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PROXIMATE QUALITIES AND LYCOPENE CONTENTS OF THREE WATERMELON (*CITRULLUS LANATUS)* FRUIT VARIETIES GROWN WITH CLIMATE-SMART INTEGRATED FERTILIZER MANAGEMENT IN SANDY LOAM SOIL

Ali CC[1], Ejiofor TE[1]*, Ifeanyieze FO[1], Okadi AO[1], Eze CM[2], Eze GE[1], Onah FC[1], Nwakile TC[1], Ugwuoke CU[1], Mgbenka RN[1], Onah O[1], Nwachukwu CU[1], Ezebuiro FN[1], Omeje BA[1], Ekenta LU[1] and EK Ogbonna[1]

Ejiofor Toochukwu Eleazar

*Corresponding author email: ejiofortoochukwu@gmail.com

[1]Department of Agricultural Education, Faculty of Vocational and Technical Education University of Nigeria, Nsukka, Nigeria

[2]Department of Statistics, Faculty of Physical Science, University of Nigeria, Nsukka, Nigeria

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ABSTRACT

The objective of the study was to determine the effect of climate-smart integrated fertilizer management on proximate qualities and lycopene contents of three watermelon (*Citrullus lanatus)* varieties grown in sandy loam soil. The experiment was conducted at the experimental farm of the Department of Agricultural Education, University of Nigeria, Nsukka between the months of August to October 2017 cropping season. The experiment was laid out in a split-plot design, with three replications, three main plots (*Citrullus lanatus* varieties (Sugar baby, Koalack and Charleston grey)) and six sub-plots (fertilization treatments). Climate-smart integrated fertilizer considered was combination of Goat manure (GM) and Nitrogen Phosphorus Potassium NPK 15: 15: 15 fertilizer which is regarded as most nutrient-rich fertilizer with climate change mitigation and adaptation potential. The study found that the pH of the watermelon varieties were statistically similar and that Charleston grey treated with 50 kg ha^{-1} NPK + 15 t ha^{-1} GM had the highest interactive effect on pH value which was statistically similar with 100 kg ha^{-1} NPK + 10 t ha^{-1} GM treatment. It was discovered that Koalack variety had the highest moisture contents when treated with 100 kg ha^{-1} NPK + 10 t ha^{-1} GM, crude protein content when treated with 150 kg ha^{-1} NPK + 5 t ha^{-1} GM, crude fibre content when treated with 20 t ha^{-1} GM, ether extract and total soluble solid contents when treated with 50 kg ha^{-1} NPK + 15 t ha^{-1} GM. For the lycopene content, it was found that Sugar baby variety had the highest mean value (0.61g/100g) when compared with Charleston grey and Koalack varieties. Sugar baby variety treated with 20t/ha^{-1} GM had highest (0.89g/100g) interactive effect when compared with other varieties and fertilizer treatments. In conclusion, the proximate qualities and lycopene contents of the three varieties increased with the increase in the amount of GM contents of the fertilizer combinations in sandy loam soil. Climate-smart integrated fertilizer improves the proximate qualities of Koalack variety and the lycopene contents of Sugar baby variety more than in other varieties grown in the same sandy loam soil. Therefore, climate-smart integrated fertilizer is recommended for the production of the identified *Citrullus lanatus* varieties as a nutrition sensitive production strategy in sandy loam soils by farmers in study area.

Key words: Integrated fertilizer, goat manure, climate-smart agriculture, soil fertility, watermelon ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 20 No. 7 December 2020 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

INTRODUCTION

Watermelon (*Citrullus lanatus* Thumb) is regarded as a fruit vegetable crop and belongs to the family Cucurbitaceae [1, 2]. It is a vine-like scrambler and trailer flowering plant [3]. Watermelon is believed to have originated from the Kalahari and Sahara deserts in Africa [1, 4] and these areas have been regarded as the point of spread to other parts of the world [2, 3]. The edible parts of watermelon include the leaves, fruits, seeds, and rinds because of their nutritional benefits [3]. The fruits contain 93% water with small amount of protein, fat, minerals and vitamins (A, B, C) [2, 3, 5]. Research has shown that the seeds of watermelon are an excellent source of protein containing both essential and non-essential amino acids in addition to oils [6, 7]. The seeds contain about 35% protein, 50% oil and 5 % dietary fibre and are rich in micro and macronutrients such as magnesium, calcium, potassium and iron [6, 7]. It is believed that the edible parts of watermelon help in the control of blood pressure and possibly prevent stroke [1, 8]. Watermelon fruits contain a high amount of lycopene. Lycopene is an antioxidant and pigment that imparts a red colour to some fruits like tomato or watermelon [3, 9]. Lycopene helps in reducing the risk of cancers of prostate gland, pancreas and stomach [5], and is believed to be a highly efficient oxygen radical scavenger that protects against cardiovascular disease as well [9].

Watermelon production plays a vital role in human nutrition, poverty reduction and improving the socio-economic status of the farmers in Nigeria. Its nutritional and health benefits have resulted in higher demand than the production capacity in Nigeria. The production of watermelon is dominant in the northern part of Nigeria because of the suitable climatic and edaphic conditions that favour the cultivation. It has been observed by Okoli and Nweke [10] that there is a higher demand for watermelon fruits in the south-eastern part of Nigeria than in the northern part where it is mostly produced.

In south-eastern Nigeria, particularly Enugu State, the soil and climatic conditions are suitable for the growth of watermelon. However, the zone is faced with serious challenges which hinder the production. Such challenges are soil nutrient deficiencies, the dearth of information on the best yielding varieties and climate change-related issues [3, 4, 11].

Therefore, to improve the production potential of watermelon in the face of climate change, soil fertility and varietal challenges in Enugu State, farmers should adopt farming practices capable of addressing and proffering solutions to the challenges like climate-smart agriculture (CSA) [2, 3]. Climate-smart agriculture is an agricultural practice that sustainably increases productivity and reduces greenhouse gas (GHG) emission which negatively influences crop production. According to FAO [12], CSA is an agricultural strategy, approach, practice or tool that sustainably increases productivity and helps to reduce the emission of GHG. The implementation of CSA can lead to the realization of the Sustainable Development Goals (SDGs) 1, 2 and 3 which centre on poverty and hunger reduction, food security, improved nutrition, promote sustainable agriculture, ensure healthy lives and promote well-being for all [13] through access to better nutrition. Researchers [2, 3, 12, 14] identified integrated fertilizer management which is the practice of combining inputs of organic matter of crop and animal residues

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with chemical fertilizers to prevent macro- and micro-nutrient deficiencies in the soil as climate-smart agriculture practice.

In the context of this study, integrated fertilizer management is the effective application of animal (Goat) residues and inorganic manure for sustainable production of watermelon crop. The integrated fertilizer management equally referred to as climate-smart integrated fertilizer [2, 3] do not only improve the soil fertility, enhance growth, yield and nutritional quality of watermelon but it is an innovative strategy for climate change adoption and mitigation. According to Ali [2], climate-smart integrated fertilizer nullifies the shortcomings associated with a single-use of organic or inorganic manure in crop production like watermelon. Apart from providing nutrients to plants, the climate-smart integrated fertilizer improves the soil structure by adding organic matter, increases the water retention and the cation exchange capacity (CEC), especially in sandy loam soils [3,15] and it equally enhances fruit flavour, taste, vitamin C and lycopene contents [2, 3].

In this study, the organic manure considered was goat manure (GM) whereas the inorganic manure considered was NPK 15:15:15 and collectively referred to as climate-smart integrated fertilizer. Goat manure is readily available and cheap in south-eastern Nigeria, and is second to poultry manure in terms of availability whereas NPK 15:15:15 is the recommended fertilizer for fruit vegetable in south-eastern Nigeria [2]. The climate-smart integrated fertilizer can be of immense benefits to crop production system, by supplying nutrients, complementing mineral fertilization and improving chemical properties in sandy loam soils. However, there is little information on its use as fertilizer and its efficiency on nutritional qualities of watermelon. Although Ejiofor *et al.* [3] worked on the impact of climate-smart integrated fertilizer on growth and yield of watermelon varieties there is a dearth of information on the impact of climate-smart integrated fertilizer on proximate qualities and lycopene contents of watermelon varieties in south-eastern Nigeria. This study was conducted to determine proximate qualities and lycopene contents of three watermelon (*Citrullus lanatus*) varieties grown with climate-smart integrated fertilizer management in sandy loam soil.

MATERIALS AND METHODS

Study location

The field experiment was carried out at the teaching and research farm of the Agricultural Education Department, University of Nigeria, Nsukka, Enugu State, Nigeria. Nsukka is an agricultural zone of Enugu state comprising of three local governments namely: Nsukka, Igbo-Etiti and Uzo-Uwani. Nsukka Agricultural zone is situated on a gentle slope with hills and valleys and located between latitude 70 211 S and 70 361 East and longitude 60 451 and 70 North [15]. It accounts for 1,117,570 out of 3,257,298 of the total population of Enugu State [17]. Rainfall distribution is between 168mm - 1700mm, with tropical climate marked by two distinct (dry and wet) seasons. The vegetation is of derived savannah predominantly producing crops like cassava, maize, cocoyam, yam, vegetables, and fruit crops among others. The soil of the experimental area is sandy loam and the physicochemical composition of the composite surface soil samples (0-30cm), before the experiment installation is described in Table 1.

Experimental design and treatments application

The experiment was conducted using a split-plot in randomized complete block design with six treatments and three replicates. The field experimental site was marked out and measured 69m long ×8.7m wide (600.3m^2). The field was divided into three equal blocks of 69m ×3.25m randomly assigned to represent each watermelon variety. The blocks were spaced 0.5m apart and labelled I, II and III. Each block was divided into three equal Split-plots of 23m ×3.25m each. Within each split-plot, a row of six raised beds of 3.25m ×1.9m was made. The beds were spaced 0.5m apart. This gave a total of 18 beds for each block and 54 beds for the entire field. The field had a total of nine split-plots laid out in three columns (blocks) and three rows. The treatments applied were as follows: (a) control (no NPK, no GM or 0 kg ha^{-1}), (b) NPK (15:15:15) at 200 kg ha^{-1} (c) GM at 20 t ha^{-1}, (d) 150 kg ha^{-1} NPK + 5 t ha^{-1} GM (e) 100 kg ha^{-1} NPK + 10 t ha^{-1} GM and (f) 50 kg ha^{-1} NPK + 15 t ha^{-1}GM. Before treatment, goat manure samples were collected and analyzed for physicochemical properties using standard laboratory methods (Table 1). The goat manure was applied on the beds two weeks before planting of the seeds and worked into the soil using hoe at the depth of 0-5cm to enable the manure decompose faster and release nutrients to the soil in August 2017, while NPK 15: 15: 15 was applied manually two weeks after planting using the ring method of application at a depth of 5cm and a distance of 10 cm from the base of crop. The three varieties of watermelon cultivated were the most commonly grown in all the agro-ecological zones in Northern Nigeria. They were Sugar baby, Koalack and Charleston grey.

The seeds of each variety were sown at the rate of two per hole and spaced out 75 × 90cm. The total seeds sown per plot were sixteen. Supplying of vacant spaces was done a week after planting. Two weeks after planting, seedlings were thinned down to one per hole leaving a total of eight stands per plot. Four stands were randomly tagged per plot for data collection. The total population (N) of the experimental stands was four hundred and thirty-two while two hundred and sixteen were sampled (n). Manual weeding was done two weeks after planting using a hoe and repeated every two weeks interval by hand pulling. Insect pests (cucumber bittles) were controlled by spraying the crops with karate at 40ml/ 20L of water at two weeks interval starting from two weeks after planting [9] to avoid interference in the applied treatments.

Evaluation of proximate qualities and lycopene contents of fruits varieties

Fruit samples of uniform ripening were randomly selected per treatment plot of each variety and analysed for pH, total soluble solids (TSS), moisture content, crude protein, crude fibre, ether extract, and lycopene contents. Proximate compositions were determined using AOAC [18] standard method. The fruits were first homogenized in Wiley Micro-Hammer Stainless mill [9]. The pH of the homogenized pulp was determined using a pH meter. The total pulp N was determined by a semi-micro-Kjeldahl procedure following Bremner, and Ulger *et al*. [9]. Protein content was calculated from the Kjeldahl nitrogen using the conversion factor 6.25 [9]. Crude fibre content was estimated from the loss in weight of the crucible and its content on ignition. Fifty gram (50 g) of homogenized pulp was digested in 1.25% tetra-oxo-sulphate (IV) acid and 1.25% sodium hydroxide. The digest was put in a crucible and transferred into a muffle furnace at 550^0 for three and a half hours (3½ h). The weight difference expressed as a percentage of the fresh weight constitutes the per cent crude fibre. The ether extract was estimated by exhaustively extracting a known weight of sample with petroleum ether (BP 60°C) using a TecatorSoxhlet apparatus. The total soluble solid was determined by using the hand refractometer and the lycopene content was determined following the standard method [9, 19] by grinding 20 ml of the homogenized pulp in 25 ml acetone and 20 ml hexane and the absorbance was read at 503 nm using a colorimeter.

Statistical analysis

Data of traits produced by watermelon variety and climate-smart integrated fertilizer treatments were analyzed by adopting 3 X 6 factorial design (three varieties of watermelon and six climate-smart integrated fertilizer treatments) laid out in a split-plot design with three replications. The Analysis of Variance (ANOVA) performed using the Statistical Package for Social Sciences (SPSS version 16.0), used a mixed model with watermelon varieties and climate-smart integrated fertilizer as fixed effects and replications as random effects. Two-way analysis of variance (ANOVA) was performed on the data collected following Gomez and Gomez in Ilupeju *et al.* [9] and significant of means were compared using Least Significant Difference (LSD) at ($p \leq 0.05$) level of significance and correlations were run among parameters to test their interaction.

RESULTS AND DISCUSSION

The results of the untreated soil (S_0) and goat manure (GM_0) analysis are presented in Table 1. The soil was sandy loam and slightly acidic while the goat manure was alkaline. However, the values of N, P and K were below the critical values of the nutrients in the soil of Guinea Savanna [2, 3, 11]. These relatively low levels of major nutrients necessitate augmentation to enhance the optimal performance of watermelon [20].

Data presented in Table 2 indicate variability of climate-smart integrated fertilizer treatments and variety on some fruits proximate quality of watermelon. The proximate qualities were all significantly ($P \leq 0.05$) affected by watermelon variety and fertilizer treatments. The findings revealed that the pH values of the watermelon varieties were statistically similar, with Charleston grey having the highest mean value followed by Koalack while Sugar baby had the least mean value. In the present study it was found that among the fertilizer combinations used, Charleston grey variety from the field that was treated with 50 kg ha^{-1} NPK + 15 t ha^{-1} GM had the highest interactive effect with a pH value which was statistically similar with 100 kg ha^{-1} NPK + 10 t ha^{-1} GM treatment. The study showed that Koalack variety had the highest moisture, crude protein, crude fibre, ether extract and total soluble solid contents followed by Charleston grey except for the moisture content of Sugar baby variety.

Among the fertilizer combinations used, the study revealed that Koalack variety treated with 100 kg ha-1 NPK + 10 t ha^{-1} GM, 150 kg ha^{-1} NPK + 5 t ha^{-1} GM, 20 t ha^{-1} GM, 50 kg ha^{-1} NPK + 15 t ha^{-1} GM and 50 kg ha^{-1} NPK + 15 t ha^{-1} GM had the highest interactive effect on moisture, crude protein, crude fibre, ether extract and total soluble contents, respectively. The findings agree with the views of Ojo *et al.* [11] that organo-mineral fertilizer appears to be a cheap, readily available, environmentally friendly and reliable source of nitrogen needed for growing watermelon. The authors further state that organomineral fertilizer is a low input technology of improving the nutrient status of tropical soils for sustainable crop production as it combines the attributes of both organic and inorganic fertilizers. This is equally in agreement that the chemical composition (accumulation of certain macro- and micronutrients) in fruit is directly influenced by the chemical composition of the fertilizer on which the crop is grown [20, 21, 22]. The study revealed that as the goat manure contents increased the parameters tested improved. The findings agree with Ilupeju *et al.* and Eziaghighala *et al.* [9, 23] that among the treatments that contain compost, there is an improvement in the parameter as the compost content increases.

Table 3 contains data collected on the effect of fertilizer types on fruit lycopene contents of three varieties of watermelon. The varietal differences, fertilizer types and their interactions significantly ($P \leq 0.05$) influenced lycopene contents. The lycopene contents of Sugar baby variety differed significantly from Charleston grey and Koalack by having the highest mean value (0.61g/100g). This is in agreement with Kyriacou *et al.* [30]; Soteriou *et al.* [31] and Makaepea *et al.* [32] that the quantity of lycopene in watermelon varies according to cultivar type and growing conditions. However, Charleston grey had a slightly higher mean value of 0.50g/100g, compared to Koalack variety which had a mean value of 0.49 but both were statistically similar. Among treatments used, 20t/ha^{-1} GM gave the highest mean value (0.76g/100g) of lycopene contents which was statistically different from five other treatments applied. More so, Sugar baby treated with 20t/ha^{-1} GM had highest (0.89g/100g) interactive effect. The findings agree with Awodun [24]; Odedina *et al.* [25]; Nweke *et al.* [26] and Uwah and Eyo [27] that the application of GM at 20 t ha^{-1} is the most effective among the rates usually used in terms of boosting nutrient and agronomic performance. The findings are equally in consonance with Barros *et al.* [15] that the application of organic fertilizer is an option that promotes effective use of nutrients by crops and encourages environmental preservation. Table 3 reveals that there are no statistical differences in the lycopene contents of all the varieties treated with 200 kg ha^{-1} NPK and 150 kg ha^{-1} NPK + 5 t ha^{-1} GM. The findings agree with Ilupeju *et al.* [9] who found that tomato variety treated with only organic manure produced fruits that contained the highest amount of lycopene. The authors state further that the higher the compost contents of some treatments, the better the plant performance in terms of fruit yield and quality. This aligns with a study [28] that combined application of the organic and inorganic fertilizer not only improves crop yield and nutritional quality but it is equally seen as climate-smart and eco-friendly practices. The findings are in per with the view of a study [2] stating that to handle the shortcomings associated with sole use of organic or inorganic fertilizers in crop production in the environment faced with climate change issues, the integral use of both organic and inorganic fertilizers is the solution. The study conducted by Ojeniyi and Adejobi [29] has shown that high and sustained crop yield can be obtained by integrating organic and inorganic fertilizers in addition to climate change adaptation and mitigation benefit inherent in it. Therefore, the application of climate-smart integrated fertilizer brings better results than mineral or organic fertilizer only, especially in sandy loam soils, because besides increasing the availability of nutrients, it increases organic matter contents that improve soil structure and sustainable environment. Besides, it promotes the reduction of production costs because, in many cases, these residues are by-products in the property or the vicinity of livestock [15].

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CONCLUSION

The results of the present study confirmed that proximate qualities and lycopene contents were affected by both watermelon varieties and climate-smart integrated fertilizer in sandy loam soil in Enugu State Nigeria. The pH of the three watermelon varieties was statistically similar and that Charleston grey treated with 50 kg ha^{-1} NPK + 15 t ha^{-1} GM had the highest interactive effect on pH value which was statistically similar with 100 kg ha^{-1} NPK + 10 t ha^{-1} GM treatment. The study found out that Koalack variety had the highest moisture contents when treated with 100 kg ha^{-1} NPK + 10 t ha^{-1} GM, crude protein content when treated with 150 kg ha^{-1} NPK + 5 t ha^{-1} GM, crude fibre content when treated with 20 t ha^{-1} GM, ether extract and total soluble solid contents when treated with 50 kg ha^{-1} NPK + 15 t ha^{-1} GM. For the lycopene content, it was found that Sugar baby variety had the highest mean value (0.61g/100g) when compared with Charleston grey and Koalack varieties. Sugar baby variety treated with 20t/ha^{-1} GM had highest (0.89g/100g) interactive effect when compared with other varieties and fertilizer treatments. Finally, the study reveals that the proximate qualities and lycopene contents of the watermelon varieties increased with the increase in the amount of GM contents of the fertilizer combinations applied in sandy loam soil.

Climate-smart integrated fertilizer improved the proximate qualities of Koalack variety and lycopene content of Sugar baby variety grown in sandy loam soils of South Eastern Nigeria. Based on the findings of this study it is recommended that farmers should go into production of the identified watermelon varieties as a nutrition sensitive crop to improve health quality of the citizens of the study area by adopting climate-smart integrated fertilizer management strategy.

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Table 1: Physiochemical properties of the study site at (0-30cm) and goat manure sample

Parameters	Soil(S_0) test value	Goat manure (GM_0) test value
pH Values		
Soil pH (water)	4.5	7.3
Soil 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)		
Potassium (K)	0.07	-
Magnesium (Mg)	1.40	-
Sodium (Na)	0.04	-
Calcium (Ca)	0.60	-
Exchangeable Acidity (me/100g)		
Aluminum (Al)	0.80	-
Hydrogen (H)	2.20	-
Cation exchangeable capacity	14.00	-
Textural class (%)		
Sand	79	-
Silt	8	-
Clay	13	-
Textural class	Sandy loam	-

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Table 2: Effect of climate smart integrated fertilizer levels and varieties on fruit proximate qualities of watermelon and the interaction effect of fertilizer levels and watermelon varieties on proximate qualities

Watermelon Varieties	Fertilizer Type	pH	Moisture Content %	Crude Protein (g/100g)	Crude Fibre (g/100g)	Ether Extract (g/100g)	Total Soluble Solid (g/100g)
Sugar baby							
	50kg/ha NPK + 15t/ha GM	5.80**	93.58*	0.22****	0.16**	0.42*	4.36**
	100kg/ha NPK + 10t/ha GM	5.80**	93.81*	0.21*	0.15**	0.39*	4.27**
	150kg/ha NPK + 5t/ha GM	5.34*	93.09*	0.23*	0.19**	0.30**	4.66**
	200kg/ha NPK	5.40*	93.11*	0.35*	0.20*	0.23*	4.98**
	20t/ha GM	5.54*	93.60*	0.32***	0.16**	0.41*	5.31*
	0kg/ha	5.26***	90.12**	0.12**	0.11***	0.01**	1.21***
	Mean	**5.52a**	**92.89a**	**0.24c**	**0.16b**	**0.29a**	**4.13a**
Koalack							
	50kg/ha NPK + 15t/ha GM	5.64**	94.13*	2.81****	1.41**	0.96*	6.89**
	100kg/ha NPK + 10t/ha GM	5.78**	95.21*	2.01*	1.33**	0.88*	6.08**

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	150kg/ha NPK + 5t/ha GM	5.62*	94.32*	2.85*	1.44**	0.61**	6.01**
	200kg/ha NPK	5.45*	94.26*	2.69*	1.08*	1.24*	5.67**
	20t/ha GM	5.91*	94.19*	3.04***	1.53**	1.21*	7.30*
	0kg/ha	5.11***	94.01**	1.02**	0.71***	1.01**	2.02***
	Mean	**5.59a**	**94.35b**	**2.40b**	**1.25a**	**0.99b**	**5.66b**
Charleston Grey							
	50kg/ha NPK + 15t/ha GM	5.89**	92.44*	0.88****	0.38**	0.39*	5.56**
	100kg/ha NPK + 10t/ha GM	5.72**	92.64*	0.74*	0.37**	0.38*	5.93**
	150kg/ha NPK + 5t/ha GM	5.71*	92.77*	0.75*	0.38**	0.36**	5.71**
	200kg/ha NPK	5.48*	92.89*	0.62*	0.34*	0.30*	4.32**
	20t/ha GM	5.43*	92.68*	0.83***	0.36**	0.35*	6.21*
	0kg/ha	5.41***	91.11**	0.51**	0.33***	0.18**	4.01***
	Mean	**5.61a**	**92.42c**	**0.72a**	**0.36c**	**0.33c**	**5.29b**

Key: Means followed by the same number of asterisks (* or letter) along the column are statistically similar (LSD, 5%)

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Table 3: Effect of climate-smart integrated fertilizer levels on fruit lycopene contents of three varieties of watermelon and the interaction effect of fertilizer levels and watermelon varieties on fruit lycopene contents

Fertilizer type	Watermelon Varieties			Mean
	Sugar baby	Koalack	Charleston grey	
Fruit Lycopene Content (mg/100g)				
50kg/ha NPK + 15t/ha GM	0.80	0.59	0.60	**0.66*****
100kg/ha NPK + 10t/ha GM	0.62	0.41	0.52	**0.51******
150kg/ha NPK + 5t/ha GM	0.51	0.42	0.48	**0.47****
200kg/ha NPK	0.44	0.43	0.43	**0.43****
20t/ha GM	0.89	0.77	0.61	**0.76*******
0kg	0.38	0.34	0.34	**0.35***
Mean	**0.61***	**0.49****	**0.50****	

Key: Means followed by the same number of asterisk (*) along the column are statistically similar (LSD, 5%)

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