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Response of Pruning on Growth, Fruit Yield, Nutritional Quality and Nutrient Uptake of Two Okra Varieties (*Abelmoschus esculentus*)

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Authors' contributions

This work was carried out in collaboration among all authors. Author MNT designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors CK, TB and IA managed the analyses of the study. Authors UA, OB and AA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Field experiment was conducted at the Research Farm of Biotechnology Advanced Research Centre, Sheda Science and Technology Complex, Garki-Abuja in 2017 and 2018 cropping seasons to evaluate response of pruning on growth, fruit yield, nutritional quality and nutrient uptake of okra. The experiment had eight treatment combinations viz: Two okra varieties (Clemson spinless and Gungo Local) and four pruning rates (0, 1 stem, 2 stems and 3 stems), replicated three times. The experiment was factorial fitted into Randomized Complete Block Design. Data were collected on number of leaves per plant, number of fruits, green fruit yield, nutritional quality and nutrient uptake. Data was analysed using analysis of variance (ANOVA) M.STAT package and treatment means compared using least significant difference (LSD) at 5% probability level. Pruning is beneficial to performance of okra. Plants with 2 stems pruning produced the highest fruit yield (11.60 t ha^{-1}) in 2018 while control plots had the least values (1.80 t ha^{-1}, 1.60 t ha^{-1}) in 2017 and 2018, respectively. It could be concluded that 2 stems pruning increased fruit yield of okra and Clemson spinless performed better than Gungo Local variety and could be recommended for farmers within the study area.

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Keywords: Okra; pruning; stem; clemson spinless; gungo local.

1. INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Monench belongs to the family of Malvaceae. It is an important soup condiment in Nigeria that forms part of the Nigerian curry dishes [1]. It is a multipurpose crop because it can be used in various forms to prepare meals. Its fresh leaves, buds, flowers, pods, stems and seeds are all edible. Immature fruits of okra are consumed as vegetables in salads, soups and stews and it is also used in stews and sauces to provide mucilaginous consistency [2]. In Nigeria, okra is grown widely in gardens for home use with its excess for markets. It is an economically important vegetable crop with a potential to increase farm incomes of small producers. This is because okra is popular, easy to grow and valuable with average retail prices [3]. The practice of harvesting okra fruits when they are still immature help to increase their nutritional value [4]. Okra plays an important role in human diet due to the supply of carbohydrates, protein, fats, minerals and vitamins. It also has several medicinal values [5]. Okra is cultivated through the tropical and warm temperate regions of the world for its fibrous fruit content but yields are usually low (2-4 t ha^{-1}) as a result of non intensive growing methods [6].

In developing countries like Nigeria, the population growth rate is so high that improved technologies including rational use of pruning of crops must be employed to meet the food demand of the people. Vegetable yield of 10 t ha^{-1} can be considered a good harvest, but yields of over 40 t ha^{-1} can be realized under optimal condition as reported by [7]. Apical debudding and branch pruning is the most important contributor to young leaf and immature pod yield [8]. Pruning is the removal of the growing part of the plant to encourage lateral branching. Apical bud pinching or nipping is a well-known practice for breaking apical dominance to encourage lateral growth, thereby increasing the potential fruiting area. According to [6], pruning has been found to increase fruit yield of okra. For tropical countries like Nigeria, high cost and scarcity of inorganic fertilizers has greatly contributed immensely to the low yield of okra experienced by farmers over the years. Hence attention has shifted to use and research on other sources of increasing farmers yield through pruning among many others. Therefore, the study was conducted to determine the response of pruning on growth, fruit yield, nutritional quality and nutrient uptake of two okra varieties in the Southern guinea Savanna zone of Nigeria.

2. MATERIALS AND METHODS

Field experiment was conducted at the Research Farm of Biotechnology Advanced Research Centre, Sheda Science and Technology Complex, Garki-Abuja in 2017 and 2018 cropping seasons to evaluate response of pruning on growth, fruit yield, nutritional quality and nutrient uptake of okra. Abuja is located at 8°10'N and 7°10'E and the climate is cold and dry from November to March and then warm and moist from April to October. The maximum and minimum temperature is 35 and 27°C, respectively. The humidity of this area is high (about74%) all year round except in January when dry wind blows from the north. The average annual rainfall is over 1250 mm. The soil is of a sandy loam texture, moderately well drained and was previously under maize cultivation before fallowing for one cropping season. The seeds were sourced from the Department of Agricultural Biotechnology, Biotechnology Advanced Research Centre, Sheda Science and Technology Complex, Garki-Abuja. The experiment had eight treatments viz: two okra varieties (Clemson spinless and Gungo Local) and four pruning rates (0, 1 stem, 2 stems and 3 stems), replicated three times. The experiment was factorial fitted into Randomized Complete Block Design. Each plot consisted of four ridges at 60 cm wide and was separated 100 cm wide. The land was cleared, raked and ridged manually. Two seeds were planted per hole at 50 cm within row and the seedlings were thinned to one per stand two weeks after emergence. Weeding was done with hoe thrice at 3, 6 and 9 weeks after planting (WAP). Data were collected on number of leaves per plant, number of fruits per plant, fruit yield, nutritional quality and nutrient uptake. The treatments were laid out in a Randomized Complete Block Design (RCBD), replicated 3 times. The determination of fruit phytochemical contents at full ripening, 6 fruit samples were randomly selected per plot and analysed for nutritional qualities such as crude Protein, Carotene, Iron, Phosphorus, Potassium, Calcium, Lycopene, Magnesium, Vitamin C contents. In order to assess these, the fruit samples were oven dried at $85^{O}C$ for 72 hours. The dried fruit samples were separately ground with a Wiley mill, and passed through a 0.5 mm sieve for tissue analysis. Total P was determined by the Vanadomolybdate method, K and Ca was determined by the flame photometry and Mg and Fe were determined by atomic absorption spectrophotometer [9]. Total N was analyzed by the micro-Kjeldahl procedure as described by [9] and crude protein was obtained by multiplying the total N by a factor of 6.25. The same method was used to determine the nutrient uptake. The determination of leaf phytochemical contents of 5 leaves were randomly selected per plot and analyzed for nutrient uptake such as N, P, K, Ca and Mg contents. Data was analysed using analysis of variance (ANOVA) M.STAT package and treatment means compared using least significant difference (LSD) at 5% probability level.

3. RESULTS

Number of leaves was not significantly ($p \geq 0.05$) different at 3, 6 and 9 WAT in 2017 and 2018 cropping seasons, respectively (Table 1). Also, number of leaves was not significant in 2017 at 3 WAT, but in 2018 2 stems pruning (3.1) significantly ($p \leq 0.05$) gave higher number of leaves than other pruning treatments. Interaction between variety and pruning had no significant ($p \geq 0.05$) influence on number of leaves in both years (Table 1).

In 2017, number of fruits of Gungo Local (21.8) was significantly ($p \leq 0.05$) higher than that of Clemson spinless (20.0). However, in 2018 the two varieties were not significantly different from each other. Pruning had significant ($p \leq 0.05$) effect on number of fruits in both years of trial. In 2017 and 2018, 2 stems pruning (24.1 and 22.0) proved its superiority over other pruning treatments and the least mean values were obtained from control plots. The interaction effect between variety and pruning was not significant ($p \geq 0.05$) in both years (Table 2).

The two okra varieties were not significantly ($P \geq 0.05$) different in terms of green fruit yield in 2017 cropping season, but in 2018 there was significant difference ($p \leq 0.05$) among them. The highest green fruit yield was obtained from Clemson spinless (11.30 t ha^{-1}) while the least mean value (10.30 t ha^{-1}) was observed in Gungo Local. Pruning had significant ($p \leq 0.05$) influence on green fruit yield in 2017 and 2018 cropping seasons, respectively. Plants of 2 stems pruning significantly proved superior over other pruning treatments in 2017 cropping season. While treatments of 1, 2 and 3 stems pruning were at par with each other, but that of 2 stems pruning gave the highest mean value fruit yield (11.60 t ha^{-1}). Interaction effect between variety and pruning had no significant ($p \geq 0.05$) influence on fruit yield (Table 2).

3.1 Nutritional Qualities of Two Okra Varieties

Protein content of Gungo Local and Clemson spinless varieties were not significant ($p \geq 0.05$) in 2017 and 2018 cropping seasons. Also, protein content was not significantly influenced by pruning in the two years of trial. The interaction between variety and pruning had no significant effect on protein content in both years.

Phosphorus content of Gungo Local (4.8 mg/100 g) was significantly ($p \leq 0.05$) higher than Clemson spinless in 2018 cropping season. While in 2017, the two varieties were not significantly higher than each other. Plants pruned at 2 stems (6.8 mg/100 g) significantly ($p \leq 0.05$) produced the highest phosphorus content, which was followed by 3 stems pruning. While plants pruned at 1 stem and control plots were at par with each other in 2017 cropping season. However, in 2018 pruning treatments were not significantly ($p \geq 0.05$) different from each other. The interaction effect between variety and pruning was not significantly ($p \geq 0.05$) influenced in the two years of trial.

Potassium content obtained in Clemson spinless (5.2 mg/100 g) was significantly ($p \leq 0.05$) higher than that of Gungo Local in 2017, while in 2018 they were at par with each other. Potassium content was not significantly influenced by pruning in 2017, but was significant ($p \leq 0.05$) in 2018 cropping season. The plants pruned at 3 stems (5.6 mg/100 g) were significantly higher than other pruning treatments evaluated in this study. Plants pruned at 1 and 2 stems were at par with each other and the least mean value was obtained from un-pruned plots.

Calcium content of Gungo Local and Clemson spinless were not significantly $p \geq 0.05$) different in both years. In 2017 cropping season, plants pruned at 2 and 3 stems were significantly at par, but were significantly ($p \leq 0.05$) higher than plants pruned at 1 stem and the control plots. While plants pruned at 1 stem and control were not significantly different from each other. Calcium content did not differ significantly in 2018 cropping season and also the interactive effect between variety and pruning was not significantly $p \geq 0.05$) motivated.

In 2017, magnesium mineral content of Clemson spinless (3.0 mg/100 g) was significantly ($p \leq 0.05$) higher than that of Gungo Local variety. But there was no significant difference between them in 2018 cropping season. Plants pruned at 1, 2 and 3 stems were not significantly $p \geq 0.05$) different from each other in 2017 cropping season. However, plants pruned at 1 stem had the highest mean value (2.9 mg/100 g). In 2018, there was no significant difference between the pruning treatments. Moreso, interactive effect between variety and pruning was not significantly $p \geq 0.05$) influenced.

Iron content of Clemson spinless (1.7 mg/100 g) was significantly ($p \leq 0.05$) higher than Gungo Local variety in 2017 cropping season. Howeverin 2018 the two varieties were not significantly different from each other. Also, pruning treatments were not significantly ($p \geq 0.05$) different from each other in both years and the interaction effect between variety and pruning was not significantly ($p<0.05$) motivated.

Carotene content of Gungo Local and Clemson spinless okra varieties were not significantly ($p \geq 0.05$) different in 2017 and 2018 cropping seasons, respectively. Plants pruned had no significant effect in 2017, but was significant in 2018 cropping season. Plants pruned at 1 stem (1.9 mg/100 g) were significantly higher than other pruning treatments and the least mean value (1.0 mg/100 g) was gotten from control plots. The interaction effect of variety and pruning had no significant ($p \geq 0.05$) effect in both years.

Vitamin C mineral content was significantly ($p \leq 0.05$) influenced by variety in 2017 and 2018 cropping seasons. Clemson spinless variety recorded the highest mean values (44.mg/100 g, 42.5 mg/100 g) in both years and the least mean values were obtained from Gungo Local. Evidently, vitamin C was significantly ($p \leq 0.05$) affected by pruning in both years of field trial. Plants pruned at 3 stems (46.2 mg/100 g) were significantly higher than other pruning treatments evaluated in 2017. Plants pruned at 1 and 2 stems were at par with each other while the least mean value was obtained from un-pruned plots. Moreso, in 2018 cropping season, plants pruned at 2 stems had the highest mean value (42.3 mg/100 g), but was not significantly ($p \geq 0.05$) different from plants pruned at 1 and 3 stems. However, plants pruned at 2 stems proved its superiority over control plots. The interaction effect between variety and pruning had no significant ($p \geq 0.05$) influence on vitamin C content.

3.2 Nutrient Uptake of Okra Plants

Nitrogen nutrient uptake was not significantly ($p \geq 0.05$) influenced by variety in 2017 and 2018 cropping seasons. Also, nitrogen content was not significantly affected by pruning treatments. The interactive effect between variety and pruning had no significant ($p \geq 0.05$) effect in the two years of trial.

Phosphorus nutrient uptake of the two okra varieties were not significantly ($p \geq 0.05$) different in both years. Moreso, pruning had no significant effect on phosphorus uptake in 2017 and 2018 cropping seasons. Also, the interaction effect of variety and pruning had no significant ($p \geq 0.05$) difference on phosphorus uptake in both years.

Potassium nutrient uptake of okra varieties was not significantly ($p<0.05$) increased in 2017, but had significant ($p \leq 0.05$) influence in 2018 cropping season in which Clemson spinless nutrient uptake (5.9 mg kg) was significantly ($p \leq 0.05$) higher than Gungo Local. The potassium uptake had no significant ($p \geq 0.05$) effect when pruning treatments were imposed in both years. The interactive effect of variety and pruning was also not significantly ($p<0.05$) influenced in the two years of trial.

Calcium uptake of okra varieties had significant ($p \leq 0.05$) effect in 2017 and 2018 cropping seasons, respectively. In both years, Clemson spinless recorded the highest mean values (409.9 mg kg, 228.5 mg kg) while the least mean values were obtained from Gungo Local. Calcium uptake was not significantly ($p \geq 0.05$) affected by pruning in 2017, but had significant ($p \leq 0.05$) effect in 2018 cropping season. Plants pruned at 3 stems (234.2 mg kg) were significantly higher than other pruning treatments. While plants pruned at 1 and 2 stems were at par with each other and the least mean value was obtained from un-pruned plots. The interactive effect of variety and pruning was not significantly ($p<0.05$) influenced in both years.

Magnesium uptake of okra varieties were not significantly ($p \geq 0.05$) influenced in 2017 and 2018 cropping seasons. Moreso, in 2017 pruning had no significant effect on magnesium uptake. However, in 2018 cropping season there was significant ($p \leq 0.05$) difference among the pruning treatments. Plants pruned at 2 stems was at par with 1 stem (2.2 mg kg, 2.0 mg kg), but were significantly higher than plants pruned at 3 stems and control plots. Interactive effect of variety and pruning was not significantly (p≥0.05) influenced in both years.

Table 1. Effect of pruning and their interaction on number of leaves of okra in 2017 and 2018 cropping seasons

Variety	Number of leaves					
	3 WAP		6 WAP		9 WAP	
	2017	2018	2017	2018	2017	2018
GL	5.2	2.8	6.1	7.8	7.3	11.3
CL	5.1	2.7	6.3	8.2	7.6	11.3
LSD:V	ns	ns	ns	ns	ns	2.3
Pruning						
0	5.1	2.5	6.1	7.8	7.5	10.9
1	5.1	2.7	6.3	7.7	7.4	10.8
2	5.3	3.1	6.4	8.2	7.8	12.2
3	4.9	2.7	6.0	8.2	7.3	10.9
LSD:P	ns	0.3	ns	ns	ns	ns
VXP	ns	ns	ns	ns	ns	ns

GL= Gungo Local, CL= Clemson Spinless, V= Variety, P= Pruning, NS= Not significant, LSD= Least Significant Difference

Table 2. Effect of pruning on number of fruits and fruit yield of two okra varieties in 2017 and 2018 cropping seasons

Variety	Number of fruits		Fruit yield (t/ha-^{1})	
	2017	2018	2017	2018
GL	21.8	20.0	4.2	10.3
CL	20.0	20.7	3.9	11.3
LSD:V	1.2	ns	ns	0.9
Pruning				
0	17.3	18.7	1.8	1.6
1	20.7	21.0	3.4	11.0
2	24.1	22.0	5.7	11.6
3	21.4	19.7	5.2	11.1
LSD:P	1.7	2.1	0.5	1.3
VXP	ns	ns	ns	ns

GL= Gungo Local, CL= Clemson Spinless, V= Variety, P= Pruning, NS= Not significant, LSD= Least Significant Difference

Table 3. Effect of pruning on fruit nutritional qualities of two okra varieties in 2017 and 2018 cropping seasons

Variety	Nutritional qualities (mg/100 g)					
	Protein		Phosphorus		Potassium	
	2017	2018	2017	2018	2017	2018
GL	3.2	4.2	6.2	4.8	4.2	5.2
CL	3.4	4.2	6.1	4.3	5.2	5.3
LSD:V	ns	ns	ns	0.2	0.6	ns
Pruning						
0	3.5	4.3	5.7	5.3	5.4	4.2
1	3.3	4.1	5.6	4.9	4.5	4.8
2	3.1	4.2	6.8	5.0	4.5	4.9
3	3.2	4.3	6.4	5.0	4.3	5.6
LSD:P	ns	ns	0.3	ns	ns	0.5
VXP	ns	ns	ns	ns	ns	ns

GL= Gungo Local, CL= Clemson Spinless, V= Variety, P= Pruning, NS= Not significant, LSD= Least Significant Difference

Table 4. Effect of pruning on fruit nutritional qualities of two okra varieties in 2017 and 2018 cropping seasons

Variety	Nutritional qualities (mg/100 g)					
	Calcium		Magnesium		Iron	
	2017	2018	2017	2018	2017	2018
GL	67.0	68.3	2.5	2.4	1.5	1.4
CL	68.6	67.9	3.0	2.5	1.7	1.5
LSD:V	ns	ns	1.0	ns	0.1	ns
Pruning						
0	66.3	69.1	2.5	2.7	1.7	1.4
1	66.9	68.7	2.9	2.4	1.6	1.4
2	69.2	68.0	2.8	2.2	1.7	1.5
3	68.7	68.8	2.8	2.4	1.6	1.4
LSD:P	1.3	ns	0.3	ns	ns	ns
VXP	ns	ns	ns	ns	ns	ns

GL= Gungo Local, CL= Clemson Spinless, V= Variety, P= Pruning, NS= Not significant, LSD= Least Significant Difference

Table 5. Effect of pruning on fruit nutritional qualities of two okra varieties in 2017 and 2018 cropping seasons

Variety	Nutritional qualities (mg/100 g)			
	Carotene		Vitamin C	
	2017	2018	2017	2018
GL	1.2	1.6	41.5	40.0
CL	1.2	1.8	44.7	42.5
LSD:V	ns	ns	2.5	1.5
Pruning				
0	1.2	1.0	40.5	39.6
1	1.2	1.9	43.3	41.8
2	1.1	1.4	41.8	42.3
3	1.2	1.6	46.2	41.3
LSD:P	ns	0.4	4.2	2.2
VXP	ns	ns	ns	ns

GL= Gungo Local, CL= Clemson Spinless, V= Variety, P= Pruning, NS= Not significant, LSD= Least Significant Difference

Table 6. Effect of pruning on nitrogen, phosphorus and potassium uptake of two okra varieties in 2017 and 2018 cropping seasons

Variety	Nutrient uptake (mg/kg)					
	Nitrogen		Phosphorus		Potassium	
	2017	2018	2017	2018	2017	2018
GL	2.1	2.2	44.6	47.6	4.1	5.7
CL	2.3	2.3	44.9	47.5	4.0	5.9
LSD:V	ns	ns	ns	ns	ns	0.1
Pruning						
0	1.9	2.1	41.7	48.4	3.8	5.8
1	2.3	2.3	45.0	45.3	3.5	5.8
2	2.1	2.2	46.3	45.8	4.4	5.5
3	2.4	2.4	45.9	50.6	4.5	6.0
LSD:P	ns	ns	2.7	3.2	ns	ns
VXP	ns	ns	ns	ns	ns	ns

GL= Gungo Local, CL= Clemson Spinless, V= Variety, P= Pruning, NS= Not significant, LSD= Least Significant Difference

Table 7. Effect of pruning on calcium and magnesium uptake of two okra varieties in 2017 and 2018 cropping seasons

Variety	Nutrient uptake (mg/kg)			
	Calcium		Magnesium	
	2017	2018	2017	2018
GL	396.9	220.5	2.1	1.8
CL	409.9	228.5	2.0	1.8
LSD:V	2.2	5.5	ns	ns
Pruning				
0	405.6	212.3	2.1	1.6
1	407.3	224.8	2.0	2.0
2	398.8	226.6	2.0	2.2
3	402.0	234.2	1.9	1.4
LSD:P	ns	8.9	ns	0.4
VXP	ns	ns	ns	ns

GL= Gungo Local, CL= Clemson Spinless, V= Variety,
P= Pruning, NS= Not significant,
LSD= Least Significant Difference

4. DISCUSSION

The significant increase in the number of leaves obtained from this study was as a result of stems pruned at the early stage of plants growth. The result obtained was in line with [10,11] who reported that the treatment that is enhanced in branch production increased young leaf production in okra. From this study, the results showed that plants pruned produced more flowers and fruits than un-pruned plants. In this study, pruning of 1, 2 and 3 stems produced fruits that were significantly edible than the un-pruned plants. This is in conformity with [6,12] who reported that pruned plants gave more larger and desirable percentage of food quality fruits. The result from this study also corroborated with [13] who reported that pruning significantly increased number of pods per plant. In agreement with the above author [14] also stated that a pruned and staked tomato plant will produce larger fruit two to three weeks earlier than un-pruned one.

The fruit yield obtained in Clemson spinless over Gungo Local variety agrees with the findings of [15] who stated that plants differed in their genetic make-up. This view is also in line with that of [16-18]. The results of this study revealed that Clemson spinless significantly recorded the highest fruit yield of 11.30 t ha^{-1} which was higher than the range of 2-3 t ha^{-1} reported by [19,18] who used the same variety for field trial. Furthermore, the highest fruit yield of 11.60 t ha^{-1} was recorded when 2 stems pruning was imposed and was higher than the mean values obtained from other pruning treatments in both years The fruit yield mean values obtained from this study agrees with the findings of [12,17] who revealed that plants pinched produced higher fruit yield than un-pinched plants.

From this study, the result proved that Clemson spinless had better nutritional qualities than Gungo Local variety and there was also better nutrient uptake absorbed by the plants. In the overall, there was inconsistence in the nutritional values and nutrient uptake obtained in this study for the varieties used. Clemson spinless closely followed by Gungo Local variety recorded some nutritional values and nutrient uptake needed by the plants for growth. This is in agreement with [20,21] who reported that there was inconsistence in the nutritional values obtained from the tomato varieties used.

5. CONCLUSION AND RECOMMENDATION

Based on this study, it could be concluded that Clemson spinless performed better than Gungo Local in terms of fruit yield, nutritional quality and nutrient uptake absorbed by the plants. From this study also, it is clear that plants pruned at 2 stems did better than other pruning treatments. It can therefore, be recommended for adoption by farmers within the study area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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