Synergistic Approach: Enhancing Lime Plant Growth and Development through Integrated Pitcher Irrigation and Jute Agro Textile Management in Entisol Soil.

Abstract:

Citrus fruits, particularly lime (*Citrus aurantifolia*), are of significant agricultural importance due to their high vitamin C and acetic acid content. This study investigates the impact of water conservation techniques on lime production, with a focus on plant phenological development. Conducted at the Jaguli Instructional Farm (BCKV) from June 2019 to May 2022, the experiment evaluated the effects of pitcher irrigation combined with varying jute agro textile strengths (800, 500, 200 GSM) and pitcher exhaustion levels (25%, 50%, 75%, and full exhaustion). Lime seedlings were transplanted, and jute agro textiles were applied post-planting, with unglazed 10-liter pitchers buried in 36 sq.m plots arranged in a two-factor strip plot design with three replications. Key phenological parameters, including plant height, fruit weight, yield, storage life, and ascorbic acid content, were monitored alongside correlation analyses of agronomic variables. The combination of 500 GSM jute textile with 25% pitcher exhaustion significantly enhanced plant growth, yield quality, and phenological development. This treatment also showed the highest benefit-cost ratio, suggesting its suitability for sustainable lime cultivation in water-scarce environments while optimizing plant productivity.

Keywords: Lime (*Citrus aurantifolia*), Water conservation techniques, Pitcher irrigation, Jute agro textiles, Soil moisture management, Ascorbic acid content, Sustainable agriculture.

INTRODUCTION

Jute agro textiles (JAT) have emerged as a highly effective solution for enhancing soil health and crop productivity by addressing significant limitations in traditional agricultural practices. Available in woven and non-woven forms, JATs provide a range of benefits including soil conservation, erosion control, runoff reduction, and weed suppression (Olesen et al., 1995; Pain et al., 2013). Additionally, JATs enhance soil moisture retention, facilitate water uptake and drainage, and support plant growth through lignin decomposition, thereby improving soil structure and fertility. Entisol soils, characterized by their young age and lack of a fully developed horizon, are prevalent in river valleys and coastal areas, covering approximately 16% of the ice-free land globally. These soils challenge agricultural productivity due to their limited nutrient availability and poor water-holding capacity. However, integrating JAT with advanced irrigation and mulching techniques offers a promising approach to optimizing resource efficiency in citrus cultivation within these soils. This study investigates the synergistic potential of utilizing JAT alongside pitcher irrigation methods to enhance lime plant growth and yield in Entisol soils. By examining the multifaceted benefits of JAT integration, this research aims to provide insights into sustainable agricultural practices that can improve crop production in challenging soil conditions.

Irrigation is a critical input for crop growth, particularly in arid and semi-arid regions where water supply is limited (Adhikary et al., 2020). The combination of mulching with pitcher irrigation improves water use efficiency by reducing evaporation and conserving soil moisture. This, in turn, enhances microbial activity and the decomposition of organic matter, increasing soil organic content (Adhikary and Pal, 2020). This technique also improves soil physical properties such as density, porosity, aggregation, and suitability, while reducing crust formation and controlling soil erosion (Pal et al., 2020). Pitcher irrigation, an ancient and efficient system used in arid and semiarid regions, often employs small, cost-effective pitchers, involves burying unglazed earthen pitchers up to their necks in the soil and filling them with water, which slowly seeps out through the porous walls into the root zone (Siyal et al., 2009; Pal et al., 2020). This method is highly efficient, conserving 50% of water compared to conventional irrigation methods, and is particularly beneficial in water-scarce regions (Shrivastava et al., 2010). The technique has proven effective for various crops, including watermelons, tomatoes, and okra, in countries such as India, Pakistan, Brazil, Germany, and Indonesia (Umalaxmi et al., 2017; Mahata et al., 2021).

Combining JAT with pitcher irrigation can achieve stable soil moisture levels that support crop growth even in saline soils. This integrated approach conserves water and enhances soil fertility and structure, making it a viable solution for sustainable agriculture in Entisol-dominated regions. The current study aims to explore the effects of pitcher irrigation and JAT management on lime fruit production in Entisol soils. Through this investigation, we seek to enhance our understanding of how these integrated practices can improve agricultural productivity and sustainability in challenging soil environments.

Material and Methods

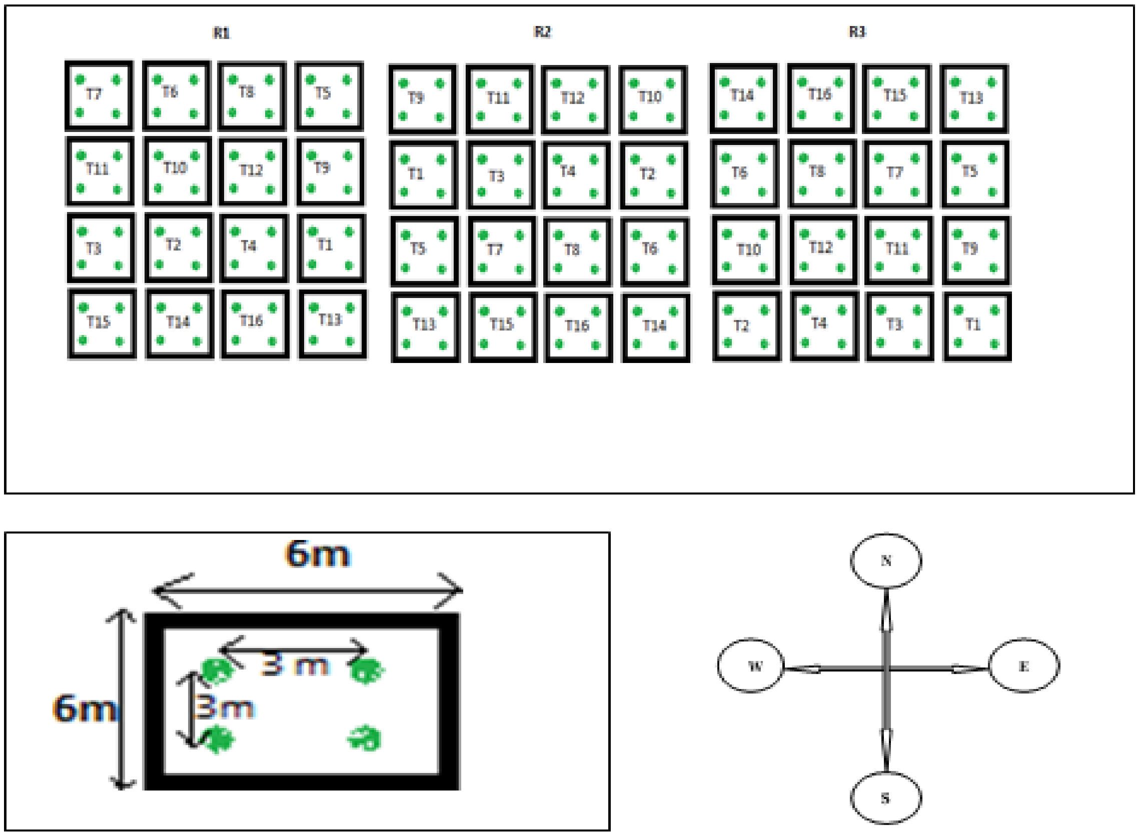
The experimental research was conducted over the three-year experimental period from June 2019 to May 2022, at the Jaguli Instructional Farm in Mohanpur, Nadia, as part of Bidhan Chandra Krishi Viswavidyalaya for Soil and Water Conservation. Situated in the subtropical region near the Tropic of Cancer, the farm lies within the new Alluvial zone of West Bengal, characterized by almost flat terrain and minimal to mild erosion levels. Bounded by North 24 Parganas, Bangladesh, Hooghly, and Murshidabad, the site experiences a subtropical climate with hot, dry summers from April to June and cold winters from December to January. Warm temperatures prevail, often accompanied by heatwaves, sudden downpours, and storms during the summer season due to depressions in the Bay of Bengal. The peak temperatures occur in May, while January is the coolest month. The southwest monsoon season typically extends from the first week of June to the first week of October, contributing over 75% of the annual rainfall, which averages 1607 mm. Relative humidity ranges from 82 to 95% between June and October, decreasing to 70% in January, while wind speeds vary from 0.2 to 2.3 km/hr throughout the year. Temperature starts to decline in November, reaching its lowest point in January before gradually rising again in February. Over the three-year experimental period, the total rainfall recorded in the field area was approximately 4632.18 mm.

The soil in the experimental field area is categorized as recently deposited alluvial soil (Entisol) in West Bengal. The usage of organic manures and fertilizer is required because the soil has a clay loam in texture, reacts in a slightly acidic to neutral manner, and has a low to medium fertility level. The initial soil in the area had a bulk density of 1.32 (g cc-1), Water Holding Capacity of 45.70%, Porosity50.37%, Structural coefficient 0.67%, Mean Weight Diameter 0.75mm, Geometric Mean Diameter 0.62 mm, pH 6.95, organic C 0.69, available N 175.69 kg ha-1, available P 18.62 kg ha-1 and available K 127.45kg ha-1.

Experimental treatments and design

The field trial on the citrus crop Lime (*Citrus aurantifolia*) variety Sai Sarbati was conducted at Jaguli Instructional Farm Nadia under (B.C.K.V) from June 2019 to May 2022 to examine the various effects of pitcher irrigation and jute agro textiles management on lime fruit growth and yield. Here are details on field area treatments, design, and layout are mentioned below: Based on this, the experiment was set up in a split-plot design with a combination of sixteen treatments consisting of four tiers of irrigation i.e., I1: Pitcher filled with water after exhaustion of 25% volume of pitcher, I2: Pitcher filled with water after exhaustion of 50% volume of pitcher, I3: Pitcher filled with water after exhaustion of 75% volume of pitcher I4: Pitcher filled with water after full exhaustion of pitcher assigned in main plots and four tiers of Jute agro textile i.e., J1: 800 GSM (Gram per Square Meter) JAT, J2: 500 GSM JAT J3: 200 GSM JAT, J4: No JAT (control), allotted in subplots with three replications.

Fig 1: Treatment setup



Crop management

The experimental site was meticulously prepared for cultivation through a comprehensive plowing process, including both crosswise and lengthwise plowing, followed by thorough harrowing with a power tiller to break up clods. This preparation ensured that the soil was adequately pulverized to achieve a loose and friable condition, ideal for planting. Within the experimental site, three blocks or replications were established, each further divided into 12 subplots according to the designed layout. Each subplot measured 3 X 3 meters, with a 0.5-meter-wide buffer strip between them to minimize the potential effects of seepage from neighboring plots. Additionally, a drainage channel, 1 meter in width, was incorporated between the irrigation treatments in each replication to manage water flow effectively. During the planting phase, one healthy and vigorous one-year-old air-layering lime tree, contained within pots measuring 60-69 cm in height, was strategically placed in the center of a pit measuring 50 X 50 X 50 cm. This pit was filled with 10 kilograms of farmyard manure, 1 kilogram of bone meal, and 1 kilogram of neem cake, combined with the topsoil. This planting was conducted immediately following the onset of the monsoon rain on June 15, 2015. To aid in irrigation pitcher pots of 10 liters capacity were buried within the effective root zone area of the crop @ one pitcher pot per plant and water was refilled after 100%, 75%, 50%, and 25% exhaustion of water from the pitcher. Additionally, jute agro textile was placed in a treatment-specific manner following the transplanting of the lime tree into the field, as per the predetermined plan.

Standard intercultural operations, such as weeding, pruning, earthing up, and plant protection measures, were consistently applied to all treatments, following the recommended package of practices for the region. The lime fruits were harvested when they showed signs of transitioning from dark green to light green or yellow, and when they exhibited softness upon squeezing. Harvesting occurred two years after planting, specifically in June 2021. Remarkably, in the subsequent year (2022), fruit harvesting also took place in June, yielding both a greater quantity and improved quality compared to the previous year. At the time of harvest, various parameters including plant height, number of fruits per plant, length and diameter of fruits, and fruit weight were meticulously measured for each treatment and replication, allowing for a comprehensive evaluation of the experimental outcomes.

Quality attributes

The ascorbic acid (mg g^{-1}) content in the fruit was determined using a visual titration method with 2,6-dichlorophenol indophenol, following Rosenberg's instructions from 1945. This involved adding a standardized solution of the indicator to the fruit extract until a color change occurred, indicating the endpoint of the reaction between ascorbic acid and the indicator. The amount of ascorbic acid was then calculated based on the volume and concentration of the titrant added to reach the endpoint. This method provides a reliable means of quantifying the ascorbic acid content in fruit samples, aiding in the assessment of their nutritional value and quality.

Soil sample analysis

Surface soil samples (0–0.15 m depth) were collected as representatives and subjected to air-drying, grinding, and analysis to determine the available macronutrient content using established methodologies. The available nitrogen (N) content was assessed using the hot alkaline potassium permanganate method as described by Subbiah and Asija in 1956. For available phosphorus (P), extraction was performed using a 0.5 M $NaHCO_3$ solution at pH 8.5, followed by measurement using the colorimetric method outlined by Olsen in 1954. Available potassium (K) was extracted using neutral 1N NH4OAc and quantified using a flame photometer, following the procedures outlined by Knudsen et al. in 1982. Furthermore, the physical, physicochemical, and chemical properties of the background soil sample were determined using standard methodologies as detailed by Jackson in 1973. These analyses were conducted to ensure the reliability and validity of the soil data obtained for the study.

Statistical analysis

The statistical analysis of the gathered field data regarding growth, yield attributes, and various parameters followed the established methodology as outlined by Gomez and Gomez (1984). Standard error of the mean (±) and critical difference (CD) values were calculated at a significance level of 5% to facilitate robust statistical analysis and interpretation. Reference to Fisher and Yates tables (1979) aided in condensing the "F" and "t" table values necessary for determining significant differences (CD).

Results and Discussion

Effects of Irrigation Levels on Plant Height

The data indicates a significant effect of different irrigation levels on plant height over three years. In the first year, the highest plant height was recorded under I2 (146.50 cm), followed closely by I3 (145.50 cm), with the lowest height observed in I4 (143.25 cm). By the second year, the tallest plants were again observed under I2 (248.75 cm), while I1 (246.25 cm) and I3 (245.00 cm) showed similar heights. In the third year, I2 maintained the highest plant height (354.50 cm), while the lowest was recorded under I4 (342.75 cm). The standard error of the mean (SE(m)±) values were 0.157, 0.097, and 0.173 for years one, two, and three, respectively, with critical difference (CD) values of 0.471, 0.291, and 0.519. This indicates that the differences in plant height due to irrigation levels were statistically significant each year. The consistency of I2 yielding the highest plant height suggests that this irrigation level optimally supports growth.

Effects of JAT Treatments on Plant Height

Different JAT treatments also showed a significant effect on plant height. In the first year, J2 yielded the tallest plants (149.50 cm), while J4 produced the shortest (140.75 cm). The trend continued in the second year, with J2 reaching 256.50 cm, compared to J4 at 236.25 cm. By the third year, J2 again showed the tallest plants (367.50 cm), and J4 the shortest (333.75 cm). The SE(m)± values were 0.235, 0.097, and 0.203 for years one, two, and three, respectively, with corresponding CD (0.05) values of 0.705, 0.291, and 0.609. These data highlight that J2 consistently promotes maximum plant growth, indicating its effectiveness as a JAT treatment.

Interaction Effects of Irrigation and JAT (I x J)

The interaction between irrigation levels and JAT treatments was significant. In the first year, the highest plant height was observed in T6 (I2J2) at 153.00 cm, while T16 (I4J4) recorded the lowest (138.00 cm). In the second year, T6 again resulted in the tallest plants (260.00 cm), with T16 having the shortest (232.00 cm). The third year followed this trend, with T6 yielding the tallest plants (370.00 cm) and T16 the shortest (335.00 cm). The SE(m)± values were 0.373, 0.434, and 0.392 for the three years, respectively, with corresponding CD (0.05) values of

1.119, 1.302, and 1.176. These results indicate significant interaction effects, demonstrating that the combination of I2 irrigation level and J2 JAT treatment is the most beneficial for plant growth.

Overall Implications for Plant Growth

This study demonstrates that both irrigation levels and JAT treatments significantly influence plant height. Optimal irrigation (I2) consistently promoted the highest plant growth across all three years, likely due to better water availability and uptake efficiency, which are critical for photosynthesis and nutrient transport. The effectiveness of J2 as the most beneficial JAT treatment suggests it may provide necessary nutrients or growth conditions that synergize well with I2, leading to improved plant height.

The interaction effects further support the synergy between specific irrigation levels and JAT treatments, with I2J2 (T6) consistently producing the tallest plants. This synergy indicates that optimal irrigation combined with effective JAT management can significantly enhance plant growth, likely due to improved soil moisture and nutrient availability. The statistical validation through SE(m)± and CD (0.05) confirms the reliability and significance of the observed differences. The lower SE(m)± values across years indicate precise measurements, while the CD (0.05) values substantiate the significance of the differences between treatments. This study underscores the importance of tailored irrigation and nutrient management strategies in achieving optimal plant growth, with potential applications in agricultural practices to enhance crop productivity.

Effects of Irrigation Levels on Fruit Production and Morphology

The study evaluated the influence of four irrigation levels (I1, I2, I3, I4) on the number of fruits per plant, fruit length, and fruit diameter over two years. The results indicated significant differences among treatments.

Number of Fruits per Plant: Irrigation level I2 consistently produced the highest values, with 64.50 fruits in Year 2 and 220.50 fruits in Year 3, significantly higher compared to the other irrigation levels.

Fruit Length: The longest fruits were also under I2, measuring 3.71 cm in Year 2 and 4.17 cm in Year 3.

Fruit Diameter: Under I2, fruit diameter was greatest, measuring 3.62 cm in Year 2 and 4.10 cm in Year 3.

Statistical analysis confirmed the significance of these differences, with low SE(m)± and CD values indicating reliable results. These findings suggest that irrigation level I2 optimally supports fruit development, likely by providing an adequate balance of water, enhancing nutrient uptake, and promoting overall plant health.

Effects of JAT Treatments on Fruit Production and Morphology

The impact of four JAT treatments (J1, J2, J3, J4) was also examined.

Number of Fruits per Plant: Under J2, the number of fruits was 61.00 in Year 2 and 223.00 in Year 3, the highest among all JAT treatments.

Fruit Length: Under J2, fruit length was superior, measuring 3.88 cm in Year 2 and 4.35 cm in Year 3.

Fruit Diameter: The largest diameter was also under J2, with values of 3.76 cm in Year 2 and 4.26 cm in Year 3.

SE(m)± and CD values confirmed the statistical significance of these results. The superior performance of J2 could be attributed to its composition, likely including growth-promoting factors that enhance both the quantity and quality of fruit production, improving nutrient availability, root development, and overall plant vigor.

Interaction Effects Between Irrigation Levels and JAT Treatments

The interaction between irrigation levels and JAT treatments revealed complex and significant effects on fruit production and morphology. Among the various combinations, T6 (I2J2) consistently resulted in the highest number of fruits per plant (72.00 in Year 2 and 231.00 in Year 3), the longest fruits (3.98 cm in Year 2 and 4.40 cm in Year 3), and the largest fruit diameters (3.81 cm in Year 2 and 4.31 cm in Year 3). These results were statistically validated with SE(m)± and CD values confirming their significance. The combination of I2 and J2 appears to create an optimal environment for fruit development, maximizing nutrient uptake and utilization, thus promoting better fruit set and growth.

This study demonstrates that both irrigation levels and JAT treatments significantly affect fruit production and morphology, with the combination of I2 and J2 yielding the best results. The significant interaction effects between these factors further underscore the importance of integrated management practices. These findings have important implications for agricultural practices, suggesting that optimizing irrigation levels and selecting appropriate agronomic treatments can substantially enhance fruit yield and quality. Future research should explore the physiological and molecular mechanisms underlying these effects and extend these findings to other crops and environmental conditions for broader applicability.

Effects of Irrigation Levels on Fruit Weight, Yield, and Storage

The study delved into the impact of four distinct irrigation levels (I1, I2, I3, I4) on fruit weight, yield, and storage over two years.

Fruit Weight: In the first year, the mean fruit weights were 33.00 kg (I1), 40.25 kg (I2), 33.50 kg (I3), and 32.00 kg (I4). By the second year, these values increased to 41.00 kg, 42.50 kg, 40.50 kg, and 40.50 kg, respectively. Statistical analysis revealed significant variations among the irrigation treatments (SE(m)±: 0.140; CD: 0.420). Notably, I2 consistently yielded the heaviest fruits, indicating it as the optimal irrigation level for maximizing fruit weight.

Yield: Yield results displayed noteworthy differences. In the initial year, yields were 1.90 tonnes ha^{-1} (I1), 2.62 tonnes ha^{-1} (I2), 1.80 tonnes ha^{-1} (I3), and 1.27 tonnes ha^{-1} (I4). By the second year, these values rose to 9.20, 8.88, 8.54, and 8.31 tonnes ha^{-1}, respectively. I2 consistently outperformed other levels in enhancing both fruit weight and overall yield (SE(m)±: 0.002 for Year 1; CD: 0.006).

Fruit Storage: Regarding fruit storage, durations in the initial year were 13.00 days (I1), 13.75 days (I2), 12.26 days (I3), and 12.01 days (I4). In the second year, storage increased to 14.00 days (I1), 14.50 days (I2), 13.70 days (I3), and 13.00 days (I4). The significant differences in storage durations (SE(m)±: 0.141; CD: 0.423) highlight the benefits of I2 for prolonging fruit storage life.

Effects of JAT Treatments on Fruit Weight, Yield, and Storage

The research also examined the effects of four JAT treatments (J1, J2, J3, J4) on fruit weight, yield, and storage, showing significant differences:

Fruit Weight: Year 1 results indicated mean fruit weights of 36.25 kg (J1), 39.75 kg (J2), 35.50 kg (J3), and 34.25 kg (J4), with J2 producing the heaviest fruits. In Year 2, these weights increased to 41.00 kg (J1), 45.00 kg (J2), 38.25 kg (J3), and 36.75 kg (J4). Statistical significance was confirmed (SE(m)±: 0.130; CD: 0.391), affirming J2's superiority in maximizing fruit weight.

Yield: The yield results reflected a similar trend. In the first year, yields were 1.90 tonnes ha^{-1} (J1), 2.88 tonnes ha^{-1} (J2), 1.80 tonnes ha^{-1} (J3), and 1.10 tonnes ha^{-1} (J4). By the second year, the yields rose to 9.20, 8.88, 8.54, and 8.31 tonnes ha^{-1}, respectively. J2 consistently yielded the highest fruit yield (SE(m)±: 0.002 for Year 1; CD: 0.006).

Fruit Storage: Storage durations varied among treatments, with J1 storing fruits for 13.00 days, J2 for 14.00 days, J3 for 12.25 days, and J4 for 12.00 days in the first year. In Year 2, these values rose to 14.50 days (J1), 14.50 days (J2), 13.00 days (J3), and 12.50 days (J4). The statistical analysis (SE(m)±: 0.141; CD: 0.423) revealed significant differences, supporting J2's role in enhancing fruit storage longevity.

Interaction Effects Between Irrigation Levels and JAT Treatments

The interaction between irrigation levels and JAT treatments was also significant in affecting fruit weight, yield, and storage. T6 (I2J2) demonstrated the highest values for fruit weight (45.75 kg in Year 2), yield (9.50 tonnes ha^{-1}), and storage (15.25 days). Statistical validation confirmed the significance of these interactions (SE(m)±: 0.371; CD: 0.111).

This highlights the potential of combining optimal irrigation practices (I2) with effective JAT treatments (J2) to enhance not only fruit weight and yield but also storage capabilities. The significant interaction effects suggest a synergistic relationship between these factors, which could lead to improved agricultural practices and crop management strategies.

Conclusion

In conclusion, this study demonstrates the effectiveness of integrating pitcher irrigation with jute agro textiles (JAT) as a sustainable strategy for enhancing lime (*Citrus aurantifolia*) cultivation, particularly in Entisol soils known for their limited water and nutrient retention. The combination of 500 GSM JAT with 25% pitcher exhaustion produced significant improvements in key plant growth parameters, including plant height, fruit weight, yield, and ascorbic acid content. These results highlight the potential of this integrated system to enhance water use efficiency while simultaneously improving soil health. The application of JAT improved soil moisture retention and structure, promoting better nutrient uptake and increased microbial activity. Pitcher irrigation provided a consistent water supply directly to the root zone, optimizing moisture levels and minimizing water wastage. The synergy between 500 GSM JAT and 25% pitcher exhaustion treatment consistently delivered superior agronomic performance across multiple growing seasons.

These findings hold practical significance, especially for regions prone to water scarcity and soil degradation, as the integrated approach offers a viable and sustainable method for improving agricultural productivity while conserving valuable water resources. Although the study briefly references the favorable benefit-cost ratio, further economic analysis could reinforce its feasibility for adoption by farmers in semi-arid and arid regions aiming to enhance lime yields with minimal resource input. In addition, this research provides valuable insights into sustainable agriculture, demonstrating how innovative irrigation methods combined with eco-friendly mulching materials like JAT can significantly enhance crop performance and soil health. Future research should explore the long-term impacts of this system on soil fertility, crop resilience, and its adaptability to different crops and agro-climatic regions. By tailoring irrigation and mulching practices, farmers can enhance their crops' yield and quality, contributing to more resilient and resource-efficient agricultural systems.

Table 1: Effect of Irrigation Levels and JAT Treatments on plant height, fruit production, fruit weight, yield, and storage

Plant height (cm)			
Treatment	**1 Year**	**2 Year**	**3 Year**
Irrigation level (I)			
I1	144.00	246.25	350.75
I2	**146.50**	**248.75**	**354.50**
I3	145.50	245.00	349.50
I4	143.25	243.25	342.75
SE(m)±	0.157	0.097	0.173
CD (0.05)	0.471	0.291	0.519
JAT (J)			
J1	146.50	249.50	355.25
J2	**149.50**	**256.50**	**367.50**
J3	142.50	241.00	341.00
J4	140.75	236.25	333.75
SE(m)±	0.235	0.097	0.203
CD (0.05)	0.705	0.291	0.609
Interaction			
T_1 (I_1 J_1)	146.00	251.00	358.00
T_2 (I_1J_2)	144.00	256.00	369.00
T3 (I_1J_3)	141.00	240.00	341.00
T_4 (I_1J_4)	145.00	238.00	335.00
T_5 (I_2J_1)	149.00	254.00	362.00
T_6 (I_2J_2)	**153.00**	**260.00**	**370.00**
T_7 (I2J_3)	143.00	242.00	346.00
T_8 (I_2J_4)	141.00	239.00	340.00
T_9 (I_3J_1)	148.00	249.00	353.00
T_{10} (I_3J_2)	150.00	254.00	367.00
T_{11} (I_3J_3)	145.00	241.00	343.00
T_{12} (I_3J_4)	139.00	236.00	335.00
T_{13} (I_4J_1)	143.00	244.00	353.00
T_{14} (I_4J_2)	151.00	256.00	367.00
T_{15} (I_4J_3)	141.00	241.00	343.00
T_{16} (I_4J_4)	138.00	232.00	335.00
I X J			
SE(m)±	0.373	0.434	0.392
CD(0.05)	1.119	1.302	1.176
J X I			
SE(m)±	0.471	0.194	0.406
CD(0.05)	1.413	0.582	1.218

	No. of fruits per plant		Length of fruit (cm)		Diameter of fruit (cm)	
Treatment	**Year 2**	**Year 3**	**Year 2**	**Year 3**	**Year 2**	**Year 3**
Irrigation level (I)						
I1	57.00	215.00	3.66	4.16	3.57	4.04
I2	**64.50**	**220.50**	**3.71**	**4.17**	**3.62**	**4.10**
I3	53.00	211.50	3.65	4.13	3.51	4.02
I4	39.00	207.25	3.59	4.09	3.46	3.95
SE(m)±	0.300	0.480	0.020	0.020	0.000	0.000
CD (0.05)	0.900	1.440	0.060	0.060	0.014	0.007
JAT (J)						
J1	56.00	214.75	3.66	4.15	3.61	4.04
J2	**61.00**	**223.00**	**3.88**	**4.35**	**3.76**	**4.26**
J3	51.50	210.25	3.64	4.08	3.50	3.98
J4	45.00	206.25	3.43	3.98	3.34	3.83
SE(m)±	0.180	0.220	0.010	0.010	0.010	0.000
CD (0.05)	0.540	0.660	0.031	0.035	0.030	0.012
Interaction						
T_1 (I_1 J_1)	60.00	216.00	3.67	4.11	3.59	4.04
T_2 (I_1J_2)	64.00	224.00	3.95	4.36	3.80	4.24
T3 (I_1J_3)	56.00	212.00	3.60	4.05	3.56	4.03
T_4 (I_1J_4)	48.00	208.00	3.40	4.02	3.34	3.82
T_5 (I_2J_1)	68.00	221.00	3.70	4.21	3.69	4.12
T_6 (I_2J_2)	**72.00**	**231.00**	**3.98**	**4.40**	**3.81**	**4.31**
T_7 (I2J_3)	62.00	218.00	3.70	4.10	3.59	4.04
T_8 (I_2J_4)	56.00	212.00	3.45	4.04	3.39	3.93
T_9 (I_3J_1)	56.00	213.00	3.64	4.14	3.63	4.00
T_{10} (I_3J_2)	60.00	221.00	3.86	4.36	3.80	**4.33**
T_{11} (I_3J_3)	52.00	207.00	3.62	4.09	3.44	3.94
T_{12} (I_3J_4)	44.00	205.00	3.47	3.94	3.34	3.80
T_{13} (I_4J_1)	40.00	209.00	3.63	4.11	3.51	4.00
T_{14} (I_4J_2)	48.00	216.00	3.70	4.25	3.75	4.14
T_{15} (I_4J_3)	36.00	204.00	3.61	4.06	3.41	3.91
T_{16} (I_4J_4)	32.00	200.00	3.38	3.90	3.23	3.75
I X J						
SE(m)±	0.610	0.60	0.030	0.030	0.010	0.010
CD(0.05)	1.830	1.816	0.090	0.090	0.030	0.030
J X I						
SE(m)±	0.363	0.433	0.018	0.020	0.013	0.007
CD(0.05)	1.089	1.299	0.054	0.060	0.039	0.021

Treatment	Fruit weight (Kg) Year 2	Fruit weight (Kg) Year 3	Yield (tonnes ha^{-1}) Year 2	Yield (tonnes ha^{-1}) Year 3	Fruit- storage (day) Year 2	Fruit- storage (day) Year 3
Irrigation level (I)						
I1	**33.00**	**41.00**	1.90	9.20	13.00	13.71
I2	**40.25**	**42.50**	2.62	8.88	13.75	13.51
I3	**33.50**	**40.50**	1.80	8.54	12.26	12.51
I4	**32.00**	**40.50**	1.27	8.31	12.01	12.26
SE(m)±	0.140	0.140	0.002	0.00	0.190	0.120
CD (0.05)	0.420	0.420	0.006	0.015	0.570	0.360
JAT (J)						
J1	**36.25**	**41.00**	2.06	8.77	13.75	13.77
J2	**39.00**	**46.50**	2.41	10.47	14.75	15.51
J3	**33.25**	**39.25**	1.73	8.13	12.01	12.46
J4	**30.25**	**37.75**	1.39	7.56	10.50	10.25
SE(m)±	0.250	0.270	0.01	0.00	0.080	0.310
CD (0.05)	0.750	0.810	0.025	0.000	0.240	0.930
Interaction						
T_1 (I_1 J_1)	34.00	41.00	2.04	9.07	14.00	15.00
T_2 (I_1J_2)	38.00	46.00	2.43	10.72	15.00	**16.01**
T3 (I_1J_3)	31.00	39.00	1.74	8.69	12.01	12.81
T_4 (I_1J_4)	29.00	38.00	1.39	8.32	10.99	11.00
T_5 (I_2J_1)	42.00	42.00	2.86	8.96	15.00	14.01
T_6 (I_2J_2)	**45.00**	**47.00**	3.24	11.13	**16.00**	**16.01**
T_7 (I2J_3)	39.00	41.00	2.41	8.06	13.00	13.00
T_8 (I_2J_4)	35.00	40.00	1.96	7.34	11.00	11.01
T_9 (I_3J_1)	36.00	41.00	2.01	8.69	13.00	13.03
T_{10} (I_3J_2)	38.00	45.00	2.28	10.08	14.00	15.00
T_{11} (I_3J_3)	31.00	39.00	1.61	8.11	12.02	12.00
T_{12} (I_3J_4)	29.00	37.00	1.28	7.25	10.00	10.00
T_{13} (I_4J_1)	33.00	40.00	1.32	8.36	13.00	13.01
T_{14} (I_4J_2)	35.00	48.00	1.68	9.94	14.00	15.00
T_{15} (I_4J_3)	32.00	38.00	1.15	7.64	11.02	12.03
T_{16} (I_4J_4)	28.00	36.00	0.90	7.30	10.00	8.99
I X J						
SE(m)±	0.340	0.480	0.01	0.01	0.190	0.120
CD(0.05)	1.020	1.440	0.016	0.028	0.570	0.360
J X I						
SE(m)±	0.493	0.547	0.014	0.005	0.083	0.312
CD(0.05)	1.479	1.641	0.046	0.016	0.249	0.936

Table 2: Effect of Irrigation Levels and JAT Treatments on ascorbic acid content

	Ascorbic acid (mg g^{-1})	
Treatment	**2 Year**	**3 Year**
Irrigation level (I)		
I1	73.00	76.19
I2	76.04	**77.76**
I3	72.82	**74.04**
I4	70.69	**72.90**
SE(m)±	0.182	0.800

CD (0.05)	0.546	2.400
JAT (J)		
J1	84.25	83.40
J2	77.11	77.33
J3	69.26	73.33
J4	61.94	66.83
SE(m)±	0.030	0.770
CD (0.05)	0.090	2.310
Interaction		
T_1 (I_1 J_1)	84.25	83.11
T_2 (I_1J_2)	78.54	77.40
T3 (I_1J_3)	68.54	74.26
T_4 (I_1J_4)	60.69	69.97
T_5 (I_2J_1)	**88.54**	**87.11**
T_6 (I_2J_2)	79.97	77.97
T_7 (I2J_3)	71.40	75.68
T_8 (I_2J_4)	64.26	70.26
T_9 (I_3J_1)	82.82	82.82
T_{10} (I_3J_2)	75.68	77.11
T_{11} (I_3J_3)	69.97	71.97
T_{12} (I_3J_4)	62.83	64.26
T_{13} (I_4J_1)	81.40	80.54
T_{14} (I_4J_2)	74.26	76.83
T_{15} (I_4J_3)	67.12	71.40
T_{16} (I_4J_4)	59.98	62.83
I X J		
SE(m)±	0.230	0.800
CD(0.05)	0.692	2.400
J X I		
SE(m)±	0.067	0.767
CD(0.05)	0.201	2.301

Table 3: Correlation analysis

Correlations								
	Yield	**Fruit Weight**	**Fruit Storage**	**Fruit $Plant^{-1}$**	**Length of fruit**	**Diameter of fruit**	**Plant Height**	**Vitamin C**
Yield	1							
Fruit Weight	.774**	1						
Fruit Storage	0.292	.706**	1					
Fruit $Plant^{-1}$	.983**	.685**	0.160	1				

Length of fruit	.908**	.836**	.482**	.866**	1			
Diameter of fruit	.898**	.815**	.525**	.849**	.971**	1		
Plant Height	.992**	.730**	0.263	.989**	.911**	.900**	1	
Vitamin C	-0.083	-.541**	-.909**	0.032	-.350*	-.392*	-0.073	1
**. Correlation is significant at the 0.01 level (2-tailed).								
*. Correlation is significant at the 0.05 level (2-tailed).								

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