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EFFECTS OF DEFICIT IRRIGATION AND MANURE APPLICATION ON GROWTH, YIELD AND WATER USE EFFICIENCY OF ONION (*Allium cepa L.*)

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Abstract: With increasing municipal and industrial demands for water, its allocation for agriculture is decreasing steadily. Irrigated agriculture, both now and in the future, will occur in areas with limited water resources. Insufficient water supply for irrigation will become the norm rather than the exception, and irrigation management will move from prioritizing production per unit area to optimizing production per unit of water consumed. To deal with limited resources, deficit irrigation is an integral strategy for minimizing irrigation water consumption. In this study, the growth, yield, water use efficiency, and nutritional content of onion (*Allium cepa L.*) were evaluated, as well as the interacting effects of deficit irrigation and manure treatment on these factors. The research was carried out utilizing a factorial design that was arranged in split plots and included three replications from each group. Treatments consisted of three irrigation levels (ETc 100%, ETc 75% and ETc 50%) and two manure levels (with and without manure application).

When compared to deficit irrigation alone, the results showed that the combination of deficit irrigation with the application of manure resulted in a considerable increase in plant height, stem diameter, number of leaves, bulb weight, bulb diameter, and nutrient content.

The treatment with manure and 50% ETc had the highest water use efficiency of all the treatments. Under conditions when there is a limited supply of water, the study demonstrates that a combination of deficit irrigation and the use of manure can improve onion yield.

Key words: *Onion, deficit irrigation, manure, water use efficiency, yield, nutrient content.*

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INTRODUCTION

Water scarcity has emerged as one of the most pressing global challenges of the 21st century, with far-reaching implications for food security, economic development, and environmental sustainability, [1,2]. The agricultural sector, which accounts for approximately 70% of global freshwater withdrawals, stands at the forefront of this crisis [3,4]. As the world's population continues to grow and climate change exacerbates water stress in many regions, there is an urgent need to develop and implement water-efficient agricultural practices that can maintain crop productivity while significantly reducing water consumption [5-8]. The scale of the water scarcity problem is staggering. According to recent estimates by the United Nations, over 2 billion people live in countries experiencing high water stress, and this number is projected to increase dramatically in the coming decades [9]. Climate change is expected to intensify water scarcity through altered precipitation patterns, increased evapotranspiration rates, and more frequent and severe droughts in many parts of the world [10-12]. These changes pose significant threats to agricultural production, particularly in arid and semi-arid regions that are already struggling with limited water resources.

In response to these challenges, researchers and practitioners have been exploring innovative approaches to improve water use efficiency in agriculture. One such approach that has gained significant attention in recent years is deficit irrigation, often combined with sustainable soil management practices such as organic manure application [13-14]. This integrated approach seeks to optimize water use while maintaining soil health and crop productivity, offering a promising pathway towards more sustainable agricultural systems. Deficit irrigation is an optimization strategy in which crops are deliberately exposed to a certain level of water stress, either during specific growth stages or throughout the entire growing season, without causing significant yield reduction [15-16]. This approach is based on the principle that maximizing water productivity – the amount of crop produced per unit of water consumed – may be more profitable for farmers than maximizing yields, especially in water-scarce regions [17].

The concept of deficit irrigation challenges the conventional wisdom that crops should always be fully irrigated to achieve maximum yields. Instead, it recognizes that plants have varying sensitivities to water stress at different growth stages and that moderate water deficits can sometimes trigger beneficial physiological responses, such as improved root growth or increased fruit quality [15, 18].

By carefully managing the timing and extent of water stress, farmers can potentially achieve substantial water savings with only minimal impacts on yield. However, the successful implementation of deficit irrigation requires a nuanced understanding of crop-specific responses to water stress at different growth stages, as well as the potential interactions with other agronomic practices [19-22]. This complexity underscores the need for robust scientific research to guide the development of effective deficit irrigation strategies for different crops and environments. While deficit irrigation offers significant potential for improving water use efficiency, it is not without challenges. One of the primary concerns is the risk of yield reduction if water stress is too severe or poorly timed. Additionally, deficit irrigation may affect crop quality parameters, which can be particularly important for high-value horticultural crops, [23-25].

These risks highlight the importance of combining deficit irrigation with other agronomic practices that can help mitigate the negative impacts of water stress.

This is where the application of organic manures comes into play. Organic amendments, such as farmyard manure, compost, and green manures, have long been recognized as beneficial practices in sustainable agriculture [26]. These materials can improve soil physical properties, enhance water retention capacity, increase nutrient availability, and promote beneficial soil microbial activity [27]. In the context of deficit irrigation, the potential of organic manures to mitigate the negative impacts of water stress on crop growth and yield has garnered increasing attention from researchers and practitioners alike [28]. The benefits of organic manures in agriculture are multifaceted. From a water management perspective, organic amendments can significantly improve soil structure and water-holding capacity, allowing crops to access stored soil moisture more effectively during periods of water stress [29]. This can be particularly beneficial in deficit irrigation systems, potentially extending the intervals between irrigation events and reducing overall water consumption. Furthermore, organic manures provide a rich source of nutrients that are released slowly over time, improving nutrient use efficiency and reducing the risk of nutrient leaching [26]. This steady supply of nutrients can help support crop growth and development even under water-limited conditions. Organic amendments also stimulate soil microbial activity, which can enhance nutrient cycling, improve soil structure, and potentially increase plant resistance to stress [27].

The combination of deficit irrigation and organic manure application represents a holistic approach to sustainable water management in agriculture. By simultaneously addressing water use efficiency and soil health, this integrated strategy has the potential to enhance crop resilience to water stress while maintaining or even improving soil fertility and overall agroecosystem health [28].

In this context, the study of crops that are both economically important and sensitive to water stress becomes particularly relevant. Onion (Allium cepa L.) is one such crop that fits this description perfectly. As a globally important vegetable, onion is valued for its culinary versatility and medicinal properties [30]. It is cultivated in a wide range of climatic conditions and plays a significant role in both local consumption and international trade [31].

The global importance of onion is reflected in its production statistics. According to the Food and Agriculture Organization (FAO), global onion production reached approximately 102 million tonnes in 2020, with China, India, and the United States being the top producers [31].

Onions are not only a staple food item in many cuisines worldwide but also a valuable cash crop for many smallholder farmers in developing countries. However, onion production faces several challenges, particularly in the context of water scarcity and climate change. Onions are known for their sensitivity to water stress, especially during the bulb formation stage [32]. This sensitivity is compounded by the crop's relatively shallow root system, which limits its ability to access water from deeper soil layers during dry periods. These characteristics make onion an interesting and important subject for studying the effects of deficit irrigation and potential mitigation strategies. The water requirements of onion crops vary depending on the climate, soil type, and cultivation practices, but they are generally considered to be moderate to high. In many production systems, onions receive frequent irrigation to maintain optimal soil moisture levels throughout the growing season.

However, as water resources become increasingly scarce, there is a growing need to develop more water-efficient production methods for this important crop.

Research on deficit irrigation in onion production has shown mixed results, highlighting the complexity of the crop's response to water stress. Some studies have demonstrated that moderate deficit irrigation can be applied without significant yield losses, particularly if the timing of water stress is carefully managed (Shock et al., 2005). Other research has shown that deficit irrigation can even improve certain quality parameters, such as pungency and soluble solids content, [33]. However, severe or poorly timed water stress can lead to significant reductions in bulb size and marketable yield, [32]. The potential of organic manures to mitigate the negative impacts of water stress in onion production is an area of growing research interest. Several studies have demonstrated that the application of organic amendments can improve soil water retention, enhance nutrient availability, and promote better root development in crops, [34-40). These benefits could potentially help onion plants better tolerate periods of water stress under deficit irrigation regimes. Moreover, the use of organic manures in onion production aligns with the growing consumer demand for sustainably produced foods. Organic and low-input production systems for onions have gained popularity in many markets, driven by concerns about pesticide residues and environmental sustainability, [41]. The integration of deficit irrigation and organic manure application could potentially contribute to the development of more sustainable onion production systems that meet these consumer preferences while addressing water scarcity challenges.

The study of the interactive effects of deficit irrigation and manure application on onion growth, yield, water use efficiency, and nutrient content addresses a critical knowledge gap in sustainable onion production. By investigating how these two practices interact, researchers can potentially identify synergistic effects that could lead to more effective water management strategies for onion crops. This research is particularly timely and relevant given the growing global concerns about water scarcity, food security, and sustainable agricultural practices, [9]. As the world grapples with the challenges of feeding a growing population under increasingly water-constrained conditions, the development of water-efficient production methods for staple crops like onions becomes ever more crucial. The potential implications of this research extend beyond onion production.

The insights gained from studying the interactions between deficit irrigation and organic amendments in onions could inform similar research in other crops, contributing to the broader development of sustainable agricultural practices. Furthermore, by demonstrating the potential for significant water savings in a water-sensitive crop like onions, this research could encourage wider adoption of water-efficient practices across the agricultural sector.

The study therefore sought to address a critical knowledge gap by investigating the interactive effects of deficit irrigation and manure application on onion growth, yield, water use efficiency, and nutrient content. This research is particularly timely and relevant given the growing global concerns about water scarcity, food security, and sustainable agricultural practices, [9].

MATERIAL AND METHODS

The experiment was conducted at the School of Agriculture Teaching and Research Farm, University of Cape Coast, Ghana. The soil at the site is classified as a sandy clayey loam. The study used a factorial design laid out in split plots with three replications. The main plots consisted of three irrigation levels 100% ETc (Crop Evapotranspiration), 75% ETc, and 50% ETc. The sub-plots comprised two manure levels with manure application and without manure application. The experimental field was cleared, leveled and divided into plots of 1.5 m x 2 m (3 m²). Four-week-old onion seedlings were transplanted at a spacing of 0.60 m x 0.60 m, with 12 plants per plot. Irrigation was applied every two days using watering cans. The crop water requirement (ETc) was calculated as:

$$ETc = ETo \times Kc \qquad \text{.....................(1)}$$

Where:
ETo = Reference evapotranspiration (measured using US Class A evaporation pan)
Kc = Crop coefficient (FAO values used for different growth stages)

$$ETo = Epan \times Kp \qquad \text{.....................(2)}$$

Where;
Epan = Pan evaporation
Kp = Pan co-efficient

Table 1 below outlines the key parameters measured and the methodologies used in assessing various plant characteristics and water use efficiency. These measurements were taken to evaluate the growth, yield, and nutrient content of plants under different treatment conditions.

The parameters include plant height, stem diameter, number of leaves, bulb weight, bulb diameter, number of rings, water use efficiency, and nutrient content, each determined using specific methods to ensure accurate and consistent data collection.

Table 1. Measurement Methods and Parameters for Plant and Bulb Characteristics

Key Parameters	Methodology
Plant height	Measured using a 1m ruler Six plants selected from each treatment replication for measurement
Stem diameter	Determined using a digital caliper
Number of leaves	Obtained by counting
Bulb weight	Six bulbs selected from each treatment and weighed to determine average bulb weight per plant
Bulb diameter	Measured as an indicator of bulb size Measured using calipers
Number of rings	Counted visually after cutting bulbs
Water use efficiency	Calculated as yield (g) divided by total water applied (mm)
Nutrient content	Protein was determined using Micro-Kjeldahl method for nitrogen content Phosphorus was determined using Bray No. 1 method. Carbohydrate content was determined using the phenol-sulfuric acid method. Dried and ground onion samples were extracted with hot water. The extract was reacted with 5% phenol solution and concentrated sulfuric acid, producing a golden-yellow color. The absorbance was measured spectrophotometrically at 490 nm. Carbohydrate concentration was calculated using a glucose standard curve.

Data collection and statistical analysis:

Plant height, Stem diameter, Number of leaves, Bulb weight, Bulb diameter, Number of rings, Water use efficiency, and Nutrient content (Protein, Phosphorus, Carbohydrates) were the parameters measured. Data were analyzed using analysis of variance (ANOVA) in GenStat statistical software (2020 version). Treatment means were compared using least significant difference (LSD) at $p<0.05$.

RESULTS AND DISCUSSION

Deficit irrigation and manure application on onion yield components

Table 2 presents the interactive effects of deficit irrigation and manure application on onion yield components, specifically bulb weight, bulb diameter, and number of rings.

Table 2. Interactive effects of deficit irrigation and manure application on onion yield components

Treatment	Deficit Irrigation	Bulb weight (g)	Bulb diameter (mm)	Number of rings
Manure	100% ETc	71.9a	63.4a	7.33a
	75% ETc	43.6b	58.2b	6.67ab
	50% ETc	39.5b	46.6c	6.47bc
No Manure	100% ETc	35.0b	57.1b	6.33bc
	75% ETc	25.8c	50.4c	5.67cd
	50% ETc	22.1c	44.9d	5.67cd
LSD (0.05)		25.58	4.55	1.546

Means followed by the same letter within a column are not significantly different at $p<0.05$

The results show that bulb weight was significantly affected by both irrigation levels and manure application. The heaviest bulbs (71.9 g) were produced in the treatment combining 100% ETc with manure application. This finding is consistent with the research of Nandle et al. [42] and Pejić et al. [43], who reported that increasing irrigation levels resulted in higher average bulb weights in onion. A clear trend of decreasing bulb weight is observed as the irrigation level decreases, both with and without manure application. This response to water stress aligns with the findings of Kumar et al. [32], who observed reduced onion bulb weights under deficit irrigation. However, it is notable that at each irrigation level, bulbs from plants receiving manure were consistently heavier than those without manure. For instance, at 50% ETc, bulbs with manure weighed 39.5 g compared to 22.1 g without manure. This suggests that manure application can significantly mitigate the negative effects of water stress on bulb weight, possibly due to improved soil water retention and nutrient availability [44,45].

The bulb diameter showed a similar pattern to bulb weight. The largest bulb diameter (63.4 mm) was observed in the 100% ETc with manure treatment. This result supports the findings of Shock et al. [46], who reported that onion bulb size increased with higher irrigation thresholds. The bulb diameter decreased with reducing irrigation levels, but the decline was less pronounced in treatments receiving manure. For example, at 50% ETc, bulbs were 3.8% larger in diameter with manure (46.6 mm) compared to without manure (44.9 mm). This indicates that manure application can help maintain bulb size under water-limited conditions, which is crucial for marketable yield. These results are in line with the observations of Dhaker et al. [47], who reported that organic manure application improved yield attributes in onion.

The number of rings per bulb, an indicator of bulb quality, also showed significant differences among treatments. The highest number of rings (7.33) was observed in the 100% ETc with manure treatment. This aligns with the findings of Madoli et al. [48], who reported that yield attributes of onion were significantly improved with organic manure application. The reduction in ring number was more pronounced under deficit irrigation without manure.

For instance, at 50% ETc, bulbs from plants with manure had 38.5% more rings (6.47) compared to those without manure (4.67). This suggests that manure application can help maintain bulb quality under water stress, which is important for both market value and storage life of onions.

Deficit irrigation and manure application on water use efficiency and nutrient content of onion

Table 3 presents the interactive effects of deficit irrigation and manure application on water use efficiency (WUE) and nutrient content of onion.

Table 3. Interactive effects of deficit irrigation and manure application on water use efficiency and nutrient content of onion

Treatment	Deficit Irrigation	WUE (g/mm)	Protein (%)	Phosphorus (μg/g)	Carbohydrate (%)
Manure	100% ETc	0.20b	22.10a	5927.33a	19.30a
	75% ETc	0.21b	22.36a	5934.34a	19.48a
	50% ETc	0.25a	21.33a	5930.38a	19.08a
No manure	100% ETc	0.11c	16.47b	4640.55b	14.97b
	75% ETc	0.13c	16.22b	4499.28b	14.43b
	50% ETc	0.14c	14.30b	4636.14b	14.37b
LSD (0.05)		0.023	2.87	97.42	2.14

Means followed by the same letter within a column are not significantly different at $p<0.05$

The results in Table 2 show that WUE was significantly affected by both irrigation levels and manure application. The highest WUE (0.25 g/mm) was achieved in the 50% ETc treatment with manure application. This finding supports the concept that deficit irrigation can improve water productivity in crop production, as proposed by Zhang & Oweis [49]. The increase in WUE under deficit irrigation is likely due to the plant's ability to maintain relatively high yield levels while consuming less water [16]. Interestingly, manure application enhanced WUE across all irrigation levels. For instance, at 50% ETc, WUE increased from 0.14 g/mm without manure to 0.25 g/mm with manure. This improvement can be attributed to the positive effects of organic matter on soil structure and water-holding capacity, as suggested by Yavitt et al. [50] and Nath [51]. The enhanced WUE with manure application indicates that organic amendments can play a crucial role in optimizing water use in onion production under water-limited conditions.

Protein content in onion bulbs was significantly higher in treatments receiving manure application across all irrigation levels. The highest protein content (22.36%) was observed in the 75% ETc treatment with manure. This aligns with findings by Jayathilake et al. [44], who reported increased nutrient uptake and content in onion with organic manure application.

Notably, even under deficit irrigation (50% ETc), manure application maintained higher protein levels (21.33%) compared to full irrigation without manure (16.47%). This suggests that manure can help sustain crop nutritional quality under water-limited conditions.

The phosphorus content showed a similar trend to protein content. Manure application significantly increased phosphorus levels in onion bulbs across all irrigation treatments. The highest phosphorus content (5934.34 µg/g) was observed in the 75% ETc treatment with manure. This corroborates with the findings of Gnanasundari et al. [52], who reported improved nutrient uptake in onion with organic manure application. The ability to maintain high phosphorus levels even under deficit irrigation (5930.38 µg/g at 50% ETc with manure) is particularly noteworthy, as phosphorus plays a crucial role in energy transfer and root development [53-54].

Carbohydrate content in onion bulbs was also significantly enhanced by manure application. The highest carbohydrate content (19.48%) was observed in the 75% ETc treatment with manure. This is consistent with the research of Abdelrasheed et al. [55], who found that organic amendments improved the quality parameters of onion, including carbohydrate content. The maintenance of high carbohydrate levels even under deficit irrigation with manure application (19.08% at 50% ETc) suggests that organic amendments can help sustain the nutritional and flavor qualities of onion under water stress conditions.

Effect of deficit irrigation and manure application on plant height of onion

Figure 1 illustrates the interactive effects of deficit irrigation and manure application on onion plant height over a 6-week period after transplanting. For both manure and no-manure treatments, plant height consistently increases with higher irrigation levels (50% ETc < 75% ETc < 100% ETc). This aligns with the findings of Kumar et al. [32], who observed reduced onion plant growth under deficit irrigation conditions. The 100% ETc treatments show the steepest growth curves, indicating that full irrigation promotes optimal plant height development. At each irrigation level, treatments with manure application consistently outperform those without manure in terms of plant height. This supports the findings of Dhaker et al. [47], who reported that farm yard manure was effective in increasing the growth of onion. The positive effect of manure is particularly pronounced in the later weeks of growth. The graph clearly demonstrates that manure application mitigates some of the negative impacts of deficit irrigation on plant height. For instance, the 75% ETc with manure treatment achieves similar plant heights to the 100% ETc without manure treatment by week 6. This interaction suggests that manure application can partially offset the effects of water stress on onion growth, likely due to improved soil water retention and nutrient availability [56]. All treatments show a general trend of increasing plant height over time, but with varying rates.

The steepest growth curves are observed for the 100% ETc with manure treatment, while the flattest curve is seen for the 50% ETc without manure treatment. This illustrates how both water and nutrient availability affect the rate of plant growth. The differences between treatments become more pronounced as time progresses. This suggests that the cumulative effects of irrigation and manure treatments on plant growth increase over the growing period, as noted by Jayathilake et al. [44] in their study on organic manure effects on onion. Figure 1 suggests that in water-limited conditions, applying manure could be an effective strategy to maintain reasonable plant growth. For instance, the 75% ETc with manure treatment achieves better plant height than 100% ETc without manure by week 6, indicating potential for water savings without compromising growth.

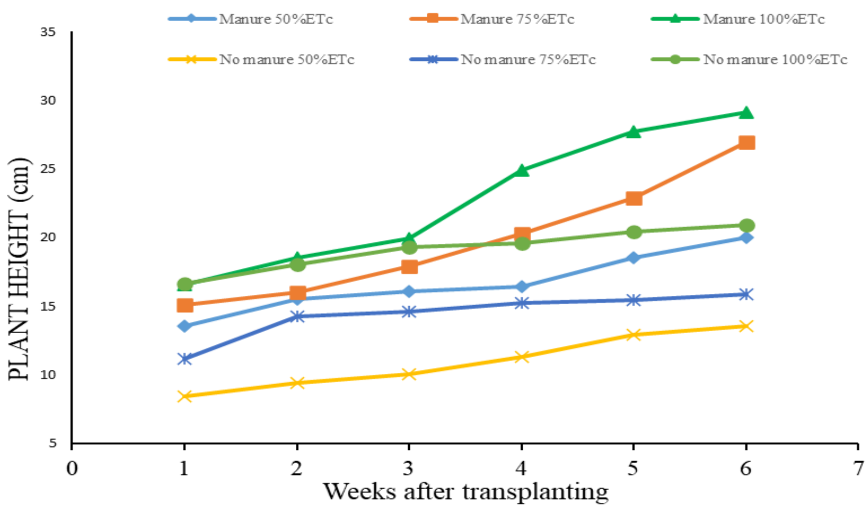

Figure 1. Interactive effect of deficit irrigation and manure application on plant height of onion

Effects of deficit irrigation and manure application on onion stem diameter

Figure 2 illustrates the interactive effects of deficit irrigation and manure application on onion stem diameter over a 6-week period after transplanting. For both manure and no-manure treatments, stem diameter generally increases with higher irrigation levels (50% ETc < 75% ETc < 100% ETc). This aligns with the findings of Kumar et al. [32], who observed that water stress negatively impacts onion growth parameters. The 100% ETc treatments, especially with manure, show the steepest growth curves, indicating that full irrigation promotes optimal stem development. At each irrigation level, treatments with manure application consistently outperform those without manure in terms of stem diameter, particularly in the later weeks.

This supports the findings of Jayathilake et al. [44], who reported that growth parameters of onion, including stem girth, were significantly increased with the application of organic manures. The positive effect of manure becomes more pronounced as the growing period progresses. The graph clearly demonstrates that manure application mitigates some of the negative impacts of deficit irrigation on stem diameter. For instance, by week 6, the 75% ETc with manure treatment achieves similar stem diameters to the 100% ETc without manure treatment. This interaction suggests that manure application can partially offset the effects of water stress on onion growth, likely due to improved soil water retention and nutrient availability [56]. All treatments show a general trend of increasing stem diameter over time, but with varying rates. The steepest growth curve is observed for the 100% ETc with manure treatment, while the flattest curve is seen for the 50% ETc without manure treatment. This illustrates how both water and nutrient availability affect the rate of stem thickening, which is crucial for supporting the developing onion plant and bulb. The differences between treatments become more pronounced as time progresses, particularly after week 3. This suggests that the cumulative effects of irrigation and manure treatments on stem growth increase over the growing period, as noted by Mandoli et al. [48] in their study on organic manure effects on onion growth traits. Figure 2 suggests that in water-limited conditions, applying manure could be an effective strategy to maintain reasonable stem growth. For instance, the 75% ETc with manure treatment achieves better stem diameter than 100% ETc without manure by week 6, indicating potential for water savings without compromising this important growth parameter.

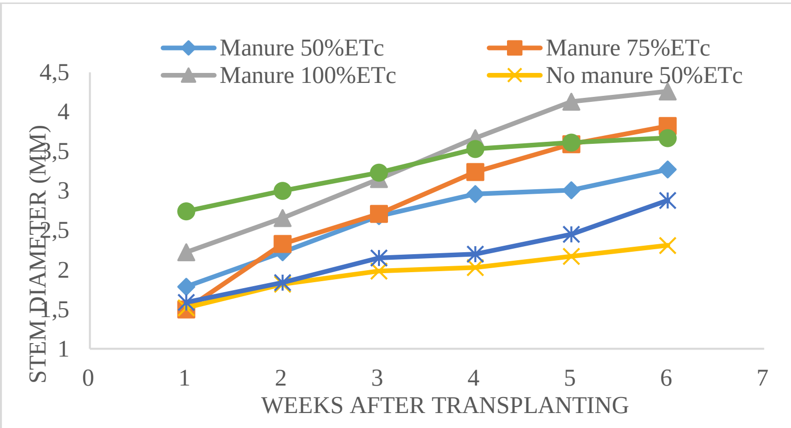

Figure 2. Interactive effect of deficit irrigation and manure on stem diameter of onion

Effects of deficit irrigation and manure application on the number of leaves

Figure 3 illustrates the interactive effects of deficit irrigation and manure application on the number of leaves per onion plant over a 6-week period after transplanting. The number of leaves per plant followed a trend similar to plant height and stem diameter.

Plants receiving 100% ETc with manure produced the highest number of leaves (8.7), which is in line with the observations of Mandoli et al. [48], who reported that growth traits such as number of leaves were significantly higher with organic manure application. For both manure and no-manure treatments, the number of leaves generally increases with higher irrigation levels (50% ETc < 75% ETc < 100% ETc). This aligns with the findings of Kumar et al. [32], who observed that water stress negatively impacts onion growth parameters, including leaf development. The 100% ETc treatments, especially with manure, show the steepest growth curves, indicating that full irrigation promotes optimal leaf production. At each irrigation level, treatments with manure application consistently outperform those without manure in terms of leaf number, particularly in the later weeks. This supports the observations of Mandoli et al. [48], who reported that growth traits such as number of leaves were significantly higher with organic manure application. The positive effect of manure becomes more pronounced as the growing period progresses. The reduction in leaf number was more pronounced under deficit irrigation without manure. This suggests that manure application can help maintain leaf production under water stress, which is crucial for photosynthetic capacity and overall plant productivity. Figure 3 clearly demonstrates that manure application mitigates some of the negative impacts of deficit irrigation on leaf production. For instance, by week 6, the 75% ETc with manure treatment achieves similar leaf numbers to the 100% ETc without manure treatment. This interaction suggests that manure application can partially offset the effects of water stress on onion leaf development, likely due to improved soil water retention and nutrient availability [56]. All treatments show a general trend of increasing leaf numbers over time, but with varying rates. The steepest growth curve is observed for the 100% ETc with manure treatment, while the flattest curves are seen for the 50% ETc and 75% ETc without manure treatments. This illustrates how both water and nutrient availability affect the rate of leaf production, which is crucial for photosynthetic capacity and overall plant productivity. The differences between treatments become more pronounced as time progresses, particularly after week 3. This suggests that the cumulative effects of irrigation and manure treatments on leaf development increase over the growing period, as noted by Jayathilake et al. [44] in their study on organic manure effects on onion growth. Figure 3 suggests that in water-limited conditions, applying manure could be an effective strategy to maintain reasonable leaf production.

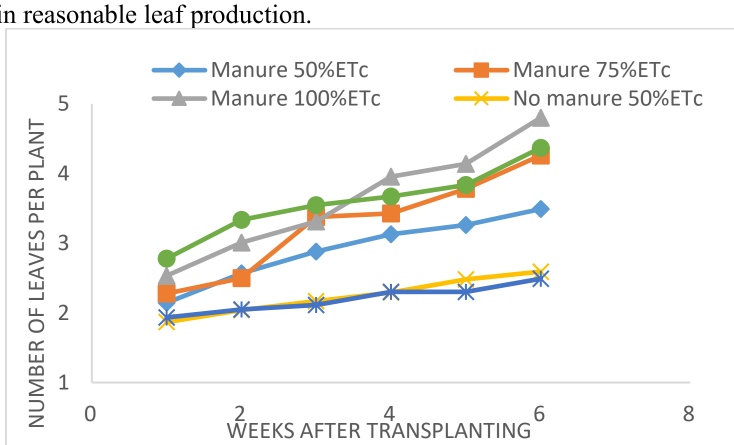

Figure 3. Interactive effect of deficit irrigation and manure on number of leaves of onion

CONCLUSIONS

Farmers in water-scarce regions should consider adopting deficit irrigation strategies combined with manure application to improve water use efficiency in onion production. This study demonstrated that combining deficit irrigation with manure application can significantly improve onion growth, yield and water use efficiency compared to deficit irrigation alone. While full irrigation (100% ETc) with manure produced the highest yields, moderate deficit irrigation (75% ETc) with manure maintained acceptable yields while improving water productivity. The 50% ETc treatment with manure achieved the highest water use efficiency, suggesting potential for water savings in water-scarce regions. Manure application also helped maintain nutrient content in onion bulbs under deficit irrigation. Hence authors recommend that manure application should be promoted as a complementary practice to deficit irrigation, as it helps mitigate the negative impacts of water stress on crop growth and nutrient uptake. These findings provide valuable insights for developing sustainable irrigation and fertilization strategies to optimize onion production under water-limited conditions. However, further research is needed to refine recommendations for different environments and assess long-term impacts on soil health and crop productivity.

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EFEKTI DEFICITARNOG NAVODNJAVANJA I PRIMENE STAJNJAKA NA RAST, PRINOS I EFIKASNOST KORIŠĆENJA VODE KOD LUKA (*Allium cepa L.)*

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Apstrakt. Povećanjem opštih i industrijskih potreba za vodom, izdvajanja vode za poljoprivredu se stalno smanjuju. Navodnjavanje u poljoprivredi, kako sada, tako i u budućnosti, biće potrebno u područjima sa ograničenim vodnim resursima.

Nedovoljno (deficitarno) snabdevanje vodom za navodnjavanje, postaće pre norma nego izuzetak. Upravljanje navodnjavanjem, mora imati prelaz sa davanja prioriteta proizvodnje po jedinici površine, na optimizaciju proizvodnje po jedinici potrošene vode.

Da bi se suočili sa ograničenim resursima, deficit navodnjavanja je integralna strategija za minimiziranje potrošnje vode za navodnjavanje.

U ovoj studiji, procenjeni su rast, prinos, efikasnost korišćenja vode i nutritivni sadržaj luka (*Allium cepa L.*), kao i interakcijski efekti navodnjavanja, deficita i tretmana sa stajnjakom na navedene faktore.

Istraživanje je sprovedeno korišćenjem faktorskog dizajna koji je raspoređen u podeljene dijagrame, i uključuje tri ponavljanja iz svake grupe. Tretmani se sastoje od tri nivoa navodnjavanja (ETc 100%; ETc 75% i ETc 50%) i dva nivoa primene stajnjaka (sa i bez primene).

U poređenju sa samo deficitarnim navodnjavanjem, rezultati su pokazali da je kombinacija deficitarnog navodnjavanja sa primenom stajnjaka rezultirala značajnim povećanjem visine biljke, prečnika stabljike, broja listova, težine lukovice, prečnika lukovice i sadržaja hranljivih materija. Tretman stajnjakom i 50% ETc imao je najveću efikasnost korišćenja vode od svih tretmana. U uslovima kada postoji ograničena zaliha vode, studija pokazuje da kombinacija deficitarnog navodnjavanja i upotrebe stajnjaka može poboljšati prinos luka.

Ključne reči: Luk (*Allium cepa L.*), deficitarno navodnjavanje, stajnjak, efikasnost korišćenja vode, prinos, sadržaj hranljivih materija

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