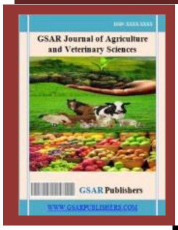

GSAR Journal of Agriculture and Veterinary Sciences
ISSN: 3048-9075 (Online)
Abbreviated key title: Glob.J. Agri.Vet.Sci.
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/journal-gjavs-home/

OPEN ACCESS

Hydroponics Production of Lettuce (*Lactuca sativa* L.) as Affected by Variety and Nutrient Solutions, Grown in Makurdi, Benue. Nigeria

By

Ogezi F. O[1]. Esang D. M[2]., Iyough, D. D[3]. and Madina P[4].

[1,2,3,4]Department of Crop Production, College of Agronomy, Joseph Sarwuan Tarka University, P.M.B. 2373, Makurdi, Nigeria.

Article History

Received: 01/08/2025
Accepted: 07/08/2025
Published: 09/08/2025

Vol – 2 Issue –8

PP: -58-64

Abstract

The experiment aimed to investigate the effect of solutions on the growth and yield of lettuce grown in Makurdi, Nigeria. The experiment is laid in a randomized complete block design with three replications. The treatments used are organic nutrient source, inorganic nutrients source and control, a variety used where (Loose-leaf, Ice berg and Butter-head). During the investigation, some physiological variables, such as growth, plant height and the number of leaves, were measured. Other characteristics like leaf area index, crop growth rate, fresh weight and overall yield were also recorded. The results of the investigation revealed that lettuce generally responded to nutrient solution. All the parameter studies have significantly ($P \leq 0.05$) responded to the nutrient solutions with inorganic nutrients solutions recorded higher in both growth and yield-related character such, as plant height (23.32cm), the number of leaves (16.74), crop growth rate (3.32), leaf area index (15.12), chlorophyll content (25.13), fresh weight (96.74) and yield (3.82t/ha). On varieties Butter-head out performed other varieties in both growth, yield and yield related characters such plant height (23.73cm), the number of leaves (17.53), crop growth rate (3.13), leaf area index (14.34), chlorophyll content (23.02), fresh weight (93.73) and yield (3.73t/ha). Based on the results obtained it can be suggested that lettuce farmers use inorganic nutrient solution which is better in both growth and yield characteristics leading to optimum yield in lettuce cultivation in the study areas.

Keywords: *lettuce, Nutrient, Solutions and Variety*

Introduction

Lettuce (Lactuca sativa L.) is arguably one of the most popular and widely consumed leafy vegetables globally, a staple in salads, sandwiches, and various culinary preparations. Its crisp texture, refreshing taste, and relatively mild flavor make it a versatile ingredient, appealing to a broad spectrum of palates. Beyond its culinary appeal, lettuce holds significant nutritional value, contributing essential vitamins and minerals to the human diet (Madina et al., 2024). While often perceived as a simple green, lettuce boasts a rich history, diverse varieties, and an evolving journey in cultivation methods, particularly with the advent of controlled environment agriculture like hydroponics.

Originating from the wild lettuce species (Lactuca serriola) native to the Mediterranean Basin and Western Asia, lettuce has been cultivated for thousands of years. Ancient Egyptians were among the first to domesticate it, primarily for its oil-rich seeds, but eventually also for its tender leaves. From Egypt, its cultivation spread to ancient Greece and Rome, where it became a prized vegetable. The Romans, who called it "lactuca" (from lac, meaning milk, referring to the milky sap found in its stems), were instrumental in disseminating it across Europe Beyond its refreshing taste, lettuce is a surprisingly nutritious vegetable, packing a significant punch of essential vitamins and minerals, especially given its low-calorie content. Its high water content (around 95%) contributes to hydration, while its rich micronutrient profile makes it a valuable addition to a balanced diet (FAO 2009).

One of the most prominent vitamins in lettuce, particularly in darker green varieties like Romaine, is Vitamin K. This fat-soluble vitamin plays a crucial role in blood clotting and bone health. Adequate Vitamin K intake is associated with stronger bones and a reduced risk of fractures. Lettuce is also an excellent source of Vitamin A, primarily in the form of beta-carotene, a powerful antioxidant that the body converts into Vitamin A. Vitamin A is vital for good vision, immune function, and skin health. Darker green leaves indicate higher

*Corresponding Author: **Ogezi F. O**

beta-carotene content. (Albaji et al., 2014). Vitamin C, a well-known antioxidant, is also present in lettuce, though in smaller amounts compared to some fruits. Vitamin C is essential for immune system support, collagen production (important for skin, bones, and connective tissues), and iron absorption. Additionally, lettuce provides a good amount of folate (Vitamin B9), a B-vitamin critical for cell division and DNA synthesis, making it especially important during pregnancy to prevent neural tube defects Meskelu et al., (2023). While not as abundant as in other vegetables, lettuce contains trace amounts of other B vitamins like Vitamin B6 and riboflavin (B2), which are involved in energy metabolism. In terms of minerals, lettuce offers potassium, important for blood pressure regulation and fluid balance, and manganese, an essential trace mineral involved in bone development and metabolism. It also provides smaller quantities of iron, calcium, and magnesium Kim et al., (2016). The overall nutritional contribution of lettuce makes it a healthful choice for promoting general well-being and supporting various bodily functions. Today, lettuce is categorized into several main types, each with distinct characteristics. Romaine (or Cos) lettuce is known for its elongated, upright leaves and crisp, slightly bitter taste, often favored in Caesar salads. Butter-head lettuce, including varieties like Boston and Bibb, features loose, soft, buttery-textured leaves that form a loose head. Crisphead lettuce, such as Iceberg, forms dense, tightly packed heads with very crisp leaves, highly valued for its crunch and longer shelf life. Loose-leaf lettuce encompasses varieties with loosely arranged leaves that do not form a head, offering a wide range of leaf shapes, colors, and textures, and are often harvested as cut-and-come-again greens. Finally, Stem (or Asparagus) lettuce, though less common in Western diets, is cultivated primarily for its thick, edible stem, consumed cooked. This remarkable diversity allows growers to select varieties best suited for their local climate, market demands, and specific growing techniques. (Rosa-Rodriguez et al., 2020)

Hydroponics, the method of growing plants without soil, using mineral nutrient solutions dissolved in water, has revolutionized lettuce cultivation. This soilless system offers numerous advantages over traditional field farming, making it an increasingly popular choice for commercial growers and home enthusiasts alike. One of the primary advantages of hydroponic lettuce cultivation is water efficiency Nyam et al., (2021). Hydroponic systems can use up to 90% less water than conventional agriculture because water is recirculated and reused, minimizing evaporation and runoff. This makes hydroponics an ideal solution for regions facing water scarcity. Secondly, faster growth rates are often observed in hydroponic systems. Plants receive a constant and precisely balanced supply of nutrients directly to their roots, eliminating the need for roots to search for nutrients in the soil Madina and Akinyemi (2023). This optimized nutrient delivery, coupled with controlled environmental conditions (temperature, humidity, light), allows lettuce to mature much more quickly. Reduced land use is another significant benefit. Hydroponic systems, especially vertical farms, can produce a massive amount of lettuce in a small footprint, making it suitable for urban farming and areas with limited arable land. This also allows for year-round production, independent of seasonal weather conditions, ensuring a consistent supply to markets. Furthermore, fewer pests and diseases are typically encountered in hydroponic environments. Since there's no soil, many common soil-borne pathogens and pests are eliminated. This significantly reduces or even negates the need for pesticides and herbicides, leading to cleaner, healthier produce and a more environmentally friendly cultivation process Ojo et al., (2023). Setting up a hydroponic lettuce system requires an initial investment in components such as reservoirs, pumps (for active systems), channels or rafts, net pots, growing media (like rockwool, coco coir, or inert clay pebbles), and a balanced hydroponic nutrient solution specifically formulated for leafy greens. Proper monitoring of the nutrient solution's pH and Electrical Conductivity (EC) is crucial to ensure optimal nutrient uptake and plant health. pH levels for lettuce typically range from 5.5 to 6.5, while EC levels vary depending on the growth stage Ameela and Ronak (2017). Lettuce, a historically significant and nutritionally valuable leafy green, is experiencing a modern renaissance through advanced cultivation techniques like hydroponics. This shift promises not only increased efficiency and sustainability in food production but also cleaner, healthier produce, making it an exciting frontier for future agriculture Madina and Akinyemi (2023). The aim of the research is to investigate the effect of organic and inorganic nutrient solutions that is effective in lettuce production.

MATERIAL AND METHOD

The experiment was carried out at Joseph Sarwuan Tarka Univeristy, Makurdi (6° 11’-7° 41’N Latitude and 7° 21’ - 8° 37’E Longitude) The experiment aimed to investigate the effect of solutions on the growth and yield of lettuce grown in Makurdi, Nigeria. The experiment is laid in a randomized complete block design with three replications. The treatments used are organic nutrient source, inorganic nutrients source and control), a variety used where (Loose-leaf, Ice berg and Butter-head). Organic nutrient source is as follows Chemical content (pH: 6.5-7.5; EC: 2.3 - 4.0; Organic Carbon: 15.4 - 32.9 %; Total N: 0.90 - 1.5 %, P: 0.3%, K: 0.2%) Physical content (Moisture: 30 - 42 %; water holding capacity: 2 - 3 g; porosity: 62 - 70 %; Bulk density: 410 - 635 kg m3) as recommendation by Bello (2015) and chemical nutrients solution as follows 120grams of NPK, 170grams of Calcium Nitrate, 55grams of Epson salt and 500ml of distilled water before it was used for the experiment. Dissolve 110grams of NPK, 170grams of Calcium Nitrate and 50grams of Epson salt separately in a warm 250ml of distilled water to allow it dissolve completely. NPK and Calcium nitrate solution are combined (solution A) and Epson solution (solution B), add 2.0ml of solution A and solution B after 5minutes in a 1liter of water to form a nutrient solution which the plants are placed in. The seeds were raised in transplanting tray in a growth media of rice husk before placing in nutrient solutions. The nursery was prepared well at a 3:1 ratio of rice husk and organic manure then it was treated for pathogen by covering it

*Corresponding Author: **Ogezi F. O**

with polythene tightly and kept for 10 days, irrigated twice a day (morning and evening) to ensure good germination and early seedling establishment, the seeds germinated between ten and thirteen days after sowing (DAS). The seedlings were transplanted to the nutrient solutions 25 days after sowing (DAS). The experiment was laid out in a randomized complete block design (RCBD) with three replicates. A nutrient solution was formulated in a container and each treatment place according to the design. There were 6 containers of nutrient solutions in each block replicated 3 times which gave the total number of 18 containers for the study. Three (3) plants were tagged for data collection following (Berry, 2012) method. During the investigation, physiological variables, such as growth in the increase in mass and size of the plant which involve the multiplication of cells plant height (measured from the base of the plant to the tip), and the number of leaves (were counted from the tagged plants). Other characters like leaf area index, crop growth rate were obtained using the below formula, chlorophyll content (was obtained using an electric choro-meter), fruit weight (was obtained using a digital weight machine). All data collected were subjected to a two-way analysis of variance (ANOVA), when treatments were found significantly different, the least significant difference (LSD) at a 5% level of probability was used in separating the mean.

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

CGR = W2−W1/ P(t2−t1)

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.

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

LAI = Total Leaf Area/ Unit Land Area

Results and Discussion

Table 1: Effect of Variety and nutrient source on plant height of lettuce grown in Makurdi, Nigeria
Weeks after transplanting (WAT)

Variety (V)	**2**	**4**	**6**	**8**
Butter head	4.13	8.02	14.72	23.73
Lose head	3.04	7.12	12.22	20.64
Ice berg	3.21	7.00	11.21	18.91
F-LSD (0.05)	0.20	0.40	1.03	2.01
Nutrient source (N)				
Organic	3.23	8.84	12.97	20.13
Inorganic	4.52	9.16	14.71	23.32
F-LSD (0.05)	1.01	1.01	2.11	2.16
Interaction				
VXN	NS	NS	NS	NS

LSD= Least Significant Differences at 5% Level of Probability, * = 95% level of probability

Table 1 is the effect of different varieties and nutrient sources on the plant height of lettuce grown in Makurdi, Nigeria. The experiment evaluated three lettuce varieties (Butter-head, Loose head, and Iceberg) and two nutrient sources (Organic and Inorganic). Plant height was measured at 2, 4, 6, and 8 weeks after transplanting (WAT). Results indicated significant effects of both variety and nutrient source on lettuce plant height. Among the varieties, Butter-head consistently achieved the greatest plant height throughout the growth period, reaching 23.73 cm at 8 WAT. Loose head followed with 20.64 cm, while Iceberg generally exhibited the lowest plant height (18.91 cm at 8 WAT) in could be related to the genetic make-up of the crop, this finding is in agreement with the finding of Bhatta (2022) who stated that varietal difference is mostly link to genetic make-up, environmental continon. Regarding nutrient sources, Inorganic fertilizer significantly promoted greater plant height compared to Organic treatment. Inorganic nutrient application resulted in taller plants at all measured time points, culminating in 23.32 cm at 8 WAT, compared to 20.13 cm with Organic sources. The F-LSD (Least Significant Differences at 5% Level of Probability) values confirmed that the observed differences due to both variety and nutrient source were statistically significant for plant height at all measured weeks after transplanting this work is collaborated with the work of Nyam et al. (2021) Who stated that quality, quantity and stage of application, more so 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., (2010) and Iorliam and Ugoo (2023) have reported findings similar to this study, affect vegetative growth of plant. However, the interaction between variety and nutrient source (VxN) was not significant. This suggests that the superior performance of Butter-head variety and Inorganic nutrient source was consistent across all combinations. These findings highlight the importance of selecting appropriate lettuce varieties and utilizing inorganic nutrient sources to maximize plant height in lettuce cultivation in Makurdi.

Table 2: Effect of Variety and nutrient source on number of leaves of lettuce grown in Makurdi, Nigeria
Weeks after transplanting (WAT)

Variety (V)	**2**	**4**	**6**	**8**
Butter head	4.16	8.52	12.82	17.53
Lose head	3.05	6.32	10.42	16.74

*Corresponding Author: **Ogezi F. O**

Ice berg	2.98	5.21	10.00	15.23
F-LSD (0.05)	1.00	1.11	0.13	1.03
Nutrient source (N)				
Organic	3.43	7.82	10.90	16.63
Inorganic	4.12	8.17	12.71	18.22
F-LSD (0.05)	0.31	1.01	2.11	2.06
Interaction				
VXN	NS	NS	NS	NS

LSD= Least Significant Differences at 5% Level of Probability, * = 95% level of probability

Table 2 is the effect of different varieties and nutrient sources on the number of leaves of lettuce grown in Makurdi, Nigeria. The experiment evaluated three lettuce varieties (Butter-head, Loose head, and Iceberg) and two nutrient sources (Organic and Inorganic). The number of leaves per plant was measured at 2, 4, 6, and 8 weeks after transplanting (WAT). Results indicated significant effects of both variety and nutrient source on the number of leaves per plant. Among the varieties, Butter-head consistently produced the highest number of leaves throughout the growth period, reaching 17.53 leaves per plant at 8 WAT. Loose head followed with 16.74 leaves, while Iceberg generally exhibited the lowest leaf counts (15.23 leaves at 8 WAT) this is not far from the fact that inherent traits may have led to this variability as reported by Madina et al., 2024 who reported that variability in vegetative and phenotypic appearance are affected by the genetic make-up of most varieties and accession. Regarding nutrient sources, Inorganic fertilizer significantly outperformed Organic treatment in promoting leaf development. Inorganic nutrient application resulted in a higher number of leaves at all measured time points, culminating in 18.22 leaves per plant at 8 WAT, compared to 16.63 leaves with Organic sources as reported by Kawamura-Aoyama (2014) who stated that cultivars grown in hydroponic systems frequently have more open heads than those cultivated on soil often purchased at the grocery store, this can be a good option because they are less susceptible to tip burn and produce more yield and could be the reason for this variability. The F-LSD (Least Significant Differences at 5% Level of Probability) values confirmed that the observed differences due to both variety and nutrient source were statistically significant for the number of leaves per plant at all measured weeks after transplanting. However, the interaction between variety and nutrient source (VxN) was not significant. This suggests that the superior performance of Butter-head variety and Inorganic nutrient source was consistent across all combinations. These findings highlight the importance of selecting appropriate lettuce varieties and utilizing inorganic nutrient sources to maximize leaf production in lettuce cultivation in Makurdi.

Table 3: Effect of Variety and nutrient source on yield related parameters of lettuce grown in Makurdi, Nigeria

Variety (V)	CGR	LAI	Chlorophyll content	Fresh weight	Yield
Butter head	3.13	14.34	23.02	97.72	3.73
Lose head	3.04	12.11	21.12	84.22	3.00
Ice berg	2.89	13.01	20.21	80.11	2.89
F-LSD (0.05)	0.60	1.00	1.20	2.13	0.53
Nutrient source (N)					
Organic	2.03	14.21	23.83	85.92	2.43
Inorganic	3.32	15.12	25.13	96.74	3.82
F-LSD (0.05)	1.00	1.01	1.21	2.81	0.86
Interaction					
VXN	NS	*	*	*	*

LSD= Least Significant Differences at 5% Level of Probability, * = 95% level of probability

Table 3 is the effect of different varieties and nutrient sources on yield-related parameters of lettuce grown in Makurdi, Nigeria. The experiment evaluated three lettuce varieties (Butter-head, Loose head, and Iceberg) and two nutrient sources (Organic and Inorganic). Key parameters assessed included Crop Growth Rate (CGR), Leaf Area Index (LAI), Chlorophyll content, Fresh weight, and Yield. Results indicated significant effects of both variety and nutrient source on most measured parameters. Among the varieties, Butter-head consistently demonstrated superior performance across multiple parameters, achieving the highest CGR (3.13), LAI (14.34), chlorophyll content (23.02), fresh weight (97.72), and yield (3.73). Loose head followed, while Iceberg generally exhibited the lowest values for these parameters, this could be related to availability of nutrient in the solutions couple with genetic make-up of the variety, this could be linked to the fact that genetic variability could have caused such difference and probably environmental factors this result conforms with the work of Santos (2018) who stated that genetic variability, adaptation to the environment and cultural practice, not only affect overall yield but also yield related characters positively. Regarding nutrient sources, Inorganic fertilizer significantly outperformed Organic treatment across all parameters. Inorganic nutrient application resulted in a higher CGR (3.32 vs 2.03), LAI (15.12 vs 14.21), chlorophyll content (25.13 vs 23.83), fresh weight (96.74 vs 85.92), and

*Corresponding Author: **Ogezi F. O**

notably, a higher yield (3.82 vs 2.43). The F-LSD (Least Significant Differences at 5% Level of Probability) values confirmed that the observed differences due to both variety and nutrient source were statistically significant for all parameters (CGR, LAI, Chlorophyll content, Fresh weight, and Yield) inorganic performed significantly higher in plant height, number of leaves, leaf diameter and leaf length, this could be related to electric conductivity in the solutions. This work collaborates with the finding of Atkin et al (2004) who reported that inorganic nutrients solution is mobile and easily absorb and assimilated faster to organic solution and have ability to resist changes in pH known as the buffer capacity, and source water differs in its buffer capacity due to dissolved elements. However, the interaction between variety and nutrient source (VxN) was not significant. This suggests that the best-performing variety performed well regardless of the nutrient source, and the superior performance of inorganic nutrient source was consistent across all varieties tested. These findings highlight the importance of variety selection and nutrient management for optimizing lettuce production in Makurdi. This work collaborates with the finding of Batista et al (2012) who reported that inorganic nutrients solution are mobile and easily absorb and assimilated faster to organic solution, Jones (2005) is a par with the finding of this work where he reported organic solution having more trace elements when compared to inorganic nutrient where they have only three major element and as such should have recorded weightier girth, lengthier root, higher fresh weight and over-all yield he added that nutrient solutions for soilless systems are often based on the source water, which can contain a range of dissolved minerals. Some of these minerals are plant nutrients that can be used, but nutrients could be present in larger quantities than plants require. High levels of some minerals, such as calcium and carbonate, can interfere with solution formulation, pH management or nutrient uptake by the plants. Jordon et al. (2018) reported higher yield of 2.18–2.58 kg m for hydroponic lettuce grown with inorganic nutrient source which was lower than the yield obtained in organic nutrient source in this study.

Table 4: Interaction between Variety and nutrient source on yield related parameters of lettuce grown in Makurdi, Nigeria

Nutrient source	Variety (V)	LAI	Chlorophyll content	Fresh weight	Yield
Organic	Butter head	14.04	23.42	96.70	3.73
	Lose head	12.21	21.22	83.24	2.60
	Ice berg	13.01	20.71	81.11	2.89
Inorganic	Butter head	15.25	24.91	98.61	3.81
	Lose head	13.71	23.33	86.90	2.33
	Ice berg	14.22	25.43	95.77	3.22
F-LSD (0.05)		1.02	1.22	2.21	0.66

LSD= Least Significant Differences at 5% Level of Probability, * = 95% level of probability

Table 4 is the interaction effect between lettuce variety and nutrient source on yield-related parameters of lettuce grown in Makurdi, Nigeria. The experiment evaluated three lettuce varieties (Butter-head, Loose head, and Iceberg) under two nutrient source regimes (Organic and Inorganic). Key parameters assessed included Leaf Area Index (LAI), Chlorophyll content, Fresh weight, and Yield. Results indicated a significant interaction between variety and nutrient source for all measured parameters. For Organic nutrient sources, Butter-head lettuce consistently showed the highest LAI (14.04), chlorophyll content (23.42), fresh weight (96.70), and yield (3.73). Loose head and Iceberg varieties performed less optimally under organic conditions. Under Inorganic nutrient sources, Butter-head again demonstrated superior performance with the highest LAI (15.23), chlorophyll content (24.91), fresh weight (98.61), and yield (3.81) this is not far from the facts that varietal variability, nutrient and environmental factors might have led to this difference, this finding agrees with the work of Ekpo et al., (2016) who reported same in lettuce production stating that yield and yield related characters are products or are mostly influenced by the plants genetic make-up, nutrient, cultural practice and environmental factors.

Interestingly, under inorganic conditions, Iceberg lettuce showed a notable improvement in yield (3.22) compared to its performance with organic sources (2.89), and also surpassed Loose head (2.33) in yield under inorganic conditions this is not far from the facts that varietal variability, nutrient and environmental factors might have led to this difference, this finding agrees with the work of Ekpo et al., (2016) who reported same in lettuce production stating that yield and yield related characters are products or are mostly influenced by the plants genetic make-up, nutrient, cultural practice and environmental factors. The F-LSD (Least Significant Differences at 5% Level of Probability) values confirmed that the observed differences due to the interaction of variety and nutrient source were statistically significant for all parameters (LAI, Chlorophyll content, Fresh weight, and Yield). These findings underscore the critical importance of selecting specific variety-nutrient source combinations to optimize lettuce production in Makurdi. Butter-head consistently performed well across both nutrient types, while the response of other varieties, particularly Iceberg, was more pronounced under inorganic fertilization. this finding collaborate with the work of Masarirambi et al., (2010) who stated that increase in yield and yield related parameters when a good combination of adaptive variety and nutrient source is used

*Corresponding Author: **Ogezi F. O**

Conclusion and Recommendation

Based on the results obtained, Significant difference P<0.05 was observed on both nutrients solution and variety with inorganic solution outperformed the organic solution so also the use of butter head performing better than the other variety in both growth and yield parameters, therefore it can be suggested that lettuce farmers use inorganic nutrient solution and butter head which is better in both growth and yield characteristics leading to optimum yield in lettuce cultivation in the study areas

References

1. Atkin, K.; Nichols, M.A. Organic hydroponics. Acta Hortic. 92004) hydroponic culture of lettuce 648, Horticultura Bra- sileira 121–127.
2. Albaji G. O., Fekadu GM, Getachew T, Zebenay D, Gizachew A, Fasil T.T. 2014 Effect of planting density on yield and yield components of lettuce (Lactuca sativa L.) at two agroecologies of Ethiopia, Afr. J. Agric. Res. 2014;17(4):549–556. Available:https://doi.org/10.5897/AJAR202 0.15384.
3. Ameeta S, Ronak C.A. (2017) Review on the Effect of Organic and Chemical Fertilizers on Plants. International Journal for Research in Applied Science & Engineering Technology. 2017; 5(2):2321 – 9653 6.
4. Batista K. P., Brady N, Weil R. Bhatta S. (2012). Influence of organic fertilizer on growth yield and quality of lettuce (Lactuca sativa L.): A review. The Pharma Innovation Journal. 2012;1073 – 1077.
5. FAO (Food and Agriculture Organization of the United Nations) 2009. Lettuce Production up in 2009. FAO/GIEWSFood Outlook, No.5, November 2009, 10
6. Ekpo, U.; Ross, A.B.; Camargo-Valero, M.A.; Williams, P.T. A comparison of product yields and inorganic content in process streams following thermal hydrolysis and hydrothermal processing of microalgae, manure and diges tate. Bioresour. Technol. 2016,200, 951–960. [CrossRef]
7. Iorliam B.I., Ugoo T.R. Effect of postharvest application of plant powders on physical quality and shelf life of okra during storage in Makurdi. Journal of Scientific Agriculture. 2023;7:51-57. DOI: 10.25081/jsa.2023.v7.8284
8. Jones, J.B. (2005) Hydroponics A Practical Guide for the Soilless Grower, 2nd ed.; CRC Press: Boca Raton, FL, USA, 2005; Volume 53, ISBN 9788578110796.
9. Jordan, E.Q., Souza, R.J., Cruz, M.C.M., Marques, V.B. and França, A.C. (2010) Lettuce and arugula yield in consorted systems under organic and mineral fertilization. HorticulturaBrasileira, 28, 36-40. http://dx.doi.org/10.1590/S0102-05362010000100007
10. Jilani MS, Ahmed P, Waseem K. (2010) Effect of plant spacing on growth and yield of two varieties of onion (Allium cepa L.) under the agro-climatic condition of. Pak J Sci. 2010;62:1.
11. Kawamura-Aoyama, R. (2014) Doses effects and organic compounds types in lettuce crop in two soils un- der protect environment. Horticultura Brasileira, 22, 28-34. http://dx.doi.org/10.1590/S0102-05362004000100
12. Kim, M.J., Moon, Y., Tou, J.C., Mou, B. and Waterland, N.L. (2016) Nutritional value, bioactive compounds and health benefits of lettuce (Lactuca sativa L.), J. Food Compos. Anal. 2016; 49: 19–34, Available:https://doi.org/10.1016/j.jfca.2016 .03.004
13. Madina, P. and Akinyemi, B. K. (2023) Effectiveness of Solutions on Soilless Production of Lettuce Grown in Makurdi and Plateau, Nigeria Advances in Social Sciences and Management November 2023, Vol-1, No-11, pp. 18-24
14. Madina P, Iyough DD, Michael OA, Ayoola K. (2023) The effect of organic manure and days of incorporation on the growth and yield of lettuce (Lactuca sativa L.) Grown in Jos Plateau State. Nigeria. Discoveries in Agriculture and Food Sciences. 2023;11(2):38-49. 30.
15. Madina P., 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.
16. Masarirambi M.T., Hlawe M.M., Oseni O.T., Sibiya T.E. (2010) Effects of organic fertilizers on growth, yield quality and sensory evaluation of red lettuce (Lactuca sativa L) cv. Veneza Roxa. Agri and Biol. J of North Ameri. 2010;1(6):1319-1324
17. Meskelu T., Abate F.S., Yadessa G.K., Getachew S. (2023) Growth and marketable yield of lettuce (Lactuca sativa L.) as affected by bio-slurry and chemical fertilizer application. Heliyon 2024;10:e23600. Available:https://doi.org/10.1016/j.heliyon.2 023.e23600.
18. Nyam D.D., Kwis M.B., Sila M.D., Deshi KE, Kwon-Ndung EH. (2021) Evaluation of growth and yield traits of lettuce treated with different organic manures in Kuru-Jos, Nigeria. Australian Journal of Science and Technology. 2021;5(2):494 -500.
19. Ojo O.O., Bashiru T.A., Ujah G.O., Agbanigo O.T., Oladele O.A. (2023) Growth and yield of lettuce (Lactuca sativa l.) In response to compost application rates. Nigerian Journal of Horticultural Science. 2023;27 (2):46 – 53. 5.
20. Olasupo I.O., Aiyelaagbe I.O.O., Makinde E.A., Afolabi W.A.O. (2018) Growth, Yield, and Nutritional Composition of Plastic Tunnel-Grown Lettuce in Response to Poultry Manure, International Journal of Vegetable Science.

*Corresponding Author: **Ogezi F. O**

2018;24:6: 526-538. DOI: 10.1080/19315260.2018.1444693.

21. Radford P.J. Growth Analysis Formulae: Their Use and Abuse. Crop Science. 1967;7:171-175. Available:https://doi.org/10.2135/cropsci1967.0011183X000700030001x
22. Rizwana Quraishi, Raka Jain, Atul Ambekar Pharmacology & Pharmacy. 2013;4(2). DOI: 10.4236/pp.2013.42022 18. VSN International Genstat Reference Manual (Release 22), Part 3 Procedures. VSN International, Hemel Hempstead, UK; 2022.
23. Rosa-Rodrigues., Tesfa T., Asres D, Woreta H. Lettuce (Lactuca sativa L.) (2020) yield and yield components as affected by mulching at Teda, Central Gondar, Northwest Ethiopia, Int. J. Sci. Res. Manag. 2020;6(9):2321– 3418. Available:https://doi.org/10.18535/ijsrm/v6i 9.ah01.
24. Santos, R.H.S., Casali, V.W.D., Conde, A.R. and Miranda, L.C.G. (2018) Lettuce quality growth with organic compound. Horticultura Brasileira, 12, 29-32.

*Corresponding Author: **Ogezi F. O**