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EFFECTS OF IRRIGATION METHODS AND COMPOUND FERTILIZER ON THE VEGETATIVE GROWTH OF PASSION FRUIT (*PASSIFLORA EDULIS* SIMS)

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SUMMARY

The study aimed at examining the impacts of various irrigation systems on passion fruit (Passiflora edulis Sims) seedlings in addition to foliar treatments through N-P-K fertilizer (20-20-20). It was carried out in the greenhouse of the green university of Al-Qasim at Babil in Iraq between 15 September 2023 and 15 March 2024. Seedlings were planted using plastic bags with the capacity of 3 kg. The study was done under experimental design of randomized complete block design with two factors. The former factor comprised two irrigation systems, which included sprinkler and drip irrigation. The second reason was that of the foliar application of N-P-K fertilizer using three levels (0, 2, and 4 g L^{-1}). The findings indicated that there were vast distinctions in the vegetative growth characteristics under investigation such as plant height, diameter of the stem, amount of branches, amount of leaves, and content of chlorophyll. The highest values were realized with the sprinkler irrigation system in addition to a compound fertilizer (N-P-K) of a concentration of 4g/L/L when compared to the drip irrigation system and the control treatment.

Keywords: Passion fruit (*P. edulis* Sims), irrigation methods, N-P-K fertilizer, foliar fertilization, vegetative growth, chlorophyll content

Key findings: Passion fruit (*P. edulis Sims*) showed the best vegetative growth values when it was combined with the sprinkler irrigation system and NPK fertilizer. Conversely, the treatment group that applied drip irrigation and applied no supplementary fertilizer, known as control treatment, did not have as many variations in the vegetative growth as compared to the other treatment groups.

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INTRODUCTION

Passifloraceae Passion fruit is an evergreen fruit that is a member of the Passifloraceae family. It is native to Brazil and northern Argentina which are tropical climates. Passionflower fruit, or passion fruit, which is also commonly referred to as passion fruit, is similar to grapes in a number of ways due to its ability to climb. It is also attractive with its good flowers. The passion fruit has a pleasant smell and taste. It is abundant in vitamins A, C and D. However, it has recently grown in popularity in Arab nations such as Iraq because of favorable climatic conditions. The best period of planting passion fruit is early March until the first half of April. This plant does not need a lot of water to be watered so it is also environmentally friendly since it does not need many irrigations in a week during winter seasons and it can survive even in desert areas. Passion fruit should also be planted where there is a shaded part of the day especially in areas with very hot summers (Paull and Duarte, 2010; Schotsmans and Fischer, 2011; Corrêa *et al.*, 2016).

The recent climate changes, which include drought and high temperature, have necessitated the need to identify viable methods and alternatives in the control of irrigation water to be used by plants. As noted by Tawfiq *et al.* (2021), sprinkler irrigation is an important and viable technique that has an economic advantage. To achieve the best water usage through irrigation, it is important to adopt modern irrigation systems and methods that are deemed safe and necessary, especially considering that there is a growing demand of irrigation water due to the changing environmental conditions. Sandy soils, especially, lack the capacity to retain water and therefore, sprinkler and drip irrigation are particularly effective in them (Albaji *et al.*, 2014).

Greeshma et al. (2023) indicated that in order to concentrate on sustainable production, they would use the other irrigation systems rather than the traditional irrigation method in the optimal and standardized utilization of water. Drip irrigation directly sprinkles water to the plants at the bottom in small frequent doses. It increases the efficiency of use of water and encourages the development of plants and particularly fruit bearing plants (Taha and Khalifa, 2024).

Passion fruit cultivars with different periods of irrigation significantly affected yield and fruit quality (Rao *et al.*, 2013). Micro-sprinklers and drip irrigation systems are indeed highly effective methods for delivering water with precision to crops, such as passion fruit. These techniques allow for better control of water distribution, ensuring plants receive the correct amount of moisture without over- or under-watering, which is crucial for optimizing crop yield and quality (Carr, 2013).

Similarly, understanding to enhance these systems must be carried out at a pace where the research is in light of the continuous growth of the world's population and concerns about food security. Accordingly, important and increasing special procedures take place to develop strategies to enhance food production (McDougall *et al.*, 2019). Fruit seedlings need supplication with food enriched with the necessary nutrients in moderate quantities to grow normally and compensate for soil fertility, especially young seedlings growing in pots, as they need essential nutrients in the form of fertilizers and chemicals (Shahbani *et al.*, 2022). In passion fruit, dry soil conditions led to poor fruit set, premature fruit, fruit drop, and defoliation, therefore reducing quality and yield.

Nitrogen is one of the most important basic elements plants need, as its role lies in accelerating and stimulating the vegetative growth of the plant and enhancing and strengthening the root system (Leghari *et al*., 2016). Al-Allaf and Hadeed (2020) explained that treating various fruit seedlings with chemical fertilizers has significant effects on the characteristics of vegetative growth and improves their development. According to Mehta *et al.* (2016), N-P-K fertilizer (250 g of N-P-K) has been added to the soil, which has contributed positively to the passion fruit plant. It caused significant increase in the height of plants, increase in the number of branches and leaves.

A research by Maulana (2024) established that treatment of passion fruit plants by application of potassium chloride fertilizer at the rate of 1.5 gm per plant had a significant positive impact on the development of the plant. The outcome of this treatment was a higher plant growth, increased leaf width, and increase in leaves. Lima *et al.* (2023) demonstrated that the sprinkler irrigation of passion fruit with two potassium (K2O 207 and 345 g plant^{-1}) levels gave a dramatic outcome of the percentage of chlorophyll and nutrient concentrations in the leaves. This study was intended to examine the potential of modifying the passion fruit plant to suit the environment of Iraq and how various irrigation and fertilization strategies would impact on the growth of the plant.

MATERIALS AND METHODS

The presented study on passion fruit began on September 15, 2023, and continued until March 15, 2024, in the greenhouse at the Al-Qasim Green University, Babil, Iraq. The research aimed to study the effect of different irrigation methods and foliar application of N-P-K fertilizer treatments on the vegetative growth of passion fruit seedlings. Seedlings' selection depended on the accurate similarity in growth strength and the age of six months. Service operations progressed for weeding and pesticide treatment of the leaf miner insect, with the seedlings identified by placing digital marks that determine the extent of the treatment used, with three replicates, and each replicate had six treatments. The distribution of seedlings was random within the design of complete random sectors. Comparing the arithmetic averages at a significance level of 0.05 used the Genstat software, as the experiment was factorial with two factors. The first factor was irrigation methods, using two methods. The first was the sprinkler irrigation method, and the second was the drip irrigation method, with the procedure as follows:

The use of the sprinkler irrigation method occurred twice a week during autumn-winter and as the plant requires as temperatures dictate in the greenhouse, especially when the weather is warm. As for spring, spraying was 3–4 times per week. The other method is drip irrigation, where in autumn-winter, it had a rate of one liter per seedling twice a week, also according to the plant's need. During spring, irrigation was 3–4 times per week.

The second factor is spraying with the compound fertilizer (N-P-K: 20-20-20) at three concentrations (control 0, 2, and 4 g L^{-1}). Spraying ensued using a hand sprayer in the early morning with the addition of a bright substance to form a foam that prevented or reduced the evaporation loss of the fertilizer sprayed on the plant. Five spraying dates comprised the following: first spray on September 15, 2023; second spray on October 15, 2023; third spray on November 15, 2023; fourth spray on March 15, 2024; and fifth spray on April 15, 2024. These five sprays happened one spray in the middle of each month from September to November. No spraying took place in January and February due to the plant's dormancy period. Spraying resumed once in March and April.

Data recording commenced after one month of the last spray, at the end of the season, to study the average increase of seedling height (cm). The seedling height measurement used a metric tape from the soil surface to the top of the seedling stem, with the average extracted for each experimental unit. The average increase in stem diameter (mm) of the seedlings, as measured, utilized a Vernier caliper at 5 cm above the soil surface, taking the average for each treatment. The mean increase of the total number of branches (branch plant^{-1}) of lateral branches on the main stem of each seedling underwent calculation before getting the average. The total number of leaves (leaf plant^{-1}) average increase for each seedling sustained estimation before averaging the number of leaves for each experimental unit. Measuring the total chlorophyll content of leaves (SPAD) employed an electronic device called SPAD.

Table 1. Effect of irrigation methods, concentration of the compound fertilizer, and their interactions on plant height of the passion fruit plant.

Irrigation methods	Compound fertilizer (g L^{-1})			Means (cm)
	0	2	4	
Sprinkler	77.33	97.00	122.33	98.89
Drip	75.00	92.67	118.67	95.44
Means (cm)	76.17	94.83	120.50	
$LSD_{0.05}$	Irrigation methods	N-P-K fertilizer	Interaction	
	2.825	3.460	4.893	

Table 2. Effect of irrigation methods, concentration of the compound fertilizer, and their interactions on the stem diameter (mm) of the passion fruit plant.

Irrigation methods	Compound fertilizer (g L^{-1})			Means (mm)
	0	2	4	
Sprinkler	1.27	1.56	1.91	1.58
Drip	1.30	1.49	1.87	1.55
Means (mm)	1.28	1.53	1.89	
$LSD_{0.05}$	Irrigation methods	Compound fertilizer	Interaction	
	2.029	0.035	0.050	

RESULTS

Seedling height

The results revealed significant differences in the passion fruit plant's plant height rate with various irrigation methods (Table 1). The sprinkler irrigation method was superior and gave the highest rate of seedling height (98.89 cm) compared with the drip irrigation (95.44 cm). One of the most popular tools is sprinkler irrigation that emulates the natural rain by scattering water over crops in the form of small droplets. It is a good and efficient method of irrigating the fields particularly those crops like passion fruit that demand constant and regulated supply of water (Rigden, 2011). Similarly, the rate of this characteristic was greatly influenced by the spraying with the compound fertilizer as concentration of 4 g L^{-1} was the best giving the highest rate of 120.50 cm as compared to the control treatment where the lowest rate was 76.17 cm. The incorporation of potassium and nitrogen fertilizers in effect has a definite and significant impact with regard to augmenting the grain production of plants. These nutrients increase crop production by enhancing the development of healthy vegetation and enhancing nutrient absorption, thus turning them important in the incorporation of fertilization plans to ensure the realization of maximum crop yields in crop production (Hasaen *et al.*, 2019).

Regarding the association between the irrigation technique and N-P-K fertilizer, the findings in the same table indicated there was a major impact on the rate of plant height characteristics. The tallest rate was 122.33 cm given by sprinkler irrigation method with the concentration of 4 g L^{-1} of the compound fertilizer than the drip irrigation method of control treatment that had the lowest rate of 75.00 cm. The findings of the study by Sezen *et al.* (2011) indicated a relatively higher role of the amount of irrigation in establishing the seed and oil production of sunflower crops compared to the approach of method of irrigation application (sprinkler irrigation regimen or drip irrigation regimen). Nonetheless, in another study the analysis of drip irrigation mentions a number of significant benefits over the sprinkler irrigation when basing on efficiency, water conservation, yield, and economic returns (Keeratiurai, 2013).

Stem diameter

The results showed irrigation methods notably affected the stem diameter rate (Table 2). The sprinkler irrigation method appeared superior with the highest rate, which reached 1.58 mm, compared with the drip irrigation, giving the lowest rate of 1.55 mm. Moreover, spraying with N-P-K fertilizer had a significant effect on the stem diameter rate, as the concentration of 4 g L^{-1} was supreme with the highest rate of 1.89 mm. Meanwhile, the control treatment provided the lowest rate for this trait, which reached only 1.28 mm. As for the results of the interaction between the two experimental factors in this table, they exhibited a noteworthy influence on the rate of said trait, as the sprinkler irrigation method and the concentration of 4 g L^{-1} of compound fertilizer emerged superior. They gave the premiere rate of 1.91 mm versus the same sprinkler irrigation method for the control treatment, resulting in the lowest rate of 1.27 mm. However, the results of a two-year experiment done by Mankotia and Sharma (2024) demonstrated a positive impact of drip irrigation and fertigation schedules on enhancing fertilization efficiency, improving vegetative growth, increasing leaf nutrient content, and boosting apple yield.

Total number of branches

The outcomes expressed that irrigation methods have nonsignificant effects on the average number of branches (Table 3). However, the compound fertilizer treatment has a considerable effect on the average of this trait, as the concentration of 4 g L^{-1} was superior, providing the highest rate of 5.16 branches $plant^{-1}$, compared with the control treatment. The latter gave the lowest rate of 2.26 branches $plant^{-1}$. Notably also from this table, a significant change between the two experimental factors existed, as the sprinkler irrigation method and the compound fertilizer concentration of 4 g L^{-1} supplied the ultimate average number of branches, which amounted to 5.30 branches $plant^{-1}$, compared with the drip irrigation method for the control treatment. It gave the lowest rate of 2.10 branches $plant^{-1}$. The guide, which has been completed, detailed the requirements for growing passion fruit, along with how soil type impacts the irrigation and fertilization methods (Rigden, 2011).

Leaves per plant

The findings revealed that irrigation methods had a significant effect on the number of leaves in passion fruit (Table 4). The sprinkler irrigation method was superior and gave the highest rate, which reached 35.56 leaves $plant^{-1}$. Compared with drip irrigation, it displayed the lowest rate, which reached 33.33 leaves $plant^{-1}$. Spraying with compound fertilizer also significantly affected the rate of said trait, as the concentration of 4 g L^{-1} was outstanding and provided the maximum rate, reaching 44.33 leaves $plant^{-1}$, while the control treatment gave the lowest rate for this trait, reaching 25.00 leaves $plant^{-1}$. Concerning the correlation of interaction between the irrigation method and the compound fertilizer, the findings in this table suggested a large size of influence on the frequency of leaf count. The spray irrigation method and the concentration of 4 g L^{-1} of compound fertilizer were exceptional, with the highest rate, reaching 45.00 leaves $plant^{-1}$, versus the drip irrigation method for the control treatment, with the lowest rate at 23.67 leaves $plant^{-1}$. A study by Nabayi *et al*. (2022) compared two different irrigation systems, and the results illustrated that overhead sprinkler irrigation for large-scale production was more effective than drip irrigation in the case of a small-scale due to plant interactions and water waste in a sprinkler system.

Total chlorophyll content

The results showed irrigation methods had a remarkable influence on the rate of chlorophyll content in passion fruit leaves (Table 5). The sprinkler irrigation method was superior, with the highest rate, reaching 37.00 SPAD, compared with drip irrigation, with the lowest rate at 35.51 SPAD. Furthermore, spraying with compound fertilizer significantly altered the rate of said trait, where the concentration

Table 3. Effect of irrigation methods, concentration of the compound fertilizer, and their interactions on the number of branches per plant of the passion fruit.

Irrigation methods	Compound fertilizer (g L^{-1})			Means (#)
	0	2	4	
Sprinkler	2.43	3.96	5.30	3.90
Drip	2.10	3.39	5.03	3.68
Means (#)	2.26	3.93	5.16	
$LSD_{0.05}$	Irrigation methods	Compound fertilizer	Interaction	
	N. S	0. 318	0.450	

Table 4. Effect of irrigation methods, concentration of the compound fertilizer, and their interactions on the leaves per plant of the passion fruit.

Irrigation methods	Compound fertilizer (g L^{-1})			Means (#)
	0	2	4	
Sprinkler	26.33	35.33	45.00	35.56
Drip	23.67	32.67	43.67	33.33
Means (#)	25.00	34.00	44.33	
$LSD_{0.05}$	Irrigation methods	Compound fertilizer	Interaction	
	3.201	3.921	5.545	

Table 5. Effect of irrigation methods, concentration of the compound fertilizer, and their interactions on the leaf chlorophyll content of the passion fruit plant.

Irrigation methods	Compound fertilizer (g L^{-1})			Means (SPAD)
	0	2	4	
Sprinkler	29.10	37.33	44.57	35.00
Drip	27.97	35.67	42.90	35.51
Means (SPAD)	28.53	36.50	43.73	
$LSD_{0.05}$	Irrigation methods	Compound fertilizer	Interaction	
	1.372	1.681	2.377	

of 4 g L^{-1} was superior, giving the uppermost rate, reaching 43.73 SPAD. Meanwhile, the control treatment gave the lowest rate for this trait, reaching only 28.53 SPAD. As for the bilateral interaction between the irrigation method and the compound fertilizer, a significant superiority was evident for this trait (Table 5), as the sprinkler irrigation method and the concentration of 4 g L^{-1} of compound fertilizer outperformed and gave the highest rate, which reached 44.57 SPAD, compared with the drip irrigation method for the control treatment. The latter provided the lowest rate, which reached 27.97 SPAD. The majority of farmers (44%) irrigated their passion fruits once per week using drip irrigation, while 34% utilized alternative water sources, such as streams, and employed methods like overhead sprinklers. Water pans also proved to be a common source of irrigation water (Mwirigi, 2019).

DISCUSSION

The enhancing of the vegetative growth characteristics that were examined in the experiment (Tables 1 to 5), i.e., plant height, stem diameter, number of branches, number of leaves, and leaf chlorophyll content, can be attributed to the use of modern irrigation methods, i.e., sprinkler and drip irrigation, which provide the plant with the maximum benefits, therefore, increasing growth and making it as equal as possible. This goes hand in hand with what Rao et al. (2013)

validated about the significance of applying alternative irrigation methods to fruit plants as an alternative to the common ones, such as drip irrigation because it has numerous characteristics. These findings are in line with the results of Al-Absi (2008), as he stated the use of drip irrigation is vital to understand the actual discharge of the dripper used and that the water distribution in the field is even to have a positive impact on the physical properties of the soil and the characteristics of growth of the plant. It was also consistent with Rao et al. (2013) who described in their research how irrigation can affect passion fruit, as it is a plant, which loves water due to its origin form of a humid tropical climate. In the experiment that was conducted to establish the impact of irrigation and nitrogen on passion fruit, Rao et al. (2014) established that increasing the levels of irrigation and nitrogen level produced the desired result of growth and efficacy of water use in irrigation.

The increase in the above characteristics refers to the effect of spraying with compound fertilizer on the role of nutrients in various metabolic processes, as nitrogen and phosphorus enter into the construction of most cell membranes, especially chloroplasts. This enhances the efficiency of carbon metabolism, thus boosting the rate of production of carbon skeleton materials, in addition to the role of potassium in increasing carbohydrate materials, which agrees with the study of Al-Allaf and Hadeed (2020) on fruit seedlings.

The presented study aimed to show the effect of using different irrigation methods, including sprinkler and drip irrigation, to compare them for efficiency and economic feasibility. Furthermore, the research synchronized with the role of foliar fertilization with compound chemical fertilizer (N-P-K) in improving the vegetative growth of fruit seedlings, especially new tropical ones in the area. This included passion fruit, which has adapted to the climate and conditions of Iraq, for water shortage and high temperatures during the seasons.

CONCLUSIONS

Researchers found sprinkler irrigation systems have major advantages, such as high watering efficiency, high vegetative growth, and less water use, therefore saving water during the vegetative growth of passion fruit in the studied stage. Besides, adding NPK fertilizer supports the plant by providing mineral nutrients at the right level, with the plan to test the two major irrigation systems in open-field conditions to validate the results.

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