International Journal of Agricultural Technology 2023 Vol. 19(2):371-390
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

# Growth and yield parameters of watermelon cultivars planted with climate-smart integrated fertilizer management in sandy loam soil

**Ali, C. C.[1], Okadi, A. O.[1], Ifeanyieze, F. O.[1], Ejiofor, T. E.[1*], Nwachukwu, C. U.[1], Nwankwo, C. U.[1], Eze, G. E.[1], Onah, O.[1], Ogbonna, E. K.[1], Nwakile, T. C.[1], Izuakor, C. F.[2], Onah, F. C.[1], Onu, F. M.[1] and Osinem, E. C.[1]**

[1]Department of Agricultural Education, University of Nigeria, Nsukka, Nigeria; [2]Department of Technology and Vocational Education, Nnamdi Azikiwe University, Awka, Nigeria.

Ali, C. C., Okadi, A. O., Ifeanyieze, F. O., Ejiofor, T. E., Nwachukwu, C. U., Nwankwo, C. U., Eze, G. E., Onah, O., Ogbonna, E. K., Nwakile, T. C., Izuakor, C. F., Onah, F. C., Onu, F. M. and Osinem, E. C. (2023). Growth and yield parameters of watermelon cultivars planted with climate-smart agriculture integrated fertilizer management in sandy loam soil. International Journal of Agricultural Technology 19(2):371-390.

**Abstract** The effect of climate-smart agriculture integrated fertilizer management on growth and yield indices of three cultivars of watermelon was determined. The results revealed varied growth and yield indices among the three cultivars of watermelon planted. Charleston grey had better vegetative growth indices. Among the three cultivars planted Sugar baby produced the highest number of flowers and fruits. It was observed that the combination of 15t/ha GM + 50kg/ha NPK treatment improved the fertility of sandy loam soil than any single application in the study area.

**Keywords**: Climate-smart Agriculture, Goat manure, NPK fertilizer, Watermelon; Yield parameters

## Introduction

Watermelon (*Citrullus lanatus* Thumb) is of the Cucurbitaceae (Kyriacou *et al.*, 2018). The crop is considered to have its origin from the Kalahari Desert region of Africa (Romdhane *et al.*, 2017; Makaepea *et al.* 2019) and had become the propagating point to other parts of the world (Ali, 2019). It is primarily planted using the seeds and grows well in tropical areas with plenty of sunlight and a temperature of more than 25 °C for proper development and growth (Betty *et al.*, 2016; Reetu and Maharishi, 2017). The authors stated further that watermelon to be the best thrives in relatively acidic

* **Corresponding Author**: Ejiofor, T. E.; **Email**: ejiofortoochukwu@gmail.com

well drained fertile soil. It is a flowering scrambler and trailer plant which is regarded as fruit vegetable crop (Adetutu *et al.,* 2015; Betty *et al.,* 2016).

The major edible parts of the consumed crop are the fruits, leaves, seeds, and rinds. The fruit is widely consumed and appreciated by people of all ages, and background because of its refreshing ability, attractive color, unique taste, and high moisture content to quench thirst (Romdhane *et al.,* 2017). Watermelon fruits are used in preparation of different kinds of foods and products such as fruit juice, salad, desert snacks, wine and cosmetics. Ali (2019) stated that according to Vanwky and Grricke the seeds are roasted and ground into tsamma meal which has pleasant malty taste while Betty *et al.* (2016) stated that the rind is chopped, dried, boiled and consumed as food among Namibians in Africa. In addition to being low in calories, watermelon fruit is enriched with nutrient elements (Betty *et al.,* 2016; Makaepea *et al.,* 2019). The watermelon fruits have about 93% water content in addition to small quantity of vitamins (A, B and C), fat, protein and minerals (Awere and Onyeacholem, 2014; Olayinka and Etejere, 2018). Research evidence has indicated that, in addition to oils, seeds from watermelon are excellent source of protein with essential as well as non-essential amino acids (Kassali *et al.,* 2015; Bianchi *et al.,* 2018). The seeds contain micro and macro nutrients likes magnesium, potassium, calcium, and iron, and also about 35%, 50% and 5% respectively for protein, oil and dietary fiber (Adeoye *et al.,* 2009; Kassali *et al.,* 2015; Romdhane *et al.,* 2017). According to Makaepea *et al.* (2019) the edible portions of watermelon help to stabilize blood pressure and potentially prevent paralysis. Watermelon fruits contain large quantity of lycopene at maturity. Lycopene is a pigment and anti-oxidant that gives red color to fruits such as tomatoes and watermelons (Ilupeju *et al.,* 2015; Betty *et al.,* 2016; Olayinka and Etejere, 2018). In view of Olayinka, and Etejere (2018) lycopene assists in handling the risk of certain chronic diseases such as prostate, pancreas, breast and stomach cancers. Lycopene is an extremely powerful oxygen radical hunter that prevents coronary heart diseases in human (Ilupeju *et al.,* 2015; Olayinka and Etejere, 2018; Makaepea *et al.,* 2019). Watermelon production assumes a critical position in human nutrition, reducing poverty and strengthening farmers' socio-economic status. The old and young, sick and healthy, educated and uneducated enjoy the watermelon fruits of which many in their leisure time usually eat the pulp, seeds, rind in their offices, homes, hospitals and market places or recreational parks. The nutritional and medicinal benefits of watermelon have made its demand higher than supply as it is common to see the marketers selling the fruits along the major markets, roads and streets. This demonstrates in agreement with Reetu and Maharishi (2017) that the global consumption of watermelon is higher than any other cucurbit family.

In Nigeria, watermelon production is mostly from the north and transported to the east where it is majorly marketed and consumed. The limitation is primarily due to the crop's favorable climatic conditions and geographic area in northern Nigeria. According to Ali (2019), planting, vegetative growth, flowering and fruiting are the critical period of watermelon production. Moreover, with the presence of government agricultural interventions and extension services in the north, farmers have access to agricultural inputs such as pesticides to control pest, different varieties of watermelon seeds to improve growth and yield, synthetic and natural fertilizer to improve their soil conditions (Ali, 2019). There are different cultivars of watermelon which influenced the growth and yield of the crops. The cultivars commonly grown in northern part of Nigeria are Sugar baby, Kolack and Charleston grey. Sugar baby fruit cultivar is sweeter in taste and smaller in size; Kolack is moderate in size whereas Charleston grey is characterized with big size but less sweet in taste (Ali, 2019). In the north, soil fertility is the main constraint of the crop growth and yield, and farmers rely on inorganic and organic fertilizers to restore lost nutrients (Eifediyi *et al.*, 2017). In contrary, both synthetic and natural fertilizers have unique problems when used for crop production (Ilupeju *et al.*, 2015; Selim, 2020).

The downside of continuously using synthetic fertilizers can lead to low yields, it is costly and not within the reach of poor farmers (Eifediyi *et al.*, 2017). It causes groundwater and food contamination after harvesting, affect the availability and uptake of nutrients by plants, reduce production and increases incidences of pest and disease and environmental pollution (Ojo *et al.,* 2014; Aniekwe and Nwokwu, 2015; Junaidi and Wulandari, 2017; Selim, 2018). The continued reliance on synthetic fertilizers can accompany to decrease in soil organic matter, increase soil acidity, soil physical properties degradation and increase erosion due to soil aggregate instability and greenhouse gas emissions (Adeoluwa and Adeogun, 2010; Selim, 2020). Inorganic or synthetic fertilizer is costly concerned and the most farmers cannot afford it (Ali, 2019; Selim, 2020;) especially now that the country is in economic recession, therefore there is need for the utilization of organic manure (goat manure) that is readily available, cheap, within the reach of the farmers and eco-friendly (Ojo *et al.*, 2014; Eifediyi *et al.*, 2017; Selim, 2020). Organic manure is substances of both plant and animal origin that is added to the soil to enhance soil fertility and increase crop performance in terms of growth, yield and nutrition. Organic manure actually raises the number of soil microbes that defend plants against infectious agents, such as nematodes and insects from soil, and it supplies crop hormones such as auxin in plants (Agbede and Ojeniyi, 2009; Usman, 2015; Shenglan *et al.*, 2020). According to Wu *et al.* (2017) and Shenglan *et al.* (2020) organic manure not only improved soil structure, texture and fertility, enhanced soil water storage capacity but also the application can improve the sweetness, hardness, as well as the vitamin content of crop varieties.

In Northern Nigeria, the benefits of organic manure (goat manure) in the production of watermelon were not fully realized due to the enormous quantities needed to meet the nutritional standard of the crop, transport and handling cost, insufficient knowledge of how to apply correct quantities and the positive effects of goat manure in the production of the crop. Therefore, particularly in times of scarcity, to reach the maximum production of watermelon in the area, at a cheaper cost, combat climate change as well as reduced greenhouse gases (GHGs) emission from inorganic fertilizer alone. There is need for effective combination of goat manure (organic manure) and inorganic fertilizer (NPK) for watermelon production which is a climate smart agricultural practice (Ali, 2019).

Climate-smart agriculture is any agricultural practices that increase production sustainably and reduce emissions of GHGs. Climate-smart agriculture, according to FAO (2010), are agricultural techniques, methods, practices or instruments that boost productivity and minimize greenhouse gas (GHG) emissions on a sustainable manner. The International Fertilizer Association (IFA) (2016) and Alo *et al.* (2016) confirmed that a key component of climate-smart agricultural practices is the proper and balanced in using plant nutrients. These activities contribute to climate change adaptations and mitigation and improve food security and nutrition. United Republic of Tanzania (2017), pointed that the techniques and practices of climate smart agriculture is site-specific based on the farming systems, climatic impacts and farmers' livelihood and socio-economic conditions. Neufeldt *et al.* (2013) claimed that the potential benefits of food protection, climate smart agricultural practices increased productivity and efficient use of scars resources. The authors have argued that agricultural practices which reduced exposure or susceptibility to climate change that are concerned in climate-smart, improving farmers' ability to cope with harsh weather conditions and reducing climate change rates. The authors pointed terracing, mulching, drought-tolerant crops, higher productivity crops, improved crop management and integrated fertilizer management as examples of climate-smart agriculture practices that farmers could use (Neufeldt *et al.*, 2013).

The combination and application of organic and inorganic sources of nutrients in this study is known as climate-smart integrated fertilizer. Therefore, the effective application of both organic (goat manure) and inorganic (NPK15:15:15) fertilizers in the soil to improve crop growth, yield, reduce GHGs emission (mitigation) and cope with the impact of climate change is known as climate-smart integrated fertilizer management. Using a climate-smart approach of integrated fertilizer in the production of watermelon can lead to the attainment of SDGs, which include ending poverty in its forms; ending hunger; achieving food security, improved nutrition, fostering sustainable agriculture and guaranteeing healthy living and promoting the welfare of all through access to quality nutrition. The combined use of natural and synthetic fertilizers are in line with the Integrated Soil Fertility (ISFM) system. Researchers like Eifediyi *et al.* (2017); Abera *et al.* (2018); Zhang *et al.* (2019) and Shenglan *et al.* (2020) who reported that integral use of natural manure and synthetic fertilizers provide sufficient quantities of nutrients to increase crop production while mitigating the risk related to chemical fertilizer use alone on the environment. Organic materials like Pig, poultry and compost manure and their mixture with mineral fertilizers have been reported to improve the soil availability of mineral elements like N, P, K, Ca and Mg, growth capacity, and fruit yield of selected crops (Awosika *et al.,* 2014; Abera *et al.*, 2018; Selim *et al.,* 2017; Selim, 2020).

However, farmers in south eastern Nigeria, especially in Nsukka agricultural zone of Enugu state where the fruits are mostly consumed are yet to start cultivating watermelon as they still belief that the crop can only grow in the north. The cost and perishable risk are associated with the transportation of the product from northern to eastern part of the country has increased the market price at which it is sold to the consumers. This situation has recently worsened in the area as a single fruit that is sold between seven hundred to nine hundred naira is now sold for one thousand five hundred naira depending on the size. However, some farmers during their interaction session with agricultural extension agents in Nsukka had reported that watermelon seeds germinated in their farm land with some attending to maturity with average of two to three fruits per plant stand. This has created the awareness and reduced the popular notion that watermelon cannot grow in the eastern Nigeria, the farmers are not sure of the best planting time, yielding variety and eco-friendly fertilizer requirement for the production. The reason being that the available land for cultivation of crop in Nsukka is depleted in fertility due to climate change, continuous cropping, leaching and bush burning. Therefore, the study aimed to determine the growth and yield parameters of watermelon cultivars planted with climate-smart integrated fertilizer management in sandy loam soil of Enugu state, Nigeria.

## Materials and methods

### *Experimental site and design for the study*

The experiment was carried out in the Agricultural Education Department, University of Nigeria, Nsukka campus. Nsukka as one of the agricultural zones in Enugu State of south eastern Nigeria lies between longitude $7^0\ 13^{/N}$-$7^0\ 35^{/N}$ and latitude $6^0\ 43^{/E}$-$7^0\ 35^{/N}$ -$7^0 00^{/E}$ (Nzeh *et al.,* 2014). The study was conducted in the year 2017 raining season starting from the month of August to October. The study area has temperature range of 27 -30 ℃ while the rainfall distribution is between 1567.1 mm to 1847 mm, with tropical climate marked by two distinct (dry and wet) seasons. Relative humidity ranges from 46.7% to 76.2% (Nwachukwu *et al.,* 2021). The study was carried out using split-plot procedure replicated thrice in RCBD (Randomized Complete Block Design). The experiment was rain fed. The treatments applied during the study were six, which include sole and combined application of NKP fertilizers and goat manure (GM). They were: (i) control (0kg/ha), (ii) NPK at 200kg/ha (iii) GM at 20t/ha, (iv) 5t/ha GM + 150kg/ha NPK (v) 10t/ha GM + 100kg/ha NPK and (vi) 15t/ha GM + 50kg/ha NPK. Weed species such as tridaxprocumbes, talinum trangulare, imperata cylindrical and guinea grass are composed of the site vegetation. Before being cleared by tractor, the experimental site was under maize cultivation for one year. Eighteen beds each measuring 1.9m × 3.25m were made in each of the three blocks measuring 3.25 × 69m making it a total of fifty-four beds in all for the study. The total experimental area was 69m × 8.7m (600.3m$^2$). The organic manure (GM) was applied on each bed two weeks before the seeds were planted and worked 0-5 cm deep in the soil. Three cultivars (Charleston gray, Koalack and Sugar baby) of watermelon as well as the six fertilizer treatments were the tested factors. The main plot was formed by the watermelon cultivars, while the subplot factors were formed by the six fertilizer levels. The three used cultivars were primarily grown in northern Nigeria. The sugar baby and koalack were obtained at AgroMolon Enugu while Charleston gray was obtained at Jubaili Agrotec Ltd, Kano (Ali, 2019).

The seeds of each watermelon cultivar were sown two per hole with planting space of 75 × 90cm. In a plot a total of sixteen seeds were sown. A week after planting, vacant spaces was supplied. Two weeks after planting, the seedlings were thinned to one seedling per hole, leaving eight watermelon stands per plot. For data collection, four stands of each watermelon cultivar were randomly selected and tagged per plot. The crop population for the experiment was 432 while the sample for the study was216. Weed control was done manually by hand pulling two weeks after planting and repeated at interval of two weeks. Pest like cucumber bittles were controlled through the praying of Karate at 40ml/20L of water at interval of 2 weeks after planting (Ilupeju *et al.*, 2015).

### *Statistical analysis*

The parameters were measured including percentage germination of each variety, number of active leaves and branches per plant by counting method, stem girth by Vernier caliper, plant height by meter rule, number of flowers and fruits per plant by counting. The analysis of variance was done on the collected data following Gomez and Gomez (1984) procedure whereas differences in the means were compared using the Turkey HSD (Honestly Significant Difference) test based on the studentized t-distribution. The Turkey HSD test is robust for multiple comparison of treatment effects as it controls type one error by taking into account the number of means that are compared (Gomez and Gomez, 1984; Ilupeju *et al.*, 2015).

Let $F_i, i = 1, 2, \ldots, m$ is the marginal mean effect of the $i^{th}$ group and $F_{j, j\neq i}$, the marginal mean of the $j^{th}$ group. $n$ is the number of replications in a group and $N = nm$, the total number of observations in the experiment. The test statistic for Turkey Honestly significant different test, is expressed as

$$Q = \frac{|F_i - F_j|}{\left(MSE/n\right)^{1/2}} \sim t_{N-n};(1)$$

Where, MSE is the mean of the estimate $\alpha$ group variances. It is expressed as

$$MSE = \frac{\sum_{i=1}^{m} s_i^2}{m}$$

Using eqt (1), different pairs of the fertilizer type (treatment effects) were compared at 0.05 level of significance and the results are presented in Table 2 and among the parameters considered, test of correlations were done to determine their interaction effects.

## Results

### *Physiochemical characteristics of the experimental area and GM samples*

Before treatment application, samples of the soil from the study site and GM were collected and analyzed for the physiochemical characteristics using standard laboratory procedures as seen in Table1.

**Table 1,** Physiochemical characteristics of the research site at (0-30cm) and GM samples

| **Parameters** | **Soil test value** | **Manure test value** |
|---|---|---|
| **pH Values** | | |
| **Soil/GM pH (water)** | 4.5 | 7.3 |
| **Soil/GM pH (KCl)** | 3.6 | 7.1 |
| **Organic Matter %** | | |
| **Organic carbon** | 1.43 | 17.08 |
| **Organic matter** | 2.43 | 29.44 |
| **Total nitrogen** | 0.20 | 2.56 |
| **Available phosphorus (mg/kg)** | 11.19 | 9.81 |
| **Exchangeable Bases (me/100g)** | | |
| **K** | 0.07 | - |
| **Mg** | 1.40 | - |
| **Na** | 0.04 | - |
| **Ca** | 0.60 | - |
| **Exchangeable Acidity (me/100g)** | | |
| **Al** | 0.80 | - |
| **H** | 2.20 | - |
| **Cation exchangeable capacity** | 14.00 | - |
| **Textural class (%)** | | |
| **Sand** | 79 | - |
| **Silt** | 8 | - |
| **Clay** | 13 | - |
| **Textural class** | Sandy loam | - |

The outcomes of the analysis of soil and GM samples are shown in Table 1. The goat manure was alkaline while, the soil was found to be slightly acidic and textual class of sandy loam.

The result showing percentage germination rate of the three cultivars of watermelon in study area are presented in Figure 1. The Kolack cultivar had the highest percentage germination rate (35%). This was followed by Sugar baby with (34%) germination rate, while Charleston grey had the least percentage germination rate (31%).

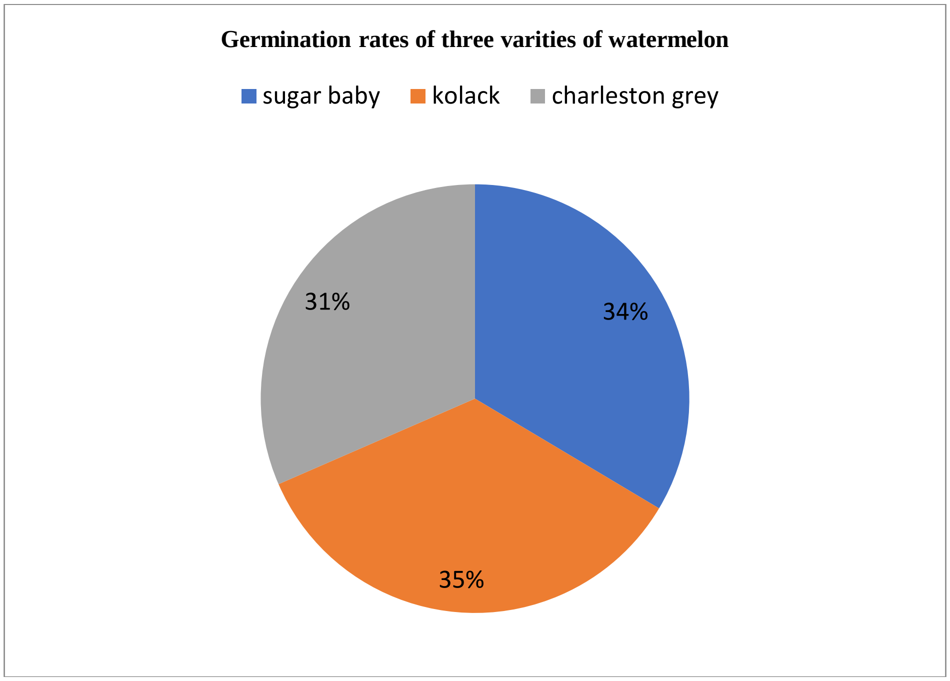


**Figure1.** Percentage germination rates of three cultivars of watermelon in Nsukka

Result presented variability in the vegetative parameters of watermelon cultivars in response to fertilizer treatment (Table 2). The number of leaves, branches, vine length and stem girth were all significantly influenced ($P \leq 0.05$) by the watermelon cultivar and treatments applied. The maximum number of leaves per plant was recorded in Charleston grey (38.46); following by Koalack (33.17), whereas the lowest number (18.82) of leaves was recorded in Sugar baby. The combined application of 15t/ha GM + 50kg/ha NPK produced highest number of leaves (39.97) which was significantly better than what was observed with other treatments with the exception of 20t/ha GM treatment that gave (39.03) number of leaves per plant. The control showed the lowest number (18.79) of leaves followed by 200kg/ha NPK treatment with 39.03 numbers of leaves per plant. The result indicated that 10t/ha GM + 100kg/ha NPK treatment had 31.24 number of leaves while5t/ha GM + 150kg/ha NPK had 31.01 numbers of leaves per plant. The number of leaves per plant improved with increasing content of goat manure, among the treatments that combined NPK fertilizer and goat manure.

The number of branches per plant differed considerably according watermelon cultivars and fertilizer treatments. Charleston grey cultivar had the highest (5.06) number of branches per plant followed by Koalack with (3.55) branches while sugar baby had the least (2.51) number of branches. However, the observations made on this parameter were not identical in response to the applied fertilizer combination. The number of branches per watermelon plant grown with 15t/ha GM + 50kg/ha NPK (4.79) was the same with the one that received 20t/ha GM treatment **(**4.74) which was greater than measured values for other treatment modalities. The number of branches per plant was 4.03 when 10t/ha GM + 100kg/ha NPK treatment was applied, when 5t/ha GM + 150kg/ha NPK and 200kg/ha NPK treatments were 3.97 and 2.76 respectively. All the treatment performed better than the control treatment that had only 1.95 numbers of branches per plant**.**

The vine length was varied between the varieties and the combination of fertilizers (Table 2). The principal variety effect indicated that Kolack had the highest vine length (145.68cm) per plant which was 88.16cm and 7.54cm higher than the length of vine obtained for Sugar baby and Charleston grey respectively. The length of vine of watermelon fertilized with 15t/ha GM + 50kg/ha NPK (155.74cm) was significantly greater than other fertilizer treatments. The result showed that the vine length of watermelon grown with 5t/ha GM + 150kg/ha NPK (125.13cm) and 20t/ha GM (125.01cm) treatments were statistically similar. The result indicated that when 10t/ha GM + 100kg/ha NPK was applied the watermelon vine length was 112.11 and 98.86cm in 200kg/ha NPK treatment. All the treatments had longer vine length when compared with the control treatment with vine length (65.82cm). The Charleston grey cultivar grown with 15t/ha GM + 50kg/ha NPK gave the highest interactive effect of vine length 192.93cm.

Variations in stem girth and fertilizer combination were significantly differed with respect to watermelon variety. The most vigorous stem was seen in Charleston gray (2.39cm), while the least was Sugar baby with (1.62cm). The use of 15t/ha GM + 50kg/ha NPK gave the highest (2.14cm) stem girth among the fertilizer compositions which did not differ significantly from 5t/ha GM + 150kg/ha NPK (2.09), 20t / ha GM (2.08) and 10t/ha GM + 100kg/ha NPK (2.04) treatments. The result pointed out that all the treatments were significantly different from the control treatment with (1.6cm) stem girth. The interaction effect between watermelon cultivar and fertilizer treatment was recorded highest in Charleston grey treated with 15t/ha GM + 50kg/ha NPK with (2.73cm) stem girth.

**Table 2.** Vegetative growth of three cultivars of watermelon at 8 weeks after planting as influenced by climate-smart agriculture integrated fertilizer levels

| Fertilizer type | Watermelon varieties | | | Mean |
|---|---|---|---|---|
| | Sugar baby | Koalack | Charleston grey | |
| **Number of leaves/plant** | | | | |
| **15t/haGM + 50kg/ha NPK** | 19.7 | 42.6 | 57.63 | **39.97a** |
| **10t/haGM+100kg/haNPK** | 17.93 | 37 | 38.8 | **31.24b** |
| **5t/haGM + 150kg/ha NPK** | 26.27 | 35.43 | 34.33 | **32.01b** |
| **200kg/ha NPK** | 16.83 | 19.2 | 23.6 | **19.88c** |
| **20t/ha GM** | 18.93 | 40.2 | 57.97 | **39.03a** |
| **0kg/ha** | 13.3 | 24.6 | 18.47 | **18.79c** |
| **Mean** | **18.82c** | **33.17b** | **38.46a** | |
| **Numberof Branches/plant** | | | | |
| **15t/ha GM + 50kg/ha NPK** | 3.1 | 4.33 | 6.93 | **4.79a** |
| **10t/haGM+100kg/ha NPK** | 2.43 | 4.2 | 5.47 | **4.03b** |
| **5t/ha GM + 150kg/ha NPK** | 2.93 | 3.7 | 5.27 | **3.97b** |
| **200kg/ha NPK** | 1.97 | 2.27 | 4.03 | **2.76c** |
| **20t/ha GM** | 2.63 | 4.83 | 6.77 | **4.74a** |
| **0kg/ha** | 2.0 | 1.97 | 1.87 | **1.95d** |
| **Mean** | **2.51c** | **3.55b** | **5.06a** | |
| **Length of vine(cm)** | | | | |
| **15t/ha GM + 50kg/ha NPK** | 91.27 | 183.03 | 192.93 | **155.74b** |
| **10t/haGM+100kg/ha NPK** | 62.43 | 142.37 | 131.53 | **112.11c** |
| **5t/ha GM + 150kg/ha NPK** | 75.5 | 151.13 | 148.77 | **125.13a** |
| **200kg/ha NPK** | 41.53 | 122.84 | 132.21 | **98.86d** |
| **20t/ha GM** | 52.87 | 168.63 | 153.53 | **125.01a** |
| **0kg/ha** | 21.5 | 106.1 | 69.87 | **65.82e** |
| **Mean** | **57.52c** | **145.68a** | **138.14b** | |
| **Stem girth (cm)** | | | | |
| **15t/ha GM +50kg/ha NPK** | 1.73 | 1.97 | 2.73 | **2.14a** |
| **10t/haGM+100kg/ha NPK** | 1.6 | 1.92 | 2.6 | **2.04a** |
| **5t/ha GM + 150kg/ha NPK** | 1.7 | 1.95 | 2.63 | **2.09a** |
| **200kg/ha NPK** | 1.57 | 1.63 | 2.27 | **1.82b** |
| **20t/ha GM** | 1.6 | 2.2 | 2.43 | **2.08a** |
| **0kg/ha** | 1.5 | 1.58 | 1.73 | **1.6c** |
| **Mean** | **1.62c** | **1.88b** | **2.39a** | |

Result presented the interaction effect of fertilizer types and watermelon varieties on the number of flowers and fruit per plant (Figure 2). The types of fertilizer are concerned, the sugar baby had the highest number (17.13) of flowers followed by Charleston grey with 13.43, while Koalack had the least (9.53) when grown with 15t / ha of GM + 50 kg / ha of NPK treatment. The greatest number of flowers were produced by Koalack (11.6), followed by Charleston grey (10.1), whereas the sugar baby had the least (8.1) when treated with 10t/ha GM + 100kg/ha NPK. The maximum number of flowers were obtained by Sugar baby (11.6), followed by Koalack (10.96), while Charleston grey had the least (10.86) when treated with 5t / ha GM + 150kg/ha NPK. The result revealed that when 200kg/ha NPK was applied Sugar baby had the highest number of flowers per plant (10.6), followed by Koalack with 5.33, while Charleston grey recorded lest number of flowers (5.1) (Figure 2). The control treatment produced the lowest number of flowers per plant when compared to other treatments as Sugar baby (5.37), Koalack (5.16) and Charleston grey (3.53). Finally, the highest number of flowers was obtained by Charleston grey, followed by Kolack, while the sugar baby had the least when nourished with 20t / ha GM.

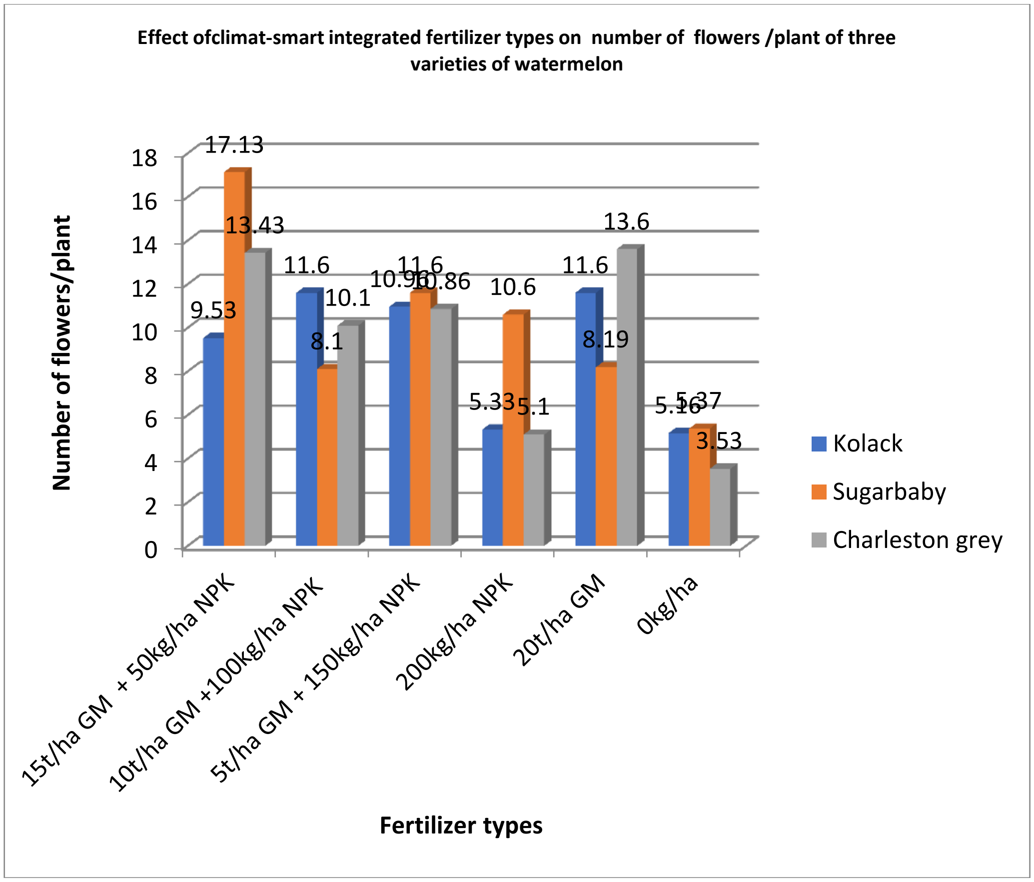


**Figure 2.** Effect of climate-smart agriculture integrated fertilizer on number of flowers/plant of three cultivars of watermelon at 6 weeks after planting

In terms of number fruits per plant, it showed that Sugar baby had the highest (9.93) followed by Koalack (7.0), while Charleston grey had the least (3.5) when fertilized with 15t/ha GM + 50kg/ha NPK (Figure 3). The application of 10t/ha GM + 100kg/ha NPK treatment showed that Sugar baby had 7.85 number of fruits per plant and followed by Koalack (5.96) while Charleston grey had 4.87 number of fruits per plant. When 5t/ha GM + 150kg/ha NPK treatment was applied to the three cultivars of watermelon, Sugar baby had 6.5 number of fruits per plant and Koalack was 4.43 while Charleston grey was 1.91. The result pointed out that when 200kg/ha NPK, 20t / ha GM and 0kg/ha treatments were applied Sugar baby cultivar had the highest number of fruits per plant with the corresponding values of 5.03, 5.43 and 2.26 respectively whereas Kolack cultivar followed by 3.08, 5.03 and 1.7 while Charleston grey had the lest with 1.46, 2.53 and1.2 number of fruits per plant respectively. All the watermelon cultivars had a greater number of fruits per plant when combined application of (NPK and Goat manure) was applied in comparison with a singular does of chemical or organic fertilizers.

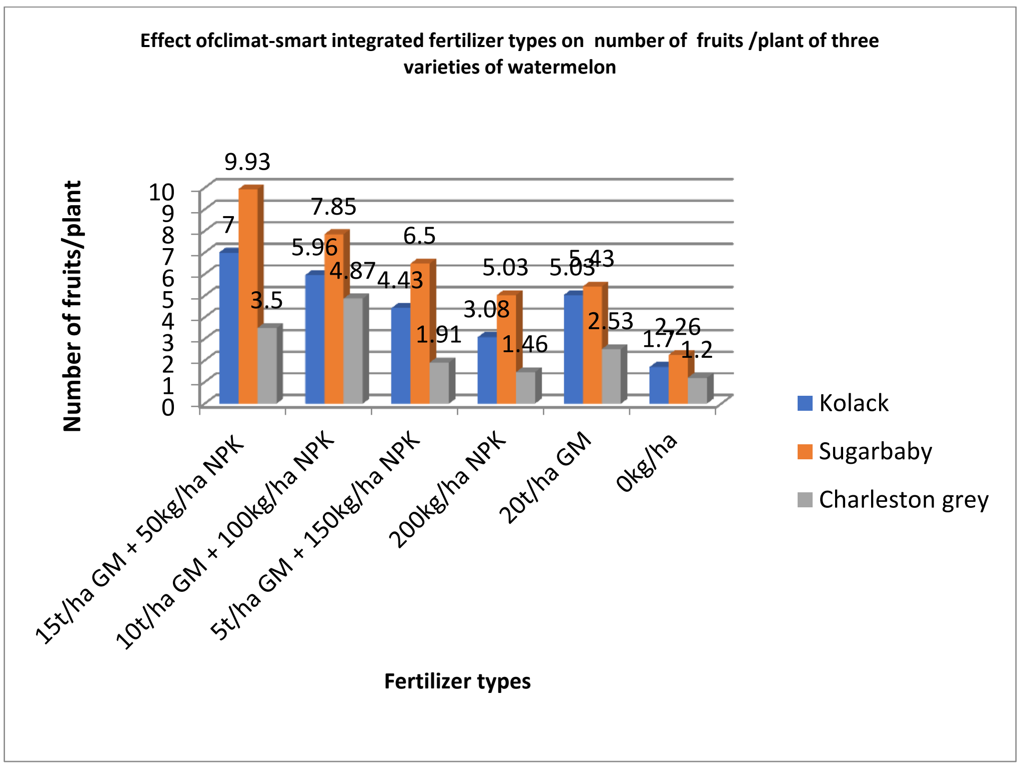


**Figure 3.** Effect of climate-smart integrated fertilizer on number of fruits/plant of three cultivars of watermelon at 8 weeks after planting

## Discussion

Based on the three watermelon cultivars planted, there was an observable difference in their percentage germination. The Kolack cultivar had the highest percentage germination rate (35%) followed by Sugar baby with (34%) germination rate, while Charleston grey had the least percentage germination rate (31%). The finding agreed with Ali (2019) that variation in percentage germination of watermelon cultivars are linked to their differences in genetic contents and germination conditions in the soil. This could be the reason why some varieties thrive in a given geographical region within a country than others. For example, Kolack and Sugar baby cultivars are dominant varieties in southeast when compared with Charleston grey that is popularly grown in northern Nigeria (Enujeke, 2013; Anikwe *et al.*, 2016; Oraegbunam *et al.*, 2016; Ali *et al.*, 2020).

The variability in the vegetative parameters of watermelon cultivars in response to fertilizer treatment was found. The number of leaves, branches, vine length and stem girth were all significantly influenced ($P \leq 0.05$) by the watermelon cultivar and treatments applied. The maximum number of leaves (38.46), branches (5.06) and stem girth (2.39cm) per plant were recorded in Charleston grey, followed by Koalack (33.17 leaves; 3.55 branches and 1.88cm stem girth ), whereas the lowest number (18.82) of leaves, (2.51) branches and (1.62cm) stem girth were recorded in Sugar baby. The findings agreed with Oraegbunam *et al.* (2016) that Charleston grey produced more vegetative parameters (number of leaves and branches) over other varieties. The findings disagreed with Ali (2019) that the number of sugar baby leaves per plant was more than other varieties, presumably because sugar baby had higher photosynthesis, excellent surface distribution, preferable leaf arrangement and chlorophyll content and more active photosynthetic enzymes. The findings of the study further revealed that Koalack variety had the highest vine length (145.68 cm) when compared with other cultivars under investigation. The findings contradicted the result found by Oraegbunam *et al.* (2016) in their study that gave credence to vine length of Charleston grey over other cultivars in vegetative performance.

Combined application of 15t/ha GM + 50kg/ha NPK produced the highest number of leaves (39.97), branches (4.79), vine length (155.74cm), and stem girth (2.14cm) which was significantly better than what was observed with other treatments with the exception of 20t/ha GM treatment that had 39.03 number of leaves, 4.74 branches, and 2.08cm stem girth per plant. The findings agreed with Ali *et al.* (2020) that watermelon grown with 15t/ha GM + 50kg/ha NPK treatment performed better than other treatments. The application of 15 t /

ha GM + 50 Kg /ha of NPK or 20 t / ha of GM could be considered to be related to optimal rate for watermelon vegetative growth. These rates had adequate quantities of essential nutrients; hence better output was achieved for plants treated with them. Similar experiences were recorded by researchers such as Eifediyi *et al.* (2017); Junaidi and Wulandari, (2017); Abera *et al.* (2018); Ali (2019) and Selim, (2020) when they experimented with combine application of organic and inorganic manure for enhancing growth and yield performance. The findings of this study was contrary to the findings that stated that, compared to the other treatments, NPK fertilizer treatment alone had a significantly higher vine length and that the highest vine length received from NPK may possibly be due to a rapid release of NPK nutrient content than other fertilizers' treatments (Ojo *et al.*, 2014; Junaidi and Wulandari, 2017; Ali, 2019).

The control (0kg/ha) treatment had the lowest (18.79) number of leaves, (1.95) branches, (65.82cm) vine length, and (1.6cm) stem girth followed by 200kg/ha NPK treatment with (39.03) number of leaves, (2.76) branches, (98.86cm) vine length and (1.82cm) stem girth per plant. The findings are in line with the findings of Ilupeju *et al*. (2015) and Shenglan *et al.* (2020) that control treatment produced the lowest growth and yield parameters when compared with other treatments applied. The results of the study revealed that the growth parameters (number of leaves, branches, vine length and stem girth) increased as the amount of goat manure increased in the combined application of NPK and goat manure. The findings are in conformity with the findings of researchers like Ilupeju *et al.* (2015); Eifediyi *et al.* (2017); Ali *et al.* (2020) and Shenglan *et al.* (2020) that greater the compost content of some treatment options, the higher the growth and yield output of the crop were recorded.

Furthermore, the study revealed that the interaction effect between watermelon cultivar and fertilizer treatment was recorded highest in Charleston grey treated with 20t/ha GM with (57.97) number of leaves. When treated with 15t/ha GM + 50kg/ha NPK Charleston grey had the highest interactive effect with (6.93) number of branches, (192.93cm) vine length and (2.73cm) stem girth. The findings agreed with Ali *et al.* (2020) that 15t/ha GM + 50kg/ha NPK treatment produced the highest interactive effect in terms of fertilizer however Koalack cultivar had highest values for the parameters observed in the study.

The number of flowers per plant was contrary with the reports of Enujeke (2013); Oraegbunam *et al.* (2016) and Anikwe *et al.* (2016) that Charleston grey had the least number of flowers when compared with other varieties like Sugar baby and Koalack when grown with integrated fertilizer. It was observed that Sugar baby produced the highest number of flowers. The consequence was in order to enable the flowers to develop into fruits; the sugar baby had greater capacity for flower development and successful photosynthetic accumulation (Ali, 2019).

In terms of number of fruits per plant, the result is confirmed by the findings of Babatola *et al.* (2002), Ogunlade *et al.* (2011), Selim and Al-Owied (2017), Selim (2018), Abera *et al.* (2018) and Selim (2020) who observed that organic and chemical fertilizer compositions improve yield performance of crops. There was an improvement in the number of fruits in Sugar baby variety treated with combine application of NPK and Goat manure when compared with other varieties. This is an indication that high numbers of leaves, branches and girth in Charleston grey and length of vine in Koalack over Sugar baby did not translate to more fruits. The high number of flowers per plant recorded in Koalack and Charleston grey cultivars over Sugar baby when treated with 10t/ha GM + 100kg/ha NPK and 20t / ha GM treatments respectively, did not lead to a corresponding higher number of fruits. This is in line with the findings of Ilupeju *et al.* (2015) and Oraegbunam *et al.* (2016) that higher number of flowers did not result in higher fruit numbers. The findings agreed with the view that improve crop growth and yield performance were commonly recorded with regard to application of organic manure or combined with limited amounts of mineral fertilizer (Babatola *et al.,* 2002; Ogunlade *et al.,* 2011; Ojo *et al.,* 2014; Eifediyi *et al.,* 2017; Shenglan *et al.,* 2020). The fact that the materials not only provided sufficient nutrients, but also the nutrients were slowly released to the plants that may be attributed to the high fruit yield of watermelon treated with integrated fertilizer. This prevents nutrient loss and leaching, as well as improving nutrient use efficiency. It could be noticed that in the combination of some treatments, the higher the goat manure component, the better the output of the crop in terms of number of leaves, branches, vine length, stem girth, flowers and fruit yield. Many research studies have shown that crops grown with integrated fertilizer increase the growth and yield performance when compared with the one grown with inorganic or organic fertilizer alone stating that it is climate-smart in nature which ensures emission reduction (Ojo *et al.,* 2014; Massri and Labban, 2014; Ilupeju *et al.,* 2015; Alo *et al.,* 2016; Ojoko *et al.,* 2017). This is in line with John *et al.* (2004); Selim (2018); Abera *et al.* (2018); Ali (2019); Selim (2020) and Ali *et al.* (2020) that sufficient quantities of nutrients are supplied by the integral use of organic manure and inorganic fertilizers which increased crop production and reduced environmental degradation which caused solely by the application of chemical fertilizer. It pointed to the fact that organic and mineral fertilizer combinations are climate-smart in practice and performs better on vegetable yields (Babatola *et al.,* 2002; Ogunlade *et al.,* 2011, Eifediyi *et al.,* 2017, Junaidi and Wulandari, 2017; Selim, 2020).

It was concluded that climate-smart integrated fertilizer management enhance chemical properties of the soil and improved the growth and yield of watermelon in the study area. The work revealed that Charleston grey performed better in terms of vegetative growth whereas, Sugar baby variety nourished with 15t/ha GM + 50kg/ha NPK gave the best yield performance when compared with Kolack and Charleston grey verities. The integral application of NPK and GM fertilizer were more beneficial to the soil and crops than the single application as indicated by higher growth and yield values obtained.

## Acknowledgements

The authors are highly grateful to all the technical staff of the Department of Agricultural Education, University of Nigeria Nsukka for all their help during the field experiment and data collection for this paper. The authors are equally grateful to the three reviewers from Department of Agricultural Education Article Publication Committee, University of Nigeria, Nsukka for proofreading of the manuscript and providing ideas and criticisms that have helped to shape this paper.

## References

Abera, T., Tufa, T., Midega, T., Kumbi, H. and Tola, B. (2018). Effect of integrated inorganic and organic fertilizers on yield and yield components of barley in LibenJawi district. The International Journal of Agriculture, 2018:1-7.

Adeoluwa, O. O. and Adeogun, O. O. (2010). Evaluation of feather as organic fertilizers on Amaranthus (*Amaranthus caudatus*), pp.111-119. Proceedings of 1st Technical Workshop on Organic Agriculture Conference 6-8 September 2010, Ladoke Akintola University of Technology Ogbomoso, University Press, Ogbomoso, Oyo.

Adeoye, I. B., Odeleye, O. M., Babalola, S. O. and Afolayan, S. O. (2009). Economic analysis of tomato losses in Ibadan metropolis, Oyo state, Nigeria. African journal of basic & applied sciences, 6:87-92.

Adetutu, A, Olorunnisola, O. S. and Owoade, O. A. (2015). Nutritive values and antioxidant activity of citrulluslanatus fruit extract. Food Science & Nutrition, 6:1056-1064.

Agbede, T. M. and Ojeniyi, S. O. (2009). Tillage and poultry manure effects on soil fertility and sorghum yield in southwestern Nigeria. Soil and Tillage Research, 64:2-9.

Ali, C. C. (2019). Effects of climate smart integrated fertilizers management on growth, yield, sensory attributes and nutritional contents of watermelon varieties in Nsukka, Nigeria. (PhD thesis). University of Nigeria, Nsukka.

Ali, C. C., Ejiofor, T. E., Ifeanyieze, F. O., Okadi, A. O., Eze, C. M., Eze, G. E., Onah, F. C., Nwakile, T. C., Ugwuoke, C. U., Mgbenka, R. N., Onah, O., Nwachukwu, C. U., Ezebuiro, F. N., Omeje, B. A., Ekenta, L. U. and Ogbonna, E. K. (2020). Proximate qualities and lycopene contents of three watermelon (*Citrullus lanatus)* fruit varieties grown with climate-smart integrated fertilizer management in sandy loam soil. African Journal of Food, Agriculture, Nutrition and Development, 20:16997-17011.

Alo, A. O., Baines, R. N., Conway, J. and Cannon, N. (2016). Smallholder Farmers' Perception of Climate Change and Strategies to Facilitate Climate Smart Farming: A Case Study of Osun State, Nigeria. A paper presented at the 4th International Climate Change Adaptation Conference Rotterdam, The Netherlands 10-13 May, 2016.

Aniekwe, L. and Nwokwu, G. (2013). Effects of Organic Manure Sources on the Growth and Yield of Watermelon in Abakaliki, Southeastern Nigeria. International Journal of Science and Research, 4:1923-1927.

Anikwe, M. A., Agu, J. C. and Ikenganyia, E. E. (2016). Agronomic evaluation of four exotic tropical variety of watermelon (*Citrullus lanatus* L.) in two agroenvironments in Nigeria. International Journal of Plant & Soil Science, 10:1-10.

Awere, S. U. and Onyeacholem, D. A. (2014). Effects of spacing and NPK 20:10:10 fertilizer on the growth and yield of watermelon (*Citrullus lanatus*) in Enugu, South Eastern Nigeria. Journal of Experimental Research, 2:93- 99.

Awosika, M. A., Awodun, M. A. and Ojeniyi, S. O. (2014). Comparative effect of pig manure and NPK fertilizer on agronomic performance of tomato (*Lycopersiconesculentum* Mill). American Journal of Experimental Agriculture, 4:1330-1338.

Babatola, L. A., Adebayo, O. B. and Lawal, O. I. (2002). Effects of different rates of poultry manure and NPK on performance of Celosia argentia. Proceedings of Horticultural Society of Nigeria, Ibadan. 14-19 May 2002, 54–56. University press Ibadan, Oyo.

Betty, T. Jacob, K., Agbenorhevi, F. D., Wireko, M. and Elsa, I. O. (2016). Watermelon seeds as food: nutrient composition, phytochemicals and antioxidant activity. International Journal of Nutrition and Food Sciences, 5:139-144.

Bianchi, G., Rizzolo, A., Grassi, M., Provenzi, L. and Scalzo, R. L. (2018). External maturity indicators, carotenoid and sugar compositions and volatile patterns in cuoredolce and rugby mini-watermelon (*Citrullus lanatus* (thunb) matsumura and nakai) varieties in relation of ripening degree at harvest. Postharvest Biology and Technology, 136:1-11.

Eifediyi, E. K., Remison, S. U., Ahamefule, H. M., Azeez, K. O. and Fesobi, P. O. (2017). Performance of watermelon (*Citrullus lanatus* L.) in response to organic and NPK fertilizers. Agriculture and Environment, 9:5-17.

Enujeke, E. C. (2013). An assessment of some growth and yield indices of six varieties of watermelon (*Citrulus lanatus* Thumb) in Asaba area of Delta State, Nigeria. International Research Journal of Agricultural Science and Soil Science, 3:376-382.

FAO (2010). The Hague Conference on Agriculture, Food Security and Climate Change: Climate-Smart Agriculture Policies, Practices and Financing for Food Security, Adaptation and Mitigation. FAO, Rome.

Gomez, A. K. and Gomez, A. A. (1984). Statistical Procedures for Agricultural Research. 2nd ed. John Wiley and Sons, New York.

Ilupeju, E. A., Akanbi, W. B., Olaniyi, J. O., Lawal, B. A., Ojo, M. A. and Akintokun, P. O., (2015). Impact of organic and inorganic fertilizers on growth, fruit yield, nutritional and lycopene contents of three varieties of tomato (*Lycopersiconesculentum* (1) mill) in Ogbomoso, Nigeria. The African Journal of Biotechnology, 14:24-33.

International fertilizer Association (IFA) (2016). The role of fertilizer in climate smart Agriculture. Contribution of the International Fertilizer Association (IFA) to the UN Climate Change Conference in Marrakesh – cop22/cmp12. Retrieved from https://www.fertilizer.org/images/library_downloads/2016_the_role_of_fertilizers_in_climate-smart_agriculture.pdf.

John, L. W., Jamer, D. B., Samuel, L. T. and Warner, L. W. (2004). Soil fertility and fertilizers: An introduction to Nutrient Management. Pearson Education, India.

Junaidi and Wulandari, Y. A. (2017). Effect of the combination of organic and inorganic fertilizers on the growth and production of melons (*Cucumis melo* L.). Advances in Intelligent Systems Research, 149:84-87.

Kassali, R, Aremu, F. J. and Shittu, B. A. (2015). An economic analysis of watermelon marketing in Oyo state Nigeria. Production Agriculture Technology, 11:43-52.

Kyriacou, M. C., Leskovar, D. I., Colla, G. and Rouphael, Y. (2018). Watermelon and Melon Fruit Quality: The Genotypic and Agro-Environmental Factors Implicated. Scientia Horticulturae, 234:393-408.

Makaepea, M. M., Daniso, B. and Afam, I. O. J. (2019). Watermelon as a potential fruit snack. International Journal of Food Properties, 22:355-370.

Massri, M. and Labban, L. (2014). Comparison of different types of fertilizers on growth yield and quality properties of watermelon (*Citrllus lanatus*). Agricultural Science, 5:475-482.

Neufeldt, H., John, M., Campbell, B. M., Beddington, Z. R., DeClerck, F., Depinto, A., Gulledge, J.,Hellin, Z., Herrero, M., Jarvis, A., Lezaks, D., Meinke. H., Rosenstock, T., Scholes, M., Scholes, R., Vermeulen, S., Wollenberg, E., and Zougmore, R., (2013). Beyond climate-smart agriculture: Toward safe operating spaces for global food systems. Agriculture & Food Securitym, 2:1-6.

Nzeh, E. C., Akogwu, C. I., Ugwu, J. N. and Nzeh, C. E. (2014). Cost-return analysis of cocoyam marketing in Nsukka agricultural zone of Enugu State, Nigeria. Sky Journal of Agricultural Research, 3:215-222.

Nwachukwu, C. U., Uzochukwu, I. E., Ifeanyieze, F. O., Ukonze, J. A. and Ali, C. C. (2021). Effect of replacing wheat bran with dried rumen digesta on the growth performance of Giant African Land Snail (*Archachatina marginata*). International Journal of Agricultural Technology, 17:1537-1546.

Ogunlade, M. O., Adeyemi, E. A., Ogunleti, D. O. and Ibiyomi, P. S. (2011). Effect of cocoa pod husk, urea fortified cocoa pod husk and NPK fertilizers on the growth and yield of Solanum macrocarpon. International Journal of Organic Agriculture Research & Development, 3:1-8.

Ojo, Z. A., Olowoke, A. A. and Obembe, A. (2014). Efficacy of organomineral fertilizer and un-amended compost on the growth and yield of watermelon (*Citrullus lanatus* thumb) in Illorin South in Guinea Savana Zone of Nigeria. international Journal of Recycling of Organic Waste in Agriculture, 3:121-125.

Ojoko, E. A., Akinwunmi, J. A., Yusuf, S. A. and Oni, O. A. (2017). Factors influencing the level of use of climate-smart agricultural practices (CSAPs) in Sokoto state, Nigeria. Journal of Agricultural Science, 62:315-327.

Olayinka, B. U. and Etejere, E. O. (2018). Proximate and chemical compositions of watermelon (*Citrullus lanatus* (thunb.) matsum and nakai cv red and cucumber (*Cucumis sativus* L. cv Pipino). International Food Research Journal, 25:1060-1066.

Oraegbunam, C. J., Njoku, O. M., Imoh, O. N., Obalum, S. E., Onyia, V. N., Atugwu, A. I. and Uchida, Y. (2016). Agronomic performance and adaptability of three varieties of watermelon (*Citrullus lanatus*) on sandy loam soil in derived savanna. Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension, 15:46-50.

Reetu, T. and Maharishi, T. (2017). Watermelon: A valuable horticultural crop with nutritional benefits. Popular Kheti, 5:5-9.

Romdhane, M. B., Haddar, A., Ghazala, I., Jeddou, K. B., Helbert, C. B., Ellouz-Chaabouni, S. (2017). Optimization of Polysaccharides Extraction from Watermelon Rinds: Structure, Functional and Biological Activities. Food Chemistry, 216:355-364.

Selim, M. M. and Al-Owied, A. J. A. (2017). Genotypic responses of pearl millet to integrated nutrient management. Biological Research, 14:156-169.

Selim, M. M. (2018). Potential role of cropping system and integrated nutrient management on nutrients uptake and utilization by maize grown in calcareous soil. Egyptian Journal of Agronomy, 40:297-312.

Selim, M. M. (2020). Introduction to the integrated nutrient management strategies and their contribution to yield and soil properties. International Journal of Agronomy. 2020:1-14.

Shenglan, Y., Tiancheng, L. and Yan, N. (2020). Effects of organic fertilizer on water use, photosynthetic characteristics, and fruit quality of pear jujube in northern Shaanxi. Open Chemistry, 18:537-545.

Soil Science Society of America (1996). Method of soil analysis part 3: chemical methods. Soil Science Society of America Inc. Madision, USA.

United Republic of Tanzania (2017). Climate-smart agriculture guideline. Ministry of agriculture and fisheries. Dares-salaam, Tanzania.

Usman, M. (2015). Cow dung, goat and poultry manure and their effects on the average yields and growth parameters of tomato crop. Journal of Biology, Agriculture and Healthcare, 5:7-10.

Wu, H., He, Y. H., Xu, Z.Y., Ni, L. and Wei, J. (2017). Effects of organic fertilizer on fruit and mineral nutrition content of sand pear. Journal of Yangzhou University (Agric Life Sci), 38:112-5.

(Received: 22 July 2022, accepted: 28 February 2023)