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The Effect of Rice Straw Extract and drought Levels on Some Vegetative and Flowering Growth Traits and Some Physiological and Biochemical Indicators of Tomato (*Solanum esculentum* Mill)

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Abstract: This study was conducted during the 2024-2025 agricultural season in the Plant Physiology Laboratory in the Department of Life Sciences, College of Education for Pure Sciences, University of Basra. The purpose of this study was to evaluate the effectiveness of three concentrations of rice straw extract (control 0, 5 and 10 g L-1) in reducing the effect of four levels of field capacity (water stress or drought stress, control 100, 75, 50 and 25%). This study aimed to investigate the effect of these two factors and their interactions on vegetative, physiological, and floral growth traits, as well as biochemical indicators of the tomato plant (Salima cultivar). The results were an increase in plant height, number of leaves, and their total area, as well as an increase in water content, leaf content of chlorophyll, carbohydrates, and protein, leaf NPK content, and total number of flowers. Conversely, proline and ABA content and the number of days required for the appearance of the first flower decreased under a concentration of 10 g L-1, especially of the extract. The number of aborted flowers was not significantly affected. The exact opposite occurred under drought levels. The effect worsened with Increased drought, especially below 25%. In addition to the above, the number of aborted flowers increases with increasing drought. As for the interaction between the two activities, concentrations and levels, I tried to extract concentrations, especially 10 g/L-1, and succeeded, albeit slightly, in improving or reducing the negative effects of drought, especially at the 25% level.

Keywords: tomato, drought, rice straw, proline, ABA

Introduction

Tomato (Lycopersicon esculentum Mill.) belongs to the Solanaceae family. It is an important vegetable crop in all countries of the world, including Iraq. Global production is estimated at approximately 180 million tons. This makes it important for a healthy diet due to its content of compounds that play a functional role in the human body, such as minerals, vitamins, lycopene, and proteins (Tilesi et al., 2021). All living organisms, including plants, require adequate amounts of water for their growth. Water resources are declining in the Arab region and globally. The Arab region is considered arid and semi-arid. Water demand is increasing due to the growing demand for vegetable crop production. Therefore, water availability is a major obstacle to sustainable agricultural development worldwide (Masood &Shahadha, 2020). It is a major concern worldwide, as it affects plant growth and development. It poses a major threat to food security because it leads to significant losses in crop yield and quality. It is also a major abiotic stress occurring in almost every ecosystem. The frequency and severity of this stress vary from system to system, impacting crop production worldwide. Water scarcity is a multifaceted stress that affects plants at different developmental stages and restricts cellular, morphological, biochemical, physiological, and molecular activities. Plants have evolved mechanisms that encompass morphological, physiological, and molecular responses (Malik et al., 2021).

From this perspective, the need arose for the use of sustainable and environmentally friendly materials that help mitigate the impact of water scarcity on plant growth. One of the most important of these materials is the use of rice straw extract. This extract contains substances that can help reduce the impact of drought or water stress on tomato plants and improve their growth. This includes the use of different concentrations of rice straw extract and its effect on tomato growth and others. Rice straw (RS) is a by-product of the rice plant. It is extracted from the harvest of rice grains. It is one of the most important agricultural and industrial wastes for the world's most important food crops (Peanparkdeee et al., 2019). Rice straw contains approximately 35% cellulose, 20% lignin, 18% hemicellulose, and 15% ash (on a dry weight basis) (Freitaset et al., 2020). Rice straw differs from most crop residues in its high silicon dioxide (SiO_2) content. The ash content (on a dry weight basis) ranges between 13% and 20%. It varies depending on the state of the straw after harvest. Ash generally contains 75% SiO_2, 10% K_2O, 3% P_2O_5, 3% Fe_2O_3, 1.3% CaO, and smaller amounts of Mg, S, and Na (Kadam et al., 2000). These substances include silicon (an abundant element in rice straw, as mentioned earlier). It is the second most abundant element in the Earth's crust and is essential for plant drought tolerance. Silicon is a mineral that has beneficial effects on the growth and productivity of a variety of plant species under different environmental conditions. However, the benefits and importance of silicon for plants are highly controversial due to differences between species, genotypes, and environmental conditions. Although silicon has been widely documented as a potential mitigator of drought stress in both accumulating and non-accumulating plants, the underlying mechanisms by which silicon improves plant water status and maintains water balance remain unclear. The aquatic environment is still clear (Min et al., 2021; Waseem et al., 2025).

Materials and Methods

The experiment was conducted during the autumn season of the 2024-2025 agricultural season in 5 kg plastic pots (measuring 24 cm x 20 cm). These pots were filled with a mixture of 1 part peatmoss and 1 part sorghum soil inside the Plant Physiology Laboratory in the Biology Department, College of Education for Pure Sciences, University of Basra, Karma Ali Campus, Basra Governorate, Iraq. The pots were placed under controlled drought conditions and according to field capacity. Artificial lighting (with a sufficient number of lamps) and appropriate temperature and humidity were provided throughout the experiment. The sorghum, peat moss, and plastic pots were sterilized under sunlight. They were covered with transparent nylon for three days. The sorghum was sieved using a 2 mm sieve. Water and soil analyses were conducted in the laboratories of the Marine Science Center to determine the characteristics of the experimental soil, as shown in Table (1). Equal quantities of experimental soil were then placed in the pots, each weighing 5 kg. Animal manure treated with pathogens was added at a rate of 0.35 kg per pot, i.e. 350 g of animal manure per pot. The plants were arranged according to a completely random distribution on laboratory tables based on experimental factors, three concentrations of the extract, four levels of field capacity (water stress or drought), and three replicates, resulting in a total of 36 pots.

Table (1): Chemical and physical properties of the potting soil and irrigation water used in the experiment

Soil analysis before and after mixing with peat moss			
Unity	Value of soil mixture	The value of the soil	The attribute
Micro Siemens .cm-1	**1.289**	**0.694**	**EC**
	7.83	**7.90**	**pH**
%	**60**		Field capacity
Microgram.GM-1	**0.059**	**0.145**	**P**
Microgram.GM-1	**4000**	**1300**	**N**
Microgram.GM-1	**6.28**	**9.02**	**K**
Microgram.GM-1	**8.45**	**2.44**	Field capacity
Soil separators for sowing			
%	**2.7**	**Silt**	
%	**8.9**	**Clay**	
%	**88.4**	**Sand**	
Water analysis			
	0.83	**EC**	
	9.93	**pH**	

Tomato seedlings (Salima) were planted on 13/11/2024 in cork plates from one of the governorate's nurseries at the age of 1-2 true leaves, with three seedlings per pot. They were watered before transferring them to the pots, and a fungicide (Plantol) was added to the soil before planting to prevent fungal growth and damage to the roots. They were monitored until they adapted to the new soil environment in the pots within 17 days. Then, the conditions were prepared for the start of the experiment, and drought levels were adopted based on the field capacity. The levels were (100% control, 57%, 50%, and 25%), achieved by dehydrating them to these levels of drought. After that, spraying operations with the extract began from 2/12/2024 once every 10 days, and they were watered based on the four drought levels above.

Method for preparing the aqueous extract concentrations of rice straw used in the experiment and the number of sprays:

Air-dried Amber Jasmine rice straw was obtained from the Mishkhab region, famous for growing Amber rice, to prepare the aqueous extract. It was then cut and ground using an electric grinder to produce straw powder. The method of (Metraux et al., 2001) was adopted in preparing this extract by placing 5 and 10 g of straw powder in a container and adding 1000 ml of boiled distilled water. Then, it was placed in a shaking incubator for 48 hours. Then, it was filtered using sterile gauze. The resulting filtrate yielded two concentrations, 5 and 10 g. L-1 of the extract. The aqueous extract of rice straw was added at the fourth/fifth true leaf stage. The addition was repeated 4 times during the pre-flowering period and twice after flowering, with ten days between each application. The extract was added by spraying on the leaves of the treated plants until the first drop of the extract appeared, using a spreading agent. The control plants were sprayed with distilled water only.

Traits studied:

Vegetative growth traits:

1. **Plant height (cm):**

Measured with a tape measure from soil level to the highest growing tip of the stem for each plant. The average was then calculated for each treatment with three replicates, and the overall average was found.

2. **Number of leaves (leaf/plant-1):**

The total number of leaves for each plant was calculated separately during the flowering period, and the overall average for the three replicates was then calculated.

3. **Leaf area (cm2/plant-1):**

Leaf area was calculated by taking photographs of the leaves of four plants in each plot and analyzing them using Image J v.1.1. Then, the leaf area was calculated (Darwish et al., 2014).

4. **Dry weight of the vegetative system (g):**

The fresh weight of the vegetative system was measured in the laboratory using a sensitive balance. It was then dried in an electric oven at 60°C for 72 hours or until the weight stabilized. The dry weight was recorded.

5. **Leaf water content (%):**

It was measured using the following equation: Leaf water content (%) = Plant fresh weight – Dry weight / Fresh weight × 100.

Physiological Characteristics:

1. **Leaf Chlorophyll Content:**

The chlorophyll content of the fourth leaf was measured using a field chlorophyll meter in SPAD units.

2. Total Soluble Carbohydrate Content in the Leaves:

It was estimated using the modified phenol-sulfuric acid method described by Dubois et al., 1956. This was done using 0.5 g of ground dry matter from the fourth leaf of the three selected plants for each experimental unit, using a spectrophotometer at a wavelength of 490 nm, and a standard curve for glucose (Abbas and Abbas, 1992). This was calculated according to the following equation:

Total Soluble Carbohydrate (mg/g dry matter) = Amount of Carbohydrate in the Standard Curve × Final Volume of Extract × Dilutions / Sample Weight

3. Percentage of Protein in the Leaves (%):

It was calculated based on the dry weight of the leaves (A.O.A.C, 1979) and according to the following equation:

Dry weight of the leaves (Protein percentage based on dry weight % = Nitrogen percentage in the leaves × 6.25)

4. Total proline content (micrograms per g^{-1} dry weight):

Proline content was estimated according to the method of (Troll and Lindsey, 1955) as follows: 0.2 g of dry matter was taken from the individually ground leaves. 5 ml of 95% ethyl alcohol was added to it. The supernatant was centrifuged to separate it. It was then evaporated until completely dry. 2 ml of distilled water was added to the remaining portion and centrifuged. 1 ml of the supernatant was taken, and its absorbance was measured at a wavelength of 520 nm using a spectrophotometer. The proline content of the samples was then estimated according to a standard curve, and the results were expressed in micrograms. g^{-1} dry matter.

5. (micrograms per kg-1 weight) Fresh): ABA 5- Abscisic acid content in leaves

Abscisic acid in leaves was extracted using a methanol solvent (80%) by adding 50 ml of the solvent to 5 g of plant sample (fresh leaves) and leaving it at 4°C for a full day. The filtrate was then taken, and the precipitate was left for re-extraction in the same way. The extracts were then combined to produce a final filtrate volume of 100 ml over a total period of 48 hours. The extract (organic fraction) was then evaporated at 40°C under vacuum using a rotary evaporator (RE-120) until the aqueous phase was reached. Clearing was then carried out by adding 3 ml of basic lead acetate (45%). The precipitate was then centrifuged at 3000 rpm for 5 minutes. One drop of sodium acetate was then added to ensure complete precipitation. Turbidity in the filtrate required retesting. 3 ml of potassium oxalate (22%) was added and centrifuged to remove the precipitate. The filtrate was collected to 50 ml with distilled water. The acidity was then adjusted to (pH = 2.5) by adding drops of 1 N sulfuric acid. The organic matter in the aqueous fraction was transferred to the organic fraction using diethyl ether solvent by partitioning the sample in a separating funnel with 50 ml of ether solvent. After shaking for 10 minutes, the solvent layer (ether layer) was isolated, and the process was repeated for the aqueous solution, repeating it three times. The ether layer was collected in a 150 ml Erlenmeyer flask. Using a rotary evaporator, the extract was evaporated to 5 ml and then transferred into small vials. 5 ml of methanol was added to the extract for each sample. Abscisic acid was determined in samples extracted with absolute methanol at a wavelength of 254 nm based on their absorption of ultraviolet light. A spectrophotometer was used for the determination. It was determined based on a standard curve using natural abscisic acid. The results were expressed in micrograms kg-1 fresh weight (Crozier et al., 1980).

Chemical properties:

Sample digestion:

The percentage of NPK elements in the leaves was estimated by taking the fifth leaf from the growing tip of five plants from each experimental unit (Al-Sahhaf, 1989). The leaves were washed and dried well in an electric oven at 70°C for two days or until the weight was constant. After grinding the dry samples using an electric grinder, 0.02 g of the dry plant sample powder was weighed and digested according to the method using sulfuric and perchloric acid (Cresser and Parsons, 1979). It was placed in a 100 ml glass beaker, and 5 ml of concentrated sulfuric acid (98%) was added to the sample and allowed to react for 24 hours. The next day, the digestion flask was heated for an hour until boiling and left to cool. Then, 3 ml of the acid mixture (4% concentrated perchloric acid + 96% concentrated sulfuric acid) was added. It was then heated until the solution turned clear and transparent. Complete the volume with distilled water to 50 ml and then measure the mineral elements.

1. **Percentage of nitrogen in leaves (%):**

Nitrogen in leaves was estimated by distillation after adding 10 M sodium hydroxide using a micro-Kjeldahl device (Page et al., 1982), followed by titration with 0.04 N hydrochloric acid, according to the micro-Kjeldahl method.

It was calculated from the following equation:

N% = Volume of hydrochloric acid consumed × acid molarity × 14 × dilution volume / Volume of sample taken at distillation × Weight of digested sample × 100

×100.

2. **Percentage of phosphorus in leaves (%):**

Phosphorus was estimated using ammonium molybdenum blue after adjusting the reaction rate of the solutions used and then measured using a spectrophotometer at a wavelength of 620 nm, as described previously (Olsen and Sommes, 1982).

3. **Percentage of potassium in leaves (%): -3-1.1.3**

Potassium was determined using a flame photometer. This was expressed according (Page et al., 1982). The results are based on a standard curve using pure potassium chloride.

Flowering Traits:

1. **Date of first flower appearance for each plant:** The number of days required for the first flower appearance of each plant in the experimental unit was calculated, and the average for the three replicates was determined.
2. **Total number of flowers per plant:** This was calculated by dividing the total number of flowers in each experimental unit by the number of plants. The average was calculated for each treatment and the three replicates.
3. **Number of aborted flowers per plant:** The number of aborted flowers during the flowering period of the experimental units was recorded.

Statistical Design of the Experiment:

The field experiment was designed as a factorial experiment with two factors. The first factor was the aqueous extract of rice straw at concentrations (0, 5, and 10 g/L-1). The second factor was the soil dryness levels (25, 50, 75, and 100%), based on the soil's field capacity. Three replicates were used for each experimental unit, i.e., 36 pots, according to a completely randomized design. The results were analyzed using a two-way ANOVA (Analysis of Variance) using the Statistical Package for Social Sciences (SPSS version 24). Means were compared at the Revised Least Significant Difference (rLSD) at a probability level of 0.05 (Al-Rawi and Khalaf Allah, 1980).

Results and Discussion:

1- Effect of rice straw extract concentrations and drought levels on tomato plant height (cm)

Considering Table (2), it is evident that rice straw extract concentrations had a significant effect on increasing shoot height. The greatest increase was at a concentration of 10 g L-1, by approximately 20.2% compared to the control (0 g L-1). The individual effect of water stress was also significant. Plant height decreased with the decrease in soil water content. The greatest effect was at a field capacity level of 25%, with a decrease of 34% compared to the control (100%). The interaction between the two factors, i.e., field capacity level and straw extract concentration, also had a significant effect. The two concentrations (5 and 10 g L-1) had an effect at all drought levels, with height increasing compared to the concentration (0 g L-1) despite drought. The best among them was (10 g L-1), with an increase of approximately (15.8, 21.9, 23.3, and 25.2%) for levels (100, 75, 50, and 25%) of field capacity, respectively. That is, the concentration (10 g L-1) was better at (25%) field capacity. Also, from the Table, it appears that the lowest plant height was (41.351 cm) under the (0 g L-1 + 25%) treatment, and the highest height was (81.335 cm) under the (10 g L-1 + 100%) treatment.

Table (2): Effect of rice straw extract concentrations and drought levels on tomato plant height (cm):

Concentration rate	**Drought levels (%)**				**Extract concentrations (g/L-1)**
	25	**50**	**75**	**100**	
55.238±1.41998	**41.351**±.05100	**48.661**±.02700	**61.425**±.02500	**68.514**±.01400	**0**
61.667±1.29641	**51.311**±.01100	**52.541**±.04100	**69.351**±.05100	**73.463**±.06300	**5**
69.197±1.22349	**55.306**±.09400	**63.447**±.03300	**78.656**±.04400	**81.335**±.03300	**10**
	49.323±1.22421	**54.550**±1.63916	**69.811**±1.46929	**74.771**±1.21188	**Average levels**
	0.038 =For levels 0.033 =For concentrations 0.025 =To interfere				**r. LSD (0.05)**

2- The effect of rice straw extract concentrations and drought levels on the number of tomato leaves (leaf/plant-1):

Table (3) shows that rice straw extract concentrations had a significant effect on increasing the number of plant leaves. The best increase was at a concentration of 10 g L-1, by about 37.9%, compared to the control (0 g L-1). The individual effect of water stress was also significant. The number decreased with the decrease in the amount of water in the soil. The greatest effect was at a field capacity level of 25%, by 39.3%, compared to the control (100%). The interaction between the two factors, i.e., field capacity level and straw extract concentration, also had a significant effect. The concentrations (5 and 10 g L-1) had an effect at all drought levels, increasing the number compared to the concentration (0 g L-1), despite the drought. The best among them was (10 g L-1), with an increase of approximately (39.1, 31.6, 37.5, and 44.8%) for levels (100, 75, 50, and 25%) of field capacity, respectively. That is, the concentration (10 g L-1) was the best at (25%) field capacity. The Table also shows that the lowest number of leaves was (10,667 leaves/plant-1) under the (0 g L-1 + 25%) treatment, and the highest number was (30,667 leaves/plant-1) under the (10 g L-1 + 100%) treatment.

Table (3): Effect of rice straw extract concentrations and drought levels on the number of tomato leaves (leaf/plant-1):

Concentration rate	Drought levels (%)				Extract concentrations (g/L-1)
	25	50	75	100	
15.000±1.73352	**10.667**±1.00000	**13.333**±1.00000	**17.333**±1.00000	**18.667**±1.00000	**0**
20.667±2.43121	**15.333**±1.00000	**18.667**±1.00000	**23.333**±1.00000	**25.333**±1.00000	**5**
24.167±2.83384	**19.333**±1.00000	**21.333**±1.00000	**25.333**±1.00000	**30.667**±1.00000	**10**
	15.111±2.13629	**17.778**±2.93000	**22.000**±2.00000	**24.889**±1.48734	**Average levels**
	1.680 = For levels **1.460 = For concentrations** **1.104 = To interfere**				**r. LSD (0.05)**

3- The effect of rice straw extract concentrations and drought levels on the leaf area of tomato plants (cm2/plant-1):

Table (4) shows that rice straw extract concentrations had a significant effect on increasing the leaf area. The greatest increase was at a concentration of 10 g L-1, by approximately 9.1%, compared to the control (0 g L-1). The individual effect of water stress was also significant. The area decreased with the decrease in the amount of water in the soil. The greatest effect was at a field capacity level of 25%, with a reduction of 10% compared to the control (100%). The interaction between the two factors, i.e., field capacity level and straw extract concentration, also had a significant effect, as the concentrations (5 and 10 g L-1) had an effect at all drought levels. The area increased compared to the concentration (0 g L-1), despite drought. The best among them was (10 g L-1), with an increase of approximately (10.3, 9.4, 7.2, and 9.4%) for levels (100, 75, 50, and 25%) field capacity, respectively. That is, the concentration (10 g L-1) was the best at (100%) field capacity. The Table also shows that the lowest area was (410.296 cm2. plant-1) under the (0 g L-1 + 25%) treatment, and the highest was (503.679 cm2. plant-1) under the (10 g L-1 + 100%) treatment.

Table (4): Effect of rice straw extract concentrations and drought levels on the leaf area of tomato plants (cm2. plant-1):

Concentration rate	Drought levels (%)				Extract concentrations (g/L-1)
	25	50	75	100	
436.763±2.72292	**410.296**±2.03600	**439.667**±4.33400	**445.355**±5.35500	**451.733**±.86700	**0**
464.400±6.56073	**431.552**±1.05200	**452.143**±2.14300	**470.512**±5.01200	**482.393**±2.00300	**5**
480.438±12.12125	**452.885**±2.07520	**473.525**±3.02500	**491.661**±7.06100	**503.679**±3.07950	**10**
	431.578±9.63480	**455.112**±9.65622	**469.176**±10.41415	**479.268**±12.69377	**Average levels**
	13.190 = For levels **11.010 = For concentrations** **8.090 = To interfere**				**r. LSD (0.05)**

4- Effect of rice straw extract concentrations and drought levels on the dry weight of tomato shoots (g):

Table (5) shows that rice straw extract concentrations had a significant effect on increasing the dry weight of the shoots. The best increase was at a concentration of (10 g L-1) by a significant percentage of approximately (50%) compared to the control (0 g L-1). Water stress also had a significant effect. Dry weight decreased with the decrease in the amount of water in the soil. The weight at the field capacity level (25%) was the lowest by (37.3%) compared to the control (100%). The synergy between the two factors, i.e., the field capacity level and the straw extract concentration, also had a significant effect at the concentrations (5 and 10 g L-1) at all drought levels. Dry weight increased at both concentrations compared to the concentration (0 g L-1) despite drought. The best among them was (10 g L-1), with significant increases of approximately (44.9, 44.5, 51.7, and 62.1%) for levels (100, 75, 50, and 25%) field capacity, respectively. That is, the concentration (10 g L-1) was the best at (25%) field capacity. The Table also shows that the lowest dry weight was (17.127 g) under the (0 g L-1 + 25%) treatment, and the highest was (65.293 g) under the (10 g L-1 + 100%) treatment.

Table (5): Effect of rice straw extract concentrations and drought levels on the dry weight of the tomato plant shoots (g):

Concentration rate	**Drought levels (%)**				**Extract concentrations (g/L-1)**
	25	**50**	**75**	**100**	
26.253±2.86360	**17.127**±2.00700	**22.755**±2.00500	**29.137**±3.00700	**35.991**±1.00100	**0**
42.940±3.92683	**34.253**±4.00300	**39.419**±4.01900	**45.361**±3.00100	**52.728**±2.02800	**5**
52.518±4.64761	**45.169**±3.00900	**47.141**±2.00100	**52.468**±2.00600	**65.293**±2.00300	**10**
	32.183±4.53508	**36.438**±4.06994	**42.322**±4.80634	**51.337**±3.25198	**Average levels**
	2.930 = For levels **2.540 = For concentrations** **1.920 =To interfere**				**r. LSD (0.05)**

5- Effect of rice straw extract concentrations and drought levels on the water content of tomato leaves (g):

Table (6) shows that rice straw extract concentrations had a significant effect on increasing leaf water content. The greatest increase was at a concentration of 10 g L-1, at approximately 32.4% compared to the control (0 g L-1). Water stress also had a significant effect. Water content decreased as the amount of water in the soil decreased. At a field capacity level of 25%, it was the lowest at 18.6% compared to the control (100%). The synergy between the two factors, i.e., field capacity level and straw extract concentration, also had a significant effect at both concentrations (5 and 10 g L-1) at all drought levels. Water content increased at both concentrations compared to the concentration (0 g L-1) despite drought. The best among them was (10 g L-1), with an increase rate of approximately (22.6, 30.6, 34.6, and 43.2%) for levels (100, 75, 50, and 25%) field capacity, respectively. That is, the concentration (10 g L-1) was the best at (25%) field capacity. The Table also shows that the lowest leaf water content was

(46.253%) under the (0 g L-1 + 25%) treatment, and the highest was (92.512%) under the (10 g L-1 + 100%) treatment.

Table (6): Effect of rice straw extract concentrations and drought levels on the water content of tomato leaves (g):

Concentration rate	Drought levels (%)				Extract concentrations (g/L-1)
	25	50	75	100	
58.320±2.00177	**46.253**±1.00300	**54.871**±2.00100	**60.592**±2.00200	**71.565**±1.00500	**0**
82.617±2.12970	**76.981**±1.00900	**81.954**±3.13072	**84.138**±2.00800	**87.396**±2.00600	**5**
86.253±3.72382	**81.374**±1.03210	**83.868**±3.00800	**87.260**±2.01000	**92.512**±2.01200	**10**
	68.203±4.59497	**73.564**±4.59143	**77.330**±4.06518	**83.824**±3.57689	**Average levels**
	2.660 = For levels 2.310 = For concentrations 1.740 =To interfere				**r. LSD (0.05)**

Tables (2, 3, 4, 5 and 6) show that both concentrations of the extract had a significant effect, with the best concentration being (10 g L-1), which significantly increased plant height, number of leaves, total leaf area, dry weight and leaf water content compared to the control (0 g L-1). This result is consistent with the findings of (Ma et al., 2019) on tomato and (Farag et al., 2015) on lettuce and eggplant. This may be due to the presence of humus-like active substances in the rice straw extract, which improve tomato growth and increase vegetative characteristics (Ma et al., 2019). The reason may also be due to the many substances contained in the extract. Straw ash generally contains 75% SiO_2 (silicon dioxide), 10% K_2O, 3% P_2O_5, 3% Fe_2O_3, 1.3% CaO, and smaller amounts of Mg, S, and Na (Kadam et al., 2000). These nutrients are important for improving growth. Drought levels also negatively affected these traits, especially at the highest drought level (25%). This may be due to the effect of water scarcity on growth, which reduces photosynthesis and root growth. Consequently, the upward flow of water and nutrients is reduced, negatively affecting growth (Al-Saadi, 2016). When straw extract was used with drought treatments, an improvement in the studied traits was observed at concentrations of 5 and 10 g L-1 compared to 0 g L-1 at all drought levels. This is consistent with what Rasool et al. (2019) found. It has been proven that the straw layer can reduce water and fertilizer stress and increase the plant growth, physiological characteristics, and fruit yield of the tomato plant. As is known, what controls plant growth is the rate of cell division, elongation and the preparation of inorganic and organic materials important for building new protoplasm and cell wall. The difference in water levels causes this, and the less water is available, the more it limits leaf expansion and elongation (Elsahookie et al., 2009; Borrell et al., 2000).

6- Effect of rice straw extract concentrations and drought levels on the total chlorophyll content of tomato leaves (SPAD):

Table (7) shows that rice straw extract concentrations had a significant effect on increasing chlorophyll content. The greatest increase was at a concentration of 10 g L-1, by approximately 10.9%, compared to the control (0 g L-1). The individual effect of water stress was also significant. Chlorophyll content decreased with decreasing soil water content, with the greatest effect being at a field capacity level of 25%, resulting in a 15.5% reduction compared to the control (100%). The interaction between the two factors, i.e., field capacity level and straw extract concentration, also had a significant effect at both concentrations (5 and 10 g L-1) at all drought levels. Chlorophyll content increased compared to the 0 g L-1 concentration despite drought, with the best concentration being 10 g L-1, with increases of approximately 13.2, 13.7, 9.4, and 6.5% for the 100, 75, 50, and 25% field capacity levels, respectively. That is, the 10 g L-1 concentration was the best at the 75% field capacity. The Table also shows that the lowest chlorophyll content was 1.790 SPAD under the 0 g L-1 + 25% treatment, and the highest was 2.325 SPAD under the 10 g L-1 + 100% treatment.

Table (7): Effect of rice straw extract concentrations and drought levels on the total chlorophyll content (SPAD) of tomato leaves:

Concentration rate	Drought levels (%)				Extract concentrations (g/L-1)
	25	50	75	100	
1.905±.08824	**1.790**±.04000	**1.889**±.02600	**1.925**±.02500	**2.017**±.01700	**0**
2.026±.15330	**1.836**±.03600	**1.956**±.02400	**2.100**±.07500	**2.212**±.01200	**5**
2.139±.16795	**1.915**±.01500	**2.084**±.08400	**2.231**±.03100	**2.325**±.05000	**10**
	1.847±.06147	**1.976**±.09716	**2.085**±.13957	**2.185**±.13762	**Average levels**
	0.035 = For levels 0.030 = For concentrations 0.023 =To interfere				**r. LSD (0.05)**

7- Effect of rice straw extract concentrations and drought levels on the total soluble carbohydrate content of tomato leaves (mg/g/l dry weight):

From Table (8), it is clear that rice straw extract concentrations had a significant effect on increasing the total soluble carbohydrate content of leaves. The greatest increase was at a concentration of 10 g/l, by approximately 24.7%, compared to the control (0 g/l). Conversely, water stress also had a significant effect, but by reducing carbohydrate content with a reduced amount of soil water. The lowest level of carbohydrate content was at a field capacity level of 25%, representing a 37.4% decrease compared to the control (100%). The synergy between the two factors, i.e., field capacity level and straw extract concentration, also had a significant effect at both concentrations (5 and 10 g/l) at all drought levels, increasing the content at both concentrations compared to the concentration (0 g/l), despite drought. The best concentration among the two was (10 g L-1), with an increase of approximately (23, 21.4, 28.3, and 27.9%) for levels (100, 75, 50, and 25%) field capacity, respectively. That is, the concentration (10 g L-1) was the best at (50%) field capacity. The Table also shows that the lowest carbohydrate content of the leaves was (14.988 mg L-1 dry weight) under the (0 g L-1 + 25%) treatment. The highest was (32.897 mg L-1 dry weight) under the (10 g L-1 + 100%) treatment.

Table (8): Effect of rice straw extract concentrations and drought levels on the total soluble carbohydrate content of tomato leaves (mg L-1 dry weight):

Concentration rate	Drought levels (%)				Extract concentrations (g/L-1)
	25	50	75	100	
19.310±4.51901	**14.988**±.91200	**16.252**±2.00200	**20.669**±2.03900	**25.331**±2.03100	**0**
22.854±4.30953	**18.333**±1.86700	**20.111**±.11100	**24.752**±2.00200	**28.221**±2.02100	**5**
25.656±5.01909	**20.774**±1.02200	**22.667**±2.01700	**26.286**±1.00800	**32.897**±2.00700	**10**
	18.032±2.76923	**19.677**±3.13756	**23.902**±2.93541	**28.816**±3.74059	**Average levels**
	1.430 = For levels 1.240 = For concentrations 0.941 =To interfere				**r. LSD (0.05)**

8- Effect of rice straw extract concentrations and drought levels on the total proline content of tomato leaves (micrograms per g-1 dry weight):

From Table (9), it is clear that rice straw extract concentrations had a significant effect on reducing the total proline content of leaves. The greatest reduction occurred at a concentration of 10 g L-1, by approximately 22.6%, compared to the control (0 g L-1). Conversely, water stress also had a significant effect. However, with increasing proline content and decreasing soil water content, the greatest reduction occurred at a field capacity level of 25%, by 37.6%, compared to the control (100%). The synergy between the two factors, i.e. field capacity level and straw extract concentration, also had a significant effect under the two concentrations (5 and 10 g L-1) with all drought levels, as the content decreased under them compared to the concentration (0 g L-1) despite the drought. The lowest among them was (10 g L-1) with a reduction percentage of about (11.9, 21.8, 26.8 and 25.4%) for the levels (100, 75, 50 and 25%) field capacity, respectively. That is, the concentration (10 g L-1) was the best at reducing under field capacity (50%). The Table also shows that the lowest proline content of leaves was 90.382 (µg/g-1 dry weight) under the 10 g L-1 + 100% treatment, and the highest was 177.185 (µg/g-1 dry weight) under the 0 g L-1 + 25% treatment.

Table (9): Effect of rice straw extract concentrations and dehydration levels on the total proline content of tomato leaves (µg/g-1 dry weight):

Concentration rate	Drought levels (%)				Extract concentrations (g/L-1)
	25	50	75	100	
144.642±4.46013	**177.185**±2.00500	**165.554**±2.00400	**133.212**±1.00200	**102.615**±2.01500	**0**
128.047±3.92555	**156.336**±2.03600	**142.074**±2.00076	**116.005**±2.00500	**97.773**±2.01100	**5**
111.992±3.79496	**132.249**±2.02900	**121.146**±1.00600	**104.189**±2.00900	**90.382**±3.03200	**10**
	155.257±4.75870	**142.925**±4.29839	**117.802**±3.84617	**96.923**±3.72616	**Average levels**
	2.330 = For levels 2.020 = For concentrations 1.520 =To interfere				**r. LSD (0.05)**

9- Effect of rice straw extract concentrations and drought levels on the abscisic acid (ABA) content of tomato leaves (μg/kg-1 fresh weight):

Table (10) shows that rice straw extract concentrations significantly reduced the ABA content of leaves. The greatest reduction occurred at a concentration of 10 g/L-1, by approximately 13.2%, compared to the control (0 g/L-1). Conversely, water stress also had a significant effect, but with increased ABA content and decreased soil water content. The highest ABA content occurred at a field capacity level of 25%, with an increase of 55.3% compared to the control (100%). The synergy between the two factors, i.e. field capacity level and straw extract concentration, also had a significant effect under the two concentrations (5 and 10 g L-1) with all drought levels, as the content decreased under them compared to the concentration (0 g L-1) despite the drought. The worst concentration among the two concentrations was (10 g L-1) with a reduction percentage of about (18.6, 20.4, 9.2 and 9.3%) for the levels (100, 75, 50 and 25%) field capacity, respectively. That is, the concentration (10 g L-1) was the worst, especially under the field capacity (75%). The Table also shows that the lowest abscisic acid content of leaves was (325.776 μg/g-1 fresh weight) under the (10 g/L + 100%) treatment, and the highest (855.483 μg/g-1 fresh weight) under the (0 g/L + 25%) treatment.

Table (10): Effect of rice straw extract concentrations and drought levels on the abscisic acid (ABA) content of tomato leaves (μg/kg fresh weight):

Concentration rate	Drought levels (%)				Extract concentrations (g/L-1)
	25	50	75	100	
592.961±3.08861	**855.483**±1.00300	**612.699**±3.04900	**503.446**±2.04600	**400.215**±2.01500	**0**
550.273±3.20356	**801.335**±1.03500	**587.945**±2.04500	**449.333**±3.03300	**362.478**±2.02000	**5**
514.746±4.10567	**776.212**±1.98800	**556.365**±2.00500	**400.629**±4.02900	**325.776**±3.02600	**10**
	811.010±3.89444	**585.670**±4.60595	**451.136**±4.06156	**362.823**±3.86031	**Average levels**
	7.990 = For levels 6.920 = For concentrations 5.230 =To interfere				**r. LSD (0.05)**

10- Effect of rice straw extract concentrations and drought levels on the total protein content of tomato leaves (% dry weight):

The results of Table (11) confirm that rice straw extract concentrations had a significant effect on increasing the total protein content of leaves. The greatest increase in protein content was at a concentration of 10 g L-1, by approximately 29.1%, compared to the control (0 g L-1). Water stress had a unique effect, as protein content decreased with decreasing soil water content. The greatest effect was at a field capacity level of 25%, with a decrease of 26.5% compared to the control (100%). The interaction between the two factors, i.e., field capacity level and straw extract concentration, also had a significant effect, as the concentrations (5 and 10 g L-1) at all drought levels also had a positive effect, increasing protein content compared to the concentration (0 g L-1), despite drought. The best among them was (10 g L-1), with an increase of approximately (32.6, 27.3, 24.2, and 31.7%) for levels (100, 75, 50, and 25%) of field capacity, respectively. That is, the concentration (10 g L-1) was the best under a field capacity of (100%). The Table also shows that the lowest protein content was (4.919%) under the (0 g L-1 + 25%) treatment, and the highest (9.950%) under the (10 g L-1 + 100%) treatment.

Table (11): Effect of rice straw extract concentrations and drought levels on the total protein content of tomato leaves (% dry weight):

Concentration rate	Drought levels (%)				Extract concentrations (g/L-1)
	25	50	75	100	
5.924±.71388	**4.919**±.10600	**5.725**±.07500	**6.344**±.13600	**6.706**±.10600	**0**
7.663±.95617	**6.494**±.09400	**7.069**±.04200	**8.444**±.24400	**8.644**±.14400	**5**
8.359±1.12841	**7.200**±.05000	**7.556**±.05600	**8.731**±.03100	**9.950**±.10000	**10**
	6.200±1.01410	**6.783**±.82288	**7.840**±1.13733	**8.433**±1.41726	**Average levels**
	0.095 = For levels 0.082 = For concentrations 0.062 =To interfere				**r. LSD (0.05)**

It is evident from Tables (7, 8, 9, 10 and 11) that the highest concentration of straw extract caused a significant increase in the contents of total chlorophyll, total carbohydrate and protein. This may be due to the increase in biomass and nutrients within the plant resulting from the presence of straw extract. However, the concentration of 10 g. L-1 of the extract caused a significant decrease in the content of proline and total abscisic acid compared to the control (0 g. L-1). This is consistent with the findings of (Ria et al., 2025). It is well known that proline and abscisic acid decrease in plants when a substance is used that increases plant activity, reduces antioxidants such as proline, and increases levels of growth-stimulating hormones such as gibberellins, auxins, and cytokinins, while reducing those that inhibit them, such as abscisic acid (Vriezen et al., 2008; Alordzinu et al., 2021). In contrast, we observe a decrease in the content of total chlorophyll, total carbohydrates, and protein due to the deterioration of photosynthesis efficiency and root growth (Al-Saadi, 2016). The rate of cell division, cell elongation, and the preparation of inorganic and organic materials important for the construction of new protoplasm and cell wall controls plant growth. Fluctuations in water levels cause this. The less water is available, the more leaf expansion and elongation are limited (Elsahookie et al., 2009; Borrell et al., 2000). Plant growth and productivity are affected by water stress. It leads to a disruption of morphological and physiological functions through the degradation of chlorophyll, inhibition of growth, and other traits such as protein (Al-Amery and Annon, 2024). When plants are exposed to water stress, the development and growth of woody species are reduced, as are shoot height, biomass, leaf area, and stem diameter. Furthermore, changes in leaf metabolism are accompanied by changes in water potential, chlorophyll fluorescence, gas exchange, photosynthesis, and dissolved organic content (Frosi et al., 2017). Proline and abscisic acid contents increased under all drought levels, especially at 25% total drought, compared to the 100% control. This is due to the influence of abscisic acid content on water stress, which impacts growth characteristics and even plant water content (Vu et al., 2015). Elevated proline levels were observed in plants, indicating that the accumulation of proline in the cytoplasm of plant cells is a mechanism for adapting to water stress conditions. However, the main osmotic regulatory process of proline occurs in the leaves of plants exposed to water stress (Patanè et al., 2016). The same tables show that the highest concentration of straw extract (10 g L-1) improved all physiological characteristics, and those with high or low levels in 100% drought-controlled plants were improved. This is consistent with (Ria et al., 2025) and contradicts (Zhang et al., 2023). The reason may be due to increased plant tolerance to water stress, reduced transpiration, and increased growth (Ria et al., 2025).

11- Effect of rice straw extract concentrations and drought levels on the nitrogen content of tomato leaves (%):

Table (12) shows that rice straw extract concentrations had a significant effect on increasing leaf nitrogen content. The greatest increase in nitrogen content was at a concentration of 10 g L-1, by approximately 28.8%, compared to the control (0 g L-1). Regarding the individual effect of water stress, the percentage of decrease in nitrogen content increased with the decrease in soil water content. The greatest effect was at a field capacity level of 25%, with a decrease of 26.4% compared to the control (100%). The interaction between the two factors, i.e., drought level and straw extract concentration, also had a significant effect, as the concentrations (5 and 10 g L-1) at all drought levels had a positive effect, increasing the amount of nitrogen compared to the concentration (0 g L-1), despite drought. The best among them was (10 g L-1), with an increase of approximately (38.5, 27.3, 22.5, and 31.7%) for levels (100, 75, 50, and 25%) of field capacity, respectively. That is, the concentration (10 g L-1) was the best under a field capacity of (100%). The Table also shows that the lowest nitrogen content was (0.787%) under the (0 g L-1 + 25%) treatment. The highest content was (1.592%) under the (10 g L-1 + 100%) treatment.

Table (12): Effect of rice straw extract concentrations and drought levels on the nitrogen content of tomato leaves (%):

Concentration rate	Drought levels (%)				Extract concentrations (g/L-1)
	25	50	75	100	
0.948±.11381	**0.787**±.01300	**0.916**±.00600	**1.015**±.00300	**1.073**±.02100	**0**
1.226±.15205	**1.039**±.00900	**1.131**±.01900	**1.351**±.01700	**1.383**±.00400	**5**
1.331±.18741	**1.152**±.00600	**1.182**±.05599	**1.397**±.00400	**1.592**±.00800	**10**
	0.993..16205	**1.076**±.12592	**1.254**±.18082	**1.349**±.22644	**Average levels**
	0.105 = For levels 0.014 = For concentrations 0.015 =To interfere				**r. LSD (0.05)**

12- Effect of rice straw extract concentrations and drought levels on the phosphorus content of tomato leaves (%):

Table (13) shows that rice straw extract concentrations also had a significant effect on increasing leaf phosphorus content. The greatest increase in phosphorus content was at a concentration of 10 g L-1, by approximately 29.2%, compared to the control (0 g L-1). Regarding the individual effect of water stress, the percentage of decrease in phosphorus content increased with decreasing soil water content. The greatest effect was at a field capacity level of 25%, with a decrease of 22.1% compared to the control (100%). The interaction between the two factors, namely drought level and straw extract concentration, also had a significant effect. Both concentrations (5 and 10 g L-1) had a positive effect at all levels of drought, increasing phosphorus content compared to the 0 g L-1 concentration. The best of the two was the 10 g L-1 concentration, with increases of approximately 26.9, 22, 32, and 37.7% for the 100, 75, 50, and 25% field capacity levels, respectively. That is, the 10 g L-1 concentration performed best at the 25% field capacity. The Table also shows that the lowest phosphorus content was 1.265% under the 0 g L-1 + 25% treatment, and the highest was 2.632% under the 10 g L-1 + 100% treatment.

Table (13): Effect of rice straw extract concentrations and drought levels on the phosphorus content of tomato leaves (%):

Concentration rate	Drought levels (%)				Extract concentrations (g/L-1)
	25	50	75	100	
1.600±.28091	**1.265**±.01000	**1.416**±.01600	**1.794**±.00600	**1.924**±.02400	**0**
2.048±.08709	**1.937**±.00700	**2.009**±.00900	**2.086**±.00600	**2.159**±.01200	**5**
2.261±.24722	**2.031**±.00300	**2.082**±.00800	**2.299**±.00600	**2.632**±.00200	**10**
	1.744±.36185	**1.836**±.31649	**2.060**±.21962	**2.238**±.31258	**Average levels**
	0.009 = For levels 0.007 = For concentrations 0.005 =To interfere				**r. LSD (0.05)**

13- Effect of rice straw extract concentrations and drought levels on the potassium content of tomato leaves (%):

Statistical analysis from Table (14) indicates that rice straw extract concentrations also had a significant effect on increasing leaf potassium content. The greatest increase in potassium content was at a concentration of 10 g L-1, by approximately 31.9%, compared to the control (0 g L-1). Regarding the individual effect of water stress, the percentage of decrease in potassium content increased with decreasing soil water content. The greatest effect was at a field capacity level of 25%, with a decrease of 36.4% compared to the control (100%). The interaction between the two factors, i.e., drought level and straw extract concentration, also had a significant effect. Both concentrations (5 and 10 g L-1) had a positive effect at all drought levels, increasing potassium content compared to the 0 g L-1 concentration, regardless of drought. The best of the two was the 10 g L-1 concentration, with increases of approximately 35.2, 31.8, 32.4, and 26% for the 100, 75, 50, and 25% field capacity levels, respectively. That is, the 10 g L-1 concentration performed best at 100% field capacity. The table also shows that the lowest phosphorus content was 2.476% under the 0 g L-1 + 25% treatment, and the highest was 5.785% under the 10 g L-1 + 100% treatment.

Table (14): Effect of rice straw extract concentrations and drought levels on the potassium content of tomato leaves (%):

Concentration rate	Drought levels (%)				Extract concentrations (g/L-1)
	25	50	75	100	
2.998.±51249	**2.476**±.00600	**2.662**±.01200	**3.103**±.00300	**3.751**±.00451	**0**
3.642±.86113	**2.807**±.00700	**3.470**±.00500	**4.283**±.00300	**4.009**±1.15474	**5**
4.402±.94771	**3.334**±.00600	**3.936**±.01100	**4.552**±.01200	**5.785**±.01000	**10**
	2.872±.37478	**3.356**±.55831	**3.979**±.68619	**4.515**±1.48447	**Average levels**
	0.288 = For levels 0.243 = For concentrations 0.184 =To interfere				**r. LSD (0.05)**

From tables (12, 13 and 14), it is noted that the biochemical indicators of tomato (a group of nutrients) were significantly affected at both extract concentrations. The best concentration was

(10 g L-1), which increased the leaf content of nitrogen, phosphorus and potassium compared to the control (0 g L-1). This is consistent with what was found by (Adachi et al., 1997). The reason may be that the extract contains nutrients similar to humus or fertilizer, which improves tomato growth and increase vegetative characteristics (Ma et al., 2019). The same tables also show that drought levels significantly reduced the nutrient content, especially below 100%. This may be attributed to the effect of water scarcity on growth, which reduces the efficiency of photosynthesis and root growth. Consequently, the upward flow of water and nutrients is reduced (Al-Saadi, 2016). Adding straw extract to plants exposed to water stress resulted in a significant increase in their tolerance to water scarcity, especially under 25% drought and a straw concentration of 10 g L-1. The extract attempted to avoid the effects of drought through the presence of straw, which can reduce water stress, increase plant growth and photosynthesis, and improve biomass (Rasool et al., 2019).

14- Effect of rice straw extract concentrations and drought levels on the number of days required for the first flower to appear in tomato plants (days):

Table (15) shows that rice straw extract concentrations had a significant effect in reducing the number of days required for the first flower to appear. The best reduction was at a concentration of (10 g L-1) by approximately (12.6%) compared to the control (0 g L-1). The individual effect of water stress also had a significant effect, increasing the number of days required for the first flower to appear as water levels in the soil decreased. The number of days required for the first flower to appear at a field capacity level of (25%) increased by (14.4%) compared to the control (100%). The interaction between the two factors, i.e., field capacity level and straw extract concentration, also had a significant effect on the two concentrations (5 and 10 g L-1) at all drought levels. The number of days required for the first flower to appear decreased compared to the concentration (0 g L-1) despite the drought. The best of the two was (10 g L-1), with a reduction rate of approximately (17.8, 15.7, 9.2, and 8.3%) for the levels (100, 75, 50, and 25%) field capacity, respectively. That is, the concentration (10 g L-1) performed best under a field capacity of (100%). The table also shows that the minimum number of days required for the first flower to appear was (89.333 days) under the treatment (10 g L-1 + 100%). The maximum was (120.667 days) under the treatment (0 g L-1 + 25%). Table (15): Effect of rice straw extract concentrations and drought levels on the number of days required for the first flower to appear in tomato plants (day):

Concentration rate	**Drought levels (%)**				**Extract concentrations (g/L-1)**
	25	**50**	**75**	**100**	
113.834±3.12564	**120.667**±2.00000	**115.333**±2.00000	**110.667**±2.00000	**108.667**±2.00000	**0**
105.667±3.50740	**115.333**±2.00000	**109.333**±2.00000	**99.333**±2.00000	**98.667**±2.00000	**5**
99.500±4.21658	**110.667**±2.00000	**104.667**±2.00000	**93.333**±2.00000	**89.333**±2.00000	**10**
	115.556±4.66668	**109.778**±4.94387	**101.111**±4.81767	**98.889**±3.72444	**Average levels**
	1.880 = For levels 1.630 = For concentrations 1.230 =To interfere				**r. LSD (0.05)**

15- The effect of rice straw extract concentrations and drought levels on the total number of flowers in tomato plants (flower/plant-1):

Table (16) shows that rice straw extract concentrations had a significant effect on increasing the total number of flowers. The greatest increase was at a concentration of 10 g L-1, by approximately 26.7%, compared to the control (0 g L-1). Water stress alone also had a significant effect, decreasing the total number of flowers as water levels in the soil decreased. The number at the field capacity level (25%) was 41.3% lower compared to the control (100%). The interaction between the two factors, i.e., the field capacity level and the straw extract concentration, also had a significant effect at the concentrations (5 and 10 g L-1) with all drought levels, increasing the total number of flowers compared to the concentration (0 g L-1) despite the drought. The best among them was (10 g. L-1) with an increase rate of about (22, 27.3, 37 and 20%) for levels (100, 75, 50 and 25%) field capacity, respectively. That is, the concentration (10 g. L-1) was better under field capacity (50%). From the table, it also appears that the lowest number of total flowers is (18,667 flowers, plant-1) under the treatment (0 g. L-1 + 25%). The highest number is (39,333 flowers, plant-1) under the treatment (10 g. L-1 + 100%).

Table (16): Effect of rice straw extract concentrations and drought levels on the total number of flowers in tomato plants (flower/plant-1):

Concentration rate	Drought levels (%)				Extract concentrations (g/L-1)
	25	50	75	100	
23.834±2.53516	**18.667**±2.00000	**19.333**±2.00000	**26.667**±2.00000	**30.667**±2.00000	**0**
28.834±2.72184	**20.667**±2.00000	**25.333**±2.00000	**32.667**±2.00000	**36.667**±2.00000	**5**
32.500±4.64928	**23.333**±2.00000	**30.667**±2.00000	**36.667**±2.00000	**39.333**±2.00000	**10**
	20.889±2.66644	**25.111**±5.20710	**32.000**±4.69042	**35.556**±4.21615	**Average levels**
	1.680 = For levels 1.460 = For concentrations 1.080 =To interfere				**r. LSD (0.05)**

16- The effect of rice straw extract concentrations and drought levels on the number of aborted flowers in tomato plants (flower/plant-1):

Table (17) shows that rice straw extract concentrations had no significant effect on reducing the number of aborted flowers, as they were significantly reduced at both concentrations (5 and 10 g L-1) compared to the control (0 g L-1). Water stress alone had a significant effect, increasing the total number of flowers as soil water content decreased. The effect was insignificant at levels (75 and 50%) compared to the control (100%). The number increased significantly at the field capacity level (25%) by (25.5%) compared to the control (100%). There was a significant difference between the two levels (75 and 25%). The interaction between the two factors, i.e. field capacity level and straw extract concentration, also had a significant effect for the two concentrations (5 and 10 g L-1) with all drought levels. The number of aborted flowers decreased significantly compared to the concentration (0 g L-1) despite the drought. The best among them was (10 g L-1) with a reduction percentage of about (15.4, 15.4, 18.7 and 17.6%) for the levels (100, 75, 50 and 25%) field capacity, respectively. That is, the concentration (10 g L-1) was better under field capacity (50%). The table also shows that the lowest number of aborted flowers was (7,333 flowers/plant-1) under the treatment (5 and 10 g L-1 + 100%). The highest number was (11,333 flowers/plant-1) under the treatment (0 g L-1 + 25%).

Table (17): Effect of rice straw extract concentrations and drought levels on the number of aborted flowers in tomato plants (flower/plant-1):

Concentration rate	Drought levels (%)				Extract concentrations (g/L-1)
	25	50	75	100	
9.834±2.11045	**11.333**±2.00000	**10.667**±2.00000	**8.667**±2.00000	**8.667**±2.00000	**0**
9.000±2.11786	**10.667**±2.00000	**9.333**±2.00000	**8.667**±2.00000	**7.333**±2.00000	**5**
8.167±1.93066	**9.333**±2.00000	**8.667**±2.00000	**7.333**±2.00000	**7.333**±2.00000	**10**
	10.444±1.94368	**9.556**±1.94368	**8.222**±1.85604	**7.778**±1.85604	**Average levels**
	2.030 = For levels N.S. = For concentrations 1.100 = To interfere				**r. LSD (0.05)**

In Tables 15, 16, and 17, we note a significant difference in the effect of the straw extract on floral growth traits, except for the number of aborted flowers, which was not significantly affected by the extract. The reduction in the number of days required for first flower appearance and the increase in the total number of flowers resulting from the addition of the straw extract to the plants may be due to the decrease in proline and abscisic acid. The slower the plant growth improvement, the better its floral development (Kojima et al., 1993; Barickman et al., 2014). Drought had the opposite effect of the extract, as it increased the number of days required for first flower appearance, increased the number of aborted flowers, and reduced the total number of flowers per plant. This result is consistent with (Yang et al., 2019). This may be due to the increased content of abscisic acid in the reproductive organs, which leads to calcium accumulation and the formation of a detachment layer, leading to flower abscission (Barickman et al., 2014). The plant genotypes also affect this effect (Ati et al., 2016). When the extract was added to plants exposed to drought, it caused a good avoidance of the effects of drought, as the study by Ria et al. (2025) showed the efficiency of straw in increasing the plant's tolerance to drought by achieving optimal growth in the early vegetative growth stage and reducing proline and abscisic acid.

Conclusions

We conclude from this study that rice straw extract alone had a positive effect on tomato growth and flowering, especially at the highest concentration in the study, 10 g L-1. Drought caused a decrease in growth parameters, especially at its highest concentration, 25%. The 10 g L-1 extract concentration had a healing capacity in reducing the negative effects of drought.

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