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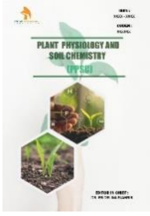

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RESEARCH ARTICLE

EFFECT OF IRRIGATION INTERVALS ON THE GROWTH, YIELD AND FRUIT QUALITY OF LEMON *(CITRUS LIMON* L.)

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ABSTRACT

This investigation was conducted at Bangladesh Agricultural University Germplasm Center (BAU-GPC) in order to find out the effects of irrigation intervals on the growth, yield, and fruit quality of lemon (cv. BAU lebu 3). A single factor experiment was carried out following randomized complete block design with three replications. The treatments were T_0 (no irrigation), T_1 (regular irrigation), T_2 (Irrigation at 15 days intervals), T_3 (Irrigation at 30 days intervals) and T_4 (Irrigation at 45 days intervals). Ten litters of water per plant was applied during each irrigation cycle. T_1 showed the best performance in respect to leaf length (5.36 cm), leaf breadth (4.86 cm), fresh weight of leaves (6.56 g), %moisture of leaves (80.91%), leaf relative water content (RWC) (79.63%), the lowest days to first flowering (21.66 days), total number of flowers/plant (53.66), the lowest days to first fruiting (6.00 days), number of fruits/plant (37.33), the least %dropped fruits/plant (15.83%), fruit length (7.90 cm), fruit breadth (5.36 cm), fruit fresh weight (131.09 g), yield (4.9 kg), fruit moisture content (82.00%), titratable acidity (TA) (5.69%), juice content (34 ml), the lowest peel thickness (1.8 mm). Since, T_2 treatment performed statistically similar results with T_1 in most of the traits and it reduces the water use thus reduce the production cost than T_1 treatment. Therefore, it can be concluded that T_2 (irrigation at 15 application days intervals) would be optimum for lemon production.

KEYWORDS

Irrigation intervals, RWC, Moisture content, Vitamin C, Juice content.

1. INTRODUCTION

In Bangladesh, the lemon (Citrus limon L.), a member of the Rutaceae family, is one of the most popular and high-quality citrus. It is also known by several vernacular names such as kagozi lebu, pati lebu in different parts of the country. It is popular for its taste, nutritional status and various uses. Lemon thrives well in tropical and warmer sub-tropic parts of India (Blanco et al., 1989). It is typically cultivated in the tropical rain forests of southern China, Cochin, and the Malay Archipelago. Although it originated in tropical regions, the lemon performs best in subtropical environments (Bose et al., 2001). The plant is widely cultivated in Bangladesh and India (García et al., 2003). It ranks thirteenth in world fruit production (WorldAtlas, 2020). The soil and climate conditions of the winter season of Bangladesh are congenial for lemon cultivation because it can survive precisely under 20-25°C temperature.

In general, the people of Bangladesh are dehydrated, not only due to a lack of proteins and caloric, but also due to a lack of different vitamins, especially vitamin C, and essential minerals, such as calcium and iron. If the people of Bangladesh had adequate access to fruits, which are generally recognized as being rich in vitamins and minerals, all of these malnutritional conditions could have been greatly mitigated. It is estimated that 93% of the population of Bangladesh is deficient in vitamin C (Morianou et al., 2021), which, unlike vitamins A, D, and E, cannot be retained in the body and must be consumed daily. Lemon is an essential form of vitamin C that is widely available in Bangladesh and can help alleviate malnutrition issues. Lemon contains a high value of citric acid, helping with digestion and has medicinal uses.

In comparison to other citrus-producing countries around the world, Bangladesh ranks very low in terms of citrus produce production. According to available statistics, the total area planted with these fruits in 2020 will be 4,083 hectares, with a total production of 1,711,104 tonnes (Knoema, 2020). Bangladesh is ideally suited for the cultivation of a variety of citrus products. In semi-arid and arid environments all over the world, water scarcity is becoming an acute problem, lowering the abundance of agricultural water and land resources. Deficit irrigation strategies can increase efficiency in water use and the sustainability of agroecosystems, but they must be used to reproduce the effects of yield loss caused by irrigation water restrictions. Research estimates the water production value of citrus trees by creating a mathematical model for each phenological stage (flowering, fruit growth, and maturation) and the entire production process (Ivan et al., 2012). Under drought conditions, a gradient of water potentials develops between the soil-root interface and the transpiring organ, the leaf, as a result of the excess demand for water caused by atmospheric or soil conditions. Stress caused by drought does not manifest abruptly, but rather develops gradually and grows gradually. In the words of arid stress causes an increase in solute concentration in the adjacent environment, resulting in an osmotic migration of water from plant cells (Hota et al., 2017).

The quantity of water received during growing seasons has an important effect on fruit yield. When plants are deprived of adequate water, growth is delayed, immature fruits are lost, and mature fruit lacks sugar and quality (Zhong et al., 2019). Additionally, vegetative growth is diminished, limiting the number of new fruiting branches. The improper development of the roots and foliage effects the number and size of the produce. During flowering and fruit formation, adequate water is especially crucial for a

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plant's productiveness. According to the existence of water deficits over 33 percent during the periods of bloom, fruit set, and bumped vegetative development in the spring leads to a reduction in yield (Selahvarzi et al., 2017). However, it is shown that shortfalls of up to 66 per cent may be tolerated throughout the summer, autumn, and winter seasons. This study was undertaken to find out the effect of irrigation intervals on physiological and biochemical traits of lemon.

2. Materials and Methods

2.1 Experimental site

The study was carried out during November 2021 to April 2022 at the Germplasm Centre of the Bangladesh Agricultural University. The experimental site is located between 24.46°N latitude and 90.24°E longitude and having altitude of 18m from sea level. The experimental area of BAU-GPC was under a subtropical climate, which is characterized by heavy rainfall during the months from April to September and scanty rainfall during the rest of the time of the year.

2.2 Soil

The soil in the experimental location had a silty loam texture and was classified as belonging to the ancient Brahmaputra Flooded Plain within Agro-ecological Zone-9. This particular soil type originates from ancient Brahmaputra deposits and is characterized by non-calcareous dark grey floodplain soil, as described by FAO and UNDP in 1988. The specified plot of land had a moderate elevation. The experimental location had a subtropical climate, which was distinguished by abundant rainfall, elevated humidity, high temperatures, and extended daylight hours spanning from April to September. Conversely, the period from October to March saw limited precipitation.

2.3 Planting material and design of the experiment

The variety BAU lebu 3 was used for the present investigation. There were five-six years old plants were selected for investigation from BAU Germplasm Centre (BAU-GPC). The plants were cleaned mostly by pruning the old leaves before starting the experiment. Thus, the plants became ready for investigation in the field. The current investigation comprised of a single-factor experiment (irrigation intervals) with five conditions and three replications. The five treatments are listed below:

T0= Control (-), T1= Control (+) regular irrigation, T2= Irrigation at 15 days intervals with 10 L of water/plant, T3= Irrigation at 30 days intervals with 10 L of water/plant, T4= Irrigation at 45 days intervals with 10 L of water/plant

First irrigation was applied in every excepted T0 treatment. The plants under T0 treatment were not irrigated (negative control). Irrigation was applied regularly (2-3 times a week) under T1 treatment.

The land had been thoroughly prepared. Each plant's margins were thoroughly cleansed and higher with soil. On the experimental allotment, the following amounts of organic and inorganic fertilizer were applied: Cowdung: 100 kilograms; Urea: 100 grams; DAP: 100 grams; MOP: 60 grams; Boron: 10 grams; Zinc: 3 grams. Approximately fifty per cent of all organic and inorganic fertilizers were administered during the preparation of the land. The balance of nutrients was administered during the fruiting period (BARC, 2018).

The single factor experiment used a randomized complete block design, with three replications. Each block consisted of five separate properties. As a result, the aggregate quantity of plants amounted to 15. The determination of plant spacing was influenced by the various treatments used.

2.4 Intercultural operation

When necessary, weeding was performed to maintain the field free of plants. During rainy days the excessive rainwater was protected by polythene sheets and drained out. The canopy area of plants was approximately 2m×2m. Thus, the base of the plants was covered by polythene sheets (2m×2m) on rainy days. All treatments, including T1 (+ control), were covered with polythene sheets on days when it rained. As a preventive measure against insect pest (Lemon butterfly), Monocrotophos was applied @1.5ml/litre of water at vegetative and reproductive stages. Also, for scale insects, Hard armoured scales are difficult to manage (Krishisewa, 2013). Different diseases of citrus such as scab were found which was controlled by spraying Dithane M-45, Tilt or Bordeaux mixture twice a month on sunny days.

2.5 Data collection

The growth, yield, and generate quality-related parameters of lemon from the sample plants were recorded. During the research, three fruits were randomly selected from each plant. Selected plants have been evaluated for all parameters, and average values were calculated.

2.5.1 Methods

Various first flowering dates were documented. The observation was then computed, starting from the date of the first irrigation. It was considered in conjunction with the flowering process of the flower. The mean number of flowers per plant was determined by conducting a count of the total number of blooms on each individual plant during the blooming period. Flowering period was observed and noted. Different dates of first fruiting were recorded, and then the date of first flowering was used to calculate the observation. Using a digital scale, the fresh weight of foliage from each treatment and replication was recorded in grammes (g). Leaf samples from the plant were collected and subjected to desiccation in an oven set at a temperature of 70°C for a duration of 72 hours. This process was carried out before calculating the consistent dry weight of the leaves. The measurement of the dry weight was conducted using a digital scale, with the unit of measurement being grammes (g). The moisture level of the leaves was calculated using the provided formula. The numerical representation was denoted as a percentage (%).

$$\text{Moisture content of leaves} = \frac{\text{Leaves fresh weight (g)} - \text{Leaves dry weight (g)}}{\text{Leaves fresh weight (g)}} \times 100$$

The following formula was used to determine the leaf's dry matter content. The value was expressed as a percentage (%).

$$\text{Dry matter content of leaves} = \frac{\text{Dry weight (g)}}{\text{Fresh weight (g)}} \times 100$$

The relative water content of the leaf was identified using the following formula. (Botanica et al., 1999) expressed it as a percentage (%).

$$\text{Leaf relative water content} = \frac{\text{Fresh weight (g)} - \text{Dry weight (g)}}{\text{Turgid weight (g)} - \text{Fresh weight (g)}} \times 100$$

In the morning, five fresh green leaf samples have been collected from each plant of the same age, and the chlorophyll index was measured with a (Force A, DX 18021, France) reading machine, and an average value was recorded. The measurement of leaf length was conducted in cm, starting at the base of the leaf and extending to the tip, with a standardised measuring scale. The leaf exhalation was also measured with a measuring scale and expressed in centimetres. The average of the fruits per plant was then calculated for each plant and recorded. The number of shaded fruits per plant for each plant, as well as the mean amount of shaded fruits produced by each plant, were recorded, and their average percentages were calculated. The length of the fruit was determined by using slide callipers to measure the distance between the fruit's neck and based on five randomly selected fruits from every plant and averaging the results. The fruit's length was obtained in centimetres (cm). The diameter of the fruit was estimated by averaging the widths of five randomly selected fruits from each plant that were measured using slide callipers. The fruit's breadth was measured in centimetres (cm). Each treatment's fruits were harvested at the green-mature stage. Three to four harvests were performed. The raw weight of the produce was determined using a digital scale and expressed in grams. The whole weight of the produce was determined. The average plant weight was calculated and expressed in kilogrammes per plant. Using the following formula, a percentage of lemon's moisture level was calculated.

$$\text{Moisture content} = \frac{IW - FW}{IW} \times 100$$

On the basis of the data gathered during the estimation of the lemon's moisture content, the percentage of dry matter was assigned using the following formula.

$$\text{Dry matter} = \frac{\text{Dry weight (g)}}{\text{Fresh weight (g)}} \times 100$$

After fruit cross-sectioning, peel thickness was measured with slide callipers and expressed in millimetres. Using a digital refractometer, It was used to estimate the Total Soluble Solids (TSS) content of lemon juice (Ranganna, 1977). The ascorbic acid content was determined using (Plummer, 1971)'s method. Ranganna stated lemons' calculable acid content (Ranganna, 1977). Jayaraman specified the total sugar content of citrus using the Anthrone calorimetric method (Jayaraman, 1981). Miller used the dinitrosalicylic acid method to determine the reduction of citrus sugar content (Miller, 1959).

2.6 Statistical Analysis

The data were subjected to statistical investigation using STATISTIX version 10 software. The F test was used to do analyses of variance (ANOVA) on all of the variables. In their study, a group researchers used the LSD test to discern the statistical significance of the disparity between the means at the 5% and 1% levels of probability (Gomez et al., 1984).

3. Results and Discussion

The study aimed to determine the impact of varying irrigation intervals on the growth, productivity, and quality of lemon crops. In our nation, different irrigation intervals are used just for the production of agricultural products. In this endeavour, therefore, various irrigation intervals are used for yielding lemons in an equitable way.

3.1 Plant growth of lemon influenced by irrigation intervals

The frequency of watering had a significant impact on the majority of days it took for each lemon plant to develop its first flower. The control group (T0) exhibited the most favourable total of days necessary for the first blooming single plant, with an average of 33.65 days. The bare minimum quantity of days necessary for first blooming one plant was found to be 21.66 in T1 (+ control) (Table 1). Skewes saw an analogous result in their empirical study (Skewes, 2013). According to their results, the use of enhanced irrigation practices resulted in a reduction in the number of days required for the onset of blooming.

The aggregate amount of lemon blossoms per plant was greatly influenced by the frequency of irrigation. The use of irrigation multiplied all kinds of flowers. T1 (+ control) had a staggering total of 53.66 flowers per plant. T0 (- control) had the fewest total flowers per plant (31,0) according to Table 1. These results align with those of (Barbera et al., 1988). The preponderance of water constraints risen flower production in citrus plants, they discovered.

Due to varying irrigation intervals, the proportion of days to first fruiting varied markedly. T0 (- control) had a majority of days to first produce per plant (12.33 days). In comparison, T1 (+ control) in Table 1 had a brief period of first flowering per plant (6.0 days). This result was consistent with that of (Hasan et al., 2016). They noted that as irrigation intensified, the proportion of days until first fruiting decreased steadily.

The fresh weight of foliage for each plant varied significantly based on irrigation frequency. As seen in Table 1, T1 (+ control) had the most fresh weight of foliage in a plant (6.56 g), as T0 (- control) had the least (5.94 g). These findings correspond to those of (Hota et al., 2017). The preponderance of water stressors increased the leaf fresh weight of citrus plants, whereas arid stress weakened the leaf fresh weight.

The leaf dry weight per plant varied substantially across the various irrigation intervals. T0 (- control) had the greatest amount of desiccated foliage on a single plant (2.27 g), while T1 (+ control) had the least amount (1.25 g). These results align with those of (Mohamed et al., 2018). They verified that a great deal of water stress decreased the leaf dry weight of citrus plants, whereas drought stress evolved leaf dry weight.

The percent moisture content of leaves per plant significantly varied with the different irrigation intervals. T1 (+ control) had the maximum percent moisture content of leaves per plant (80.91%) and the mimimum percent moisture content of leaves per plant was found (61.83%) in T0 (- control) given in Table 1The outcomes discovered are consistent with those presented by (Mohamed et al., 2018). The researchers revealed that almost all of the water deficits resulted in a reduction in the moisture content of leaves per lemon plant.

The proportion of dried matter in the leaves of each plant varied significantly with irrigation interval. In Table 1, T0 (- control) had the most significant dry matter content of leaves per plant (38.16%) and T1 (+ control) had the lowest dry matter content of leaves (19.09%). The results reported align with those of (Mohamed et al., 2018). However, drought impacts upped the dry matter content according to plants in the leaves.

The relative leaf levels of water within each plant's foliage fluctuated considerably with irrigation interval. T1 (+ control) had the highest overall leaf-relative water content of foliage per plant (79.63%), whereas T0 (- control) had the lowest (67.72%) (Figure 1). These findings are consistent with findings (Mohammed et al., 2018). The majority of water stresses increased the relative water content of lemon leaves pursuant to plants, whilst drought stress decreased this value. A group researchers reported that leaf RWC declined with increasing the soil drying condition while drought tolerant genotype maintain higher RWC during soil drying condition (Hossain et al., 2015; Hossain et al., 2014).

The irrigation intervals used in this experiment greatly impacted the leaf chlorophyll index of leaves per plant, with the maximum leaf chlorophyll index per plant appearing at T0 (- control) and the minimum occurring at T1 (+ control) (Figure 1). In their field study, they noticed identical findings (Hota et al., 2017). They discovered that most water stressors decreased the leaf chlorophyll index per plant in citrus, yet dry stress boosted the index.

Table 1: Effects of treatments on days to first flowering, total number of flowers per plant, days to first fruiting, fresh weight of leaves, dry weight of leaves, percent moisture content of leaves and percent dry matter content of leaves of lemon.

Treatments	*Days to first flowering (days)*	*Total number of flowers per plant*	*Days to first fruiting (days)*	*Fresh weight of leaves (g)*	*Dry weight of leaves (g)*	*Moisture content of leaves (%)*	*Dry matter content of leaves (%)*
T_0	33.65	31.00	12.33	5.94	2.27	61.83	38.16
T1	21.66	53.66	6.00	6.56	1.25	80.91	19.09
T_2	23.66	50.67	6.33	6.36	1.31	79.43	20.56
T_3	27.67	40.00	10.00	6.04	1.55	74.31	25.69
T_4	28.65	38.33	11.66	6.04	1.75	70.97	29.02
LSD (0.05)	4.53	6.13	1.49	0.58	0.23	2.62	2.62
LSD (0.01)	6.59	8.93	2.18	0.85	0.33	3.81	3.81
Level of significance	**	**	**	*	**	**	**

**=Significant at 1% level of probability, *= Significant at 5% level of probability

Differences in irrigation frequency greatly influenced the leaf length distribution. The maximum leaf length plant (5.36 cm) was found in T1 (+ control). Whereas, the minimum leaf length per plant (4.23 cm) was found in T0 (- control) (Table 2). Due to regular irrigation of plants, leaf length increased and leaf length decreased due to no irrigation. This result corresponded with that of (Hota et al., 2017). They saw that with more water, the leaves grew longer.

Variations in irrigation frequency greatly influenced the leaf width distribution. The maximum leaf breadth plant (4.86 cm) was found in T1 (+ control). Whereas, the minimum leaf breadth per plant (4.02 cm) was found in T0 (- control) (Table 2). Due to regular irrigation to plants, leaf breadth increased and breadth decreased due to no irrigation. This result coincided with that of (Hota et al., 2017). They reported that leaf width gradually grew as irrigation escalated.

Different irrigation intervals influenced the fruit length per plant which was significant. The longest fruit length per plant (7.90 cm) was measured in T1 (+ control) and the shortest fruit length per plant (6.77 cm) was found in T0 (- control) (Table 2). This result matched with the conclusion reached (Goramnagar et al., 2018). In their field experiment, a group of researchers realized identical outcomes (Tarim et al., 2020). They reported that fruit length per plant increased steadily as irrigation was increased.

Different irrigation intervals influenced the fruit breadth per plant which was significant. The longest fruit breadth per plant (5.31 cm) was measured in T1 (+ control) and the shortest fruit length per plant (3.88 cm) was found in T0 (- control) (Table 2). This result corresponded with that of Tarim et al. (2020). In their field investigation, Hilgeman observed a similar outcome (Hilgeman, 2020). They stated that fruit width per plant became greater as irrigation was increased.

A noteworthy degree of variance was seen in the overall quantity of fruits produced per plant as a result of varying watering intervals. The highest total number of fruits per plant (37.33) was seen in treatment T1, which served as the control group. Conversely, the lowest total number of fruits per plant (23.32) was seen in treated T0 , which served as the negative control group (Table 2). This result accorded with Levy and Boman's hypothesis (Levy and Boman's, 2020). In their field experiment, a group researchers reported comparable results (Abdelraouf et al., 2018). They reported that as irrigation increased, the total number of plants per plant eventually increased.

Due to varying irrigation intervals, the percentage of fallen fruits per plant has been shown to vary dramatically. T0 (- control) had a record-high percentage of dropped fruits per plant (39.19%), however, T1 (+ control) had a minimal percentage of dropped fruits every plant (15.83%) (Table 2). This result was consistent with that of (Halder et al., 2003). Depending on their findings, there was a gradual drop in the overall proportion of crop losses for plant when irrigation levels were raised.

A substantial disparity in terms of fruit fresh weight was observed as a result of varying irrigation intervals. The maximum fruit fresh weight (131.09 g) was found in T1 (+ control). Whereas, the minimum fruit fresh weight (91.60 g) was found in T0 (- control) (Table 2). Due to regular irrigation to plants, fruit fresh weight increased and decreased due to no irrigation. This result concurred with Stagno et al.'s (2015) conclusion. In their field experiment, observed comparable outcomes (Ginestar et al., 1996). They reported that as irrigation grew, the fresh weight of produce continuously improved.

Significantly different irrigation intervals affected the yield per plant. T1 (+ control) provided the highest output per plant (4,9 kg), while T0 (- control) produced an inferior yield per plant (2,14 kg) (Figure 2). This result agreed with the result of (Ivan et al., 2012). A group researchers found similar results in their field experiment (Elsayed et al., 2013). A group researchers showed the same result in their investigation (Morianou et al., 2021). They reported that yield per plant gradually increased with increased irrigation than non-irrigated plants.

Fruit moisture content was measured, and a significant difference in fruit moisture content between treatments was observed. T1 (+ control) was found to have the finest fruit moisture content per plant (82.0%). T0 (- control) induces the lowest fruit moisture content per plant (57.35%), as shown in Table 3. This result concurred with the result reached by (Goramnagar et al., 2018). In accordance with their findings, the produce moisture content per plant increased incrementally with increased irrigation compared to non-irrigated plants.

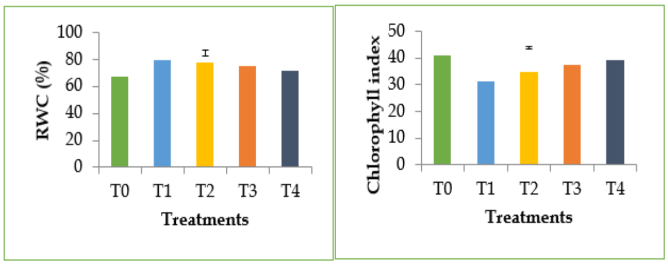

Figure 1: Effect of treatments on leaf relative water content (%) and chlorophyll index. The vertical bar represents LSD at 5% level of significance

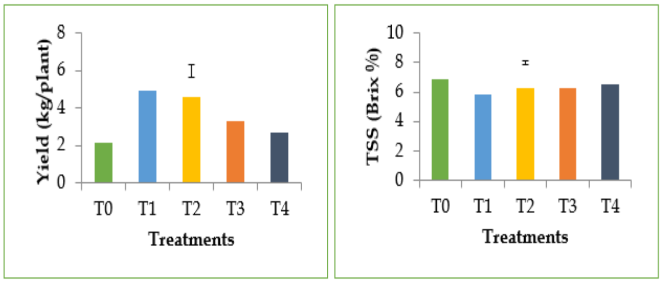

Figure 2: Effect of treatments on yield and TSS. The vertical bar represents LSD at 5% level of significance

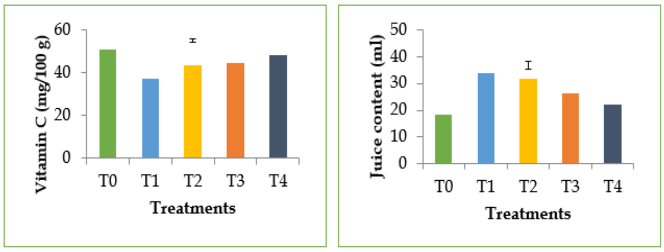

Figure 3: Effect of treatments on vitamin C and juice content. The vertical bar represents LSD at 5% level of significance

Fruit dry matter content was measured, and there was a significant difference between regimens in terms of fruit moisture content. T1 (+ control) was found to have the lowest fruit dry matter content according to plant at 17.99%. Table 3 displays that T0 (- control) generates the greatest fruit dry matter content according plant (42.6%). This result concurred with the conclusion reached by (Goramnagar et al., 2018). They reported that the fruit dry matter content based on every plant increased progressively as irrigation was reduced.

Table 2: Effects of treatments on leaf length, leaf breadth, fruit length, fruit breadth, total number of fruits per plant, % dropped fruits per plant and fruit fresh weight of lemon.

Treatments	*Leaf length (cm)*	*Leaf breadth (cm)*	*Fruit length (cm)*	*Fruit breadth (cm)*	*Total number of fruits/plant*	*% Dropped fruits/plant*	*Fruit fresh weight (g/fruit)*
T_0	4.23	4.02	6.77	3.88	23.32	39.19	91.60
T1	5.36	4.86	7.90	5.31	37.33	15.83	131.09
T_2	5.29	4.76	7.83	5.14	35.31	17.01	130.59
T_3	4.83	4.44	7.31	4.74	29.67	27.05	110.95
T_4	4.68	4.23	7.01	4.4	26.33	33.06	103.24
LSD (0.05)	0.18	0.19	0.14	0.30	4.79	5.76	6.53
LSD (0.01)	0.27	0.27	0.20	0.44	6.97	8.38	9.51
Level of significance	**	**	**	**	**	**	**

**=Significant at 1% level of probability, * Significant at 5% level of probability

There was a significant difference observed in peel thickness per fruit among the treatments. It was observed that T1 (+ control) produce the lowest peel thickness per fruit (1.8 cm). On the other hand, T0 (- control) produces the highest peel thickness per fruit (3.6 cm) (Table 3). This result resonated with that of (Levy et al., 2020). Khehra observed equivalent results in their field analysis (Khehra, 2014). They reported that epidermis thickness per fruit increased and continued to as irrigation lessened.

3.2 Biochemical traits of lemon influenced by irrigation intervals

The total soluble sugar of lemon varied significantly due to the different irrigation intervals. The maximum (6.86%Brix) and the minimum (5.80% Brix) value was observed in T0 (- control) and T1 (+ control) respectively which was similar to the findings of (Levy et al., 2020) (Figure 2).

The maximum amount of titratable acidity of lemon was observed in T1 (+

control) (5.69%), whereas, the minimum was (1.13%) in T0 (- control) which was similar to the report of giving in Table 3 (Elsayed et al., 2013). A group researchers said that the amount of titratable acidity of lemon per plant increased with increased water (Shirgure et al., 2016) .

It was found that fruits per plant of the T0 (- control) had the highest amount of ascorbic acid (Vitamin C) content (50.66mg/100g), while it was lowest (37.33mg/100mg) in the T1 (+ control) and it was similar to the findings of undertook a study on citrus and released that the amount of ascorbic acid (vitamin C) per plant rose with less water (Figure 3) (Morianou et al., 2021; Levy et al., 2013).

Similar to the findings of fruits per plant of the T0 (- control) had the highest value total sugar of lemon content (27.34%), while fruits per plant of the T1 (+ control) had the lowest total sugar of lemon content (19.51%) And conducted an experiment on citrus which presented that the total sugar content per plant increased as water content dropped (Table 3) (Shirgure et al., 2016; Wassel, 2007).

There was a significant difference between interventions regarding the reducing sugar per citrus plant. T1 (+ control) produces the least amount of lemon-reducing sugar per plant (10.29%). In contrast, T0 (- control) generates the maximum amount of lemon-reducing sugar per plant (13.03%) (Table 3). This result was consistent with the findings of (Wassel, 2007). They reported that decreasing sugar per lemon plant gradually elevated as irrigation was minimized.

Table 3: Effects of treatments on fruit moisture content, fruit dry matter content, titratable acidity, peel thickness, total sugar, reducing sugar and non reducing sugar of lemon.

Treatments	*Fruit moistue content (%)*	*Fruit dry matter content (%)*	*Titratable acidity content (%)*	*Peel thickness (mm)*	*Total sugar (%)*	*Reducing sugar (%)*	*Non-reducing sugar (%)*
T_0	57.35	42.65	1.13	3.6	27.34	13.03	14.31
T1	82.00	17.99	5.69	1.8	19.51	10.29	9.22
T_2	81.27	18.73	5.20	2.3	21.11	10.72	10.38
T_3	73.02	26.98	3.70	2.5	22.99	10.61	12.38
T_4	66.6	33.39	2.56	3.1	24.33	12.767	11.56
LSD (0.05)	2.92	2.93	0.66	0.69	1.07	1.93	2.56
LSD (0.01)	4.26	4.26	0.97	1.00	1.55	2.81	3.73
Level of significance	**	**	**	**	**	*	**

Here, **=Significant at 1% level of probability, *= Significant at 5% level of probability

The greatest value of non-reducing sugar in lemon was found in T0 (- control) (14.31%), while the lowest amount was in T1 (+ control) (9.22%), analogous to the findings of Wassel (Table 3) (Wassel, 2007). According to them, the amount of non-reducing sugar in lemon increased as the quantity of water decreased.

Due to the consequences of differing irrigation intervals, the quantity of lemon juice varied significantly. Similar to the findings, it came to light that T1 (+ control) fruits held the biggest amount of juice (34.00 ml), while T0 (- control) fruits offered the least juice (18.33%) (Shirgure et al., 2016). They claimed that the amount of lemon juice improved as irrigation progressed (Figure 3).

4. Conclusions

The purpose of this study was to investigate the effects of different irrigation intervals on the growth, production, and quality of lemon crops. Results of this research suggest that there was a notable variance in the effect of the treatment on the growth, yield, and overall quality of lemon. Treatment T1 (regular irrigation) exhibited the highest values for various parameters, including the total number of flowers for each plant, moisture content of leaves, relative water content, leaf length, leaf breadth, total number of fruits per plant, fruit length, fruit breadth, fruit fresh weight, yield per plant, fruit moisture content, titratable acidity, juice content, fruit dry matter content, and the quantity of days from dipping to first flowering and first fruiting. Additionally, Treatment 1 showed the highest percentage of dropped fruits per plant and peel thickness. Treatment T0 (control group) had the highest levels of leaf chlorophyll index, ascorbic acid (Vitamin C), total sugar, reducing sugar, and non-reducing sugar.

Considering the above finding, it can be concluded that T_2 treatment performed statistically similar with T1 in most of the traits such as leaf length, leaf breadth, %moisture content of leaves & fruits, leaf RWC, days to first flowering, days to first fruiting, total number of flowers, total number of fruits, % dropped fruits per plant, fruit length & breadth, fruit fresh weight, fruit moisture content, yield per plant, TA, juice content, fruit dry matter content and peel thickness. Hence, it may be inferred that treatment T2, namely irrigation at 15 days intervals, would be the most favourable approach for achieving good lemon production under BAU.

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