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AN AGRO-ECONOMIC APPRAISAL OF THE RESPONSE OF OKRA TO LEAF DEFOLIATION: GROWTH AND MARKETABLE YIELD

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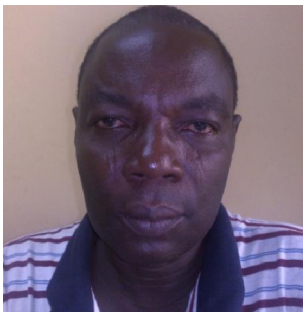

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ABSTRACT

The leaves, shoots, immature pods and dry seeds of okra are used extensively in vegetable food preparations in the tropics. The fruit is rich in minerals and vitamins, which are essential for body functions. The soft and succulent nature of the leaves make them vulnerable to attack and subsequent damage by a range of leaf eating insects, animal pests and man. Such damage results in remarkable yield loss and reduced market value. Identification of the critical stages of attack and extent of loss taking place at each stage of development of the plant could aid in planning strategies for prevention and/or control. Thus, two field experiments were conducted to determine the effect of leaf removal on the growth and marketable yield of okra. The treatments on leaf defoliation at different stages of development consisted of removal of leaves at 4 weeks after sowing (WAS) as early vegetative stage, 6WAS (at floral budding stage) and 8 WAS (at early fruiting stage). The treatments on the degrees of defoliation included the control (no leaf removal), removal of a quarter (D_{25}), half (D_{50}), three quarter (D_{75}) or total removal (D_{100}) of every fully expanded leaf. Different proportions of every leaf were removed with sharpened scissors. Each treatment was replicated four times. The experiment was 3 x 5 factorial with randomized complete block design. Current market price was used to value the yields. The removal of up to a quarter of each leaf did not affect the fruit yield significantly but the yield was significantly reduced by 39, 79 and 86% when ½, ¾ of each leaf and complete leaf were defoliated, respectively. In money terms, the losses were ₦26,390($175.93), ₦52,780($351.87), and ₦57,876($385.84) per hectare, respectively for these various defoliation levels. Removal of okra leaves during the early fruiting stage led to 82% marketable yield reduction. Complete leaf defoliation was detrimental to fruit yield. The results suggested that okra could tolerate 25% defoliation as might occur from leaf eating insects, human predators or foliage pathogenic infections but beyond this level, it would be detrimental. A programme of control of leaf predators in okra management should therefore commence prior to or at the early fruiting phase in order to realize yields of good value. Further research on commercial uses of okra and the economics of pest control on okra fields is recommended.

Key words: Agro-economic, Defoliation, Fruiting, Yield, Commercial

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INTRODUCTION

Okra (*Abelmoschus esculentus* (L) Moench) is a popular vegetable in the tropics, cultivated for its immature pods and dry seeds [1, 2]. It is a flowering plant in the mallow family and known in many English speaking countries as lady's fingers or gumbo. It is a good source of vitamins C and A, also B complex vitamins, iron and Calcium [3]. It is low in calories, a good source of dietary fibre and is fat free. The vitamin C present in its fruits and vegetables is a powerful antioxidant and anti-inflammatory, making it play a major role in fighting cancer and heart disease and also helping keep the digestive system healthy [4]. The leaves are tender and mild to eat and can be taken to control blood pressure by enhancing blood flow. Its superior fibre content helps to stabilize blood sugar as it curbs the rate at which sugar is absorbed from the intestinal tract. The greenish yellow edible oil extracted from the seeds of okra has a pleasant taste and odour and is high in unsaturated fats such as oleic acid and linoleic acid [5]. A few people eat the young shoot and leaves as vegetable salad. Okra seeds may be roasted and ground to form a caffeinate-free substitute for coffee [6].

When adequate control measures are not properly taken, the 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** and diseases such as early blight, powdery mildew (Leveillula taurica) and black mould (Carcospora abelmoschi) – a very common phenomenon in most small-holder farms in the developing tropical countries [7,8, 9]. These types of damage (either through the removal of leaves by man as vegetables or by insects, pests and diseases) on okra foliage when it is still actively growing 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 [10].

Leaf loss, according to Pandey [11], interferes with many processes of the plant, not only after flowering but also in the early vegetative phase and it may alter the flowering pattern and storage of assimilate in the vegetative structures. In the literature, there is little information on the effect of varying degrees of leaf defoliation at different stages of okra growth on marketable yield in the humid tropical environments [9, 12].

Ewete [13] had earlier reported that one of the factors limiting the yield of okra fruit in the tropics was the range of insect pests associated with the crop. Hence the determination of simulating the effects of insects, pests or diseases through the removal of leaves in okra field will help in generating the required data for providing information to farmers on the importance and timing of pest control management in okra fields. In the study area, typical of developing tropical countries, the majority of farmers take few protective measures against predations on the crops. Such measures, including hand picking of insect pests, spreading of wood ash on young leaves and frequent harvesting of immature pods were done at times at odd or arbitrary periods [14, 15]

The objective of the work reported here, therefore, was to simulate the effects of insect predation on yield of okra by removing varying proportions of leaf at different stages of growth and observing their respective yield response. This is with a view to advising the farmers on optimal pest control management for increased fruit yield of okra. The quality and quantity of fruit yield here is considered as proxy for measuring the economic value of okra produced.

MATERIALS AND METHODS

Two field trials were conducted at the Agricultural Research Farms of Adeyemi College of Education, Ondo ($07^0 05^{'}N, 04^0 55^{'}E$), Nigeria, during the rainy seasons in two consecutive years using early maturing (V35) okra that is commonly grown in the western part of the country. The soil at the site was a well-drained sandy loam with the following chemical characteristics: 1.41% organic matter, 0.268% total N; 6.6ppm available P (BRAY'S-P1):1:14 me/100g Ca; 0.31me/100 K and pH 5.5 (1:1 soil water ratio). This soil's characteristics are typical of the okra growing zone of western Nigeria.

The treatments on leaf defoliation at different stages of development consisted of removal of leaves at 4 weeks after sowing (WAS) as early vegetative stage, 6 WAS (at floral budding stage) and 8 WAS (at early fruiting stage). The treatments on the degrees of defoliation included the control (no leaf removal), removal of a quarter (D_{25}), half (D_{50}), three quarter (D_{75}) or total removal (D_{100}) of every fully expanded leaf. Different proportions of every leaf were removed with sharpened scissors. Each treatment was replicated four times. The experiment was 3 x 5 factorial with randomized complete block design.

Each plot measured 19.2m by 4.8m and plant spacing was 60 x 45cm. A single plant was established per stand giving a plant population of about 37,000 plants per hectare. All plots were regularly hand-weeded and foliar pests controlled by spraying with a mixture of 300ml ha^{-1} of cymbush 10EC (containing 100mg $Litre^{-1}$ cypemethrin) in 500 litres of water and 0.75 kg $a.i.ha^{-1}$ furadan 10% (carbofuran) at an interval of one week, five times starting on the fifth day after formation of flower buds .

Assessment of some of the indicators of growth and development, which could ultimately determine quality of yield was made by measuring plant height, branch number, leaf area indices, shoot dry weight and days to first harvest. Measurements were taken from 12 plants, randomly taken from the centre rows of each treatment plot where interaction was assumed to be optimal. Average leaf areas were determined by the method described by Tayo [16] in which a random sample of five leaves were taken from each treatment and the area determined by the graph paper method. Using the dry weight of the sample and the total leaf weight, the leaf area per plant was estimated by simple proportion. Dry weights were recorded after drying the samples continuously at 90^0C for 48 hours. Marketable fruits were harvested from 40 plants per treatment every four days and the number, weights, harvest indices and total fruit yields recorded. The selection of 12, 5 and 40 plants, leaves and plants'

fruits, respectively for analyses was based on fair representation of sample, the limitation of space and time available for the experiment.

Pods without blemish measuring 4.0cm and above in length were regarded as marketable. Yields were valued with the average of prices paid by consumers over the period covered by the study as obtained from the consumer panel.

RESULTS

The results obtained from the two trials are similar; hence, the averages of the data obtained from the experiments for the two-year period are analyzed for the results reported in this study.

As shown in table 1, plant height, shoot dry weight, branch number and leaf area indices decreased significantly while maturity period is elongated with increasing degree of leaf defoliation. It is also shown that growth was most adversely affected when defoliation occurs at the early fruiting stage (see table 1). Baloch *et al*. [17] had observed that, for the various cultivars of okra considered, the most critical period for yield determination is the early fruiting stage .The current result is, therefore, in line with their observation.

Complete leaf defoliation or defoliating three-quarters and half of each leaf at this critical stage reduced plant height, decreased shoot dry weight, branch number and leaf area index of okra. This observation has been implied by Jose and Keith [18] in their study of okra production in California when seasonal variations in weather tend to affect negatively all the growth characteristics.

Table 2 presents the results of the effect of severity of leaf defoliation on fruit yield of okra. There was significant reduction in the number of fruits per plant, weight of fruits and harvest index and fruit yield per hectare as the degree of defoliation becomes more intense. Similar observation has been made in some other countries in the tropics [12, 19].

The harvesting of first marketable fruits was delayed by two, four and six days when half of each leaf, three quarters of each leaf and the whole leaves were defoliated, respectively (see table 2).

The interactive effects of the various degrees of defoliation administered at different stages of growth of okra were significant in its growth and fruit yields (see tables 3 and 4). As the degree of defoliation increased from one quarter to complete defoliation, the percentage rates of yield reductions ranged from 0-73, 15-93 and 27-96% at early vegetative, floral budding and early fruiting stages, respectively. The effect of each rate of defoliation at the reproductive stage relative to that of the vegetative stage was pronounced. This pointed to the extreme vulnerability of the reproductive stages (especially the early flowering stage) to defoliation by pests.

DISCUSSION

The significant reduction in the growth and yields of defoliated plants might be due to the reduction in assimilates production in the plants, thereby causing shortage of metabolites movement from the plant parts to the developing fruits. Besides, this could also lead to abscission of flowers and abortion of fruits that were witnessed in the defoliated plants. The intensity of these effects increases with increase in the degree of defoliation.

Defoliation of one quarter of leaves led to a fruit yield reduction of about 15% as compared with losses of about 39, 79 and 86% when half, three quarters and the whole leaves were defoliated, respectively. It seems, therefore, that okra can tolerate at most 25% defoliation before any substantial loss occurs. A similar tolerance level has been reported in tomato and okra [20, 21].

The stage at which defoliation occurred in okra had significant effects on plant height, shoot dry weight, leaf area index (Table 1) and the fruit yields (Table 2). The growth and fruit yields of okra plants defoliated at the early fruiting stage were most adversely affected while those that 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 is necessary, particularly during this stage in order to realize full yield potentials.

At the average price of ₦9, 100($60.67) per tonne of okra during the period of study, losses ranging between ₦26, 390($175.93) and ₦57, 876($385.84) per hectare (39%-86%) could be incurred if more than half of the leaves are defoliated especially during the critical early fruiting stage.

CONCLUSION

This study has shown that the critical period for control of defoliating pests on okra fields are the early fruiting and floral budding stages of plant development if one has to realize the potential yield. The early fruiting stage is, however, more critical and, therefore, intensification of efforts to control leaf predators at this period is recommended for valuable fruit yield in okra production.

It is also recommended that further research be conducted on control of pests at the critical stages to investigate the economics of control and compare same with the losses being anticipated from the pest-induced damages. In addition, there is potential in increasing market demand for okra if other avenues of use such as in beverages and drug manufacture are explored. This also calls for further research.

ACKNOWLEDGEMENT

We are grateful to Dr C T Omotunde, Crop Physiologist, a former Senior Lecturer of Adeyemi College of Education, Ondo, for providing the expertise for carrying out the experiment.

Table 1: Effect of severity of leaf defoliation on growth of okra[+]

Treatment (Defoliation	Plant Height (cm)	No of Branches Plant $^{-1}$	Days to first Harvest (DAS)	Shoot dry Weight (g plant $^{-1}$)	Leaf area index
Degree of Defoliation					
Control (None)	68.6	3.8	52	74.7	0.88
One quarter	63.2	3.0	52	65.5	0.74
Half	51.9	3.1	54	49.4	0.59
Three quarter	46.4	2.8	57	34.3	0.25
Complete	36.4	2.5	59	20.9	0.21
LSD	10.4**	$1.3^{n.s.}$	2.08*	19.1**	0.11**
Stage of plant development					
Early Vegetative	63.1	2.8	56	44.9	0.56
Floral budding	54.9	3.3	57	33.3	0.33
Early fruiting	46.2	2.3	58	27.9	0.32
LSD	7.1 **	$1.0^{n.s}$	2.3*	11.7**	0.14**

DAS = Days after sowing, n.s. = not significant, * = significant at 0.05

WAS = Weeks after sowing, [+] = samples taken at 13WAS, ** = significant at 0.01

LSD = Least Significant Difference

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Table 2: Effect of severity of leaf defoliation on fruit yield of okra

Treatment (Defoliation)	No of Fruits plant $^{-1}$	Weight fruit -1	Harvest Index	Fruit yield (t ha $^{-1}$)
Degree of Defoliation				
Control (None)	13.3	14.1	0.55	7.36
One quarter	12.0	13.7	0.47	6.22
Half	8.3	12.1	0.40	4.46
Three quarter	5.7	6.7	0.23	1.56
Complete	3.5	5.9	0.19	1.00
LSD	2.3**	1.1**	0.11**	1.70**
Stage of plant development				
Early Vegetative	9.0	11.2	0.39	5.38
Floral budding	5.7	9.1	0.27	3.38
Early fruiting	3.5	7.3	0.21	1.34
LSD	1.3*	1.9*	0.11*	1.27*

* = significant at 0.05, ** = significant at 0.01

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Table 3: Interactive effects of stage and degree of defoliation on growth of okra

Treatment (Defoliation)	Plant Height (cm)	No of Branches Plant $^{-1}$	Days to First Harvest (DAS)	Shoot dry Weight (g plant $^{-1}$)	Leaf area Index
Early Vegetative Stage					
Control (None)	67.9	3.6	51	70.5	0.91
One quarter	67.3	3.0	52	60.2	0.80
Half	61.4	3.0	54	51.5	0.64
Three quarters	56.0	2.4	56	30.0	0.40
Complete	48.7	2.4	58	23.2	0.25
Floral budding stage					
Control	69.6	4.2	52	77.5	0.78
One quarter	62.0	3.2	53	56.0	0.60
Half	56.0	3.4	56	50.5	0.42
Three quarters	47.0	2.9	58	19.0	0.16
Complete	38.0	2.6	64	17.8	0.10
Early fruiting stage					
Control	68.5	3.5	53	71.5	0.76
One quarter	61.0	2.6	53	50.0	0.51
Half	40.0	2.9	56	36.2	0.35
Three quarters	37.0	2.4	59	20.0	0.10
Complete	25.0	2.3	62	21.5	0.06
LSD	11.5**	$1.7^{n.s-}$	4.4*	17.9*	0.10**

n. s. = not significant, * = significant at 0.05, * * = significant at 0.01

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Table 4: Interactive effects of stage and degree of defoliation on fruit yield of okra

Treatment (Defoliation)	No of Fruits plant $^{-1}$	Weight fruit $^{-1}$	Harvest Index	Fruit yield (t ha^{-1})
Early Vegetative Stage				
Control	12.0	14.3	0.57	7.82
One quarter	13.0	14.5	0.50	8.00
Half	10.0	13.5	0.42	6.30
Three quarters	6.0	8.7	0.27	3.72
Complete	4.0	6.0	0.19	2.12
Floral budding Stage				
Control	13.0	14.2	0.57	7.45
One quarter	12.1	12.8	0.47	6.3
Half	8.4	8.8	0.39	3.87
Three quarters	5.0	5.3	0.20	1.10
Complete	3.3	3.9	0.17	0.52
Early fruiting Stage				
Control	13.0	14.1	0.57	6.85
One quarter	9.0	10.0	0.44	5.0
Half	6.3	6.8	0.38	1.57
Three quarters	3.0	4.2	0.20	0.60
Complete	2.0	2.6	0.16	0.25
LSD	2.1**	2.3**	0.12*	1.51**

*- significant at 0.05, * * = significant at 0.01

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