Adamawa State University Global Journal of Geography and Environmental Sciences
(ADSU-GJGES)
Volume 06 Issue 1, 2026
ISSN: 2651-3830 (Print); 2756-4142 (Online)

Website: *gjges.adsu.edu.ng* *Email:* *gjges@adsu.edu.ng*

ORIGINAL RESEARCH ARTICLE

Effect of Different Nitrogen Levels on the Growth and Yield of Sweet Pepper [*Capsicum annuum* (L.)] in Mubi North Adamawa State, Nigeria

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DOI: https://doi.org/10.64290/gjges.v6i1.38

ARTICLE INFO

Article History:
Received 15th March 2026
Revised 23rd March 2026
Accepted 27th March 2026

Keywords:
- Sweet pepper;
- Nitrogen fertilizer;
- Growth;
- Yield;
- Mubi North

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ABSTRACT

This study investigated the effect of nitrogen levels on the growth and yield of sweet pepper [Capsicum annuum (L.)] under field conditions. The experiment was conducted using a Randomized Complete Block Design (RCBD) with four nitrogen levels 0, 50 100, and 150 kg N ha^{-1}, replicated three times. Data was collected on plant height, number of leaves, lateral branches, stem girth, number of fruit, fruit length, fruit weight, and total fruit yield, and were analyzed using analysis of variance. The results revealed that nitrogen fertilizer significantly influenced of both vegetative growth and yield components of sweet pepper. Increase in nitrogen levels enhanced growth and yield up to 100 kg N ha^{-1}, beyond which yield declined. The highest growth and yield performance were obtained at 100 kg N ha^{-1}, indicating this rate as the optimum for sweet pepper production under the conditions of the study. The findings highlight the importance of nitrogen nutrition in improving sweet pepper productivity and suggest that excessive nitrogen application does not necessarily enhance yield. The study recommends the application of 100 kg N ha^{-1} for optimal performance and efficient nutrient use in sweet pepper cultivation.

Introduction

Sweet pepper commonly known as bell pepper, is scientifically known as [(*Capsicum annuum* (L)]. It belongs to the *Solanaceae* family, often referred to as the nightshade family, which also includes other economically important crops such as tomatoes, potatoes, and eggplants. It is a valuable vegetable crop cultivated worldwide for its nutritional, economic, and culinary importance. It is rich in vitamins A and C, and provides a source of income for many small- and large-scale farmers. In many developing countries, the demand for sweet pepper is increasing due to its role in food security and dietary diversity. Sweet pepper domestication can be traced back to Central and South America, particularly southern Mexico in regions such as Oaxaca, Chiapas, and Puebla (Pickersgill, 2007). Archaeological evidence reveals that wild pepper species were cultivated as early as 5000–6000 BCE by indigenous peoples who developed an advanced understanding of plant breeding. Over generations, they selectively bred the plants for traits such as flavor, fruit size, and reduced pungency. The development of the sweet pepper involved a significant reduction in the production of capsaicin, the chemical responsible for the spiciness found in hot peppers. Through intentional selection, early farmers produced varieties that were milder and more palatable to a wider audience (Bosland & Votava, 2012). These non-pungent varieties eventually evolved into the modern sweet or bell peppers we consume today. The global distribution of sweet pepper began during the Age of Exploration. Sweet peppers, however, quickly gained favor in Europe for their unique taste and versatility. From Europe, sweet peppers spread rapidly to Africa, the Middle East, and Asia, particularly through colonial trade routes and agricultural adaptation. In India, China, and parts of Southeast Asia, the pepper became an integral part of local agriculture and cuisine. The plant's ability to thrive in both tropical and temperate climates contributed to its broad geographic distribution (DeWitt & Bosland, 2009). In modern times, sweet peppers are cultivated in almost every region of the world. Countries such as China, Mexico, Turkey, the United State, and Indonesia are among the top global producers (FAO, 2023). With the advancement of greenhouse technology, peppers can now be grown year-round in cooler climates as well, significantly expanding their availability and economic value.

Sweet pepper thrives best in warm, frost-free environments. It is a warm-season crop that grows optimally in temperatures ranging between 20°C and 30°C (FAO, 2020). Temperatures below 15°C can significantly hinder germination and growth, while temperatures above 35°C can result in flower drop, poor fruit set, and sunscald (Bosland & Votava, 2012). Excessive heat also negatively affects pollen viability, leading to reduced yields. Humidity levels play a significant role in pepper production. While sweet peppers require adequate humidity for growth, high relative humidity—especially above 85%—can favor the development of fungal diseases such as powdery mildew and bacterial leaf spot (Rubatzky & Yamaguchi, 2012). On the other hand, very low humidity, particularly in dry, windy climates, can lead to increased transpiration and physiological disorders like blossom end rot. Light intensity is another crucial factor. Sweet pepper requires full sunlight for at least 6–8 hours a day. Shaded conditions reduce photosynthetic activity, which may lead to spindly growth and poor fruit development (Rai *et al.*, 2011). Additionally, sweet pepper is sensitive to photo-period and grows best under day-neutral conditions. Sweet pepper is adaptable to a variety of soil types, but for optimal growth and productivity, it prefers well-drained, loamy or sandy-loam soils rich in organic matter (FAO, 2020). Good soil structure is essential for healthy root development and nutrient uptake. Water-logging or compacted soils can restrict root growth and predispose the plant to root diseases. Soil pH is a key determinant of nutrient availability. Sweet pepper grows best in slightly acidic to neutral soils with a pH range of 6.0 to 6.8 (Bosland & Votava, 2012). Below pH 5.5, the risk of aluminum and manganese toxicity increases, while a pH above 7.5 may lead to deficiencies in micronutrients such as iron and zinc.

Globally, sweet pepper is a major horticultural crop grown in both open fields and protected environments such as greenhouses. According to the Food and Agriculture Organization (FAO, 2023), the top producers of sweet and chili peppers (combined) include China, Mexico, Turkey, Indonesia, and the United State. China leads by a significant margin, accounting for over 45% of the world's production. The country's dominance is due to large-scale greenhouse cultivation, advanced irrigation systems, and favorable government policies. Mexico, the second-largest producer, is also the leading exporter of fresh sweet peppers, particularly to the United State and Canada (USDA, 2022). The adoption of greenhouse farming has significantly increased pepper yields and extended growing seasons in Mexico and parts of Europe, especially Spain and the Netherlands. Greenhouse production is a growing trend worldwide, especially in developed countries where climate control allows year-round cultivation. In Europe, countries such as the Netherlands and Spain have become key exporters due to high-tech farming and favorable climatic zones (Heuvelink, 2018).

In Nigeria, sweet pepper is cultivated primarily in the northern regions due to their relatively cooler and drier climate, which is more suitable for pepper cultivation. States such as Kano, Kaduna, Plateau, Bauchi, and Gombe are key production zones (National Horticultural Research Institute [NIHORT], 2021). However, compared to global standards, sweet pepper production in Nigeria remains largely subsistence-based, with most farmers relying on rain-fed agriculture and traditional farming techniques. One of the major challenges facing sweet pepper production in Nigeria is the lack of irrigation infrastructure, especially in dry seasons when market demand peaks. Additionally, poor access to improved seed varieties, fertilizers, and pest management strategies hampers productivity. Post-harvest losses due to poor storage and transportation also affect the value chain significantly (Adeoye *et al.*, 2017). They are a nutritious vegetable that can be eaten raw or cooked, added to various dishes, and used in some natural remedies. Sweet peppers can be eaten raw as a snack, in salads, or with dips. They can be roasted, grilled, or stir-fried. Bell peppers are commonly stuffed with various fillings like rice, meat, vegetables, or cheese. They can be diced and added to pasta sauces, omelets, pizzas, or stir-fries. Slices or strips can be added to salads, sandwiches, and wraps. They can be blended into sauces, dips, and salsas. Bell peppers are rich in vitamins C and A, fiber, and antioxidants. They help protect against cell damage and may reduce the risk of certain diseases. Vitamin C in peppers supports immune health. Carotenoids in bell peppers may protect against vision loss. Nitrogen plays a vital role in the synthesis of amino acids, proteins, and chlorophyll. Adequate nitrogen availability promotes vigorous vegetative growth, which includes increased stem elongation, leaf area, and photosynthetic efficiency. According to Hochmuth and Hanlon (2010), applying nitrogen at recommended rates significantly increased the biomass and canopy size of bell pepper plants, thereby enhancing their capacity for fruit production. Excess nitrogen, however, may lead to excessive vegetative growth at the expense of fruiting, delaying flowering and reducing fruit quality (Kawabata *et al.*, 2007).

Despite its potential, sweet pepper production in many regions remains below optimal levels. Among the major limiting factors are poor soil fertility and inadequate fertilizer management. Nitrogen is a vital macro-nutrient needed for vegetative growth and fruit development. Urea, which contains 46% nitrogen, is one of the most commonly used nitrogen fertilizers in crop production. When applied appropriately, urea can significantly improve plant height, leaf area, and fruit yield. However, overuse or under-use can lead to adverse effects such as nutrient imbalances, reduced yield, or environmental pollution through leaching and volatilization. Understanding the appropriate rate of urea application is essential for maximizing crop productivity while minimizing costs and environmental impacts. This research is therefore aimed at determining the optimal urea fertilizer rate that enhances the growth and yield of sweet pepper under field conditions. Several studies have demonstrated a positive correlation between nitrogen application and sweet pepper yield, especially when applied in split doses throughout the growing season. Abdul-Rahman *et al*. (2013) observed that sweet pepper plants treated with 150 kg N/ha had significantly higher yields compared to those with lower or no nitrogen application. The yield increase is attributed to enhanced flower formation, fruit set, and increased fruit size. Nitrogen Use Efficiency is a measure of how effectively plants utilize applied nitrogen. Fertilizer management practices such as fertigation (applying fertilizer via irrigation) and using slow-release nitrogen sources can improve NUE and minimize nitrogen losses through leaching and volatilization (Cantliffe *et al*., 2000). Mubi North is specifically required for this study because the area is known for vegetable farming, but there is limited information on the appropriate urea fertilizer rate for sweet pepper under the local soil and climatic conditions. Conducting the study in Mubi North will help determine the optimal nitrogen level suitable for the environment, which will improve sweet pepper growth, yield, and nitrogen use efficiency among farmers in the area

The objectives of the study are to; evaluate the effect of nitrogen fertilizer levels on the growth and yield of sweet pepper; and identify the optimal rate of nitrogen fertilizer application for maximum yield in sweet pepper.

Materials and Methods

The study was conducted at Food and Agriculture Organization/Tree Crop Programme (FAO/TCP) Farm, Department of Crop Science Faculty of Agriculture Adamawa State University Mubi, located at latitude 9˚30 - 11°00 N and longitude 12°13 - 13°45 E with elevation of 696m above the mean sea level. The area experiences an average annual rainfall of 800-1000mm and average temperature of 18°C during hamatan period and 40°C as maximum in April. The soil in the study area is predominantly loamy/sandy loam, known for good drainage and moderate fertility.

Experimental Design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with four treatments replicated three times. Each plot measured 2m × 2m with 0.5m spacing between plots and 1m between blocks with 16 plants per plot in the year 2025.

Treatments Details

Four different rates of nitrogen fertilizer was applied:

T_1: 0 N kg/ha (Control – no nitrogen fertilizer)
T_2: 50 N kg/ha
T_3: 100 N kg/ha
T_4: 150 N kg/ha

The fertilizer was applied in two splits dose: half at four weeks after transplanting, and the other half at flowering stage.

Land Preparation and Transplanting

The land was cleared, ploughed, and leveled. Beds were raised and marked according to the experimental layout. Healthy sweet pepper seedlings (4–5 weeks old) were transplanted at a spacing of 50 cm × 50 cm, with one seedling per hole.

Crop Management Practices

Weeding: Manual weeding was carried out at three weeks interval.

Pest and Disease Control: Insecticides and fungicide was applied when necessary using standard dosages.

Data Collection

The following growth and yield parameters were recorded from five tag plants randomly selected per plot:

Growth parameters:

i. Plant height (cm) was measured from the base to the tip of the plant with a meter rule.
ii. Number of leaves was counted manually.
iii. Number of branches (lateral stems) were counted manually.
iv. Stem girth (cm) was measured at the base of the plants using a caliper.

Yield parameters:

i. Number of fruits per plant was counted at harvest.
ii. Average fruit weight (g) was measured using a digital scale.
iii. Fruit length (cm) was measured from the fruit's stem end to the blossom end (tip) using a ruler.
iv. Total fruit yield per plot (kg) was converted to yield per hectare.

Statistical Analysis

Data collected was subjected to Analysis of Variance (ANOVA) using Statistical Analysis Software (SAS, 2008). Differences between treatments means was compared using Least Significant Difference (LSD) at a 5% level of significance.

Results

Physico-Chemical Properties of the Soil at the Experimental Site for the year 2025 Growing Season.

The result of the physical and chemical properties of the soil at the experimental site at the depths of 0-20 cm and 20-40 cm for the year 2025 growing season is presented on Table 1. The physical analysis of the soil of the experimental site at the depths of 0-20 cm and 20-40 cm gave a particular distribution of 68.8% and 70.8% sand; 14.4% and 11.4% silt; and 16.8% and 17.8% clay. The textural class was found to be sandy loam. Bulk density at 0-20 cm and 20-40 cm are 1.4 and 1.46 cm, particle density 2.38 and 2.43 cm^3, total porosity (%) 37.5 and 39.92 respectively.

The result of chemical properties at the depths 0-20 cm and 20-40 cm showed a soil pH (1:2) values of 6.7 and 6.8, electric conductivity 0.07 and 0.09, organic carbon 1.06

and 0.54, total nitrogen 0.1 and 0.05, available phosphorus 9.26 and 8.74. These indicate that the soil is slightly acidic. The electric conductivity (ds/m) of the soil increases from 0.07 to 0.09, the total nitrogen was found to be low which initiated this research.

Effect of Nitrogen Fertilizer Levels on Growth Parameters of Sweet Pepper (Capsicum annum) in Mubi North Adamawa State during 2025 Growing Season

The effects of different nitrogen fertilizer levels on plant height, number of leaves, lateral branches, and stem girth of sweet pepper at six (6) and nine (9) weeks after transplanting (WAT) are presented on Table 2. The results showed significant ($p < 0.05$) differences among treatments for all growth parameters measured.

Table1: Physical and chemical Properties of the Soil in the Experimental Site at the Depths of 0-20 and 20-40 cm for 2025 Growing Season in Mubi.

Parameter	**0-20 cm**	**20-40 cm**
Physical Properties		
Sand (%)	68.8	70.8
Silt (%)	14.4	11.4
Clay (%)	16.8	17.8
Textural Classes	Sandy Loam	Sandy Loam
Bulk Density (g/cm^3)	1.49	1.46
Particle Density (g/cm^3)	2.38	2.43
Total Porosity (%)	37.5	39.92
Chemical Properties		
pH (1:2)	6.7	6.80
E Conductivity (s/m)	0.07	0.09
Organic Carbon (%)	1.06	0.54
Total Nitrogen (%)	0.09	0.05
Av Phosphorous (g/kg)	9.26	8.74
Exchangeable Bases		
Calcium (c mol/kg)	1.85	8.80
Potassium (c mol/kg)	0.56	0.23
Magnesium (c mol/kg)	2.25	1.20
Sodium (c mol/kg)	0.08	0.78
FB TEB (c mol/kg)	4.74	11.01
TEA (c mol/kg)	1.51	1.87
CEC (c mol/kg)	6.24	12.88
PSB (%)	85.67	88.72
ESP (%)	1.32	6.09

Table 2: Effect of Nitrogen Levels on Growth Parameters

Treatment Levels (kg N ha^{-1})	P —H (cm)		N —L (no)		L —B (no)		S —G (cm)	
	6 WAT	9 WAT	6 WAT	9 WAT	6 WAT	9 WAT	6 WAT	9 WAT
0	16.400	35.200	11.333	22.333	1.000	2.333	1.033	1.250
50	24.933	48.566	16.000	31.333	2.333	4.000	1.220	1.490
100	31.900	54.767	23.667	38.000	3.333	5.000	1.487	1.857
150	27.800	51.600	26.103	42.233	4.000	5.333	1.280	1.663
P of F	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.000
LSD	1.510	1.018	0.882	0.913	0.527	0.333	0.066	0.038

Keys: PH - Plant Height, NL – Number of Leaves, LB – Lateral Branches, SG – Stem Girth and WAT – Weeks after Transplanting

Plant Height (cm)

The result of effect of nitrogen levels on plant height of sweet pepper (Table 2) showed significant ($p < 0.05$) difference among treatments for plant height at both 6 and 9 WAT. Plant height increased progressively with increasing nitrogen levels up to 100 kg N ha^{-1} at both 6 and 9 WAT. Plants that received 100 kg N ha^{-1} recorded the tallest plant heights with a mean value of 31.90 cm and 54.77 cm at 6 and 9 WAT, while the control (0 kg N ha^{-1}) recorded the shortest plant heights with a mean value of 16.40 cm and 35.00 cm at 6 and 9 WAT respectively. A further increase in nitrogen to 150 kg N ha^{-1} slightly reduced plant height with a mean value of 27.8 cm and 51.6 cm at 6 and 9 WAT.

Number of Leaves

The result of effect of nitrogen levels on number of leaves of sweet pepper is presented in Table 2. The results showed significant ($p < 0.05$) differences among treatments for number of leaves at both 6 and 9 WAT. Nitrogen fertilizer significantly affected the number of leaves at both growth stages. Number of leaves increased steadily with increasing nitrogen up to 150 kg N ha^{-1}. The highest number of leaves (26.10 and 42.23 at 6 and 9 WAT), was obtained from plants treated with 150 kg N ha^{-1}, while the lowest values were recorded in the 0 kg N ha^{-1} with an average mean of 11.33 and 22.33 at 6 and 9 WAT.

Lateral Branches

The result of effect of nitrogen levels on lateral branches of sweet pepper (Table 2) shows that, effect of nitrogen levels on lateral branches is highly significant ($P< 0.001$) at both 6 and 9 WAT. The number of lateral branches also increased significantly with nitrogen application. At 6 and 9 WAT, plants fertilized with 150 kg N ha^{-1} had the highest number of lateral branches with a mean value of 4.00 and 5.33 respectively, followed closely by those that received 100 kg N ha^{-1} with mean value of 3.33 and 5.00, while the 0 kg N ha^{-1} produced the fewest with an average value of 1.00 and 2.33.

Stem Girth (cm)

The result of effect of nitrogen levels on stem girth of sweet pepper is presented on Table 2. The result shows that effect of nitrogen levels on stem girth is highly significant ($P< 0.001$) at both 6 and 9 WAT. The thickest stems were recorded at 100 kg N ha^{-1} (1.49 cm at 6 WAT and 1.86 cm at 9 WAT), while the 0 kg N ha^{-1} had the thinnest stems (1.03 cm at 6 WAT and 1.25 cm at 9 WAT). A slight reduction at 150 kg N ha^{-1} (1.28 cm and 1.66 cm) was recorded.

Effect of Nitrogen Fertilizer Levels on Yield Parameters of Sweet Pepper

The effects of varying nitrogen levels on yield components of sweet pepper—namely, number of fruits per plant, fruit length, fruit weight, and yield per hectare—at harvest are presented on Table 3. The results revealed significant ($p < 0.05$) differences among nitrogen treatments for all yield parameters measured.

Table 3: Effect of Nitrogen Levels on Yield Parameters

Treatment Levels (kg N ha^{-1})	Number of Fruits (no)	Fruit Length (cm)	Fruit Weight (g)	Yield Per Hectare (kg)
0	2.333	3.200	16.667	41.667
50	5.333	4.500	25.233	63.250
100	11.667	6.000	32.700	81.250
150	8.333	5.433	29.400	73.333
P of F	0.000	0.000	0.000	0.000
LSD	0.745	0.213	1.366	3.520

Number of Fruits

The results of number of fruits at harvest presented on Table 4 revealed significant ($p < 0.05$) differences among nitrogen treatments for number of fruit per plant. The highest mean value of fruits number was recorded at 100 kg N ha^{-1} (11.67), while the 0 kg N ha^{-1} produced the lowest number with a mean value of 2.33. Number of fruit increased steadily with increasing nitrogen up to 100 kg N ha^{-1}, beyond which there was a decline at 150 kg N ha^{-1} which recorded an average value of 8.33.

Fruit Length (cm)

The result of fruit length at harvest is presented in Table 4.3. A highly significant difference ($p \le$ 0s.01) was observed in fruit length due to nitrogen application. The longest fruits with mean value of 6.00 cm were produced by plants supplied with 100 kg N ha^{-1}, while the shortest was observed on 0 kg N ha^{-1} with average value of 3.25 cm. A slight reduction was recorded at 150 kg N ha^{-1} with an average value of 5.43.

Fruit Weight (g)

The result of fruit weight at harvest is presented in Table 4.3. Nitrogen fertilizer significantly ($p \le 0.01$) influenced fruit weight. The highest mean value of fruit weight (32.70 g) was recorded at 100 kg N ha^{-1}, followed by 29.40 g at 150 kg N ha^{-1}, while the 0 kg N ha^{-1} recorded the lowest average value (16.67 g).

Yield per Hectare (kg)

The result of fruit yield per hectare at harvest is presented on Table 3. Nitrogen application had a highly significant ($p \le 0.01$) effect on total fruit yield per hectare. The plants treated with 100 kg N ha^{-1} recorded the highest yield with a mean of 81.25 kg ha^{-1}, while the 0 kg N ha^{-1} produced the lowest yield (41.67 kg ha^{-1}). Yield increased progressively with nitrogen up to 100 kg N ha^{-1} and declined slightly thereafter at 150 kg^{-1} with a mean value of 73.33 kg^{-1}.

Discussion

The results of this study revealed that nitrogen fertilizer had a significant effect on the vegetative growth parameters of sweet pepper [*Capsicum annuum* (L.)] at 6 and 9 weeks after transplanting (WAT) during the 2025 cropping season in Mubi North, Adamawa State. The parameters assessed included plant height, number of leaves, number of lateral branches, and stem girth.

Plant height increased progressively with nitrogen application, with the tallest plants recorded at 100 kg N ha^{-1} at both 6 and 9 WAT with a mean value of 31.90 cm and 54.77 respectively. This indicates that nitrogen enhanced vegetative growth by stimulating cell division and elongation. The control plants (0 kg N ha^{-1}) recorded the shortest plant height with a mean value of 16.40 cm and 35.20 cm at 6 and 9 WAT, showing the importance of nitrogen in promoting vigorous plant growth. The slight decline at 150 kg N ha^{-1} (27.80 and 51.60 cm at 6 and 9 WAT) may be due to excessive vegetative growth that caused shading or nutrient competition, which could limit plant height. This finding agrees with the observations of Toungos & Yahya (2018), who reported that moderate nitrogen application significantly increased plant height in sweet pepper, while excessive levels had no additional benefit.

The number of leaves per plant also increased significantly with increasing nitrogen levels. The highest number of leaves was recorded at 150 kg N ha^{-1} with a mean value of 26.10 and 42.23 at 6 and 9 WAT, followed by 100 kg N ha^{-1} (23.67 and 38.00 at 6 and 9 WAT), while the 0 kg N ha^{-1} plants had the fewest leaves with a mean value of 11.33 and 22.33 at 6 and 9 WAT. This suggests that nitrogen promotes leaf production and expansion, thereby increasing the photosynthetic surface area of the plant. These results are in agreement with the findings of Islam, et al (2018), who reported that nitrogen fertilizer improved leaf production and overall vegetative growth in pepper and Bar-Tal *et al.* (2001) who noted that excessive nitrogen application can lead to luxuriant vegetative growth, which may interfere with flowering and fruit development due to competition for assimilates.

Similarly, the number of lateral branches increased with nitrogen application up to 150 kg N ha^{-1} which recorded a mean value of 4.00 and 5.33 cm at 6 and 9 WAT respectively. The highest number of branches at 150 kg N ha^{-1} indicates that nitrogen enhances branching by stimulating axillary bud development. Branching is an important growth component as it increases the plant's potential fruit-bearing sites. This agrees with the report of Aminifard *et al*. (2012) and Saqib, et al (2022), who observed that high nitrogen rates tend to promote vegetative growth at the expense of branching and reproductive development.

Stem girth also responded positively to nitrogen fertilizer application, with the thickest stems recorded at 100 kg N ha^{-1} (1.49 cm and 1.86 cm at 6 and 9 WAT). Nitrogen enhances stem diameter by improving the development of vascular tissues, which support water and nutrient transport within the plant. The reduced stem girth at 150 kg N ha^{-1} (1.28 and 1.66 cm at 6 and 9 WAT) may be attributed to excessive vegetative growth leading to competition for assimilates. These findings are in consonance with that of Saqib *et al*. (2022) who found that nitrogen application improved growth and fruit yield of sweet pepper up to an optimum level.

Overall, the results clearly show that nitrogen fertilizer plays a vital role in the vegetative development of sweet pepper. The optimum nitrogen rate for achieving maximum growth performance was found to be 100 kg N ha^{-1}, beyond which growth parameters declined slightly. This suggests that excessive nitrogen application does not necessarily enhance growth but may instead lead to nutrient imbalance or excessive vegetative expansion. The findings of this study are in agreement with earlier reports that emphasize the importance of applying nitrogen at optimum rates to achieve balanced vegetative and reproductive growth in sweet pepper.

The results from this study showed that nitrogen fertilizer significantly influenced the yield parameters of sweet pepper [*Capsicum annuum* (L.)] at the first harvest. The parameters measured included number of fruits, fruit length, fruit weight, and yield per hectare. The response of sweet pepper to different nitrogen levels shows that the crop performed best at a moderate nitrogen rate of 100 kg N ha^{-1}.

The number of fruits per plant increased progressively with increasing nitrogen levels up to 100 kg N ha^{-1} and declined slightly at 150 kg N ha^{-1}. This indicates that nitrogen application enhanced flowering and fruit setting up to an optimum level, beyond which further increase reduced fruit number. The reduction at higher nitrogen levels could be attributed to excessive vegetative growth that diverted assimilates away from fruit formation. This agrees with the findings of Aminifard *et al*. (2012), El-Tohamy *et al*. (2009), and Bar-Tal *et al*. (2001), who reported that moderate nitrogen levels significantly improved fruit formation in sweet pepper, while excessive nitrogen caused a decline in fruit number due to luxuriant vegetative growth.

Similarly, fruit length and fruit weight increased with increasing nitrogen rates up to 100 kg N ha^{-1} and slightly decreased at 150 kg N ha-^{1}. The significant increase in these parameters suggests that nitrogen plays an important role in enhancing cell division, cell enlargement, and overall fruit development. The slight decline at higher nitrogen levels could be due to imbalanced nutrient uptake or shading effects from excessive foliage. These results are in line with the observations of Aminifard and Bayat (2018), who found that excessive nitrogen can reduce fruit size and quality by promoting vegetative growth at the expense of reproductive organs and also Toungos and Yahya (2018), reported that excessive nitrogen suppressed Performances.

The yield per hectare followed a similar trend as other yield components, with the highest value (81.25 kg ha^{-1}) recorded at 100 kg N ha^{-1}. Beyond this rate, the yield declined slightly at 150 kg N ha^{-1} (73.33 kg ha^{-1}). This suggests that nitrogen significantly increased yield up to an optimum level, after which additional nitrogen did not translate to higher yield. The improvement in yield up to 100 kg N ha^{-1} could be due to better vegetative growth, efficient photosynthetic activity, and improved translocation of assimilates to developing fruits. The result is in line with findings of Akanbi *et al*. (2010), who reported that excessive nitrogen supply can delay maturity and reduce total yield.

In general, all the measured parameters (number of fruits, fruit length, fruit weight, and yield per hectare) were highly significant ($P \leq 0.01$), indicating that nitrogen fertilizer had a strong influence on sweet pepper performance. The results therefore suggest that the application of 100 kg N ha^{-1} is the optimum rate for achieving maximum fruit yield and quality of sweet pepper under the environmental conditions of Mubi North, Adamawa State.

Conclusion

This study investigated the effect of different nitrogen levels on the growth and yield of sweet pepper (*Capsicum annuum* L.) under field conditions in Mubi North adamawa State Nigeria. The study was conducted at FAO/TCP farm of the Department of Crop

Science Adamawa State University Mubi. The experiment was laid in a complete randomized block design with four nitrogen levels (0, 50, 100, and 150 kg N ha^{-1}), replicated three times. Data were collected on plant height, number of leaves, lateral branches, stem girt, fruit number, length, and weight, and fruit yield per hectare. It was subjected to analysis of variance (ANOVA) and differences between treatments were compared using least significant difference.

The study therefore established that nitrogen plays a vital role in performance of sweet pepper, influencing both growth and yield. The optimum rate for achieving maximum yield under the experimental conditions was found to be 100 kg N ha^{-1} with an average mean value of 81.25 kg ha^{-1}, beyond which yield decline.

The findings of this study clearly demonstrated that nitrogen fertilizer significantly influenced vegetative growth and yield performance of sweet pepper. Increasing nitrogen levels led to progressive improvements on vegetative growth and yield performance up to a certain level. Among the nitrogen rates evaluated, the application of 100 kg N h^{-1} consistently produced the highest plant growth and fruit yield, while further increases beyond this rate resulted in a decline in performance.

This indicate that nitrogen is an essential nutrient for sweet pepper growth, but excessive application does not necessarily translate into higher yield and may even have negative effects on plant development. Therefore, under the soil and climatic conditions of the study area, 100 kg N ha^{-1} is considered the optimum rate for achieving maximum yield and efficient fertilizer use in sweet pepper production.

Recommendations

Farmers cultivating sweet pepper under similar agro-climatic conditions should apply 100 kg N ha^{-1} for optimum yield and efficient fertilizer use.

Extension agents should educate farmers on proper fertilizer management to avoid over-application and environmental pollution.

Further research should be conducted to determine the interaction of nitrogen with other essential nutrients such as phosphorus and potassium for balanced plant nutrition.

Studies across different soil types and climatic zones are also recommended to validate the optimum nitrogen requirement for sweet pepper production.

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