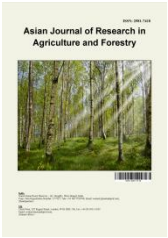

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Optimizing Irrigation and Nitrogen Levels for Enhanced Cabbage Growth in Yobe's Semi-Arid Region

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study investigated the effects of irrigation schedules and nitrogen fertilizer application rates on the growth and productivity of cabbage in Damaturu, Yobe State. Using a Randomized Complete Block Design (RCBD) in a 3x5 factorial arrangement with three replications, we tested three irrigation intervals "3, 6, and 9 days" and five nitrogen fertilizer levels "0, 25, 50, 75, and 100 kg ha^{-1}" on an improved cabbage variety (Datdiku-5m). Results indicated cabbage growth positively responded to optimal irrigation intervals and increasing nitrogen fertilizer rates. The combination of 6-day irrigation intervals and 100 kg ha^{-1} of nitrogen fertilizer resulted in impressive outcomes: a tallest head height of 18.92 cm, the largest head diameter of 16.95 cm, maximum plant height of 24.92 cm, the largest plant spread of 37.12 cm, a maximum marketable yield of 63.5 t/ha, and the

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highest total yield of 71.52 t/ha (Table 3). This combination ensures an adequate supply of water and nutrients, promoting robust growth and significant yield in semi-arid region. In contrast, lower irrigation intervals (9 days) and reduced nitrogen levels (0-50 kg ha^{-1}) led to stunted growth and lower productivity metrics, illustrating the critical role of proper water and nutrient management in achieving optimal cabbage yields. Therefore, adopting a 6-day irrigation schedule and applying 100 kg ha^{-1} of nitrogen fertilizer may effectively increase cabbage yield. Future research should explore different nitrogen fertilizer rates and the combined effects of various nutrients with different irrigation intervals to further assess their impact.

Keywords: Optimizing; irrigation; nitrogen fertilizer; cabbage and yield.

1. INTRODUCTION

The climate of the Yobe region, classified as semi-arid by the Nigerian Meteorological Agency [1], is characterized by low and erratic rainfall coupled with high temperatures. The region typically receives an average annual rainfall of 400 to 600 millimeters (15.7 to 23.6 inches), concentrated primarily between June and September during the rainy season. The dry season, which lasts from October to May, is marked by soaring temperatures, with peaks often exceeding 40°C (104°F) during the driest months, leading to significant evaporation rates and water scarcity [2].

Cabbage (Brassica oleracea var. L.), a biennial plant from the Brassicaceae family, thrives in cooler weather and is cultivated globally for its dense heads of overlapping leaves. Derived from the wild colewort of Western Europe and the northern Mediterranean, cabbage has been a staple vegetable since ancient times [3]. It is highly regarded for its nutritional benefits, rich in vitamins A, B1, B2, and C, and known for aiding digestion, preventing constipation, and potentially offering protection against certain cancers [3]. Globally, cabbage is produced in over ninety countries, with leading producers including China, India, South Korea, Germany, Japan, and South Africa [3]. In 2009, approximately 3.2 million hectares were dedicated to cabbage cultivation across 124 countries, yielding around 71 million tons. In Africa alone, production reached 2 million tons in 2008, marking a 20% increase over the previous decade [4]. Cabbage typically requires about 440 mm of water, though this varies based on climate and the growing season. Water needs increase as the plant matures, particularly towards the end of the season, necessitating irrigation every 3 to 12 days depending on various factors such as soil type and climate [5]. Effective irrigation practices are crucial; poor management not only wastes water but also diminishes crop yield and quality.

Cabbage is a vital crop in Yobe's semi-arid region, playing a significant role in both the local economy and nutrition [6]. With its adaptability to varying climatic conditions, cabbage thrives in these areas, providing a reliable source of income for farmers and contributing to food security [7]. Rich in essential vitamins and minerals, cabbage enhances the dietary diversity of communities, addressing malnutrition challenges [8]. Additionally, its relatively short growing cycle allows for multiple harvests throughout the year, supporting livelihoods and promoting sustainable agricultural practices [9]. As Yobe continues to face climate-related challenges, the cultivation of cabbage presents an opportunity for resilience, economic development, and improved health outcomes for populations in the region [10]. Studying cabbage production in Yobe State is vital for developing resilient agricultural practices in arid and semi-arid environments. Insights gained from this research can enhance productivity and sustainability, enabling farmers to improve yields and income, which supports local economic development and food security. As climate change alters weather patterns and intensifies extreme events, understanding cabbage cultivation in regions like Yobe State is essential for adapting agricultural methods to these evolving conditions.

2. MATERIALS AND METHODS

2.1 Description of Study Area

Damaturu is situated at approximately 11.76°N latitude and 11.96°E longitude. Damaturu experiences a semi-arid climate typical of the Sahel region. It has hot temperatures year-round with a pronounced dry season and a shorter rainy season. Temperatures can be quite high, often exceeding 40°C (104°F) during the hottest months, while the rainy season usually brings some relief with occasional thunderstorms from June to September.

2.2 Soil Sampling and Analysis

Three Soil samples were collected from a depth of 0-15 cm prior to starting the experiment. These samples were air-dried, ground to pass through a 2 mm sieve, and stored in clean plastic containers for subsequent physical and chemical analysis. After removing any debris, the soil was then air-dried at room temperature in the laboratory. Analysis was conducted on various properties including pH, organic carbon (%), total nitrogen (%), available phosphorus (ppm), exchangeable potassium (meq/100g soil), calcium, magnesium, sulfur, zinc, and boron. These analyses were performed using the standard methods outlined by Olsen [11] as presented in Table 1.

2.3 Experimental Design and Treatments

The field trial was established in a factorial experiment as Randomized Complete Block Design (RCBD) with three replications. Sowing was done on 5th, April, 2024 at Dikumari village community irrigation site, Damaturu Yobe State. The experiment was started after transplanting to the main field. Two factors were considered in this experiment, irrigation scheduling on three (3), six (6) and nine (9) days' interval. The second factor which was nitrogen fertilizer set at five levels, level 1 (0 N kg ha^{-1}), level 2 (25 N kg ha^{-1}), level 3 (50 N kg ha^{-1}), level 4 (75 N kg ha^{-1}), and level five (100 N kg ha^{-1}) and the application schedule is bi-weekly. The experiment was set up as 3x 5 factorial arranged in Randomized Complete Blok Design (RCBD) with the three replications. Thus, there were 15 treatment combinations (Table 3). Spacing of 60 x 45 cm was used for the experimental plots.

2.4 Experimental Procedures

Cabbage seedlings of the chosen variety (Datdiku-5m) were cultivated in a seed bed a month prior to their transplantation (April, 2024). After thirty days of growth (May, 2024), the experiment was set up as 3x 5 factorial arranged in Randomized Complete Blok Design (RCBD) with three replications. The more vigorous and uniform seedlings were relocated to the field, with a planting distance of 60 cm by 45 cm was maintained.

2.5 Data Collection

To evaluate the Impact of Irrigation schedules and Nitrogen Levels on the growth and Productivity Dynamics of cabbage, six (6) parameters were considered: height head, biggest head diameter, Plant spread, Plant height, marketable and unmarketable yield, highest and lowest yield were recorded and used for the computation analysis. Data were collected on bi-weekly basis from month of April to July 2024.

Table 1. Initial physical and chemical soil properties of the study area

Table 1A. Soil physical properties

Soil characteristics	Analytical value
Sand	17.2%
Silt	47.2%
Clay	35.6%
Textural class	Silt clay loam
Bulk density	1.4 g/cm3
Particle density	2.6 g/cm3

Table 1B. Soil chemical properties

Soil characteristics	Analytical value	Interpretation
Soil pH	5.54	Highly acidic
Organic Matter (%)	1.24	Low
Total N (%)	0.06	Very Low
Available P (ppm)	80.50	Very High
Exchangeable K (med/100 g)	0.14	Low
Exchangeable Mg (meq/100g)	0.32	Very Low
Available S (ppm)	5.43	Low
Available B (ppm)	0.10	Very Low
Zinc (ppm)	1.0	Medium

Table 2. Treatments combination of irrigation schedules with fertilizer

Days of irrigation application	Nitrogen fertilizer levels (kg ha⁻¹)	Treatment combination
3 days interval	0	3 days x 0 kg ha⁻¹
	25	3 days x 25 kg ha⁻¹
	50	3 days x 50 kg ha⁻¹
	75	3 days x 75 kg ha⁻¹
	100	3 days x 100 kg ha⁻¹
3 days interval	0	6 days x 0 kg ha⁻¹
	25	6 days x 25 kg ha⁻¹
	50	6 days x 50 kg ha⁻¹
	75	6 days x 75 kg ha⁻¹
	100	6 days x 100 kg ha⁻¹
9 days interval	0	9 days x 0 kg ha⁻¹
	25	9 days x 25 kg ha⁻¹
	50	9 days x 50 kg ha⁻¹
	75	9 days x 75 kg ha⁻¹
	100	9 days x 100 kg ha⁻¹

Table 3. Effects of nitrogen fertilizer and irrigation on plant growth parameters

Treatments		Highest head diameter (cm)	Tallest head height (cm)	Plant spread (cm)	Plat height (cm)
Irrigation (days)	Nitrogen fertilizer (kg ha⁻¹)	Means			
3 Days	0 kg ha⁻¹	13.53	8.93	23.16	18.31
	25 kg ha⁻¹	13.07	11.79	27.23	19.72
	50 kg ha⁻¹	14.43	11.69	32.16	19.31
	75 kg ha⁻¹	14.53	12.61	33.65	20.02
	100 kg ha⁻¹	15.23	14.57	35.12	21.07
6 Days	0kg ha⁻¹	13.37	11.12	27.55	21.64
	25kg ha⁻¹	14.55	12.69	29.03	20.60
	50kg ha⁻¹	17.47	13.12	32.22	20.67
	75kg ha⁻¹	18.53	14.22	33.89	23.87
	100kg ha⁻¹	18.92	16.95	37.12	24.92
9 Days	0kg ha⁻¹	10.34	11.45	27.43	16.31
	25kg ha⁻¹	14.53	11.99	29.06	16.92
	50kg ha⁻¹	14.90	12.72	30.16	16.90
	75kg ha⁻¹	15.73	11.78	31.81	20.38
	100kg ha⁻¹	16.83	13.53	35.11	21.15
Mean		16.24	13.37	31.46	20.14
C V %		13.92	12.28	11.37	12.19
L S D		1.10	1.37	2.66	1.34

3. RESULTS AND DISCUSSION

3.1 Effect of Nitrogen Fertilizer and Irrigation Interval on the Height of the Tallest Cabbage Heads

The tallest head height (18.92 cm) was achieved with 100 kg/ha of nitrogen fertilizer. This indicates a significant positive correlation between nitrogen levels and cabbage growth. Nitrogen is a critical nutrient for plants, primarily because it is a key component of amino acids, the building blocks of proteins, and enhances photosynthesis. The presence of nitrogen fertilizers supports robust development, as indicated by numerous studies, including the research [12]. Their findings demonstrate that optimal nitrogen levels significantly boost cabbage growth parameters, including head height. Thus, nitrogen fertilizer is essential for maximizing cabbage yields. The results show that the 6-day irrigation interval correlates with

greater head height compared to the 9-day interval. The more frequent watering enhances soil moisture, which is vital for nutrient uptake and overall plant health [13]. Underscore that frequent irrigation promotes optimal soil moisture, which is critical for cabbage growth. The 6-day interval likely prevents stress conditions that could impede growth, while the longer interval (9 days) may lead to water stress, limiting nutrient absorption and, consequently, growth.

The most favorable conditions (18.92 cm head height) resulted from the synergistic effects of adequate nitrogen and frequent irrigation. This highlights the importance of a balanced approach to fertilization and irrigation in agricultural practices. By providing both sufficient nutrients and optimal water supply, farmers can enhance cabbage growth effectively.

3.2 Effect of Nitrogen Fertilizer and Irrigation Interval on the Largest Head Diameter

The success of the 6-day irrigation interval can be attributed to its ability to provide a more consistent and stable water supply. Cabbage plants require regular moisture to maintain optimal physiological functions. Research by Kader [14] and [15] indicates that stable irrigation prevents water stress and promotes healthy growth. By maintaining soil moisture levels, the 6-day interval likely supported better nutrient uptake and overall plant health, resulting in larger heads. In contrast, the 3-day irrigation interval may not have provided sufficient stability for the cabbage plants, leading to potential water stress. This stress is particularly detrimental when combined with zero nitrogen levels [16]. Suggested that while frequent watering can prevent stress, insufficient nitrogen exacerbates growth issues. Therefore, the shorter irrigation interval likely contributed to reduced growth conditions.

The application of 100 kg ha^{-1} of nitrogen fertilizer played a crucial role in enhancing plant growth. Nitrogen is vital for developing chlorophyll, improving photosynthesis, and overall plant metabolism. Studies, such as those by McLaughlin and Sheikh [17], highlight the importance of adequate nitrogen levels in increasing crop yield and quality. The higher nitrogen rate likely facilitated better nutrient uptake, supporting larger cabbage heads and healthier plants. In contrast, the absence of nitrogen resulted in stunted growth and smaller head sizes. Nitrogen deficiency is known to significantly limit plant growth and yield, as demonstrated by Brouder and Volenec [18]. Without sufficient nitrogen, the plants were unable to perform essential physiological processes, leading to reduced leaf area and poor crop performance.

Table 4. Effects of nitrogen fertilizer and irrigation on yield

Treatments		Unmarketable yield (t/ha)	Marketable yield (yield t/ha)	Total yield (t/h)
Irrigation (days)	Nitrogen fertilizer (kg ha^{-1}")		Means	
3 Days	0 kg ha^{-1}	16. 48	21. 73	39. 02
	25 kg ha^{-1}	21. 54	21. 36	42. 9
	50 kg ha^{-1}	19. 60	26. 64	45. 25
	75 kg ha^{-1}	20. 92	27. 72	49. 34
	100 kg ha^{-1}	12. 05	38. 88	50. 25
6 Days	0 kg ha^{-1}	29.87	19. 95	50. 10
	25 kg ha^{-1}	26. 33	36. 79	63. 12
	50 kg ha^{-1}	12. 53	44. 04	56. 56
	75 kg ha^{-1}	10. 68	52. 23	62. 92
	100 kg ha^{-1}	6.58	53. 47	69.97.
9 Days	0 kg ha^{-1}	13. 62	22. 61	36. 24
	25 kg ha^{-1}	12. 51	23. 41	34. 85
	50 kg ha^{-1}	11. 90	40. 99	52. 89
	75 kg ha^{-1}	11. 25	45. 17	56. 37
	100 kg ha^{-1}	10.27	51.48	61.75
Mean		19.66	31.36	51.63
C V %		34.93	27. 44	17. 09
L S D		5.12	6 .72	4. 90

3.3 Effect of Nitrogen Fertilizer and Irrigation Interval on the Plant Height

Nitrogen is a vital nutrient that plays a crucial role in promoting plant growth. The data indicate that increased nitrogen levels correspond to greater plant height, aligning with the findings of Smith et al. [19], who noted that plant height improved significantly with nitrogen application until a saturation point was reached. The highest recorded height of 24.92 cm at 100 kg ha^{-1} suggests that this level is effective in enhancing growth, likely due to nitrogen's role in amino acid synthesis and chlorophyll production, which are critical for photosynthesis and overall plant vigor. The results also highlight the importance of irrigation frequency. Plants receiving water every 6 days exhibited significantly better growth compared to those on a 9-day schedule. Consistent moisture is essential for optimal nutrient uptake, and the findings from Williams et al. [20] reinforce this, indicating that more frequent irrigation enhances plant height and growth metrics. Study by Garcia and Martinez [21] supports this, showing that regular irrigation leads to increased biomass and height. This suggests that adequate and timely water supply is crucial for maximizing the benefits of nitrogen fertilization. The interaction between nitrogen levels and irrigation intervals is particularly noteworthy. The combination of high nitrogen doses with frequent irrigation creates an ideal environment for plant growth, maximizing both nutrient availability and moisture. This synergy likely explains the pronounced differences in plant height observed between treatment groups.

3.4 Effect of Nitrogen Fertilizer and Irrigation Interval on the Plant Spread

The study found that plants receiving 100 kg/ha of nitrogen fertilizer had the largest spread, measuring 37.12 cm, while those with no nitrogen recorded a mere 23.16 cm. This illustrates that adequate nitrogen levels are crucial for promoting vegetative growth, enhancing leaf area, and thereby increasing plant spread. Nitrogen is vital for the synthesis of amino acids, which are the building blocks of proteins necessary for growth. Higher nitrogen levels likely stimulate robust leaf and stem development, allowing plants to cover more ground. This is supported by previous studies indicating that nitrogen fertilization enhances leaf area and biomass [22] and [23]. The largest spread was also associated with a 6-day irrigation interval. In contrast, more frequent irrigation (every 3 days) led to the smallest plant spread. Less frequent irrigation may encourage deeper root systems, allowing plants to access water and nutrients more effectively. Research indicates that spaced irrigation intervals foster root development and enhance nutrient uptake efficiency [24] and [25]. Stronger root systems contribute to healthier, more expansive plants. The most significant plant growth occurred with a combination of high nitrogen application and less frequent irrigation. This synergistic effect suggests that the right balance of nutrients and water can optimize growth conditions. The combination likely allows plants to maximize nutrient use while developing strong root systems. The interplay between nitrogen availability and irrigation scheduling is crucial for achieving optimal plant health and spread.

3.5 Effect of Nitrogen Fertilizer and Irrigation Interval on the Highest and Lowest Marketable Yield

The maximum marketable yield of 63.5 tons per hectare was achieved with a treatment of 100 kg/ha of nitrogen fertilizer and a 6-day irrigation interval. Conversely, the minimum yield of 19.07 tons per hectare was recorded for cabbage grown without nitrogen fertilizer and with a 6-day irrigation interval. This yield was statistically comparable to that of cabbage grown under a 9-day irrigation interval with no nitrogen application. The minimal unmarketable yield of 6.5 tons per hectare was observed with 100 kg ha^{-1} of nitrogen fertilizer and a 6-day irrigation schedule. In contrast, the maximum unmarketable yield of 29.75 tons per hectare was noted with the 6-day irrigation schedule but without nitrogen fertilizer. The findings emphasize that nitrogen fertilizer is crucial for achieving higher marketable yields. The combination of nitrogen and frequent irrigation resulted in the highest marketable yield while minimizing unmarketable produce. This aligns with previous studies, such as those by Smith et al. [26] and [27], which highlight the positive impact of nitrogen on cabbage yield. Frequent irrigation (every 6 days) was beneficial for both marketable and unmarketable yields [28]. Corroborate this by demonstrating that more frequent irrigation enhances cabbage yield and quality, supporting the current study's findings. Optimal nitrogen and irrigation practices not only increased marketable yields but also significantly reduced unmarketable produce [29]. Found similar results, indicating

that proper nutrient management and irrigation practices are essential for minimizing unmarketable yields.

3.6 Effect of Nitrogen Fertilizer and Irrigation Interval on the Highest and Lowest Total Yield

The treatment yielding the highest result, 71.52 t/ha, was achieved with a 6-day irrigation interval and 100 kg ha^{-1} of nitrogen fertilizer. This combination suggests a strong interaction between water availability and nutrient supply, highlighting that both frequent irrigation and adequate nitrogen levels are essential for maximizing crop productivity. Frequent irrigation enhances soil moisture, allowing for better nutrient uptake, while a higher nitrogen application provides the essential nutrients needed for optimal growth. The study's findings are corroborated by previous research, such as that conducted by Jones et al. [30], which demonstrated that improved irrigation schedules and sufficient nitrogen application lead to enhanced crop yield and nutrient efficiency. Thus, the high yield observed under these conditions reflects an optimal environment for plant growth. In contrast, the lowest yield of 35.91 t/ha occurred with a 9-day irrigation interval and 25 kg/ha of nitrogen fertilizer. This stark difference underscores the detrimental effects of both infrequent irrigation and low nitrogen availability. The results indicate that insufficient moisture and nutrients can severely restrict crop performance, illustrating the necessity of maintaining both factors at adequate levels for successful cultivation. The findings align with the research of [19], which indicated that a combination of inadequate irrigation and nitrogen deficiency could lead to significantly reduced yields. The low yield in this case emphasizes the critical nature of these two variables in agricultural practices [31].

The significant difference in yield between the 6-day and 9-day irrigation intervals 71.52 t/ha compared to 35.91 t/ha can be attributed to the interplay of water availability and nutrient uptake. A 6-day irrigation interval ensures that the soil remains consistently moist, which is crucial for facilitating the movement of nutrients to plant roots. This consistent moisture prevents drought stress, allowing plants to fully utilize available nitrogen and other nutrients, thereby enhancing growth and productivity. In contrast, the 9-day irrigation interval likely leads to periods of inadequate soil moisture, which can hinder nutrient absorption. Plants under stress from dry conditions may not effectively take up nitrogen, resulting in poor growth and lower yields. Furthermore, with only 25 kg ha^{-1} of nitrogen fertilizer, the plants receive insufficient nutrients to support their growth needs, compounding the negative effects of infrequent watering [32].

3.7 Potential Study Limitations

Variations in soil type, texture, and fertility among study plots can significantly affect nutrient availability and water retention, thereby influencing plant growth independently of irrigation and nitrogen application. Nevertheless, differences in pest populations and plant disease may also impact plant health, potentially skewing results, as these factors can harm plants regardless of irrigation and nitrogen levels.

3.8 Sustainability of the Practice

By allowing the soil to dry slightly between irrigation, root systems can develop more effectively, improving water absorption and reducing the overall volume of water needed. Also applying the optimum level of nitrogen, growers can reduce the risk of nitrogen leaching into groundwater, which can lead to pollution of water bodies. Proper nitrogen levels promote better plant growth and yield, reducing the need for additional fertilizer applications, which can further limit environmental impact. Implementing best practices for nitrogen application, such as split applications or using slow-release fertilizers, can improve soil structure and fertility over time, contributing to long-term sustainability.

3.9 Statistical Analysis

To analyze the effects of LSD, a mixed-model ANOVA was employed to assess differences across various conditions. Post-hoc tests was utilized for pairwise comparisons when significant effects were found. Data visualization was handled using R, and Statistical significance was set at $p < 0.05$.

4. CONCLUSION

In conclusion, optimizing cabbage growth hinges on the strategic combination of nitrogen fertilizer and irrigation practices. The ideal conditions for maximum cabbage head growth are achieved through frequent irrigation every six days and the application of 100 kg ha^{-1} of nitrogen fertilizer.

This synergy not only fosters robust plant development but also enhances marketable yields while minimizing unmarketable produce. Specifically, while high nitrogen levels promote growth, their effectiveness is maximized when paired with adequate irrigation. Conversely, a balanced approach of higher nitrogen with less frequent irrigation can be beneficial for plant spread. Therefore, implementing these tailored practices will significantly improve crop yield and nutrient uptake efficiency, ultimately supporting sustainable cabbage cultivation. This study highlights the critical interplay between nitrogen fertilizer application and irrigation intervals in optimizing cabbage growth and yield. The key findings indicate that the application of 100 kg ha^{-1} of nitrogen significantly enhances various growth parameters, including head height, plant height, spread, and overall yield. Specifically, the tallest cabbage heads measured 18.92 cm, and the largest head diameter was observed under this nitrogen level, demonstrating a clear positive correlation between nitrogen and plant growth. Furthermore, a 6-day irrigation interval emerged as optimal for maintaining soil moisture, which is crucial for nutrient uptake and overall plant health, leading to substantial increases in marketable yields. The highest marketable yield of 63.5 t/ha was achieved with the combined treatment of high nitrogen and frequent irrigation, while the lowest yield corresponded to treatments lacking nitrogen. These results reinforce the conclusion that both adequate nutrient supply and consistent water availability are essential for maximizing crop productivity. Despite potential limitations such as soil variability and pest pressures, the findings underline the importance of a balanced approach to fertilization and irrigation in cabbage cultivation. Implementing these practices not only boosts yields but also contributes to environmental sustainability by minimizing water usage and reducing the risk of nitrogen leaching. Future research could further explore these dynamics across varying soil types and climatic conditions to enhance our understanding of sustainable agricultural practices. Overall, this study supports the notion that integrated nutrient and water management strategies are vital for optimizing cabbage production, ensuring both economic viability and environmental stewardship

5. RECOMMENDATION

Based on the research findings, the study puts forward the following recommendations:

i. Implement a combination of 6-day irrigation scheduling and 100 kg/ha of nitrogen fertilizer for maximum cabbage head growth.
ii. For optimal plant height, use a higher nitrogen dose of 75 kg/ha alongside a frequent irrigation schedule every 6 days.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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