Asian Journal of Research in Crop Science

Volume 9, Issue 4, Page 176-184, 2024; Article no.AJRCS.125320
ISSN: 2581-7167

Variety of Lettuce (*Lactuca sativa* L.) Growth and Yield in Response to Various Organic Fertilizers in Makurdi, Nigeria

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Authors' contributions

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

Article Information

DOI: https://doi.org/10.9734/ajrcs/2024/v9i4309

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/125320

Original Research Article

Received: 14/08/2024
Accepted: 17/10/2024
Published: 29/10/2024

ABSTRACT

This study was conducted in 2023 at the nursery of the Teaching and Research farm of the Department of Crop production of Joseph Sarwuan Tarka University Makurdi, Benue State, Nigeria. The experimental treatments were two (2) varieties of lettuce (ice berg and Butter head) and three (3) organic manure sources (Poultry dropping, cow dung, goat manure) and a control. An experiment was set up as a 2 x 4 factorial design using a randomized complete block design (RCBD) with three replications. Data were collected from the following parameters, plant height, plant diameter, number of leaves, leaf area index (LAI), crop growth rate (CGR), roof weight, and fresh weight. All the study parameters of lettuce were significantly (P<0.05) different, on both organic manure, and variety. The iceberg variety surpassed the butter head variety, with statistically significant (P<0.05) differences observed in several parameters: plant height (20.32 cm), number of

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Cite as: *P., Madina, Ugoo, T. R, and Adorolo, M. O. 2024. "Variety of Lettuce (Lactuca Sativa L.) Growth and Yield in Response to Various Organic Fertilizers in Makurdi, Nigeria". Asian Journal of Research in Crop Science 9 (4):176-84. https://doi.org/10.9734/ajrcs/2024/v9i4309.*

leaves (23.85), leaf area index (15.19 cm^3), crop growth rate (1.54 g m^3 per day), chlorophyll content (23.32 mg/g), fresh weight (83.86 g), root weight (20.23 g), and yield (3.19 t/ha) Similarty, poutry droppings obtained significantly ($P<0.05$) better results in terms of plant height (21.73 cm), number of leaves (23 92), leaf area Index (16.75 cm^2), crop growth rate (3.70 g m^3 per day), chlorophyll content (25.73 mg/g), fresh weight (632.02 g), root weight (22.13 g) and yield (3.75 t/ha) as compared to other organic manure sources such as cow dung, goat manure and control. In addition, a significant difference ($P<0.05$) was observed in the interaction between lettuce varieties selection and organic fertilizers at various levels, particularly with the high level of iceberg x poultry manure

Keywords: Lettuce; organic manure; variety; growth; yield.

1. INTRODUCTION

The state of the soil and its health are essential to agricultural productivity. One of the biggest obstacles to the food security and income levels of smallholder farmers in developing nations who are extremely dependent on their land and feel a strong sense of attachment to it is the degraded soils and fertility status of tropical soils [1-4].

The concern over food intake that has been overly treated with chemicals is growing every day because it is known that certain chemicals, when ingested in excess of reasonable limits, can lead to short- and long-term health problems. Additionally, since vegetable lettuce is consumed in its natural state, consumers' concerns about the farming practices of this crop are also growing [5-7]. While mineral fertilizers are often used in lettuce cultivation and provide good yields, other factors to take into account include consumer health, production costs, and product quality [6]. A strategy to lessen reliance on chemical fertilizers is to explore for substitute sources, including organic fertilizers, which are affordable, easily accessible, eco-friendly, and highly productive. Worldwide interest has been shown in organic fertilizers since they are a source and repository of certain essential plant nutrients [8].

Lettuce (*Lactuca sativa* L.) is an exotic African vegetable [9,4] that is prized for its nutritional and therapeutic benefits. It is one of the world's most popular vegetables due to its high fiber content, low calories, fat, and salt. Furthermore, it contains iron, folic acid, vitamin C, and bioactive substances that are beneficial to health [10]. Its cultivation through small-scale irrigation and in home gardens has grown in recent years [11].

As such, there has been an increase in its demand in metropolitan areas recently. In Nigeria, the ideal growing conditions for lettuce are loose, nitrogen-rich soils with a pH of 6.0 to 6.8 [12,6]. In Nigeria, it is a widely consumed vegetable crop that is utilized in many different recipes. Of all the salad crops, lettuce is one of the most extensively planted and occupies the largest production space globally [13, 14,6]. It is mostly eaten fresh and is high in fiber, phenolic compounds, minerals, and vitamins [10,14]. Thus, this study's goal was to assess how different organic fertilizers applied to lettuce cultivars affected their growth and production in Makurdi, Nigeria.

2. MATERIALS AND METHODS

2.1 Experimental Location

This study was carried out in 2023 at Joseph Sarwuan Tarka University Makurdi (JOSTUM), in Benue State, Nigeria, at the nursery sector of the Teaching and Research farm of the Department of Crop Production. Makurdi, a tropical area inside Nigeria's Southern Guinea Savannah Agro-Ecological zone, is situated at Lat. 7.410N and Long 8.280E, 97 meters above sea level.

2.2 Experimental Treatments and Design

The experiment was designed as a 2 x 4 factorial design, arranged within a Randomized Complete Block Design (RCBD) and replicated three times. The treatments were two (2) varieties of lettuce (Factor A by Iceberg and Butter-head) and tour (4) organic manure types (Factor B by Poultry dropping, goal manure, Cow dung and a control) was used. All the organic manure are collected from animal kept under intensive care and was allowed to undergo partial decomposition for three months following the recommendation of Yusuf and Paul [15] before it was used for the experiment.

2.3 Land Preparation, Planting and Application of Fertilizers

Lettuce (Iceberg and Butter-head) were used. Lettuce seeds were sown in nursery trays and

were watered twice a day to ensure good germination and establishment, the seeds germinated in 5-8 days after sowing days after sowing (DAS). The seedlings were transplanted in the main field after 20-25 days after sawing (DAS), the nursery establishment is important because directly sowing of seeds may not germinate well. A $4m^2$ plot was laid out with 1m between plots and 1m between blocks. There were 5 plots each within a block which gave the total number of 24 plots for the study, a spacing of 15 x 75cm was adopted for the research, Agronomic practice such as weeding was done manually twice at 2 and 4 weeks after planting to ensure weed free plots. There was no infestation of pest in the experiment and hence, no chemicals were sprayed. All the data were collected within the net plot of $4m^2$ where a total of 5 plants were tagged for data collection within each net plot. Harvesting was done 40 days after transplanting by uprooting the whole plant. The roots were removed with a knife.

2.4 Organic Fertilizers Sample Analysis

Following standard methods, a sample of all the organic manure types of 0.5 kg was examined for Dry matter, OM, Total Nitrogen and available P. The results of the analysis indicated that the poultry manure (85% Dry Matter, Organic Material 42%, Total Nitrogen 6.2%, Total Phosphorus 3.8% and Total Potassium 2.18%), Goat manure (Dry matter 43%, Organic Material 34%, Total Nitrogen 3.1%, Total Phosphorus 1.60% and Total Potassium 2.1%), Cow dung (Dry matter 15%, Organic Material 21%, Total Nitrogen 9.0%, Total Phosphorus 0.3% and Total Potassium 0.7%) respectively.

2.5 Data Collection on Growth and Yield

Data on leaf number, leaf area index and plant height (by measuring leaf height and leaf width using ruler were determined by taking five randomly selected plants for each treatment. Likewise, data on plant diameter (were measured with a vernier calliper), leaf area index (using a formula below), crop growth rate (using a formula below) and root weight, fresh weight as well as yield was then weighted using hanging digital meter.

Formula for Leaf Area Index (LAI) is given below; as describe by Radford [16]

$$LAI = \frac{\text{Total Leaf Area}}{\text{Unit Land Area}} \quad \text{----} \quad \text{-----} \quad (1)$$

Formula for Crop growth rate (CGR) is given as as describe by Rizwana [17]

$$CGR = \frac{W2-W1}{P(t2-t1)} \quad \text{---} \quad (2)$$

Where;

P = Ground area,

W1 = Dry weight of plant/m2 recorded at time t1,

W2 = Dry weight of plant/m2 recorded at time t2,

t1 and t2 were the interval of time, respectively and it is expressed in g/m2/day.

2.6 Statistical Data Analysis

The growth and yield data were tabulated correctly and then subjected to two-way analysis of variance (ANOVA) using the GENSTAT statistical software [18]. The Least Significant Difference (LSD) test was performed at $P \leq 0.05$ to compare all significant treatment means.

3. RESULTS AND DISCUSSION

3.1 Vegetative Growth of Lettuce as Influenced by Variety and Different Organic Fertilizer Application

The Iceberg lettuce variety significantly ($P<0.05$) impacted growth, with an average plant height of 20.32 cm, 23.06 leaves, a leaf area index of 15.19 cm^3, and a crop growth rate of 3.54 glm" per day. In comparison, the Butter-bead variety, which recorded significantly lower plant height (18.98 cm). number of leaves (20.87), leaf area index (14.23 cm^3), and crop growth rate (2.02 g/m^3 per day). The results in Table 1 showed that the Iceberg variety was supenor in terms of growth metrics. Differences in the genetic, morphological, and biochemical traits that influence the biomass accumulation among various vegetative parts of fruits and vegetables may be the cause of the notable differences between the two varieties in terms of plant height, number of leaves, leaf area index, and crop growth rate. Jilani et al. [19], Nyam et al. [6], and Iorliam and Ugoo [20] have reported findings similar to this study, focusing on onions, lettuce, and okra, respectively, and citing varietal variations in crop performance.

Poultry manure produced the highest growth values among the nutrient sources in terms of all parameters, especially with regard to plant height (21.73cm) and crop growth rate (3.70g/m²/day). In contrast, the untreated plots (control) demonstrated a significantly lower crop growth rate, highlighting the significance of nutrient supplementation. This pattern of highest to lowest performance for nutrient sources was seen in the following order: goat manure, chicken manure, cow dung, and untreated (control). This research provides important information for sustainable farming practices by highlighting the potential of organic nutrient sources, especially chicken droppings, to improve lettuce growth in the area. According to a previous study by Nyam et al. [6], on lettuce grown in Jos, poultry manure performed better for the majority of the metrics. Other organic sources, such as pig and cow dung, followed in decreasing order of performance, while control came in last. Additionally, Masarirambi et al. [21] observed that applying chicken manure, followed by cow dung, and then inorganic fertilizer, increased the yields of the "Veneza Roxa" type of lettuce. Similarly, Ojo et al. [4] used compost at a rate of 5 tons per hectare to get the best growth and output of lettuce. Ullah et al. [22] came to the conclusion that under the agroclimatic conditions of the Peshawar Valley, lettuce of the "Chinese cultivar" would grow and yield at its optimum when fed with poultry manure at a rate of 10 tons per hectare. Furthermore, Sanni et al. [3] found that combining organic manure with fertilizers high in phosphorus is an effective way to maintain soil fertility while growing lettuce.

3.2 Yield of Lettuce as Influenced by Variety and Different Organic Fertilizer Application

According to Table 2 or Fig. 1, the Butterhead variety recorded the lowest chlorophyll concentration (20.98 mg/g), while the Iceberg variety recorded the highest chlorophyll content (23.32 mg/g). This difference was statistically significant ($P<0.05$). Poultry dung dramatically increased the quantities of chlorophyll on organic nutrient sources, averaging an astonishing 25.73 mg/g; the control group produced the lowest amount, 18.01 mg/g. Other nutrient sources, such as goat dung and calf dung, had moderate chlorophyll contents of 20.28 mg/g and 22.00 mg/g, respectively, and there was a statistically significant difference between them. The comprehension of nitrogen management techniques for enhancing lettuce production in sustainable agriculture systems is enhanced by this discovery. Similar to this study, Chowdhury and Rahman [23] found that whereas local cultivars in the control plot had the lowest chlorophyll content, greater lettuce growth, yield, and nutrient accumulation were attained in the poultry manure treatment.

The Iceberg variety outperformed Butterhead with an average root weight of 20.23g, and the difference between the two types was statistically significant as shown in Table 2 or Fig. 2. The addition of poultry manure greatly increased the average root weight, which was an amazing 22.12g. The control group, on the other hand, had the lowest root weight (16.87g). Goat manure and calf dung produced modest root weights of 20.12g and 18.32g, respectively. The study emphasizes the advantageous effects of organic nutrient sources on root growth, especially chicken manure. A like pattern was noted for the fresh weight of lettuce (Fig. 3). The plants with the highest fresh and root weights were those treated with chicken manure. Uddin et al. [27]; Draghici et al. [28]; Chowdhury and Rahman, [23] have produced findings that are comparable to these. This could be explained by the fertilizer's nutritional composition. Ghanbarian et al. [26] observed that cantaloupe (Cucumis melo) plants treated with chicken dung show a somewhat greater profitable yield compared to those receiving no chicken manure. Comparable outcomes were shown with okra [24], broccoli [25], and lettuce [22]. The poultry manure's high levels of readily available potassium and phosphate make it eligible for accreditation. Madina et al. [29] in his work attributed high chlorophyll in lettuce to the availability of nutrients particularly nitrogen which is slightly high amount in poultry dropping when compared with other organic sources. Iceberg variety (3.19t/ha) produced more lettuce yield than butter-head variety (2.63t/ha), and the difference was statistically significant (table 2 or Fig. 4). With an enhanced production of 3.75t/ha, poultry manure regularly surpassed other nutrient sources, while the untreated plots (control) yielded the least amount of 1.75t/ha. Additionally, a respectable moderate output of 2.00t/ha and 2.50t/ha, respectively, were obtained by goat dung and cattle dung. This highlights how important organic nutrients are for increasing lettuce output, especially chicken manure. Earlier researchers like Uddin et al. [24], Draghici et al. [25], and Chowdhury and Rahman [23] have reported comparable study findings indicating that plants fed with poultry manure exhibited the

highest growth metrics and marketable yield. This might be explained by the fertilizer's nutritional composition. According to Ojo et al. [4], using 5 t/ha of compost was ideal for lettuce growth and productivity. Ullah et al. [22] also discovered that lettuce grown on poultry manure grows to its full potential and yields more leaves. Furthermore, Meskelu et al. [11] and Madina et al. [30] have confirmed that the use of organic manure (bio-slurry) either by itself or in conjunction with chemical fertilizers has the potential to boost lettuce and tomato output and save farmers money on the purchase of chemical fertilizers and to reduce the cost of production.

Table 3 investigate the interaction effects between lettuce varieties and organic nutrient sources on yield parameters in Makurdi. Two lettuce varieties, Iceberg and Butterhead, were subjected to three organic nutrient sources (Cattle Dung, Poultry Manure, and Goat Manure) along with a control treatment. The parameters evaluated were chlorophyll content, fresh weight, and yield (tonnes per hectare). Results indicated significant interactions between lettuce varieties and organic nutrient sources for all measured parameters. For Iceberg lettuce, the highest chlorophyll content (25.73 mg/g), fresh weight (82.02 g), and yield (3.75 t/ha) were recorded with Poultry Manure, whereas the lowest values were observed in the control treatment (18.01 mg/g, 55.21 g, and 1.75 t/ha, respectively). Similarly, Butterhead lettuce showed the highest values with Poultry Manure for chlorophyll content (22.24 mg/g), fresh weight (78.54 g), and yield (3.00 t/ha), contrasting with the lowest values in the control treatment (17.45 mg/g, 50.43 g, and 1.11 t/ha, respectively).

Table 1. Effect of variety and organic nutrient sources on the growth parameters of lettuce grown in Makurdi

	Plant Height (cm)	Number of Leaves	Leaf Area Index (LAI)	Crop Growth Rate (CGR)
Varieties				
Ice berg	20.32a	23.86a	15.19a	3.54a
Butter head	18.98b	20.87b	14.23b	2.02b
LSD (0.05)	2.92	3.18	2.31	1.08
Nutrient source				
Cattle Dung	17.28c	19.12c	12.00c	2.10c
Poultry Manure	21.73a	23.92b	16.75a	3.70a
Goat Manure	19.00b	20.91a	13.88b	2.90b
Control	15.01d	15.21d	10.75d	1.04d
LSD (0.05)	3.20	3.10	3.92	1.02
Interaction AXB	NS	NS	NS	NS

Means within variety and nutrients sources Colum having the same letter do not differ significantly at (P<0.05) level of significance using LSD

Table 2. Effect of variety and organic nutrient sources on the yield parameters of lettuce grown in Makurdi

	Chlorophyll content	Fresh weight (g)	Root Weight (g)	Yield (t/ha)
Varieties				
Ice berg	23.32a	83.86a	20.23a	3.19a
Butter head	20.98b	70.87b	18.65b	2.63b
LSD (0.05)	2.02	5.18	3.02	1.31
Nutrient source				
Cattle Dung	20.28b	68.12c	18.32c	2.00c
Poultry Manure	25.73a	82.02a	22.12a	3.75a
Goat Manure	22.00c	79.91b	20.12b	2.50b
Control	18.01d	55.21d	16.87	1.75d
LSD (0.05)	1.20	3.10	3.54	1.22
Interaction AXB	*	*	NS	*

Means within variety and nutrients sources Colum having the same letter do not differ significantly at (P<0.05) level of significance using LSD

Table 3. Interaction between variety and organic nutrient sources on the yield parameters of lettuce grown in Makurdi

Varieties	Nutrient source	Chlorophyll content	Fresh weight (g)	Yield (t/ha)
Ice berg	Cattle Dung	20.28b	68.12c	2.00c
	Poultry Manure	25.73a	82.02a	3.75a
	Goat Manure	22.00c	79.91b	2.50b
	Control	18.01d	55.21d	1.75d
Butter head	Cattle Dung	19.98b	60.34c	1.80c
	Poultry Manure	22.24a	78.54a	3.00a
	Goat Manure	20.12c	72.99b	2.01b
	Control	17.45d	50.43d	1.11d
	LSD (0.05)	1.54	3.00	1.12

Means within variety and nutrients sources Colum having the same letter do not differ significantly at (P<0.05) level of significance using LSD

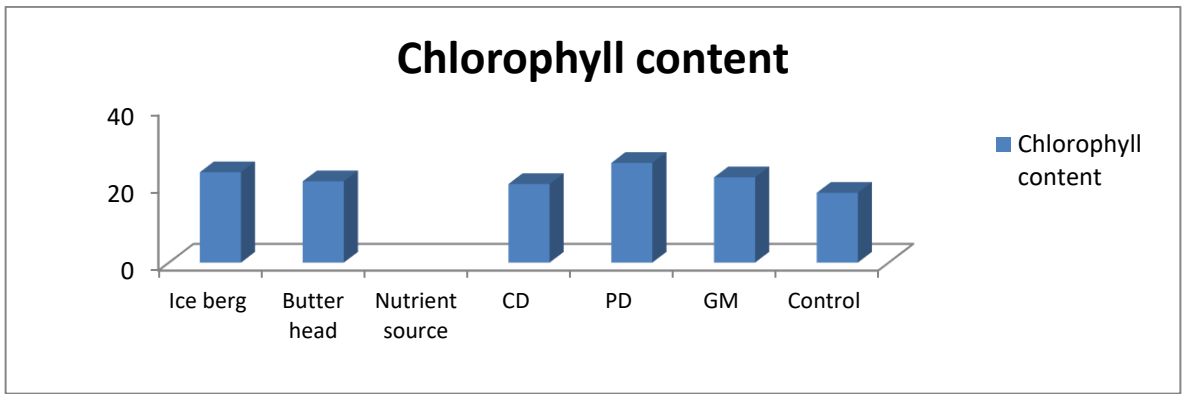

Fig. 1. Effect of variety x nutrient sources on the chlorophyll content of lettuce grown in Makurdi

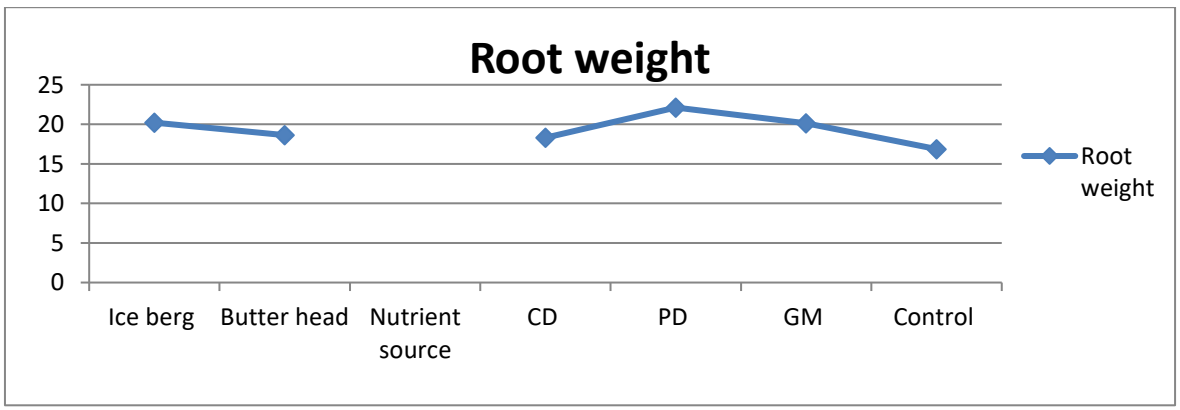

Fig. 2. Effect of variety x nutrient sources on the root weight of lettuce grown in Makurdi

Overall, Poultry Manure consistently demonstrated superior performance across both lettuce varieties, significantly enhancing chlorophyll content, fresh weight, and yield compared to other nutrient sources. These findings underscore the importance of selecting appropriate organic nutrient sources tailored to specific lettuce varieties to optimize yield parameters in agricultural production systems [31], this finding collaborate with the work of Sharma et al [32] who stated that a increase in yield and yield related parameters when a good combination of adaptive variety and nutrient source is used [33]. Also reported that the poultry dropping releases it nutrient fast, gradually and throughout the crop life time in the field.

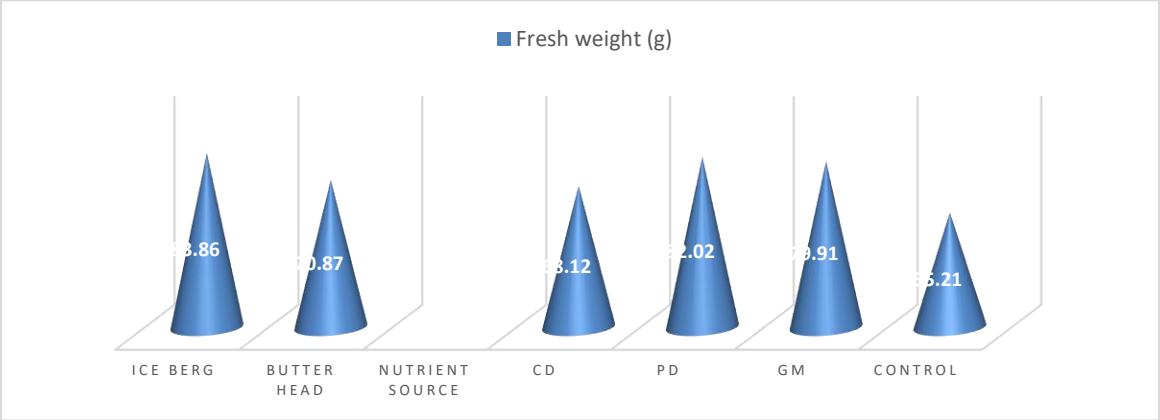

Fig. 3. Effect of variety x nutrient sources on the fresh weight of lettuce grown in Makurdi

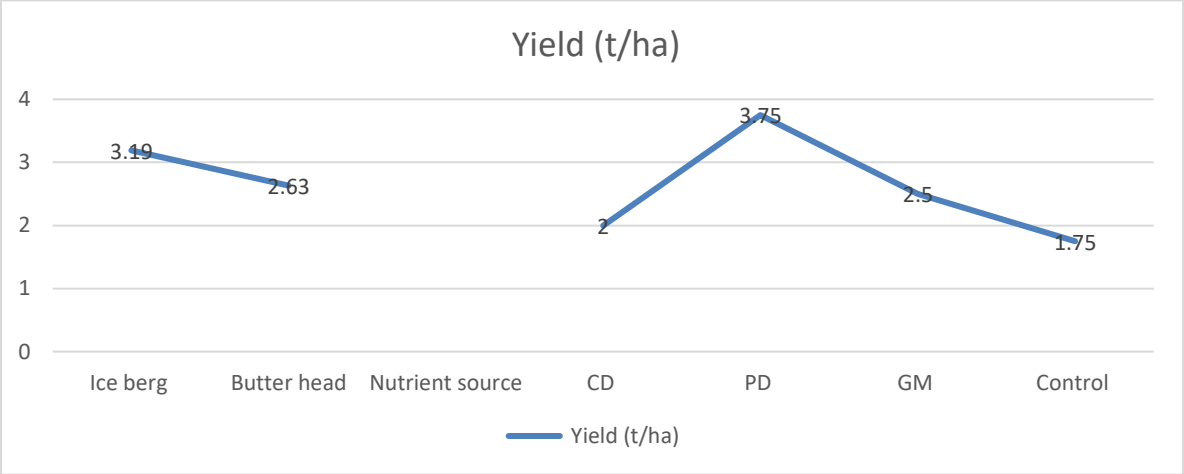

Fig. 4. Effect of variety x nutrient sources on the yield of lettuce grown in Makurdi

4. CONCLUSION

All growth and yield characteristics studied showed that the iceberg variety of lettuce outperformed the butterhead variety. Compared to the other nutrient sources and the control, poultry manure considerably improved lettuce growth and yield characteristics, with a significant difference from cattle dung or goat manure. The control plots had the lowest growth and yield characteristics among the lettuce cultivars tested in this study. Furthermore, the use of cow dung and goat manure improved lettuce growth and production. In conclusion, it may be suggested that poultry manure be applied to iceberg variety at 10t/ha to obtain optimum growth and yield of lettuce in Makurdi. However, in the absence of poultry manure, lettuce farmers can utilize cattle dung or goat manure for enhanced yield in Makurdi.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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