close the water source at the beginning of each line in order to control the irrigation time. The distance between emitter and another was 0.4 m, and between line and another was 0.75 m, the area of the experimental unit was 1.2 m^2. The drip irrigation system was evaluated before starting the planting process, as water was collected in volumetric containers over a period of 15 minutes in order to calculate the emitters discharge rate, the percentage of variation between the emmiters and the homogeneity coefficient, The homogeneity coefficient for the drip irrigation system was 85%. Eggplant seeds were planted the Thraya variety, which is a prolific variety and is used in open cultivation as well as in greenhouses in cork plates, using a culture medium for growing seedlings, which was bought from the Dabana Agricultural Company on the date 15/7/2024, when they reached the appropriate age in the greenhouses in 8/10/2024, they were then transferred to the field, the distance between one seedling and another is 0.4 cm, and the number of plants in one experimental unit was 15 plants. the balanced chemical fertilizer 20-20-20 NPK of German origin was added and according to the fertilizer doses recommended by (Khaleghi et al,2021) for the eggplant crop was calculated. It was divided into five doses: the first dose a month after planting, and the period between dose and the befor it dose was two weeks, until the fifth dose, and all of them were added with irrigation water. Crop management including: irrigation, fertilization, and weeding, were carried out throughout the experimental season, according to the plant's requirements. The experiment was irrigated when the depletion rate was 50% of the field capacity. A meter was installed to calculate the water quantities at the beginning of the experiment, and the water quantities were calculated for each level separately.

Statistical analysis : Analysis of variance was used to assess significance, and statistical comparisons between groups were performed using Duncan's test a statistical program (SAS).

Studied characteristics

1. **Plant height (cm)** : Measured from the zone where the plant attaches the soil to the highest point of the plant with a tape measure.
2. **Chlorophyll content** : Chlorophyll was measured by Spad –meter 502 plus from Konica Minolta a Japanese company.
3. **Proline content (mg g^{-1}):** Proline was determined in fresh flag leaf according to the method described by (Bates et al ,1973).
4. **Relative water content (RWC)** : Measured by taking a leave from the plant and calculating its fresh weight, It was placed in a container containing water for 24 hours, It was taken out and dried using a piece of cloth its saturated weight was calculated , and then it was placed in an electric oven at 65 °C for 24 hours, Its dry weight was recorded while the

relative water content was calculated according to (Turner,1981) using the following equation :

(RWC) % = [fresh weight − dry weight / turgid weight − dry weight] × 100

1. **Plasma membrane permeability :** determined by recording of electrolyte leakage (EL) as described by (Valentovic et al, 2006) with a few modifications. Plant material (0.5 g) washed with deionized water was placed in tubes with 20 ml of deionized water and incubated for 24 h at 25°C. Subsequently, the electrical conductivity of the solution (L1) was measured. Samples were then autoclaved at 120 °C for 20 min and the final conductivity (L2) was measured after equilibration at 25°C. The EL was defined as follows

EL (%) = (L1 / L2) × 100

2. **Total yield (ton ha^{-1})** : Calculated by multiplying the yield of one the plant by the number of plants in the greenhouse.

Table 1. Some Physical and chemical characteristics of field soil before planting

No.	Characteristics	Value		Unit
1	Soil particles	Sand	319.35	g kg^{-1}
		Silt	480.15	
		Clay	200.50	
2	Soil texture	Loam		
3	pH	7.25		———
4	EC	7.9		ds m^{-1}
5	Bulk density	1.36		M gm m^{-3}
6	Soil Field Capacity	25		%
7	Calcium Carbonate	230.1		g Kg^{-1}
8	Available N	52.23		mg Kg^{-1}
9	Available P	6.80		
10	Available K	135.15		

) Estimated according to the methods mentioned in (Page et al., 1982) and (Black, 1965

Plant height (cm): The data in Table 2 indicate the effect of water stress and spraying with eucalyptus leaf extract on plant height (cm), the results showed that were significant differences between the treatments. The full irrigation treatment (W1) gave the highest rate of plant height, which reached (62.172) cm, compared to the W2 treatment, which had a plant height rate of (47.808) cm . These results are consistent with was indicated by (Li et al ,2024) It was shown that water stress increased led to a significant decrease in plant height. As for the effect of spraying with eucalyptus leaf extract, spraying with 1 ml L^{-1} achieved the highest increase in plant height rate reaching (70.866) cm compared to spraying with 2 ml L^{-1} and the comparison which reached values of (54.656) and (39.448) cm respectively. While The interaction treatment between irrigation for 30 minutes (W1) and spraying at the level of 1 ml L^{-1} recorded the highest rate of plant height, which reached (77.400) cm this difference in the rate of plant height is perhaps attributed to the fact that increasing irrigation levels may lead to an increase in the absorption of nutrients, the permeability of cell membranes, an increase in the efficiency of photosynthesis, and an increase in the rate of vegetative growth which is positively reflected in this trait compared to other irrigation treatments.

Table 2. Effect of water stress and spraying with eucalyptus leaf extract on plant height (cm)

Irrigation water level	Eucalyptus leaf extract level			Average
	S0	S1	S2	
W1	47.290 d	77.400 a	61.826 c	62.172 a
W2	31.606 e	64.333 b	47.486 d	47.808 b
Average	39.448 c	70.8667 a	54.656 b	

Chlorophyll content: The results shown in Table (3) indicate the effect of water stress and spraying with eucalyptus leaf extract on chlorophyll concentration, The results showed that reducing the irrigation period in treatment W2 compared to the full irrigation treatment W1 led to a significant decrease in the chlorophyll concentration in eggplant leaves. The data showed an increase in chlorophyll concentration as the irrigation period increased, the highest average was (62.172) for the W1 treatment, while the W2 treatment decreased to (47.808) as the irrigation period decreased, This is consistent with the result (AL_Kadem,2022). While the spraying with eucalyptus leaf extract was achieved by the 1 ml L^{-1} spraying treatment, which achieved the highest average chlorophyll concentration, reaching (70.866) compared to the control treatment and spraying at the 2 ml L^{-1} level, which reached (39.448 and 54.656) respectively, the reason for the decrease in chlorophyll content may be that allelic chemicals work to limit the functions of some enzymes by inhibiting them.. These values are consistent with founded (Hadi,2018) . The combination of irrigation for the longest period (W1) and spraying at the level of 1 ml L^{-1} gave the highest chlorophyll concentration of (73.463) The due for this decrease in chlorophyll content is attributed to the increased activity of enzymes responsible for chlorophyll decomposition and inhibition of protein synthesis and photosynthetic pigments, also spraying with a substance containing eucalyptus leaf extract reduced this effect resulting from water stress, as this substance helps to retain water molecules inside the plant.

Table 3. Effect of water stress and spraying with eucalyptus leaf extract on Chlorophyll

Irrigation water level	Eucalyptus leaf extract level			Average
	S0	S1	S2	
W1	46.1867 c	73.4633 a	56.1300 b	58.5933 a
W2	36.4333 e	55.6500 b	45.4733 d	45.8522 b
Average	41.3100 c	64.5567 a	50.8017 b	

Proline content : The values in table (4) show that reducing the irrigation period led to a significant increase in the proline rate in eggplant leaves, The rate increased from (1.947) mg g^{-1} in the irrigation treatment W1 to reached (2.928) mg g^{-1} for W2 treatment , This is consistent with the results of (Pirzad et al,2011). the results obtained show an increase in proline concentration with increasing intensity of water stress to which the plant is exposed as a result of new proline formation due to the conversion of glutamic acid into free proline under water stress conditions (Stewart and Boggess ,1978) or it may be attributed to the degridationand dissolution of proline rich protein (Diaz et al.2005). As for the effect of spraying with eucalyptus leaf extract, the 1 ml L^{-1} spraying treatment gave the lowest value in the proline rate, which amounted to (1.636) mg g^{-1}, compared to the control treatment and spraying at the level of 2 ml L^{-1}, which amounted to (2.855 and 2.823) mg g^{-1} respectively while the interaction treatment between irrigation for 30 minute (W1) and spraying at the level of 1 ml L^{-1} recorded the lowest proline rate which amounted to (1.065) mg g^{-1}

Table 4. Effect of water stress and spraying with eucalyptus leaf extract on proline content (mg g^{-1})

Irrigation water level	Eucalyptus leaf extract level			Average
	S0	S1	S2	
W1	2.134 d	1.065 e	2.643 c	1.947 b
W2	3.513 a	2.206 d	3.066 b	2.928 a
Average	2.823 a	1.636 b	2.8550 a	

Relative water content (%) : The results in table (5) indicate that reducing the irrigation time with irrigation water in treatment W2 compared to treatment W1 led to a significant decrease in the

relative water content in eggplant leaves and that the highest increase in the relative water content rate was in the treatment W2 which reached (64.532) % while in the treatment W1 it reached (76.991) % , Our results are in agreement with (Mohawesh, 2016). While As for the other experimental factor, which is the effect of spraying with eucalyptus leaf extract the 1 ml L^{-1} spray treatment achieved the highest significant difference in relative water content and reaching (79.201) % compared to the control treatment and the 2 ml L^{-1} spray which reached (61.458 and 71.625) % respectively, the higher the concentration of the extract, the lower the relative water content. This may be due to the fact that the extract had a greater inhibitory effect, which led to the dissolution of toxic chemical compounds within the plant this data is consistent with was found (Andualem et al,2024). The interaction treatment between irrigation for 30 minutes (W1) and spraying at the level of 1 ml L^{-1} gave the highest rate of relative water content reaching (84.536) %.

Table 5. Effect of water stress and spraying with eucalyptus leaf extract on Relative water content (RWC) %

Irrigation water level	Eucalyptus leaf extract level			Average
	S0	S1	S2	
W1	68.527 d	84.536 a	77.910 b	76.991 a
W2	54.390 f	73.867 c	65.341 e	64.532 b
Average	61.458 c	79.201 a	71.625 b	

Plasma membrane permeability: The results shown in table (6) show that reducing the irrigation period in the W2 treatment compared to the W1 full irrigation treatment led to a significant decrease in the permeation of the plasma membrane in eggplant leaves as the rate of decrease was from (30.848)% in the 30 minutes treatment to reach (52.257) % in the 15 minutes treatment, The reason behind this is that plant membranes are subject to continuous changes with increasing membrane permeability under environmental conditions (Blokhina et al, 2003). These results are consistent with was reached by (Quan et al, 2004), where they found that the highest percentage of plasma membrane permeability was under water stress conditions for maize plants. All the research conducted has shown that water stress leads to damage to plant membranes. While the effect of spraying with eucalyptus leaf extract spraying with 1 ml L^{-1} achieved the lowest value in plasma membrane permeation and reached (32.548)% compared to the control treatment and spraying at the level of 2 ml L^{-1}, which gave values (50.703 and 41.405) % respectively. While the treatment that combined irrigation for the longest period and spraying at a level of 1 ml L^{-1} (W1 x S1) recorded the lowest significant decrease rate of plasma membrane reaching (24.283) %.

Table 6. Effect of water stress and spraying with eucalyptus leaf extract on Plasma membrane permeability %

Irrigation water level	Eucalyptus leaf extract level			Average
	S0	S1	S2	
W1	38.013 d	24.283 f	30.251 e	30.848 b
W2	63.403 a	40.814 c	52.560 b	52.257 a
Average	50.703 a	32.548 c	41.405 b	

Total Yield (ton ha^{-1}): The results in the table (7) confirm that reducing the irrigation water levels in treatment W2 compared to the full irrigation treatment W1 led to a significant decrease in the total yield of eggplant plants Whereas the rate of this decrease in the total yield of the treatment W1 was (7.004) tons ha^{-1} while in the treatment W2 it was (4.471) t ha^{-1} this can be attributed to the fact that water stress caused by water shortages causes a decrease in fruit set as the soil water level decreases. This is also explained by the fact that low soil moisture can lead to desiccation of pollen and plant

stigma, as well as unnecessary elongation of the flower style, which can lead to a reduction of up to 50% in fruit set and final fruit yield,this result is consistent with its existence (Darko et al,2018). As for the effect of spraying with eucalyptus leaf extract, spraying with 1 ml L^{-1} achieved the highest significant value in the total yield amounting to (8.130) t per ha^{-1} compared to the control treatment and spraying at the level of 2 ml L^{-1} which amounted to (3.553 and 5.935) t per ha^{-1} respectively , The reason behind the low yield may be due to the fact that eucalyptus leaves contain a large amount of toxic substances due to the concentration of toxic glycosides, and this toxicity increases when the plant grows in hot climates than in areas with abundant rainfall (Gleadow and Woodrow, 2002). (Qasim ,1993) also confirmed the presence of some compounds that have a greater ability to dissolve in water, which leads to an increase in their concentration in water, and thus they act as a growth inhibitor. The reason for this may also be due to the fact that these extracts contain compounds that become highly toxic when used in high concentrations. Tannin compounds are at the forefront of these toxins, which inhibit the length of the root system, which is reflected in the overall yield, as these toxic substances bind to enzymes and reduce their effectiveness. They may also bind to enzymes involved in the intermediate reactions leading to auxin formation, which leads to its formation being obstructed or formed in very small quantities (Al-Jabouri, 2000). While he interaction treatment between full irrigation (W1) and spraying at a level of 1 ml L^{-1} of eucalyptus leaf extract gave the highest significant total yield rate of (9.986) t ha^{-1} compared to the other treatments.

Table 7. Effect of water stress and spraying with eucalyptus leaf extract on total yield (ton ha^{-1})

Irrigation water level	Eucalyptus leaf extract level			Average
	S0	S1	S2	
W1	4.0834 e	9.986 a	6.943 b	7.004 a
W2	3.023 f	6.273 c	4.926 d	4.741 b
Average	3.553 c	8.130 a	5.935 a	

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Conclusions

Th Based on the findings of this study, water stress significantly affected the growth, physiological traits, and yield of eggplant (Solanum melongena L.). Full irrigation (W1) consistently resulted in superior plant height, chlorophyll content, relative water content, and total yield, while reducing proline accumulation and plasma membrane permeability compared to the deficit irrigation treatment (W2). Spraying with eucalyptus leaf extract at a concentration of 1 ml L^{-1} (S1) positively enhanced growth and physiological performance, leading to the highest total yield, whereas higher concentration (2 ml L^{-1}) exhibited inhibitory effects likely due to allelopathic compounds. The interaction between full irrigation and 1 ml L^{-1} eucalyptus extract (W1 × S1) produced the most favorable results across most measured parameters. Therefore, moderate application of eucalyptus leaf extract combined with adequate irrigation can be recommended as an effective strategy to improve eggplant performance under field conditions, while excessive extract concentrations or severe water stress may negatively affect productivity.

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