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Study of the Chemical Characteristics and Dry Weight of Cucumber Plants under the Influence of Shading Levels and Different Irrigation Methods

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ABSTRACT

Background: The cucumber is considered one of the most consumed plants because it's involved in many diet systems and different types of food, it's rich in many vitamins, like vitamin K; and it has a high-water content. This study investigates cucumber plants' chemical composition and weight, which are essential factors in plant physiology, under different amounts of shading and irrigation systems.

Methods: The experiment involved two water methods, specifically surface and drip irrigation techniquesand three levels of shading, specifically 60%, 45% and 30%. There were three replicates, with each replicate consisting of 6 treatments. The experimental unit had 10 plants.

Result: The findings demonstrated that the amount of shading significantly impacted the chemical properties and weight of cucumber plants. Specifically, the 30% and 45% shade treatments resulted in a more significant nitrogen percentage in the leaves, corresponding increases of 0.79% and 0.73%, respectively. The leaves exposed to the 30% shade treatment exhibited the most significant phosphorus percentage, measuring 0.37%. The leaves exhibited a potassium concentration of 2.60%, Additionally, the chlorophyll content was measured at 3.88 mg/100 g^{-1} fresh weight and 48.06 g dry weight. The shading treatment of 30% demonstrated superior performance in measuring the maximum proline concentration, reaching a value of 1.24 mg $plant^{-1}$. The drip watering method resulted in a nitrogen concentration in the leaves that exceeded 0.77%. The leaf composition contains a potassium concentration of 2.66%.The irrigation approach yielded the driest weight, amounting to 43.39 grams. The drip irrigation method demonstrated its superiority by measuring the highest proline concentration in the leaves, reaching 1.25 mg $plant^{-1}$. The interaction between the extent of shading and various irrigation techniques significantly affected the chemical properties and weight of the dried substance.

Key words: *Cucumis melo* var, Irrigation methods, Shading levels.

INTRODUCTION

Cucumber [*Cucumis melo* var. *flexuous (L.) Naudin*] belongs to the Cucurbitaceae family. It is a cucurbit that has been chiefly cultivated and distributed in tropical and subtropical regions since ancient times. The immature fruit is eaten raw or pickled, especially in Mediterranean countries. It has been appreciated since ancient times for its crunchy texture, refreshing qualitiesand non-sweet flavour. These details are emphasized by their depiction in frescoes, statuesand mosaics from Egyptian civilization and the Roman Empire, as well as other sources in ancient Islamic and Jewish texts (Sivakumar and Netzel, 2022).

Cucumber is rich in vitamin K, facilitating calcium absorption from dietary sources, promoting bone healthand decreasing the risk of osteoporosis and fractures. One of the most significant health benefits of cucumbers is their high antioxidant content, including pectin. These antioxidants act as a shield, combating free radicals and reducing the risk of cancerous tumors. Cucumber contain dietary fiber, which enhances gastrointestinal motility and decreases the likelihood of digestive issues such as indigestion, constipation, bloatingand flatulence. They are also fiber-rich vegetables that contain beneficial nutrients such as potassium and magnesium. These nutrients contribute to cardiovascular health by reducing the risk of high blood pressure, heart attacksand atherosclerosis. Additionally, cucumber help lower harmful cholesterol levels in the blood (Flores-León *et al.,* 2021).

High solar radiation in the summer led to increased crop respiration and reduced photosynthesis. In addition, the rainy season, which occurs in the summer, causes decreased lighting inside the greenhouse (Subhapriya and

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Santhosh, 2023). Low-light conditions can reduce crop growth and productivity. An investigation was undertaken to assess the impact of shadow on the development and productivity of cucumbers throughout the summer season. A 50% shade cover was installed in one of the greenhouses to reduce the intensity of light inside the greenhouse. This study concluded that a 50% shade treatment led to a noticeable improvement in cucumber growth during the summer. Moreover, the growth and fruit characteristics under the shade treatment were superior to the control treatment (Yu *et al.,* 2023).

Furthermore, our findings suggest that the use of coloured shade nets can alter the quality and quantity of light, potentially influencing plant growth and the nutritional quality of crops (Singh *et al.,* 2023).

Shading is a way to control temperature by reducing light entering the greenhouse (Hesham *et al.,* 2016). The internal temperature of the greenhouse can be reduced by effectively reducing the flow of infrared rays that emit heat (Qianjun *et al.,* 2024).

Irrigation is one of the most critical factors for the success of cucumber cultivation. Providing sufficient soil moisture at essential stages of plant growth improves plant cells' metabolism and enhances the efficacy of the mineral nutrient administered to the crop. Consequently, even a slight degree of water stress can trigger detrimental effects on the crop's growth and productivity (Saif *et al.,* 2003; Adhikary and Pal, 2020).

Water scarcity leads to many physiological changes, such as changing the root-to-shoot ratio, decreasing leaf area or number of leavesand ultimately reducing plant growth and productivity. Research has consistently shown that the total amount of irrigation water, a direct indicator of water scarcity, significantly affects the fresh fruit yield of cucumber at all growth stages (Mao *et al.,* 2003).

The scarcity of water will have a substantial effect on the output of crops that will be irrigated in the future. Efficient irrigation water utilization is imperative when water supply is scarce. Various irrigation techniques have been employed on cucumber crops in agricultural greenhouses in northern China to maximize yields, produce substantial economic gainsand enhance water utilization efficiency. In a study of Liu *et al.* (2022), to evaluate the effects of drip irrigation on cucumber yield and corresponding economic benefits, local surface irrigation was used as a comparison treatment. The results unequivocally demonstrated the superiority of drip irrigation, with cucumber yields 4.3% and 3.1% higher than those under traditional irrigation, respectively. However, drip irrigation's total seasonal irrigation depth was approximately 50% less than for irrigation. the water used for drip irrigation and the economic productivity of drip irrigation was nearly 100% greater than those for traditional irrigation methods.

Drip irrigation is the best irrigation method as it efficiently uses water and allows for better control of the amount of water reaching the plant during the flowering stage. One of the advantages of drip irrigation is that the water reaches the plant directly, which saves the plant from water stress (Malve *et al.,* 2020). Drip irrigation is a globally recognized and extensively adopted irrigation method that is very efficient and conserves water. It is trendy in dry and semi-dry areas. it can enhance both crop output and quality, as well as boost water and fertilizer efficiency (Wang *et al.,* 2021; Wang *et al.,* 2018). There are two purposes for this study; (i) to investigate the impact of different shading levels on cucumbers' chemical characteristics and dry weightand (ii) to investigate the impact of various irrigation techniques on cucumbers' chemical properties and weight.

MATERIALS AND METHODS

Implementation of the experiment

A field experiment was carried out during the summer of 2022 at the demonstration farm in Balad Rose district to study the chemical characteristics and dry weight of cucumber plants under the influence of shading levels and different irrigation methods. The experiment included two irrigation methods (surface and drip). And three levels of shading (60, 45 and 30%), The study was conducted in a randomized complete block design (R.C.B.D) with a split plot arrangement where there were three replicated blocks. Each replicate included 6 treatments and the experimental unit had ten plants. During the experiment, the greenhouse's light intensity was measured according to the shading treatment (Fig 1).

Experimental design

The experiment used a randomized complete block design (R.C.B.D) with three replications following a split-plot arrangement. Every replication consists of six coefficients. The data were statistically examined using the SAS Statistical Program (ver. 2003) and the arithmetic means were compared using the Duncan multinomial test at a significance level of 0.05.

Agricultural operations

The soil service process was carried out by ploughing the land with disc harrows since the soil is gypsum, then leveling and amending the land. The field was divided into three main sectors, each sector including six treatments with 18 experimental units. The distance between the lines was 10 cm^2 and the distance between one plant and another was 40 cm. Fertilizing the field with triple superphosphate (TSP), a source of phosphorus, at a rate of 100 kg/ha. the planting process was done manuallyand nitrogen fertilizer (urea) at 46% N was added to 200 kg ha^{-1} in two batches. The water utilized for irrigation is well water. The weeds were removed manually whenever necessary. Table 1 exhibits the physical and chemical characteristics of the experimental ground.

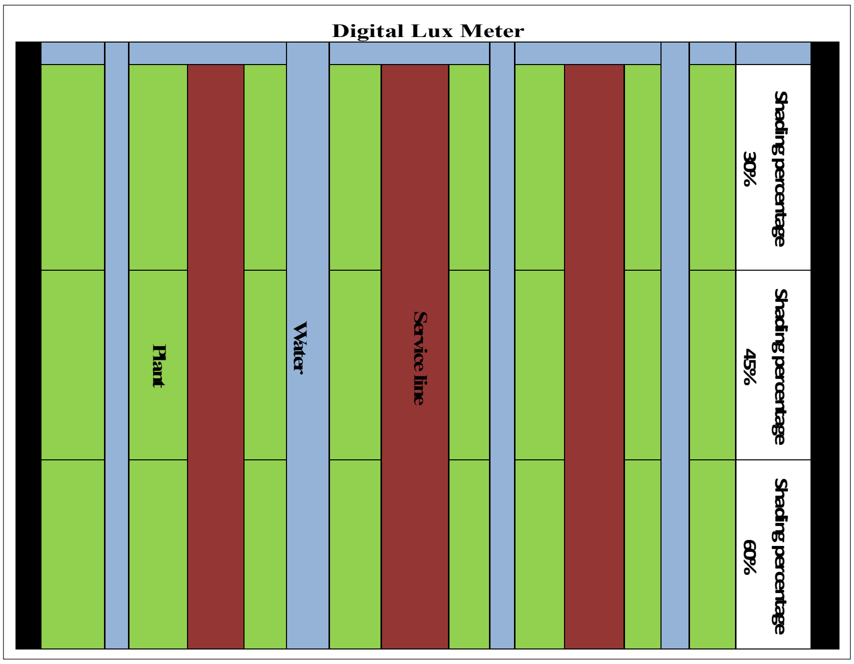

Fig 1: Measuring light intensity rates using a spectrophotometer.

The analyses of studied parameter

The percentage of nitrogen, phosphorus, potassiumand iron in the leaves (%)

The assessment of samples was conducted at the Soil and Water Resources Laboratory affiliated with the College of Agriculture at the University of Diyala. Included the procedure of taking five leaves from each experimental unit, there after placing the leaves in an electric oven at 65°C for 72 hours until a constant weight was achieved in the case of the experiment (Al-Sahhaf, 1989).

Then, they were groundand 0.2 grams of the ground sample were taken. The samples were digested by adding 4 ml of concentrated sulfuric acid and 2 ml of perchloric acid (Jones and Steyn, 1973).

The percentage of nitrogen in the leaves

Jackson (1991) described a method for estimating the percentage of nitrogen using a Micro Kjeldahl device.

The percentage of potassium in the leaves

The potassium percentage shown in the same sample as described above was analyzed by using a flame photometer based on the procedure given by Haynes (1980).

Proline acid concentration in leaves

Proline was determined with a spectrophotometer at 520 nm according to the method described in Bate *et al.* (1973).

Total chlorophyll content in leaves (mg 100 g^{-1} fresh weight)

The total chlorophyll content was estimated by mashing 5 grams of tender plant leaves in a ceramic mortar with 20 ml of 80% acetone for 5 minutes until the pigments were extracted from the tender leaves.

The absorption of light was read with a Spectrophotometer at the wavelengths of 665-645 nanometers, after which the amount of chlorophyll (mm. L^{-1}) was estimated through the following equations (Aron, 1949):

$$\text{Total chlorophyll } (mg^{-1}) = 20.2 \times D(645) - 8.02\ D\ (663)$$

Then it was converted to 100 g^{-1} fresh weight

$$100\ mg^{-1} = \frac{mg\ L^{-1} \times \text{final volume of extract (liter)}}{\text{Weight of sample (g)}} \times 100$$

Dry weight of the plant (g)

Five plants were selected and dried entirely in an electric oven at 65°C until their weight was stableand then the plant was weighed to extract its dry weight.

RESULTS AND DISCUSSION

Chemical properties and dry weight

The findings from Table 2 demonstrate that the shading levels substantially impacted the cucumber plant's chemical properties and dry weight. Specifically, the 30% and 45% shade treatments resulted in nitrogen levels in the leaves that were 0.79% and 0.73% higher, respectively. The leaves subjected to the 30% shadow treatment exhibited the most excellent phosphorus ratio, measuring 0.37%. The potassium content in the leaves reached a level of 2.60%. The chlorophyll content in the leaves is 3.88 mg per 100 grams of fresh weight and 48.06 grams of dry weight. Among the different treatments, the 60% shading treatment showed the lowest values for the characteristics. The nitrogen content in the leaves was 0.68%. The phosphorous content in the leaves reached 0.27%. The potassium content in the leaves reached a concentration of 2.43%. The chlorophyll content in the leaves is 3.17 mg per 100 g of fresh weight and 36.11 grams of dried weight.

Irrigation methods significantly affected the chemical characteristics and dry weight of cucumber plants, as the surface irrigation method was superior to the percentage of nitrogen in the leaves and reached 0.77%. the percentage of potassium in the leaves is 2.66%. The irrigation method was superior in giving the highest dry weight, reaching 43.39 grams. There were no significant differences between the irrigation methods regarding the percentage of phosphorus in the leaves and the chlorophyll content in the leaves.

Table (2) showed that the interaction between shading levels and different irrigation methods significantly affected the chemical characteristics and dry weight. The 30% shading treatment and the drip irrigation method exceeded the percentage of nitrogen in the leaves, reaching 0.81%. The percentage of phosphorus in the leaves reached 0.39%. The percentage of potassium in the leaves reached 2.76%. The chlorophyll content in the leaves is 3.98 mg per 100 grams per fresh weight. The treatment with 30% shading and the surface irrigation method recorded the highest weight of 49.23 grams. The treatment recorded a 60% shading percentage and the surface irrigation method recorded the lowest percentage of nitrogen in the leaves, reaching 0.62%. The percentage of phosphorus in the leaves reached 0.26%. The percentage of potassium in the leaves reached 2.31%. The chlorophyll content in the leaves is 3.12 mg 100 gm^{-1} fresh weight and the dry weight is 36.55 gm.

Table 1: Physical and chemical characteristics of the experimental ground.

Parameter	Value	Unit
pH	7.60	-
EC	3.43	MS
Mg	15.0	ppm
K	110.0	ppm
Ca	120.0	ppm
N	25.0	ppm
P	8.40	ppm
Na	867.0	ppm
Lime	19.0	%
Gypsum	16.0	%
Organic matter	1.10	%
sand	41.50	%
Silt	48.0	%
Clay	10.50	%
texture	Loam	-

Proline concentration in leaves (mg $plant^{-1}$)

The results of Table 3 indicated that shading levels significantly affected the proline concentration in the cucumber plant leaves, as the 30% shading treatment recorded the highest concentration, which amounted to 1.24 mg/plant. The 60% shade treatment recorded the lowest proline concentration in the leaves: 0.87 mg/plant. Irrigation methods also significantly affected the concentration of proline in the leaves of the cucumber plant, as the drip irrigation method was superior in recording the highest concentration of proline in the leaves, which reached 1.25 mg/plant. The surface irrigation method recorded the lowest concentration of proline in the leaves, 0.81 mg/plant. The interaction between shading levels and different irrigation methods led to a significant effect on the concentration of proline in the leaves. The 30% shading treatment and the drip irrigation method recorded the highest proline concentration in the leaves, reaching 1.46 mg/plant. The 60% shading treatment and the surface irrigation method recorded the lowest proline concentration in the leaves.

Table 2 shows using different irrigation methods led to significant differences in chemical characteristics and plant dry weight. The drip irrigation method excelled in terms

Table 2: Effect of chemical characteristics and dry weight of cucumber plants under the influence of shading levels and different irrigation methods.

Irrigation methods	Shading ratio	N%	P%	K%	Chlorophyll mg 100 gm^{-1} fresh weight	Dry weight gm/plant
Surface	30	0.77B	0.36a	2.45b	3.78b	49.23a
	45	0.69D	0.29c	2.39c	3.62c	44.39c
	60	0.62E	0.26d	2.31c	3.12e	36.55d
Drip	30	0.81A	0.39a	2.76a	3.98a	46.89b
	45	0.78B	0.32b	2.68a	3.77b	42.61c
	60	0.74C	0.29c	2.55b	3.22d	35.68d
Average irrigation methods	Surface	0.69B	0.30a	2.38b	3.50a	43.39a
	Drip	0.77A	0.33a	2.66a	3.65a	41.72b
Average percentage of shading	30	0.79A	0.37a	2.60a	3.88a	48.06a
	45	0.73A	0.30b	2.53b	3.69b	43.20b
	60	0.68B	0.27c	2.43c	3.17c	36.11c

According to Duncan's multinomial test, this means that taking the same letter for each factor or the interaction between them does not differ significantly (P≤0.05).

Table 3: Effect of shading levels and different irrigation methods on the proline concentration of cucumber plants.

Irrigation methods	Shading ratio	Proline mg/plant
Surface	30	1.03c
	45	0.76d
	60	0.66e
Drip	30	1.46a
	45	1.23b
	60	1.08c
Average irrigation methods	Surface	0.81b
	Drip	1.25a
Average percentage of shading	30	1.24a
	45	0.99b
	60	0.87c

According to Duncan's multinomial test, this means that taking the same letter for each factor or the interaction between them does not differ significantly ($P \leq 0.05$).

Table 4: Weekly lighting rates (candle foot-1).

	Shading ratio		
Readings	30%	45%	60%
Reading1	1086	822	546
Reading2	1088	824	548
Reading3	1067	791	515
Reading4	1067	794	518
Reading5	1059	782	506
Reading6	1065	786	510
Reading7	1066	779	503
Reading8	1049	776	500
Reading9	1047	773	497
Reading10	1049	778	502

of the percentage of nitrogen in the leaves, the percentage of phosphorus in the leaves, the percentage of potassium in the leaves, the content of chlorophyll in the leavesand the dry weight of the plant. The reason for this superiority may be attributed to the fact that drip irrigation led to the availability of water only around the plant, the plant receiving sufficient waterand the absence of the growth of harmful weeds in the planting site, which competes with the plant for nutrients and lighting, which leads to improving the photosynthesis capacity of the plant and thus absorbing and accumulating elements in the plant. Thus, increasing the percentage of nitrogen, phosphorusand potassium in the leaves (Wang *et al.,* 2012). The increase in the plant's dry weight may be attributed to the increased ability of the plant to absorb water available in the root system area and the dissolved nutrients it carries, which participate in cell division and increase cell turgor pressure (Elsahookei *et al.,* 2007). The stomata swell, leading to the continued flow of CO2 into the plant tissues. This activates the carbon synthesis process and then transports and distributes the metabolic products it supplies to the plant (Elsahookei *et al.,* 2013).

The results of Table 3 also showed that using different irrigation methods led to significant differences in the proline content in the leavesand the drip irrigation method was superior in giving the best proline content in the leaves. The reason for this superiority may be attributed to the fact that the drip irrigation method has many advantages compared to surface irrigation, including eliminating surface runoff, distributing water at the same level, High water use efficiency, flexibility in fertilization, Preventing the growth of weeds and the infection of plants with diseases (Yang *et al.,* 2023).

Table (2) showed that shading levels significantly affected vegetative growth variables. The percentage of shading exceeds 60% in terms of the percentage of nitrogen, phosphorus, potassium, chlorophylland dry weight of the plant. This superiority may be attributed to the fact that a high percentage of shading increased plant height by enhancing the photolysis of auxin (Table 4), while low lighting inhibited the photolysis of auxin (Korobova *et al.,* 2023). When shaded, the decrease in transpiration due to the decrease in leaf temperature enhanced the elongation of stem cells, leading to an increase in plant height. The increase in the number of leaves is due to low light, which led to an increase in photosynthesis and, thus, an increase in the number of leaves (Lusk, 2002; Ha. *et al.,* 2021). The increase in the number of branches is due to the 60% shading that reduced the temperature and thus increased plant activity by increasing photosynthesis (Xue *et al.,* 2023). The results of Table 3 note that shading levels significantly affected the yield variables represented by the number of fruits. This superiority may be attributed to the fact that low lighting improved the growth of female flowers under greenhouse conditions by reducing the temperature. The cucumber plant needs low temperatures ranging between 10-15°C and less than 8-10 hours (RDA, 2018a), The increase in fruit weight is because cucumber fruits swell more at night than during the dayand especially 4-5 hours after sunset, the current that transports photosynthesis products to the leaves becomes more active (RDA, 2018b).

CONCLUSION

The most important conclusions reached from the study:

1. Coverage levels significantly affected the chemical characteristics and dry weight of cucumber, as the 30% coverage level improved most of the studied characteristics.
2. Different irrigation methods significantly affected the chemical characteristics and dry weight of cucumbers, as the drip irrigation method was superior in most of the studied characteristics.
3. The interaction between coverage levels and irrigation methods significantly affected the chemical characteristics and dry weight of the cucumber, as the interaction treatment between the 30% coverage level and the drip irrigation method improved most of the studied characteristics.

Conflict of interest

All authors declared that there is no conflict of interest.

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