**Effect of different poultry manure levels and plant spacing on the growth and yield of cucumber (*Cucumis Sativus* Linn.) In lowland condition**

**ABSTRACT**

The study examined the impact of poultry manure and plant spacing on cucumber growth and yield in the School of Agriculture and Food Sciences Research site in September 2024. The experiment was laid out in a Randomized Complete Block Design (RCBD) in a split plot arrangement, replicated three times. A well decomposed manure comprising four different levels of poultry manure (0t/ha-1, 5t/ha-1, 10t/ha-1, and 15t/ha-1) and two plant spacing (50cm x 50cm and 75cm x 75 cm). The results showed that poultry manure at 15t/ha-1 with plant spacing of 75 cm x 75 cm had longer vine length (141.47 cm), more branches (2.35), numbers of leaves (113.0), and leaf area (33.4 cm2) which resulted into bountiful fruit production with number of fruit (39.25), fruit length (25.0 cm/ha), average fruit weight (62.05 g/ha) and yield (235.13 t/ ha). In conclusion, poultry manure should be applied at a rate of 15 t/ha using plant spacing of 75 cm x 75 cm should be used by both smallholder and commercialized farmers in order to achieve rapid growth and yield of cucumber in Sierra Leone.

***Key words:*** Poultry manure, plant spacing, Physicochemical, Organic manure, Cucumber, Sierra Leone, Njala,

**1. INTRODUCTION.**

“Vegetable production in sub-Saharan Africa plays an important role in food security and poverty reduction. Although vegetables such as cucumber, tomato, pepper, and onion are an important emerging cash crop for the agricultural sector in Sierra Leone, their production and marketing systems are facing many challenges. Soil-nutrient capital is steadily depleting and the population of Sierra Leone is increasing, with farmers incapable of adequately improving the soil due to the limitation of accessible productive lands, preventing fallowing. Soils of Sierra Leone have inherently low fertility and do not receive adequate nutrient replenishment. With many farmers typically applying insignificant amounts of fertilizers, coupled with continuous cropping, soil degradation and declining soil fertility continue to pose major threat to sustainable food production by smallholders” (MAFFS 2009). “Coupled with other constraints including soil moisture stress, low nutrient capital, erosion risks, low pH with aluminium (Al) toxicity, high phosphorus (P) fixation, low levels of soil organic matter, poor farming methods and a loss of soil biodiversity, food security may not be achieved in the near future unless urgent intervention measures are undertaken” (WFP 2009). Thus, the main strategy employed for improving agricultural productivity in Sierra Leone is the application of inorganic fertilizers. However, the potential success of this strategy is low due to problems of accessibility and affordability for smallholder farmers.

“According to the 2018 world production report, China (67,601,863 tons), Turkey (1,890,904 tons), Russia (1,604,346 tons) and Iran (650,882 tons) are the largest cucumber producer countries. The world yield average of cucumber is reported to be between 15–22 ton” (X. Liu et al., [2020](https://www.tandfonline.com/doi/full/10.1080/23311932.2023.2221103)). “The Food and Agriculture Organization Corporate Statistical Database (FAOSTAT) also reported 91.25 million tons (2,261,318 ha) in 2020 with an average yield of 40.4 tons” (Onanuga *et al*., [2022](https://www.tandfonline.com/doi/full/10.1080/23311932.2023.2221103)). “The productivity trend between 2018 and 2020 shows an increment of approximately of 20 tons. However, even though Africa has untapped potential for cucumber cultivation, its current production and average yield is very low and the number of smallholder farmers producing cucumber is inadequate. In the African continent, South Africa is cultivating cucumber for commercial purposes both in open and greenhouse conditions” (Maluleke, [2022](https://www.tandfonline.com/doi/full/10.1080/23311932.2023.2221103)). “For processing purposes, South Africa farmers are producing cucumber in the open fields while in greenhouses for fresh consumption” (Karanisa et al., [2022](https://www.tandfonline.com/doi/full/10.1080/23311932.2023.2221103)).

“In recent times, Poultry manure (PM) has drawn interest recently as a possible organic fertilizer source because of its high nutritional content and affordable price. Rich in nitrogen, phosphorus, potassium, and other vital elements, PM has been demonstrated to raise crop output, improve soil fertility, and improve the quality of agricultural products” (Jansson, J. K.; & Hofmockel, K. S. (2020)). The primary growth-hindering mineral nutrient for agricultural crops worldwide is nitrogen (N) (Mutale-Joan et al., 2020). Furthermore, there is proof that agricultural yields have dropped dramatically as a result of inadequate and reduced nutrient availability as aridity increases in a changing environment (Shahzadi et al., 2023 and Du et al., 2020). “The use of chemical fertilizers has been reported to increase crop yields, but their use is limited by the high cost, scarcity during the time of its need (planting season), soil acidity, and nutrient imbalance. As a result, it was discovered that using organic manure such as PM helped boost agricultural yields” (Yılmaz, Ş.; Şahan, T. 2020). Compared to chemical fertilizers, PM is inexpensive, always accessible, ecologically benign, and has the capacity to enhance soil structure and have a lasting impact (Singh et al., 2020). The application of poultry manure enhances soil N by over 53% and also considerably increases exchangeable cations (Adekiya et al., 2019). The amount of nutrients released (soil chemical characteristics), maize development, and yield may also be impacted by the pace at which PM is sprayed. e. PM helps maize grow and produce more by providing it with nitrogen (Adekiya et al., 2019). Timsina (2018) reported that “using indigenous available organic nutrient source can enhance the efficiency and reduce the quantity of chemical fertilizer required. Apart from enhancing nutrient use efficiency, integrated nutrient use also maintains soil health, enhances yield, and reduces cost of production. The physical and chemical properties of soil improve with the application of poultry manure” (Enujeke, 2013). Poultry manure at 10-50 t/ha have positive impact on soil physical attributes such as soil temperature, water holding capacity and improves the number of pores (Ewulo *et al*,. 2008).

Being resource limited, most smallholders cannot afford the conventional soil fertility management strategies dominated by high use of inorganic fertilizers and agrochemicals considering their escalating prices. Poultry manure is not limiting to easy availability, but also provide all essential nutrients to the plants and maintaining the soil fertility and give superior growth and yield. In Sierra Leone, there is dire needs to assess the used of poultry manure and plant spacing vegetable production. The main aim these research is i) To determine the physico-chemical properties of the soil sample before and after, ii) To assess the growth response of Cucumber as influence by poultry manure and plant spacing, iii) To evaluate the yield response of cucumber as influence by poultry manure application and plant spacing. Therefore, the present research was aimed to determine the optimum level of poultry manure and plant spacing for better cucumber production in Sierra Leone.

**2. MATERIAL AND METHOD**

**2.1 Experimental setup.**

A field experiments was conducted at the School of Agriculture and Food Sciences lowland (September) 2024. The area lies on an elevation of 54 m above sea level on latitude 8ᵒ6N and longitude 12ᵒW of the equator. Njala experiences a distinct dry and wet season. The mean annual rainfall total was 3010 mm.The experiment was laid out on a Randomized Complete Block Design (RCBD) replicated three times. The total experimental area was 192.0m2 (24 m x 8 m) with a bed size of 5m x 3m (15m2), Three rates of well decomposed poultry manure levels (0 t ha-1, 5 t ha-1, 10 t ha-1, and 15 ha-1) with two Plant spacing of (50cm x 50cm, and 75cm x 75cm). Thinning was practiced when the seedling has three true leaves. Weeding was done manually using hoe and pesticide was applied at 2nd 3rd 4th week after planting to protect the plant against insects such as melon fly and aphid white flies. Five plants from each plot where tagged from which growth and yield parameters would be recorded the data was recorded for the main vine length (cm) number of lateral branches, number of leaves on the main vine number of fruits per plant, fruit weight and fruit yield. All data collected were subjected two-way analysis of variance (ANOVA) using the STATISTICA software version 12 (Stat Soft Inc., Tulsa, OK, USA) and means were separated using the DUNCAN MULTIPLE RANGE TEST (DMRT) at 0.05 level of significant.

**3. RESULT AND DISCUSSION**

**3.1 Soil Analysis**

“Prior to the application of poultry manure on the experimental plots, soil samples were collected at depth of 15 to 25 cm and analyzed for different physicochemical in the laboratory of Soil Science Department, Njala University. The physicochemical properties as shown in table 1 below indicate that the soil is of sandy loam textural class and slightly acidic with a pH of 6.50. It had an organic matter content of 4.50% and organic carbon of 3.46 %. The N, P and K contents were 1.60 %, 8.0 mg kg-1 and 9.5 cmol kg-1 respectively”. (Oke et al. 2020)

**Table 1. Physical, and chemical properties of soil sample of the experimental soil.**

|  |  |  |
| --- | --- | --- |
| **Properties** | **Before planting** | **After planting** |
| Soil pH | 4.5 | 5.0 |
| Sand % | 44.4 | 44.0 |
| Silt% | 8.20 | 8.12 |
| Clay | 5.40 | 5.30 |
| Ca (Cmol) | 30.5 | 29.05 |
| Nitrogen (% N) | 0.027 | 1.6 |
| Phosphorus(P)(mg/soil) | 8.18 | 8.0 |
| Potassium(K)(mg/soil)  Electrical Conductivity(µS/cm)  Soil organic Carbon (%)  Organic Matter % | 66.4  39  4.64  4.55 | 9.5  39  3.46  4.50 |

**3.2 Cucumber growth parameters.**

**Vine length (cm)**

Result below shows a significant (p<0.05) difference on the Vine length at 4, 6 and 8 Weeks after planting. From the results, plant treated with poultry manure at 15t/ha-1 had the longest vine with average mean of (33.58 cm, 59.28 cm and 141.47 cm) followed by cucumber plant grown with the application of poultry manure at 10 t/ha-1 (23.11 cm, 56.07 cm, 102. 34 cm) while cucumber plant grown without the use of manure (control) had the least performance across the weeks after planting. According to the results of Enujeke (2013), high levels of poultry manure encouraged the production of maize. However, result further shows a significant (p<0.05) differences on the level of spacing on cucumber vine length across the weeks after planting. From the findings, planting spacing of 75 cm x 75 cm recorded longer vine compared to those spaced at 50 cm x 50 cm respectively. These result get support from the work done by Ban *et al*., (2011) who observed that in row plant spacing has a significant effect on the growth and yield of watermelon.

**Vine of cucumber plant.**

Vine branches of cucumber plant Result on stem branches shows a significance (p<0.05) differences at 4, 6 and 8weeks after planting. From the result, cucumber plant treated with poultry manure at 15t/ha-1 had the best performance with average mean of 2.21 cm, 1.90 cm, 2.35 cm. followed by cucumber plant treated with poultry manure 10 t/ha-1 while cucumber plant grown without the use of poultry organic manure (the control) had the least performance with average mean of 1.28 cm, 1.77 cm and 2.19 cm. According to the results of Enujeke (2013), high levels of poultry manure encouraged the production of maize. However, there was also a significant (P<0.05) difference on the planting spacing throughout the study period. From the findings cucumber planted using a planting spacing of 75 cm x 75 cm shown higher plant branches comparing those planted using 50 cm x 50 cm. in the study, result shows that the higher the planting distance, the more potential of the crop to grow. These result get support from the work done by Ban *et al*., (2011) who observed that in row-plant spacing has a significant effect on the growth and yield of watermelon.

**Leaf number per cucumber plant.**

From result obtained below shows the leaf count production of cucumber to different poultry manure rate and spacing at 4, 6 and 8 weeks after plating. From cucumber plant shows that cucumber plant grown with the application of poultry manure at 15t/ha-1 had the best performance in leaf production with mean value of (58.9, 90.4 and 113.0) while cucumber plant grown without the use of manure produced the least number of leaves. Poultry manure contains nitrogen which boosts the growth of the plant. This statement is approved by the results of Enujeke *et al.* (2013) who reported that “poultry manure (which is superior animal manure) was contained more nutrients, which improved the physical condition of soil for plant growth and development”. Interestingly, the application of poultry manure on cucumber using 75 cm x 75 x75 cm spacing produced more leaf count compared to those with 50 cm x 50 cm which shows that planting spacing has a significant influence on the growth of plant.

**Leaf Area of cucumber plant (cm2)**

From the tables below a significance (p<0.05) difference on cucumber leaf area using different poultry manure rate and spacing’s at 4, 6 and 8 weeks after plating. Leaf area shows that cucumber plant grown with the application of poultry manure 15t/ha-1 had the best performance in leaf production with mean values of 29.49 cm2, 32.35 cm2, and 33.41 cm2 compared to those without poultry manure which produces narrow leafs per plant. These results resemble with the findings of (Adesina et al 2014), who stated that poultry manure improved the vegetative growth of pepper plants, and enhanced the nutrients uptake. However, the application of poultry manure on cucumber using 75 cm x 75 x75 cm spacing produces broader leaf of (25.64, 33.18, and 33.55) compared to those with 50 cm x 50 cm which shows that planting spacing has a significant influence on the growth of plant.

**Table 2: Growth response of cucumber as affected by poultry manure levels and Plant Spacing at 2WAP**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | **Vine Length (cm)**  **2WAP** | **Vine Branches**  **2WAP** | **Number of Leaves**  **2WAP** | **Leaf Area (cm2)**  **2WAP** |
| 0t/ha-1 | 19.33c | 1.28c | 26.9d | 22.06c |
| 5t/ha-1 | 20.88b | 1.48b | 36.10c | 23.91b |
| 10t/ha-1 | 23.11ab | 1.55ab | 47.4b | 25.69ab |
| 15t/ha-1 | 33.58a | 2.21a | 58.9a | 29.49a |
| **Spacing** |  |  |  |  |
| 50 cm x 50cm | 20.86b | 1.49b | 36.6b | 22.41b |
| 75cm x 75cm | 27.59a | 1.78a | 48.35a | 25.64a |
| **F-Statistics** |  |  |  |  |
| Treatment | 57.8\*\*\* | 11.94\*\*\* | 7.76\*\*\* | 4.04\* |
| Spacing | 63.6\*\*\* | 6.18\* | 24.02\*\*\* | 18.84\*\*\* |
| Treatment x Spacing | 5.91\*\* | 0.36ns | 5.46\*\* | 3.87\* |

*Values are presented as mean ± standard deviation, NS indicates non-significant difference, \*\*\* indicates p-value < 0.001, \*\* indicates p-value < 0.05.*

**Table 3: Growth response of cucumber as affected by poultry manure levels and Plant Spacing at 4WAP.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | **Vine Length (cm)**  **4WAP** | **Vine Branches**  **4WAP** | **Number of Leaves**  **4WAP** | **Leaf Area (cm2)**  **4WAP** |
| 0t/ha-1 | 41.62d | 1.69c | 47.1c | 20.40d |
| 5t/ha-1 | 44.08c | 1.77b | 49.6b | 29.45c |
| 10t/ha-1 | 56.07ab | 1.77b | 59.7b | 30.01b |
| 15t/ha-1 | 59.28a | 1.9a | 90.4a | 32.35a |
| **Spacing** |  |  |  |  |
| 50 cm x 50cm | 39.15b | 1.57b | 49.15b | 29.86b |
| 75cm x 75cm | 61.38a | 2.00a | 60.25a | 33.18a |
| **F-Statistics** |  |  |  |  |
| Treatment | 82.7\*\*\* | 1.39ns | 1.84ns | 5.06\*\* |
| Spacing | 538.1\*\*\* | 34.9\*\*\* | 7.74\*\* | 29.88\*\*\* |
| Treatment x Spacing | 57.24\*\*\* | 4.32\* | 2.07ns | 12.37\*\*\* |

*Values are presented as mean ± standard deviation, NS indicates non-significant difference, \*\*\* indicates p-value < 0.001, \*\* indicates p-value < 0.05.*

**Table 4: Growth response of cucumber as affected by poultry manure levels and Plant Spacing at 6WAP.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | **Vine Length (cm)**  **6WAP** | **Vine Branches**  **6WAP** | **Number of Leaves**  **6WAP** | **Leaf Area (cm2)**  **6WAP** |
| 0t/ha-1 | 63.89d | 2.19d | 69.3d | 30.36d |
| 5t/ha-1 | 82.75c | 2.05c | 79.4c | 32.73c |
| 10t/ha-1 | 102.34b | 2.21b | 98.2b | 33.01b |
| 15t/ha-1 | 141.47a | 2.35a | 113.0a | 33.41a |
| **Spacing** |  |  |  |  |
| 50 cm x 50cm | 77.16b | 1.9b | 99.35b | 31.21b |
| 75cm x 75cm | 118.1a | 2.5a | 112.1a | 33.55a |
| **F-Statistics** |  |  |  |  |
| Treatment | 30.52\*\*\* | 1.83ns | 2.85ns | 2.74ns |
| Spacing | 46.43\*\*\* | 43.64\*\*\* | 2.19ns | 7.98\*\*\* |
| Treatment x Spacing | 3.31\* | 9.97\*\*\* | 0.84ns | 10.79\*\*\* |

*Values are presented as mean ± standard deviation, NS indicates non-significant difference, \*\*\* indicates p-value < 0.001, \*\* indicates p-value < 0.05.*

**3.2 Number of fruits, Fruit length, Fruit weight and Yield of cucumber as affected by poultry manure levels and Plant Spacing.**

**Numbers of fruits.**

Table 4 below shows a significant (P≤0.05) effect on the number of fruits of cucumber to different poultry manure level and spacing. The number of fruits/ha was 39.25a in plants to which poultry manure was applied at 15t/ha and 12.00 in cucumber that did not receive poultry manure (Table 4). This indicating that high poultry manure level improved the yield of cucumber. Poultry manure improved the availability of nutrients to plants, bulk density and the water holding capacity of the soil. This, in turn, increases the vegetative growth, accelerate the division of meristematic tissue and metabolic reactions and the plants take more food as a result of which increase in the number of fruits/ plant-1occurred. However, given a plant spacing of 75 cm x 75 cm were having higher fruit productions of cucumber compared to 50 cm x 50 cm spacing.

**Fruits length (cm).**

“The poultry manure levels and spacing significantly affected (P≤0.05) the fruit length of cucumber. Maximum fruit length (25.00a) was seen in plants, which received poultry manure at 15t/ha, while minimum fruit length (15.88d) was observed in plants which did not received any poultry manure (Table 4). The fruit length might be increased due to the optimum amount of macro and micro nutrients available in poultry manure, which is required for the synthesis of photo assimilates and the enhanced amount of photo assimilates produced maximum fruit length” (Oke et al. 2020). Agyarko and Asiedu (2012) also reported that “fruit size and fruit girth of cucumber was improved with poultry manure application. Findings on the plant spacing shows that planting cucumber with spacing of 75 cm x 75 cm recorded longer fruit compared to those with 50 cm x 50 cm”. These results are supported by Goreta et al. (2013) who reported that with increased spacing average fruit weight of watermelon and fruit size distribution shifted to large categories.

**Average fruit weight of cucumber (g).**

“Maximum average fruit weight (62.05g) was observed in plants supplied with poultry manure at 15t/ha, while the minimum average fruit weight (25.34g) was noted in those plants which did not receive poultry manure from Table 4 The increase in average fruit weight might be due to the high concentration of nutrients in high poultry manure level which boost up the growth and yield”. (Oke et al. 2020) However, result further shows that cucumber planted using spacing of 75 cm x 75 cm shows maximum fruit weight with the minimum average fruit weight reveals from planting spacing of 50 cm x 50 cm. 50cm (1925g). The result showed that by increasing spacing the fruit weight also start increasing gradually these result are in agreement with the finding of Doneta *et al*., (2011) who reported that “with increased spacing average fruit weight of watermelon and fruit size distribution shifted to larger categories”.

**Yield of cucumber fruits (t/ha).**

The yield was increased from 96.09t/ha in control plants to 235.13t/ha in plants which received poultry manure at 15t/ha. The background of high yield was more number of leaves /plant, which captured more sun light to promote the photosynthesis and respiration and as a result, the plant produced maximum yield. Interestingly, cucumber planted using spacing of 75 cm x 75 cm recorded yield than those planted using 50 cmx 50 cm respectively. Similar result was also recorded by Hamide *et al*., (2013) who reported that spacing effect was observed on yield.

**Table 5: Number of fruits, Fruit length, Fruit weight and Yield of cucumber as affected by poultry manure levels and Planting Spacing.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | **Number of fruit** | **Fruit length (cm)** | **Fruit weight(g)** | **Yield (kg/ha)** |
| 0t/ha-1 | 12.00d | 15.88d | 25.34d | 96.09d |
| 5t/ha-1 | 13.13c | 14.13c | 30.68c | 92.98c |
| 10t/ha-1 | 20.50b | 16.88b | 31.49b | 101.86b |
| 15t/ha-1 | 39.25a | 25.00a | 62.05a | 235.13a |
| **Spacing** |  |  |  |  |
| 50 cm x 50cm | 17.81b | 16.50b | 40.02b | 115.95b |
| 75cm x 75cm | 24.63a | 19.44a | 54.76a | 127.08a |
| **F-Statistics** |  |  |  |  |
| Treatment | 33.98\*\*\* | 22.8\*\*\* | 23.7\*\*\* | 9.84\*\*\* |
| Spacing | 9.94\*\* | 8.44\*\* | 2.36ns | 0.16\*\* |
| Treatment x Spacing | 4.49\* | 1.11ns | 0.25ns | 0.23ns |

**CONCLUSIONS.**

Based on above findings, it can be concluded that poultry manure at 15t/ha-1 significantly increased the growth and yield of cucumber. The used of poultry manure level at 15t/ha-1 with a plant spacing of 75 cm x 75 cm significantly increased the vine length, number of leaves, number of branches, fruit length, fruit weight and fruit yield with Plant spacing of 50cm x 50cm consequently gave the least values in all the growth and yield parameters. It is recommended that cucumber producer should use poultry manure level at 15t/ha-1 with plant spacing of 75 cm x 75 cm in raising the crop for maximum production.

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.

**REFERENCES**

1. Adesina, J. M., Sanni, K. O., Afolabi, L. A. & Eleduma, A. F. (2014). Effect of variable rate of poultry manure on the growth and yield of pepper (Capsicum annum) in South Western Nigeria. Academia Arena, 6(1): 9-13
2. Adekiya, A. O.; Agbede, T. M.; Aboyeji, C. M.; Dunsin, O.; Simeon, V. T. Biochar and Poultry Manure Effects on Soil Properties and Radish (Raphanus Sativus L.) Yield. Biol. Agric. Hortic. 2019, 35, 33−45.
3. Agyarko, K. & Asiedu, E. K . (2012). Cocoa pod husk and poultry manure on soil nutrients and cucumber growth. Journal of Advance Environmental biology, 6(11): 2870-2874.
4. Doneta, B. Milijana, G. & Boric. J. (2011). Plant spacing and cultivar effect on melon growth and yield component. Proceedings of American Society of Horticultural Science. 109: 238 – 248.
5. Du, Y.; Cui, B.; Wang, Z.; Sun, J.; Niu, W. 2020. Effects of Manure Fertilizer on Crop Yield and Soil Properties in China: A MetaAnalysis. Catena 2020, 193, No. 104617.
6. Enujeke, E. C. (2013). Effects of Poultry Manure on Growth and Yield of Improved Maize in Asaba Area of Delta State, Nigeria. Journal of Agriculture and Veterinary Science (IOSR JAVS), 4 (5): 24-30.
7. Goreta, S., Perica, S., Dumicic, G., Bucan, L., & Zanic, K. (2013). Growth and yield of watermelon on polyethene mulch with different spacing and nitrogen rates. Hort. Sci. 366 – 369.
8. Hamide, D.S.J.A., Cure, & J.R. Schultheis (2013). Plant spacing influences watermelon yield and yield components. Hort. Science. 28 (9): 885 – 887.
9. Jansson, J. K.; & Hofmockel, K. S. (2020). Soil Microbiomes and Climate Change. Nat. Rev. Microbiol. 2020, 18, 35−46.
10. Karanisa, T., Achour, Y., Ouammi, A., & Sayadi, S. (2022). Smart greenhouses as the path towards precision agriculture in the food-energy and water nexus: Case study of Qatar. *Environment Systems and Decisions*, 42(4), 1–26. <https://doi.org/10.1007/s10669-022-09862-2>
11. Liu, X., Li, Y., Ren, X., Chen, B., Zhang, Y., Shen, C., Wang, F., & Wu, D. (2020). Long-term greenhouse cucumber production alters soil bacterial community structure. *Journal of Soil Science and Plant Nutrition*, 20(2), 306–321. <https://doi.org/10.1007/s42729-019-00109-9>.
12. Maluleke, M. K. (2022). Metabolite profile of African horned cucumber (Cucumis metuliferus E. May. Ex Naudin) fruit grown under differing environmental conditions. *Scientific Reports*, 12(1), 1–18. <https://doi.org/10.1038/s41598-022-07769-1>.
13. Mutale-Joan, C.; Redouane, B.; Najib, E.; Yassine, K.; Lyamlouli, K.; Laila, S.; Zeroual, Y.; Hicham, E. A. Screening of Microalgae Liquid Extracts for Their Bio Stimulant Properties on Plant Growth, Nutrient Uptake and Metabolite Profile of Solanum Lycopersicum L. Sci. Rep. 2020, 10, 2820.
14. Mangila, E., Tabiliran, F. P., Naguit, M. R. A. & Malate, R. (2007). Effects of Organic Fertilizer on the Yield of Watermelon. Threshold, 2: 27-35.
15. MAFFS. 2009. National rice production and self-sufficiency study 2008, Annual Report. Ministry of Agriculture, Forestry and Food Security, Sierra Leone.
16. Onanuga, A. O., Fat, R. W., & Fat, R. M. W. (2022). Influence of biochar, rock phosphate, and urea nitrogen fertilizer on growth and yield of Cucumber (Cucumis sativus) grown in standoff, southern Alberta greenhouse. *Journal of Agricultural Science*, 14(8), 30. <https://doi.org/10.5539/jas.v14n8p30>.
17. Shahzadi, E.; Nawaz, M.; Iqbal, N.; Ali, B.; Adnan, M.; Saleem, M. H.; Okla, M. K.; Abbas, Z. K.; Al-Qahtani, S. M.; & Al-Harbi, N. A., 2023. Silicic and Ascorbic Acid Induced Modulations in Photosynthetic, Mineral Uptake, and Yield Attributes of Mung Bean (Vigna Radiata L. Wilczek) under Ozone Stress. ACS Omega 2023, 8, 13971−13981.
18. Singh, T. B.; Ali, A.; Prasad, M.; Yadav, A.; Shrivastav, P.; Goyal, D.; Dantu, P. K. 2020. Role of Organic Fertilizers in Improving Soil Fertility. In Contaminants in Agriculture: Sources, Impacts and Management; 2020; pp 61−77.
19. Tavakoli, Y. & Khoshkam, S. T. (2013). The impact of organic fertilizers on production of organic green house cucumber. Mediterranean Journal of Social Science, 4 (14) 249-254.
20. Timsina, J. 2018. Can Organic Sources of Nutrients Increase Crop Yields to Meet Global Food Demand? Agronomy 2018, 8, 214
21. Gangwar, K. S., Singh, K. K., Sharma, S. K. & Tomar, O. K. (2006). Alternative tillage and crop residue management in wheat and rice in sandy loam soil of indo-Gengetic plains Till.Res. 94: 55-63.
22. WFP. 2009. Rapid food security and vulnerability assessment among the main livelihood groups in Eastern and Southern Provinces and in Western Area of Sierra Leone. World Food Programme, Sierra Leone.
23. Yılmaz, Ş.; Şahan, T. 2020. Utilization of Pumice for Improving Biogas Production from Poultry Manure by Anaerobic Digestion: A Modeling and Process Optimization Study Using Response Surface Methodology. Biomass Bioenergy 2020, 138, No. 105601.
24. Oke, O. S., Jatto, K. A., Oyaniyi, T., Adewumi, O. T., Adara, C. T., Marizu, J. T., ... & Adebayo, G. J. (2020). Responses of different poultry manure levels on the growth and yield of cucumber (Cucumis sativus linn.) in Ibadan, Nigeria. Journal of research in forestry, wildlife and environment, 12(3), 206-215.