



## RESEARCH ARTICLE

### ASSESSMENT OF DAMAGE CAUSED BY *PODAGRICA DECOLORATA* ACCORDING TO THE STAGES OF OKRA (*ABELMOSCHUS ESCULENTUS*) DEVELOPMENT IN THE DRY SEASON AND RAINY SEASON IN WEST-COTE D'IVOIRE

N'guessan YAO<sup>1\*</sup>, Adagba OBODJI<sup>2</sup>, Olo SIB<sup>1</sup>, Konan Fabrice ASSOUHO<sup>3</sup> and Senan SORO<sup>1</sup>

<sup>1</sup>Department of Agronomy and Forestry, University of Jean Lorougnon Guede, BP 150 Daloa, Côte d'Ivoire, <sup>2</sup>Faculty of Science and Technology, University of Alassane Ouattara, BPV18 Bouaké, Côte d'Ivoire, <sup>3</sup>Department of Fish and Wildlife Resources, Polytechnic University of San Pedro, 01 BP 1800 San Pedro 01, Côte d'Ivoire

#### ARTICLE INFO

##### Article History:

Received 15<sup>th</sup> December, 2025  
Received in revised form  
25<sup>th</sup> January, 2026  
Accepted 18<sup>th</sup> February, 2026  
Published online 29<sup>th</sup> March, 2026

##### Keywords:

Okra, Damage, *Podagrica Decolorata*,  
Season, Côte d'Ivoire.

##### \*Corresponding author:

N'guessan YAO

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**Citation:** N'guessan YAO, Adagba OBODJI2, Olo SIB, Konan Fabrice ASSOUHO and Senan SORO. 2026. "Assessment of damage caused by podagrica decolorata according to the stages of okra (*abelmoschus esculentus*) development in the dry season and rainy season in west-Cote d'Ivoire.". *International Journal of Current Research*, 18, (03), 36460-36463.

#### ABSTRACT

Okra is a vegetable renowned for its nutritional properties. It helps improve the standard of living of rural populations in Côte d'Ivoire. However, okra cultivation faces a major challenge in the form of the pest *Podagrica decolorata*. The aim of this study is therefore to assess the damage caused by *P. decolorata* in both the dry and rainy seasons over two consecutive years with a view to proposing effective control strategies at specific times. Sampling was carried out on 32 central plants, eliminating the plants at the edges. The study revealed that *P. decolorata* attacks all parts of the okra plant, with a preference for the leaves, with an attack rate of up to 100% at the flowering-fruiting stage. The extent of damage to the leaves revealed that in the dry season, the leaves are heavily attacked by *P. decolorata* at the pre-flowering and flower bud stages. The results of this study offer a good perspective in the control of this pest and thus improve okra production in Côte d'Ivoire.

## INTRODUCTION

Okra (*Abelmoschus esculentus*) is a vegetable plant that is widely grown in tropical, subtropical and warm temperate regions (Yildiz *et al.*, 2025). Its annual production worldwide is estimated at nearly 11.5 million tonnes. In Côte d'Ivoire, okra is one of the most widely grown vegetables, with an estimated annual production of 183,000 tonnes (FAOSTAT, 2023). It is a plant that provides products with significant nutritional value, even exceeding that of tomatoes (Kaur *et al.*, 2025). It contains high levels of protein, carbohydrates, vitamins A and C, iron, phosphorus, potassium and magnesium (Nizigiyimana *et al.*, 2022). The fresh or dried leaves and fruits have antidiabetic, antioxidant and anti-hyperlipidaemic effects (Murad *et al.*, 2020). Extracts from young okra pods have moisturising and diuretic properties. Okra seeds have anti-cancer and fungicidal properties (Durazzo *et al.*, 2018). Economically, okra can generate significant income for producers and can help reduce poverty in rural areas. However, climatic factors such as temperature and water, as well as cultivation on small areas, limit the production and marketing of okra (Sawadogo *et al.*, 2009). In addition, okra suffers from numerous attacks that seriously limit its cultivation, the most

well-known of which are insects and diseases (Amiteye *et al.*, 2021). There are several varieties of okra, the most susceptible to fungal diseases being the local varieties. Conversely, the improved varieties are resistant (Tuo *et al.*, 2025). The insects that cause enormous damage to okra crops include defoliators, piercing-sucking insects and vectors of viral diseases (N'guessan *et al.*, 2020). Among the insect pests of okra is *Podagrica decolorata*, a flea beetle that causes enormous damage to okra crops (Soro *et al.*, 2016). These attacks can not only reduce the marketability of the pods, but also affect producer profitability and food security. The objective of this study is to measure the extent of damage according to developmental stages in dry and rainy seasons in order to provide a database for the implementation of integrated pest management strategies.

## MATERIALS AND METHODS

**Presentation of the study area:** This study was conducted on the outskirts of the city of Man, capital of the Tonkpi region located in western Côte d'Ivoire, 578 km from Abidjan, with the following geographical coordinates: 07°20 and 07°35 north latitude; 07°25 and 07°45 west longitude.

**Assessment of damage caused by *Podagrira decolorata*:** The biological material consisted of okra (plant material) and *Podagrira decolorata* (pest). The experimental design used was Fisher's three-block design. Each block consisted of three elementary plots. Each elementary plot contained 60 okra plants. Once a week, one elementary plot was randomly selected per block to assess the damage. Sampling was carried out on 32 central plants, eliminating the plants at the edges. The damage caused to the leaves, flower buds, flowers and fruits by *P. decolorata* was observed according to the phenological stage until the end of the okra cycle each season for two consecutive years. This made it possible to determine the estimated attack rate (as a percentage) by the ratio of the number of organs attacked to the total number of organs visited on the 32 plants in the elementary plot selected per block. The following formula was used to calculate this attack rate.

$$\text{Organ attack rate (\%)} = 100 \times \frac{\text{Number of organs attacked}}{\text{Total number of the organ concerned}}$$

**Assessment of the extent of damage caused to leaves by *Podagrira decolorata*:** The assessment of the extent of damage consisted of first creating a visual scale using the severity index. Each targeted leaf was classified into a severity category. All leaves were counted on the 32 plants inspected and then classified into a leaf damage index category at all phenological stages and in each season over two consecutive years. The severity index was determined to estimate the severity of damage to the plants. The codes for this index are: 1: 0 to 25% damage; 2: 25 to 50% damage; 3: 50 to 75% damage; and 4: 75 to 100% damage. The following formula was used to calculate this attack rate.

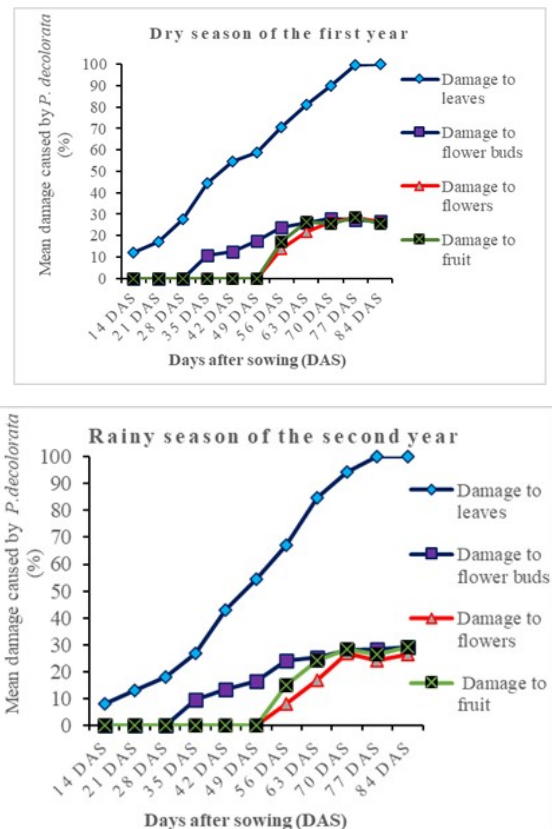
$$\text{Leaf attack rate} = 100 \times \frac{\text{Number of leaf attacked}}{\text{Total number of leaf concerned}}$$

**Statistical data analysis:** The analyses were performed using Statistica software version 7.1 (StatSoft, 2005). This involved analysis of variance (ANOVA) and Fisher's LSD test, which enabled analysis of the damage rates on okra organs and the extent of damage to leaves using the damage severity index. Homogeneous groups were separated based on Fisher's LSD test at a 5% threshold.

## RESULTS

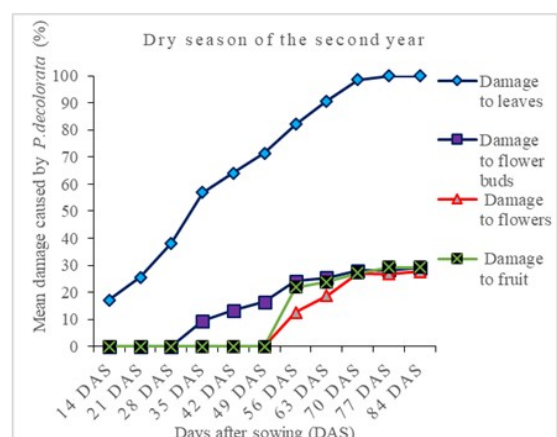
**Impact of *Podagrira decolorata* on okra in dry and rainy seasons (Assessment of damage according to stages of development of the first year):** Damage to reproductive organs (flower buds, flowers and fruits) was around 28% and highly significant ( $p = 0.001$ ). However, this damage was less severe, despite having a direct impact on reproduction and fruiting. The leaves were by far the most attacked organ, reaching a total infestation of 100% regardless of the phenological stage of the okra in the dry season of the first year. The results in the rainy season of the first year show that the intensity of *Podagrira decolorata* attacks varies significantly according to the age of the okra plants, with highly significant differences for all organs studied ( $p = 0.001$ ). The leaves are the most severely affected organ, with an attack rate that increases exponentially from 14 days after sowing (DAS), when it was 17.16%, to 100% at 77 DAS, indicating a strong preference for or vulnerability of the leaves. In contrast, reproductive organs (flower buds, flowers and fruits) showed significantly lower attack rates despite statistically significant variations with age. The maximum

values recorded at 84 DAS remained moderate, around 27 to 29% in the rainy season of the first year (Figure 1).



**Figure 1.** Damage caused by *Podagrira decolorata* according to phenological stages in the dry and rainy seasons of first year

**Impact of *Podagrira decolorata* on okra in dry and rainy seasons (Assessment of damage according to stages of development of the second year):** Okra leaves suffered a high rate of attack by *P. decolorata*, increasing exponentially from  $17.16 \pm 0.44\%$  on the 14th day after sowing to 100% on the 77th day after sowing. Flower buds, flowers and fruits showed low attack rates, with respective maxima of  $29.06 \pm 01.18\%$ ,  $27.63 \pm 1.54\%$  and  $29.20 \pm 0.78\%$  at 84 DAS. Statistical analyses confirm highly significant differences for these organs ( $p = 0.001$ ). Leaves were the most affected, with an exponential increase in attacks reaching 100% on the 84th day after sowing. Statistical analysis revealed highly significant differences between damage rates and okra plant development for all organs studied (leaves, flower buds, flowers and fruits with  $p = 0.001$ ). In contrast, flower buds, flowers and fruits showed lower attack rates ranging from 25.19% to 29.10% (Figure 2).



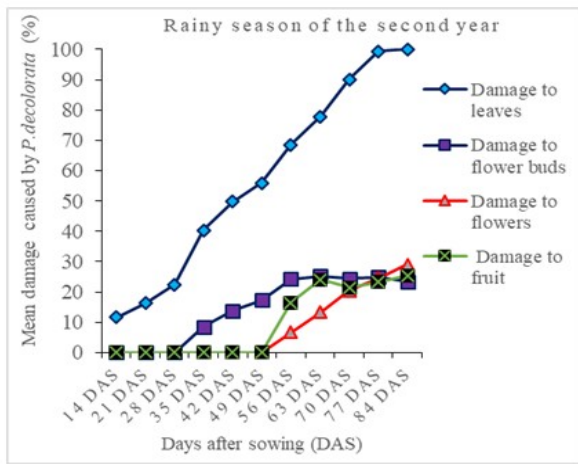


Figure 2. Damage caused by *Podagrica decolorata* according to phenological stages in the dry and rainy seasons of second year

**Extent of damage in the first year:** The study reveals a significant increase in leaf damage during the okra cycle. The percentage of damaged leaves, initially low at 14 DAS (index 1, or approximately 25% of surface area destroyed), gradually increases to reach 100% between 70 and 84 DAS depending on the season in year 1. The leaf damage index reached its maximum value (index 4, corresponding to 75-100% of the surface area destroyed). Statistical analysis highlights highly significant differences between leaf damage indices at different phenological stages ( $p = 0.001$ ), confirming that the intensity of attacks varies greatly depending on the stage of okra development (Table I).

**Extent of damage in the second year:** During the dry season of the second year, the leaf damage index, which was 1 on the 14th day after sowing, reached its maximum value of 4 on the 70th day after sowing. Statistical analysis showed highly significant differences between the leaf damage indices of the different phenological stages ( $p = 0.001$ ). In the rainy season of year 2, the leaf damage index, which was 1 on the 14th day after sowing, reached its maximum value on the 84th day after sowing with an index value of 4 (leaf damage ranging from 75-100%). Statistical analysis indicated highly significant differences between leaf damage indices at different phenological stages ( $p = 0.001$ ) (Table II).

## DISCUSSION

All parts of the okra plant are attacked by *Podagrica decolorata*, with attack rates varying from one part to another. Damage to flower buds, flowers and fruit is less severe than damage to okra leaves. This damage was caused by *P. decolorata* throughout the okra cycle. The results of this study are consistent with those of Ossey (2019), who estimated that attacks on flower buds, flowers and fruits using chewing mouthparts could be explained by the fact that these organs contain the nutrients necessary to satisfy the physiological needs of the pest. However, the leaves suffered high rates of attack at all phenological stages. This could be explained by their nutritional richness. Leaves produce and store the energy necessary for the growth and development of insects. Leaves are also tender, rich in water and easy for these chewing insects to pierce or chew.

Table I. Extent of damage to leaves in the first year

Phenological stage	Days after sowing (DAS)	First year			
		Dry season (%) of damaged leaves on 32 plants		Leaf damage index	Rainy season (%) of damagedleaves on 32 plants
Pre-flowering	14	12.16 ± 2.12h	1d	08.10 ± 2.06i	1d
	21	17.20 ± 2.31h	1d	13.21 ± 2.60h	1d
	28	27.80 ± 2.90g	1.33 ± 0.58cd	18.14 ± 1.41h	1d
	35	44.69 ± 3.31f	1.67 ± 0.58cd	27.06 ± 03.79g	1.67 ± 0.58c
Flower bud	42	54.39 ± 4.77e	2.67 ± 0.58b	42.97 ± 3.31f	2c
	49	58.93 ± 2.75e	2.67 ± 0.58b	54.58 ± 5.14e	2c
	56	70.65 ± 3.63d	3b	67.29 ± 9.77d	3b
Flowering - fruiting	63	81.23 ± 3.54c	3b	84.87 ± 5.56b	3b
	70	89.79 ± 5.16b	3.67 ± 0.58a	94.32 ± 3.84ab	4a
	77	99.66 ± 0.57a	4a	99.92 ± 0.12a	4a
	84	100a	4a	100a	4a
	F	295.57	25.64	136.31	149.8
	DoF	10	10	10	
	p	0.001	0.001	0.001	

NB: In the column, for the parameter, the percentage of damaged leaves and the leaf damage index whose mean values have different letters are statistically different ( $p < 0.05$ ). The letters correspond to the ranks obtained after ranking the percentage of damaged leaves and the leaf damage index. Highly significant:  $p \leq 0.001$ ; p: % probability; F: Fisher's LSD test; df: degrees of freedom; %: percentage

Table III. Extent of damage to leaves in the first year

Phenological stage	Days after sowing (DAS)	Second year			
		Dry season (%) of damaged leaves on 32 plants		Leaf damage index	Rainy season (%) of damaged leaves on 32 plants
Pre-flowering	14	17.16 ± 0.76i	1d	11.62 ± 1.78j	1d
	21	25.55 ± 2.62hi	1d	16.32 ± 1.70i	1d
	28	38.20 ± 3.22g	1d	22.38 ± 1.63h	1d
	35	56.94 ± 8.30e	1.67 ± 0.58cd	40.33 ± 3.52g	1.33 ± 0.58d
Flower bud	42	64.08 ± 6.23d	2c	49.78 ± 2.48f	2c
	49	71.36 ± 7.42c	2c	56.00 ± 1.96e	2c
	56	82.10 ± 8.39b	3b	68.54 ± 3.12d	2.67 ± 0.58b
Flowering - fruiting	63	90.71 ± 3.97ab	3b	77.78 ± 3.87c	2.67 ± 0.58b
	70	98.60 ± 2.43a	4a	90.11 ± 1.92ab	3b
	77	100a	4a	99.37 ± 0.68a	3.67 ± 0.58a
	84	100a	4a	100a	4a
	F	110.40	149.8	580.76	28.75
	DoF	10	10	10	
	p	0.001	0.001	0.001	

Attack rates and leaf damage indices were high in all seasons during the flowering-fruiting stage. This could be explained by the emission of volatile substances by the host plant that attract these flea beetles. The results of this study are similar to those of Honda *et al.* (2010). The abundance of nutrients may also have attracted large numbers of flea beetles during the flowering-fruiting stage. These results are consistent with those of Tano *et al.* (2019), who found that *P. decolorata* remains on the plant as long as it has nutrient reserves and can also serve as shelter. A low number of flea beetles was observed during the pre-flowering phase. This could be explained, on the one hand, by the fact that there were insufficient nutritional resources to attract a large number of flea beetles and, on the other hand, by the fact that their numbers decline in all seasons when the plants senesce and nutritional resources diminish. The low number of flea beetles could be explained by the fact that the host plants on the experimental plots did not have sufficient resources to encourage their proliferation. The results of this study contradict those of Hala *et al.* (2006), who found low numbers of flea beetles during the dry season and during plant senescence. According to these authors, the low numbers, or even absence, of flea beetles during the dry season could be explained by the lack of fresh host plants. The extent of damage to leaves up to 70 days after sowing in the dry season is greater than that observed in the rainy season. This could be explained by a high population of *P. decolorata* due to humidity on the experimental plot. This high level of damage to okra leaves during the dry season could also be explained by the scarcity of host plants. Intermittent rainfall during the rainy season prevents rapid growth of the flea beetle population. This is due, on the one hand, to the washing away of eggs and larvae that are in the soil or at the base of the seedlings. Increased humidity could also slow down the growth of flea beetle populations, caused by a slowdown in the activity of their reproductive organs.

## CONCLUSION

Our study shows that damage assessment based on the phenological stages of okra revealed that *Podagrica decolorata* is very harmful during the flowering and fruiting stages. This allows for optimised control at this stage, enabling action to be taken at the precise moment and better control of these pests. This study showed that okra leaves are the most prized parts of the plant. This allows control measures to be focused on the target parts. Damage is more severe in the dry season than in the rainy season. This is important for adapting cultivation practices in order to adjust sowing dates.

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