



## **Effect of Varying NPK 15-15-15 Fertilizer Application Rates on Growth and Yield of *Cucumis melo L.* (Muskmelon)**

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### **Author's contribution**

*The sole author designed, analysed, interpreted and prepared the manuscript.*

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### **ABSTRACT**

Muskmelon (*Cucumis melo L.*) is cultivated for the nutritional and medicinal values. Information on nutrient requirements which is important components of improved cultural practices for production. A field experiment was conducted at the Teaching and Research Farm of Ekiti State University, Ado-Ekiti, Nigeria in the rainy seasons of 2017 and 2018. This study aims to evaluate the growth and yield responses of muskmelon to varying rates of NPK 15-15-15 fertilizer rates (0, 167, 333 and 500 kg ha<sup>-1</sup>) in a randomized complete block design. Data were collected on growth parameters, number and weight of fruits. The data were subjected to analysis of variance and treatment means separated with Duncan's multiple range test. NPK fertilizer rates increased vegetative growth and fruit yield linearly. Muskmelon's response to varying rates of NPK 15-15-15 followed the same trend in the two seasons, and fertilizer application reduced day to flowering significantly. The 500 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer produced a significantly higher number of fruits ha<sup>-1</sup>, but 333 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer produced higher quality fruits culminating in higher fruit yield (17.3 t ha<sup>-1</sup>) and therefore recommended.

**Keywords:** *Muskmelon; NPK 15-15-15 fertilizer; plant density; growth and yield.*

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## 1. INTRODUCTION

Muskmelon (*Cucumis melo* L.), sometimes known as cantaloupe, is a member of the family Cucurbitaceae cultivated mainly in the tropics and sub-tropics for its nutritional and medicinal values [1]. It is a high feeder crop requiring large amounts of nutrients, especially nitrogen (N), phosphorus (P), and potassium (K) for active growth and yield under field conditions [2].

Adequate N supply promotes vegetative growth, fruit production and fruit size, as well as crops yield. Muskmelon has an indeterminate growth habit, which makes N supply necessary up to and during the harvest period such that the total requirement and uptake according to the crop phenology would assist in adequate fertilization [3]. Thus, positive growth and yield responses were reported to the maximum level of 120, and 150 kg N ha<sup>-1</sup> fertilizer [4,5] beyond which the fruit dry matter was not significantly affected as the crop exhibited luxuriant vegetative growth [6]. Plants utilize P throughout the growth period to ensure the proper start and continuous growth needed for high average fruit weight and yield. However, due to inadequate research on muskmelon responses to P fertilizers, farmers tend to apply rates based on experiences and the availability of NPK fertilizers often used at rates higher than needed by the crop in particular soils with implications of higher production costs and contamination of surface and groundwater. The availability of P is low in soils while the tissue P concentration in cucurbits is generally in one order of magnitude lower than N such that the N: P ratio in fertilizer schemes is about 2:1 [2]. The roles of K in maintaining ionic balance and water status in plants explain the involvement in numerous biochemical and physiological processes associated with increased growth performance, yield, and quality attributes [7]. The studies on K fertilization to improve muskmelon productivity have not given consistent results. The observation of [8,9] showed that K application did not significantly affect vegetative growth and total fruit yield of sweet melon and greenhouse-grown *Galia melon* plants respectively. However, [10] observed a significant increase in the average fruit weight of muskmelon with a rise in solution K concentration.

Numerous studies on the influences of N, P and K combinations on the growth and yield of cucurbits conclude that fertilization should be

reasonable for developing and attaining the yield potentials of crops, reducing production and preventing the environmental pollution due to the over-use as a form of fertilizer in cropping systems. The best performance in all growth parameters of cucumber was obtained from the nutrient combination that consisted of NPK 100: 50: 50 kg ha<sup>-1</sup> [11]. The effects of the main and combined N and P application rates on egusi melon (*Colocynthis citrullus* L.) studied by [12] observed that the highest values of growth parameters, fruit and seed yield ha<sup>-1</sup> in the 60 kg N + 13.2 kg P ha<sup>-1</sup> treatment. The effects of N, P, and K on watermelon showed that fruit yield plant<sup>-1</sup> and yield ha<sup>-1</sup> were highest at fertilizer combination containing 125 kg N, 100 kg P and 60 kg K ha<sup>-1</sup> [13]. The study by [14] on the effect of NPK 20-10-10 fertilizer rates on watermelon in Enugu and obtained the highest growth and yield attributes at 400 kg ha<sup>-1</sup> and recommended as the fertilizer rate for the south-eastern zone of Nigeria.

The observation by [15] indicated that N, P and K application increased the lengths of the main creeper, number of leaves on the main creeper, number of sub-creeper, average fruit weight and yield of muskmelon (var. Jaunpuri) with the highest values obtained at 100 kg N, 60 kg P and 60 kg K ha<sup>-1</sup> treatment. The best combination for growth performance and fruit yield of sweet melon as noted by [8] was 120 or 180 kg N + 72 kg K<sub>2</sub>O ha<sup>-1</sup>. The fertilizer recommendation of the University of Florida, USA, is 170 kg N, 170 kg P<sub>2</sub>O<sub>5</sub>, and 170 kg K<sub>2</sub>O ha<sup>-1</sup> for muskmelon production [16]. The effect of N, P, and K on muskmelon using the 312-D optimized saturation method was assessed by [17]. They determined the relationships between balanced NPK fertilization and yield, total soluble solids, and economic benefit parameters. The main effects of N, P, and K increased yields by 31.2-31.5, 5.8-7.5, and 5.2-5.5% respectively, over the control treatment with the N × P and N × K interactions significant. Still, the P × K interaction was not significant.

The review by [18] on the effects of fertilizers and densities on cucurbits, such as gourd, melon, cucumber, pumpkin, and watermelon was robust. Still, there is the paucity of research information on muskmelon especially with NPK 15-15-15 fertilizer. This study is, therefore, aimed at evaluating the effects of varying NPK 15-15-15 fertilizer rates on the growth and yield of muskmelon.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Site

The experiment was carried out in 2017 and 2018 at the Research Field of the Department of Crop, Horticulture and Landscape Design of the Teaching and Research Farm of Ekiti State University, Ado-Ekiti, Nigeria. Ado-Ekiti is in the rain forest ecological zone that experiences a tropical climate characterized by rainy and dry seasons that span March to October and November to February respectively.

### 2.2 Experimental Layout

The experimental plot was divided 4 × 4 m subplot, and laid out in Randomized Complete Block Design (RCBD) in three replicates. Surface soil (0-15 cm) samples were collected randomly from the experimental plot, air-dried, sieved using a 2 mm sieve, and analyzed following the soil analytical procedures described by [19]. Seeds of muskmelon (cantalupensis group) were sowed at 10000 plants ha<sup>-1</sup> (1 × 1 m spacing) in the sub-plot and seedlings thinned to 1 hill<sup>-1</sup> after emergence. Four (4) rates of NPK 15-15-15 fertilizer: 0 (control), 167, 333, and 500 kg ha<sup>-1</sup> were applied at four weeks after sowing (WAS) to the muskmelon plants. Plot weeded manually fortnightly, and the plants sprayed with Kombat 2.5 EC (25 g of Lambda Cyhalothrin l<sup>-1</sup>) insecticide twice before flowering.

### 2.3 Data Collection

Three plants were randomly selected and tagged in each treatment from which data were collected weekly on growth and yield parameters. The number of leaves and the number of branches were counted, while a meter rule was used to measure the vine length. Leaf area was determined as Leaf area = 3.30 + 0.63 (W<sup>2</sup>), where W is leaf width [20]. Record on the day to first flowering, and 50% flowering was taken with the number of flowers plant<sup>-1</sup> counted. The number of fruits plot<sup>-1</sup> were counted, and fruit length and width by Vernier calliper. The number of seeds fruit<sup>-1</sup> were counted, fruit flesh thickness (fruit pulp width) measured by Vernier calliper, and fruit weight and seed weight measured with weighing balance.

### 2.4 Statistical Analysis

The data collected were subjected to the generalized linear model of SAS (Statistical Analysis System) for ANOVA, and the treatment

means separated using Duncan's Multiple Range Test at 0.05 level of probability.

## 3. RESULTS

### 3.1 Characteristics of the Soils Used for the Studies

Table 1 shows the properties of the soils used for the studies. The soil particle size analysis shows the soil was loamy sand with 821.20 g kg<sup>-1</sup> sand, 100.00 g kg<sup>-1</sup> silt, and 78.80 g kg<sup>-1</sup> clay in 2017 with a pH of 5.06. The soil has 13.20 g kg<sup>-1</sup> organic matter, 0.70 g kg<sup>-1</sup> total N, and 25.10 mg kg<sup>-1</sup> available P. The exchangeable K, Ca, Mg, and Na contents were 0.20, 6.22, 0.65 and 0.09 cmol kg<sup>-1</sup> respectively. In 2018, the soil had 856.00, 66.80, and 87.20 g kg<sup>-1</sup> for sand, silt, and clay respectively, with increased pH of 5.32, organic matter of 25.00 g kg<sup>-1</sup>, total N of 0.80 g kg<sup>-1</sup> but reduced available P of 18.54 mg kg<sup>-1</sup>. The exchangeable K, Ca, Mg, and Na contents of soil in 2018 were 0.28, 5.82, 0.86, and 0.08 cmol kg<sup>-1</sup> respectively.

### 3.2 Effect of Varying Rates of NPK 15-15-15 Fertilizer Applications on Some Growth Parameters of Muskmelon

The effect of varying rates of NPK 15-15-15 fertilizer applications on some growth parameters is showed in Table 2. The use of 500 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer on muskmelon plants produced the highest number of leaves plant<sup>-1</sup> (104.03), which was significantly higher than 97.00, 75.33, and 55.87 for 333, 167 and 0 kg ha<sup>-1</sup> NPK fertilizer applications respectively in the year 2017.

The results indicated that increasing the fertilizer rates propelled increasing in the growth to reach 333 kg ha<sup>-1</sup> above, which were declining except in the number of leaves. The application of 333 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer to muskmelon plants in 2017, gave average leaf area (96.54 cm<sup>2</sup>), plant height (115.97 cm) and branch length (114.29 cm) which were significantly higher than 94.66 cm<sup>2</sup>, 106.86 cm and 104.41 cm; 80.04 cm<sup>2</sup>, 90.07 cm, and 95.44 cm; and 57.07cm<sup>2</sup>, 77.69, and 65.57 cm for 500, 167 and 0 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer application rates. Although the application of 333 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer gave plants with a higher number of branches (5.67) in 2017, which did not differ from 5.50 for 500 and 167 kg ha<sup>-1</sup> and 5.17 for 0 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer applications. The same sequence followed for 2018. The

application of 500 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer produced a muskmelon plant with a significantly higher number of leaves plant<sup>-1</sup> (101.83) than 89.83, 69.58, and 55.67 for 333, 167 and 0 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer application rates. However, the application of 333 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer with higher leaf area (99.35 cm<sup>2</sup>), plant height (109.22 cm), and branch length (109.22) did not differ significantly from 98.48 cm<sup>2</sup> (leaf area), 107.59 cm (plant height), and 108.51 cm (branch length) for the 500 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer rate. The 333 and 500 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer rates gave the same value of 6.00 branches in 2018, which was not significantly higher than 5.67 and 5.33 for 167 and 0 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer applications. Generally, the application of NPK 15-15-15 fertilizer increases muskmelon growth significantly from non-fertilized plants.

### 3.3 Effect of Varying Rates of NPK 15-15-15 Fertilizer Applications on Days to First Flower and 50% Flowering, and Fruiting of Muskmelon

Table 3 shows the effect of varying rates NPK 15-15-15 fertilizer applications on flowering and fruiting of muskmelon. The average number of flowers plant<sup>-1</sup> (12.17) produced by the use of 500 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer on muskmelon plants in 2017 was higher than 9.83 produced in 2018, which were significantly higher than the lower treatments. The average number of fruits plant<sup>-1</sup> at harvest was 1.67 at 333 and 500 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer rate in 2017 and did not differ significantly from lower rates.

This trend also followed in 2018. It took 33 DAS for non-fertilized muskmelon plants to produce flowers, which was significantly higher than 30 DAS for fertilized muskmelon plants. But the reverse was 50% flowering, which was at 34-35 DAS in fertilized muskmelon plants and significantly lower than 38 DAS for the non-fertilized muskmelon plants.

### 3.4 Effect of Varying Rates of NPK 15-15-15 Fertilizer Applications on Yield and Yield Components of Muskmelon

Table 4 shows the effect of varying rates of fertilizer applications on yield and yield components of muskmelon. The use of 500 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer on muskmelon plants produced 16875.2 and 16779.3 fruits ha<sup>-1</sup> which did not differ significantly from 16563.0 and 16467.3 for 333 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer application. Although the use of 500 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer on muskmelon plants produced a higher number of fruits ha<sup>-1</sup>, 333 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer rate produced better quality muskmelon fruits and increased fruit yield. The fruit yield of 17.1 and 17.3 t ha<sup>-1</sup> produced at 333 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer rate were not significantly higher than 15.1 and 16.1 t ha<sup>-1</sup> for 500 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer application. The 333 kg NPK 15-15-15 fertilizer ha<sup>-1</sup> produced the larger fruit (1.1 kg) and the highest fruit pulp width (2.4 cm). Although 500 kg ha<sup>-1</sup> 15-15-15 fertilizer rate produced muskmelon fruits with a significantly higher number of seeds (343.5 and 343.7), 333 kg ha<sup>-1</sup> NPK 15-15-15 fertilizer rate gave higher seed weight (4.4 kg).

**Table 1. Physical and chemical properties of the soils used for the studies in 2017 and 2018**

Soil properties	(2017)	(2018)
pH (H <sub>2</sub> O)	5.06	5.32
Organic carbon (g kg <sup>-1</sup> )	7.60	14.60
Organic matter (g kg <sup>-1</sup> )	13.20	25.20
Total nitrogen (g kg <sup>-1</sup> )	0.70	0.80
Available phosphorus (mg kg <sup>-1</sup> )	25.10	18.54
Exchangeable bases (cmol kg <sup>-1</sup> )		
K	0.20	0.28
Ca	6.22	5.82
Mg	0.65	0.86
Na	0.09	0.08
Sand (g kg <sup>-1</sup> )	821.20	856.00
Silt (g kg <sup>-1</sup> )	100.00	66.80
Clay (g kg <sup>-1</sup> )	78.80	87.20
Textural class	Loamy sand	Loamy sand

**Table 2. Effect of varying rates of NPK 15-15-15 fertilizer applications on some growth parameters of muskmelon**

Fertilizer rate (kg ha <sup>-1</sup> )	2017				2018					
	Number of leaves	Leaf area (cm <sup>2</sup> )	Plant height (cm)	Branch length (cm)	Number of branches	Number of leaves	Leaf area (cm <sup>2</sup> )	Plant height (cm)	Branch length (cm)	Number of branches
0	55.87d	57.07d	77.69d	65.57d	5.17a	55.67d	66.91c	66.21c	53.77c	5.33a
167	75.33c	80.04c	90.07c	95.44c	5.50a	69.58c	92.92b	74.76b	73.95b	5.67a
333	97.00b	96.54a	115.97a	114.29a	5.67a	89.83b	99.35a	109.22a	109.22a	6.00a
500	104.03a	94.66b	106.86b	104.41b	5.50a	101.83a	98.48a	107.59a	108.51a	6.00a

Mean values with the same letter(s) in the same column are not significantly different at 5% probability (DMRT)

**Table 3. Effect of varying rates of NPK 15-15-15 fertilizer applications on flowering and fruiting of muskmelon**

Fertilizer rate (kg ha <sup>-1</sup> )	2017				2018			
	Number of flowers	Number of fruits	Day to first flower	Day to 50% flowering	Number of flowers	Number of fruits	Day to first flower	Day to 50% flowering
0	6.00c	1.00b	33.33a	38.50	5.67c	1.00a	33.33a	38.00a
167	9.50b	1.17ab	30.50b	34.83b	8.33b	1.67a	30.50b	35.50b
333	11.33a	1.67a	30.67b	35.17b	9.17ab	1.67a	30.17b	34.50b
500	12.17a	1.67a	30.167b	34.50b	9.83a	1.67a	30.17b	34.33b

Mean values with the same letter(s) in the same column are not significantly different at 5% probability (DMRT)

**Table 4. Effect of varying rates of NPK 15-15-15 fertilizer applications on yield and yield components of muskmelon**

Fertilizer rate (kg ha <sup>-1</sup> )	Number of fruits ha <sup>-1</sup>	Fruit length (cm)	Fruit diameter (cm)	Fruit size (kg)	Fruit yield (t ha <sup>-1</sup> )	Pulp width (cm)	Number of seeds	Seed weight (g)
<b>2017</b>								
0	10000.3d	10.8d	8.6b	0.5d	5.3c	1.5b	182.3c	2.8b
167	11711.7c	13.7c	10.3a	0.7c	8.1b	2.2a	316.2a	3.0b
333	16563.0a	16.1a	10.7a	1.1a	17.1a	2.4a	240.8b	4.4a
500	16875.2a	14.8b	10.5a	0.9b	15.1a	2.2a	343.5a	3.5ab
<b>2018</b>								
0	10007.3d	10.2c	8.8b	0.4c	4.5c	1.5b	228.3c	2.7b
167	12000.0c	12.8b	10.1a	0.7b	8.6b	2.2a	316.2ab	3.5ab
333	16467.3a	15.7a	10.6a	1.1a	17.3a	2.4a	257.5bc	4.4a
500	16779.3a	14.1b	10.5a	1.0a	16.1a	2.2a	343.7a	3.0b

Mean values with the same letter(s) in the same column are not significantly different at 5% probability (DMRT)

#### 4. DISCUSSION

The particle size analysis indicated that the texture of soils in the study site was loamy sand, which is suitable for short-season vegetable crops, primarily when supplied with adequate amounts of water and nutrients. The soils were moderately acidic, but because of the low status of the major nutrients, especially N, fertilizer application is imperative. Although soil test interpretation is not available for vegetables, the critical N level at  $1.1 \text{ mg g}^{-1}$  established for crop production in Nigeria [21], shows that the soils are low in total N with values at  $0.7$  and  $0.8 \text{ mg g}^{-1}$ . The available P and exchangeable K values are medium-high compared to critical levels at  $10 \text{ mg kg}^{-1}$  for P, and  $0.20 \text{ cmol kg}^{-1}$  for K. This implies that N supply would receive more attention than P and K, whose values in the soils can explain why the results obtained from the application of compound NPK fertilizer in muskmelon and watermelon production are often not predictable [22,2].

The positive response of muskmelon to NPK fertilizer application, as indicated by the significant increase in vegetative growth and fruit yield agreed with several studies on cucurbits; cucumber [23], watermelon [13], pumpkin [24], gourd [25] and egusi melon [12]. The increase of plant length as the amount of nitrogen fertilizer applied increased is in agreement with reports on musk melon from [5] and cucurbits from [11,26,27,13]. Thus, the best vegetative growth occurred at the highest fertilizer rate applied [6]. However, further increase above  $333 \text{ kg ha}^{-1}$  NPK 15-15-15 fertilizer declined vegetative growth. The higher the quantity of fertilizer applied, the better was the vegetative growth performance of the muskmelon. While [26] observed best vegetative growth performance at the application of  $150 \text{ kg ha}^{-1}$  of NPK 20-10-10 fertilizer in watermelon at  $7000 \text{ plants ha}^{-1}$ , this study obtained best vegetative growth performance at  $333 \text{ kg ha}^{-1}$  NPK 15-15-15 fertilizer application in muskmelon at  $10000 \text{ plants ha}^{-1}$ . The application of NPK 15-15-15 fertilizer reduced the days to flowering, which agreed with the observations by [11] that the application of fertilizer reduced the days to flowering, fruit set, and maturity.

The result from the study agreed with several reports on fruit yield increases in muskmelon due to fertilizer application. Increasing of the fruit yield performance of muskmelon with the higher

the quantity of N-fertilizer may be due to the accumulation of biomass of fruit and distribution of dry matter [28]. In this study, the number of fruits  $\text{plant}^{-1}$ , average fruit weight, and total fruit yield  $\text{ha}^{-1}$  increased with increasing rates of NPK fertilizer where the  $333 \text{ kg ha}^{-1}$  NPK 15-15-15 treatment equivalent to  $50 \text{ kg N ha}^{-1}$  gave the best performance, which did not differ from  $500 \text{ kg ha}^{-1}$  NPK 15-15-15 as  $75 \text{ kg N ha}^{-1}$ . The report by [5] indicated that muskmelon fruit yield increased with an increase in N fertilizer rate, and the application of  $150 \text{ kg N ha}^{-1}$  gave the highest single fruit weight, fruit vine weight, and fruit yield. However, [6] observed maximum fruit biomass at  $90\text{-}100 \text{ kg N ha}^{-1}$  which showed that dry fruit matter declined as N supply increased beyond  $93 \text{ kg N ha}^{-1}$ , whereas, [29,13] reported the highest fruit yield of watermelon at  $120 \text{ kg N ha}^{-1}$ . The optimum rate of NPK 15-15-15 ( $50 \text{ kg N ha}^{-1}$ ) i.e  $333 \text{ kg ha}^{-1}$  observed as optimum in this study exceeds the  $60 \text{ kg ha}^{-1}$  NPK 15-15-15 ( $9 \text{ kg N ha}^{-1}$ ), which gave the best growth and yield performance of watermelon [27]. The treatment which gave the best watermelon growth and fruit yield performance was  $150 \text{ kg ha}^{-1}$  for NPK 20-10-10 (equivalent to  $30 \text{ kg N ha}^{-1}$ ) fertilizer [26]. However, [14] reported that a rate of  $400 \text{ kg ha}^{-1}$  NPK 20-10-10 (equivalent to  $80 \text{ kg N ha}^{-1}$ ) gave the best yield of watermelon. The N fertilization rates have no significant effect on the fruit pulp width of muskmelon but the number of seeds and seed weight, as observed by [30]. The application of fertilizer increased muskmelon fruit production with a higher rate of producing more fruits.

#### 5. CONCLUSION

Application of varying rates of NPK 15-15-15 fertilizer increased the vegetative growth and yield of muskmelon. The vegetative growth and fruit yield  $\text{ha}^{-1}$  obtained from the  $500 \text{ kg ha}^{-1}$  NPK 15-15-15 fertilizer rate did not differ significantly from those of  $333 \text{ kg ha}^{-1}$  rate that gave the larger fruits. The study recommends the application of  $333 \text{ kg ha}^{-1}$  NPK 15-15-15 fertilizer at density of  $10000 \text{ plants ha}^{-1}$ , which gives significantly higher marketable fruit yield and better vegetative growth performance. Farmers willing to grow muskmelon can adopt this recommendation for optimum growth and a good fruit yield.

#### COMPETING INTERESTS

Author has declared that no competing interests exist.

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