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EFFECT OF ARTIFICIAL DEFOLIATION ON GROWTH, DEVELOPMENT AND YIELD OF POTTED OKRA *(Abelmoschus esculentus)* IN ANYIGBA

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ABSTRACT

The experiment was carried out during 2012 cropping season to determine the effect of defoliation on growth and yield of Okra *in Anyigba, southern Guinea savannah Agro-ecological zone of Nigeria.* Anyigba lies on latitude $7^0$15'N and $7^0$29'N longitude $7^0$11'E and $7^0$32'E with average altitude of 420 meters above the sea level. The area lies in derived guinea savannah zone, with average annual rainfall of 1600mm and the daily temperature ranges from 25^0C-35^0C. *The pot trial method was used to determine the effect of artificial defoliation on the growth and yield of okra. The defoliation was carried out at the early vegetative stage (3 weeks old), flowering stage (5 weeks old) and early fruiting stage (7 weeks old). The treatment comprised of five levels of defoliation (0, 25, 50, 75 and 100 percent) placed in a Randomized Complete Block Design (RCBD) with six replications. Significant means were separated using Fishers Least Significant Difference. There was a significant ($p \leq 0.05$) influence of defoliation on growth and yield parameter such as plant height, plant diameter, number of leaves, leaf area, pod length, pod diameter, pod weight and number of pods. Reduction in growth and yield parameters were function of increasing defoliation levels or intensity. Defoliation at 0 to 25 percent were tolerable for okra plant growth and development while it showed detrimental effects on Okro growth and yield at 75 and 100 percent. Hence, defoliation not higher than 25 percent was recommended to meet farmers' pod-leaf requirements.*

Keywords: Artificial defoliation, Growth, Development, Yield, Okra

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INTRODCTION

Okra (*Abelmoschus esculentus* (L) Moench), an annual pod bearing plant of tropical and sub-tropical regions is eaten as vegetable. The pod which is typically ridged but may be almost round contains many small seeds and a gummy substance which gives Okra its special character. It is nick named *Ladies Fingers* because of the general appearance of the pod, and probably because it originated from Ethiopia (Benchasri, 2012).

Okra is a fast-growing annual vegetable, widely consumed in Africa, where a total of 1 - 2 million hectares annually are under cultivation. It is a leading fruit in the Nigerian market on

the basis of land area under production and values. Fresh Okra fruit contains 2.1g protein, 0.2g fat, 8g carbohydrate, 36 g calories, 1.7g fibre, 175.2mg minerals, 232.7mg vitamins and 88 ml. of water per 100 g of edible portion (Kelemu *et al.,* 2005).

Okra requires moderate rainfall of 80 - 100cm, which should be well distributed to produce its young edible fruits over a relatively long period. An average temperature of 20 to 30^0C is considered optimum for growth, flowering and fruiting. The optimum pH for Okra is 6.5, but soil type does not appear to influence growth or development to any marked extent, as wide range of soil types have been found suitable, except laterite and acidic soils. A well drained soil, preferably clay loam or silt loam is, however, ideal for its cultivation. Recommended spacing for optimum yield, growth, and quality pods is 60cm by 60cm (Bake *et. al*., (2017).

Kelemu, *et al.* (2005) stated that in the absence of adequate control measures, Okra leaves are most often damaged by a range of leaf eating insect pests such as grasshoppers, leaf rollers (*Hanitalodes derogate*), caterpillars, spider mites (*Tetranychus spp*.), *Podagrica spp. Sylepta derogate,* jassids *(Amrasca biguttula) (*Rabin *et al., 2019)* and diseases such as early blight, powdery mildew (*Leveillula taurica*) and black mould (*Cercospora abelmoschi*), a very common phenomenon in most small-holder farms in the developing tropical countries. These types of damage (either through the removal of leaves by man as vegetables or by insects, pests and diseases) on Okra foliage during active growth on the field may reduce the physiological activities of the plant and decrease the supply of assimilates to the developing pods thereby causing appreciable yield loss (James *et al*., 2010).

Okra has many uses and it is variable in nutrient composition. The importance of Okra fruit in our diet cannot be over-emphasised as it serves as an important source of dietary fibre, source of vitamin A, B, and C as well as calcium, phosphorus, iron and iodine. It is said to be of economic importance because of its nutritional value that has the potential to improve food security. It also has health benefits, which include stabilizing the blood sugar by curbing the rate at which sugar is absorbed by intestinal tract. Okra pod when eaten acts as lubricant for the large intestines; the fibre in the pod absorbs water causing fibrous bulk in stool, and it also prevents constipation. Because of its slippery mucilage, its gelatinous texture, it is not as harsh on the intestines as the fibre that comes from wheat. Matured fruit and stems containing crude fibre are used in the paper industry. Its seeds are used as a non caffeinated_substitute for coffee and can also be a source of seed oil. It is secondary source of gum and the fibres of its stem are used for rope making. The foliage provides a good source of fodder for livestock.

Watcharaphong *et al*., (2019) reported the antioxidant, antidiabetic, antifatigue, neuro-protective and anti-hyperlipidemic properties of Okra seed extracts. The effects of defoliators can cause reduced seed yield depending on the intensity of defoliation and stage of growth of the crop. Therefore, quantifying yield decrease resulting from defoliation may play an important role in predicting yields, establishing threshold for pesticide treatments or assessing indirect damage caused by pests (James *et al.,* 2010). Leaf loss interferes with many processes of the plant at different

stages of crop development, be it at the flowering phase or early vegetative phase and it may alter the flowering pattern and storage of assimilate in the vegetative structures. In the literature, there are little information on the effect of varying degrees of leaf defoliation at different stages of okra growth (Kelemu, *et al*., 2005). The objectives of the study therefore were:

1. To determine the effect of defoliation on growth and yield of Okra.
2. To determine the most economic defoliation level that will ensure that both pod and leaf demand of the farmers are met.

MATERIALS AND METHODS

Experimental Site: The experiment was carried out during the 2012 cropping season in front of the green house, Faculty of Agriculture, Kogi State University, Anyigba. Anyigba is located in the southern Guinea savannah agro ecological zone of Nigeria. Anyigba lies on latitude $7^0$15'N and $7^0$29'N, longitude $7^0$11'E and $7^0$32'E with average altitude of 420 meters above the sea level. The area lies in derived guinea savannah zone, with average annual rainfall of 1600mm and the daily temperature ranges from 25^0C to 35^0C. The pot trial method was used to determine the effect of artificial defoliation on the growth and yield of okra.

Treatment and Experimental Design: The treatment for the research consisted of five levels of defoliation: T_1, T_2, T_3, T_4, and T_5 signifying 0, 25, 50, 75 and 100% respectively, assigned to pots using the Randomized Complete Block Design (RCBD) in six replications. The defoliation was carried out at early vegetative stage (3 weeks old), flowering stage (5 weeks old) and early fruiting stage (7 weeks old).

Seed Source: The okra (*Abelmoschus esculentus* (L) Moench) seeds used for the research were obtained from Agricultural Development Project (ADP) office in Anyigba, Kogi State and the cultivar of okro used was NHAe 47-4, a photo periodic neutral variety.

Soil Collection/Filling of Pots: A total of thirty (30) pots were filled with top soil collected from fallow land. The analysis of the soil carried out in the Soil Science Laboratory of Kogi State University, Anyigba, revealed that the textural class is sandy loam.

Sowing: The Okra seeds were sown at a depth of 3cm using dibbing method at the rate of two (2) seeds per hole, which was later thinned to one plant per stand at two weeks after crop emergence.

Cultural Practices: Routine cultural operation such as weeding at two weeks interval by hand picking the weeds; and regular soil pulverization to enhance water infiltration and aeration was sustained throughout the experimental period. The defoliation was carried out at the early vegetative stage (3 weeks old), flowering stage (5 weeks old), and at early fruiting stage (7 weeks old).

Data Collection

Plant height: Height of plant was determined using a meter rule from the base of the plant to the terminal growing part (Harish, 2009).

Stem diameter: Stem girth taken at 2cm above the base of the main stem was

measured monthly using Vernier Calliper.

Number of Leaves per plant: The number of leaves per plant was counted and recorded at 30, 60, and 90 days after sowing (DAS).

Leaf Area (cm^2): The leaf area per plant was recorded at 30, 60, and 90 days after sowing (DAS). The leaf area was measured using leaf product method.

Leaf area = Leaf length (cm) x leaf breadth (cm) x 0.75

After measuring leaf area of individual leaves, leaf area per plant was worked out and expressed in cm^2 per plant.

Number of harvested pods: The total number of pods produced per plant was recorded as summation of six harvests.

Pod length: This was determined using a meter rule and recorded as mean of all harvests per treatment.

Pod diameter: This was measured using a Vernier Callipers and recorded as mean of all harvests per treatment.

Pod weight: The harvested pod was placed on Metler weighing scale and the weight determined to two decimal places.

Statistical Analysis: The growth and yield parameters collected were subjected to Analysis of Variance (ANOVA) to evaluate the effects of artificial defoliation on Okra. Means were separated using the fisher least significant difference (F-LSD) at 5% ($P \leq 0.05$) level of significance.

RESULTS AND DISCUSSION

Effect of Defoliation on Okro Plant Height

The effect of defoliation on Okro plant height is as summarized in Table 1 below. Defoliation had a significant ($p \leq 0.05$) effect on plant height at 30, 60 and 90 DAS. Plant height was highest at zero per cent level of defoliation (23.50, 39.23 and 81.97cm at 30, 60 and 90 DAS, respectively). The least values were obtained at 100 per cent defoliation (8.62, 12.17 and 24.85cm respectively at 30, 60 and 90 DAS respectively). Vasilas and Seif (1985) reported that plant height decreased significantly with increasing degree of defoliation. It was observed that plant height reduced with increasing intensity of defoliation. This could be attributed to interference with photosynthesis and which consequently will affect the plant height and other growth parameters, and eventually the yield. This is similar to the findings of Ibrahim *et al.* (2010) on cowpea and that of Adeniyi and Ayandiji (2011).

Effect of defoliation on Okro leaf Area.

The effect of defoliation on Okro leaf Area is as summarized in Table 2. Defoliation had a significant ($p \leq 0.05$) effect on leaf area with the highest leaf areas obtained during the first, second and third defoliation (844.02, 3811.17 and 3328.72 cm^2 respectively) at 0 percent defoliation. The least leaf area was observed at 100 percent defoliation (366.97, 872.83 and 1769.38 cm^2 respectively at 30, 60 and 90 DAS). Defoliation had significant ($p \leq 0.05$) effect on okra leaf area, and this result tallied with the report of Ibrahim *et al* (2010) and that of Adeniyi and Ayandiji, (2011).

Table 1: Effect of defoliation on Okra plant height (cm)

Percent defoliation	Plant Height (cm)		
	30DAS	60 DAS	90 DAS
0	23.50[a]	39.23[a]	81.97[a]
25	14.95[b]	29.55[b]	72.20[b]
50	12.73[c]	19.50[c]	42.38[c]
75	9.15[d]	20.08[c]	42.72[c]
100	8.62[d]	12.17[d]	24.85[d]
LSD	0.94	1.10	0.50

[a-d]Means within the same column with different superscripts differ significantly (P ≤ 0.05). LSD = Least Significant Difference; DAS = Days after sowing.

Table 2: Effect of defoliation on Okra leaf area

Percent defoliation	Leaf area (cm^2)		
	30 DAS	60 DAS	90 DAS
0	844.02[a]	3811.17[a]	3328.72[a]
25	449.90b	2245.00[b]	2747.12[b]
50	381.58[c]	1860.50[c]	2818.60[b]
75	395.13[c]	909.17[d]	1877.12[c]
100	366.97[d]	872.83[d]	1769.38[c]
LSD	1.58	0.71	0.71

[a-d]Treatment means within the same column with different superscripts are significantly (P≤ 0.05) different. LSD = Least significant difference; DAS = Days after sowing.

Effect of Defoliation on Stem Girth Diameter

The effect of defoliation on stem girth diameter is as shown in Table 3 below. Defoliation had a significant (p ≤ 0.05) effect on plant diameter at 30, 60 and 90 DAS. Plant diameter was highest at zero per cent level of defoliation having 1.05 cm, 1.42 cm and 1.87 cm at 30, 60 and 90 DAS respectively. The least values were observed at 100 per cent defoliation (0.50, 0.48 and 0.70 cm at 30, 60 and 90 DAS respectively).

Defoliation also reduced the stem diameter which is contrary to the findings of Tucker, *et al.* (2004) who stated that increased levels of defoliation did not have significant (p ≥ 0.05) effect on stem diameter. .

Table 3: Effect of defoliation on Okra stem girth (cm)

Percent defoliation	Okra stem diameter (cm)		
	30 DAS	60 DAS	90DAS
0	1.05[a]	1.42[a]	1.87[a]
25	0.62[c]	1.07[ab]	1.68[b]
50	0.73[b]	0.80[b]	1.38[c]
75	0.40[e]	0.65[c]	1.83[a]
100	0.50[d]	0.48[d]	0.70[d]
LSD	1.08	0.93	0.96

[a-e]Means within the same column with different superscripts are significantly (p≤ 0.05) different. LSD = Least Significant Difference; DAS = Days after sowing.

Effect of defoliation on number of Okro leaves

The effect of defoliation on number of Okro leaves is summarized in Table 4 below. Defoliation had significant ($p \leq 0.05$) effect on the number of leaves at 30, 60 and 90 DAS. Number of leaves was highest at zero per cent level of defoliation having 8.17 at 30 DAS with the lowest at 75 and 100 per cent level of defoliation with 2.17. This was similar to the findings of Ibrahim *et al.* (2010) in his experiment with vegetable cowpea who stated that increasing intensity of defoliation lead to a corresponding decrease in the number of leaves. Number of leaves is also influenced by plant spacing (Bade *et. al*., 2017). Umashankara, (2007) in his experiment with fodder maize also observed that defoliation significantly reduced the number of leaves at 90 DAS. Harish, (2007) also had similar results in his experiment with sweet sorghum.

Effects of defoliation on Okro yield parameters

The effects of defoliation on Okro yield parameters are presented in Table 5 below. The number of pods was highest at 0 percent level of defoliation (6.83) while the least value was at 100 percent level of defoliation with 0.33 fruits. Pod diameter was also highest (0.65 cm) when the okra seedlings were not defoliated (0% defoliation) while the least value (0.25cm) was obtained at 50% defoliation. Pod length was highest at 25 percent level of defoliation (4.87 cm) which was also similar to those from non-defoliated okra plant (0% defoliation). The least pod length (0.58cm) was observed at 100 percent defoliation. The pod weight was highest at 0 percent level of defoliation while lest value was obtained for 100% defoliated okra plant (0.43g).

Defoliation had significant ($p \leq 0.05$) effect on yield parameters such as number of pods, pod length, pod diameter and pod yield. This is similar to the findings of Ibrahim *et al*. (2010) who stated that the yield and yield parameters were significantly affected by stage and intensity of defoliation. Adeniyi and Ayandiji, (2011) similarly stated in their findings that fruit yields of okra plants defoliated at the early fruiting stage were most adversely affected while those that were defoliated at early vegetative stage were least affected. For example, the average percentage reduction in total fruit yield when plants were defoliated at early fruiting, floral budding and early vegetative stages were 82, 54 and 27% respectively. The adverse effect of defoliation during the reproductive stage on fruit yield tends to suggest that fruiting in okra depends largely on post flowering photosynthesis. Thus, adequate protection against insects and diseases are necessary, particularly during this stage in order to realize full yield potentials. Similar observation had been made in some other countries in the tropics (Youdeowei, 2002). Ibrahim *et al*. (2010) also reported a significant reduction in pod length; and pod weight by defoliating at the vegetative stage. He further stated that number of pods were reduced by defoliating at both vegetative and flowering stages and this also underscores the effects of defoliating insects such as Jassids etc. on yield (pod) reduction (Rabin*, et, al*. 2019). Umashankara, (2007) in his experiment with fodder maize also observed that defoliation significantly reduced cob girth. This is similar to observations of Harish, (2007) in his experiment with sweet sorghum where defoliation significantly reduced the panicle girth. Sandesh *et al*., (2019) reported that

synthetic fertilizers produced more fruits but poultry manure had the best cost-benefit ratio. .

Table 4: Effect of defoliation on number of Okro leaves

Percent defoliation	Leaf number		
	30 DAS	60 DAS	9 0DAS
0	8.17[a]	8.33[a]	5.83[b]
25	6.00[b]	8.33[a]	6.50[a]
50	4.50[c]	7.17[b]	5.17[b]
75	2.17[d]	5.67[d]	4.00[c]
100	2.17[d]	6.16[c]	2.83[d]
LSD	0.81	1.15	1.49

[a-d]Means within the same column with different superscripts are significantly (p< 0.05) different. LSD = Least Significant Difference; DAS = Days after sowing.

Table 5: Effect of defoliation on Okra yield parameters

Percent defoliation	Okra yield parameters			
	No.of pod	Pod diameter(cm)	Pod length (cm)	Pod weight (g)
0	6.83[a]	0.65[a]	4.75[c]	**18.85[a]**
25	5.50[b]	0.53[b]	4.87[c]	**14.37[b]**
50	3.50[c]	0.25[c]	4.12[ab]	**7.32[d]**
75	5.50[b]	0.53[b]	3.65[b]	**11.80[c]**
100	0.33[d]	0.53[b]	0.58[c]	**0.43[e]**
LSD	1.21	1.03	1.18	**0.47**

[a-d]Means along the same column with the different superscripts are significantly (p ≤ 0.05) different. LSD = Least significant difference.

CONCLUSIONS

- Artificially defoliation of okra affects the vegetative and developmental characters, yield and yield parameters of okra.
- The performance of okra was low at 75 and 100 percent levels of defoliation hence, detrimental to okra growth and development.
- Defoliating at 50 percent and above had adverse effects on the performance of okra while defoliating at lower levels of 25 percent and below were tolerable and less detrimental to the growth and development of okra plant.
- It is economically profitable to control defoliating pests on okra fields at the early fruiting and floral budding stages of the plant development if the farmer is to realize good harvest.

RECOMMENDATIONS

- The early fruiting stage is more critical and therefore, intensification of efforts to control leaf predators at this period is recommended for valuable fruit yield in okra production. The impact of defoliation due to insect injury, disease incidence and mechanical damage during the different

stages of crop growth and their influence on pod yield and quality of okra may be further investigated.

- Farmers can defoliate Okra plant for other uses up to 25 percent level of defoliation without detrimental effect on crop yield.
- Further studies should be carried out on the effect of defoliation on the growth and yield of okra so as to better manage pests of okra which cause defoliation.

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