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INTENSIFICATION CAPACITY DEFENSIVE OF LAGENARIA SICERARIA (MOLINA) STANDLEY (CUCURBITACEAE) SENSITIVE ACCESSIONS TO INSECT PESTS BY THE PROVISION OF ORGANIC FERTILIZER

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Abstract:
Lagenaria siceraria (Molina) Standley is cultivated mainly for its oil-rich seeds and high nutrition value. However, production of L. siceraria is characterized by low yields, mainly due to beetle foliar damage. The evaluation of foliar damage on different accessions was based on Proportion of Damage Foliar (PDF) and Severity of Damage (SeDa). Of all accessions, only NI431 was a proportion of leaves destroyed below 50%. Leaf surface damage for this accession was less than 25%. In contrast, NI227, NI219 and NI180 were characterized by more than 80% of the attacked leaves. The use of cattle droppings significantly reduced the number of leaves destroyed and the extent of damage in the NI227. Beef droppings also improved the yield of the plants of NI227. The difference in yield for NI227 between the two treatments (fertilized and unfertilized) was 33.53%. These results showed that it is possible to improve the productivity of NI227 through the use of organic manure. In contrast to NI227, Severity of the Damage was the same for both NI431 accession treatments. This result showed that NI431 accession would be tolerant of insect pest and that this tolerance is related to genetic and non-nutritional factors of the soil.

Keywords: Organic manure; Lagenaria siceraria; insect damage; Proportion of Damage Foliar; Severity of Damage.

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1. Introduction

Countries in sub-Saharan Africa are characterized by insufficient food production to food security objectives. One of the causes of low production is related to diseases and especially to insects pests

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observed on cultivated plants [1]. Several authors have shown a linear relationship between the insect damage to varieties and yield reduction [2] and [3].

With regard to cucurbits, the decline in production due to insect pests is widely reported in the literature. The fly, *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae) causes on *Cucumis melo* L. decrease of production range from 30 to 100% [4]. It is also noted a yield reduction up to 50% of cucumber, *Cucumis sativus* L. (Cucurbitaceae) in Senegal due to *Didacus spp* (Diptera: Tephritidae) [5].

The supply of markets to *L. siceraria* seems insufficient in view of the potential need of consumers despite its socio-economic importance and the nutritional quality of the oilseed variety [6]. In Côte d'Ivoire, many studies have shown that the average yield of *L. siceraria* remains low in production areas [7]. This was made in the sub region, particularly in Benin where the number of fruits per plant does not exceed three [8]. Studies carried out on the entomofauna of *L. siceraria* have shown that the main cause of less production of this plant is caused to defoliating insects [9]. Therefore, it is necessary to control insects in order to increase the yield of *L. siceraria*. The control method commonly used is the use of chemical insecticides.

But in some cases, chemicals insecticides would pollute soil and water. On other hand, it’s often unattainable for rural population because it’s too expensive. In addition, under constant insecticide pressure, insect pests often develop resistance [10] and [11]. In this context, the use of resistant cultivars is the best alternative [12].

The low durability of resistance related to the adaptation of new pathogens reinforces the need to propose solutions to improve resistance management. One of them is to give plants the means to defend themselves, or strengthen their own defenses, rather than directly fighting the pests.

So, many authors including [13] propose preventive control by adopting appropriate cultural practices. Indeed, several studies have shown that the ability of plants to resist pests is related to the optimization of physical, chemical and especially biological properties of soils [14]. Also, organic fertilization can improve insect resistance according to several authors on various plants [13] and [14].

The purpose is to estimate the effect of organic fertilization on the vigor of plants susceptible to insect damage and which could thus improve resistance of these plants. We therefore proposed to conduct an experiment to first identify the accessions with significant foliar damage and then evaluate the effect of organic fertilization on intensity of the damage insect pests of these accessions.

2. Materials and Method

2.1. Study Site

We conducted our experiments in Manfla located at 400 km north of Abidjan (Cote d’Ivoire) in 2008 and 2009. This locality is characterized by production of *Lagenaria siceraria.* The mean monthly (March–June for the first cropping in 2008) was 138.88 mm. In second cropping season

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(July–December), the mean monthly rainfall was 76.91 mm. In 2009, it was 100.13 mm. The mean monthly temperature was respectively 32°C, 31°C and 32°C for the first, second and third cropping cycle.

2.2. Plant Material and Experimental Design

Nineteen accessions were used for the first experiment on a plot of 50 m x 30 m. These accessions were selected from the collection of the University Nangui Abrogoua (Abidjan, Côte d'Ivoire). The collection of *L. siceraria* and their sites are shown in **Table 1**. Seedlings were made according to a randomized complete block. Each accession is being represented by 5 plants. The planting distance was 3 m between and within rows with 1,5 m of edges. Three seeds were sown by hole and thinned to the lifting. Manual weeding was carried out during plant developpement. Two of the nineteen accessions will be selected based on the foliar insect damage for the second experiment. This one was carried out on a plot of 768 m2 (32 m x 24 m). The plot was subdivided into four subplots of 96 m2 (8m x 12m). Seeds of each accession were sown on each sub-plot with or without beef droppings (**Figure 1**).

Table 1: Collection area of *Lagenaria siceraria* accessions

Accessions	**Locality**	**Collection area**
NI219	Alépé	South
NI227	Alépé	South
NI252	Alépé	South
NI180	Bongouanou	Southeast
NI174	Bongouanou	Southeast
NI185	Bongouanou	Southeast
NI354	Bondoukou	East
NI359	Bondoukou	East
NI347	Bondoukou	East
NI304	Bondoukou	East
NI106	Gohitafla	Centre
NI421	Mankono	North
NI420	Mankono	North
NI425	Ouangolo	North
NI429	Ouangolo	North
NI430	Niéllé	North
NI431	Niéllé	North
NI432	Ouangolo	North
NI434	Ouangolo	North

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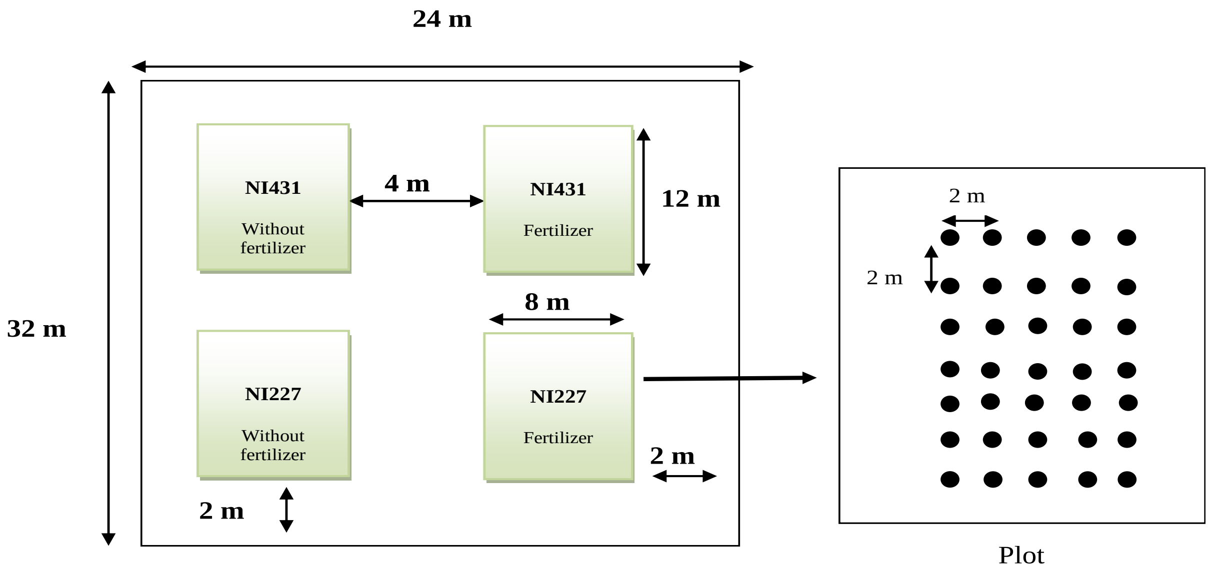

Figure 1: Experimental design of seedling

2.3. Evaluation of Proportion and Severity Foliar Damage on Accessions

The nineteen accessions were classified according to a visual diagnosis based on foliar damage. Proportion of Damage Leaf (PDF) and Severity of the Damage (SeDa) caused by beetles were assessed during the vegetative stage of the plant.

Proportion of Damage Leaf (PDF) was calculated using the following formula:

$$PDF = \frac{\text{nLD}}{\text{nLt}} \text{x } 100$$

nLD: number of Leaves Damage by beetles; nLt: number of Total Leaves of a plant.

The accessions were classified according to a visual diagnosis based on observations of insect damage on leaves. Severity of damage (SeDa) was evaluated by assigning a score to each plant. The rating ranges from 1 to 5. So, 1 is used to plants which are more than half of the leaves from 1 to 25% of leaf area destroyed. Plants which have 26 to 50% of the surface leaf destroyed for more than half of the leaves have the score 2. The scores 3 and 4 are assigned to plants with more than half of leaves from 51 to 75 and 76% to 100% leaf area destroyed respectively. Finally score 5 is reserved for plants died because of insect damages.

The two accessions based on the level of fairly contrasting foliar damage will be used to evaluate their reactions to insects in presence of organic manure.

2.4. Impact of Organic Manure on Foliar Damage on The Two Accessions

The organic manure used is represented by beef droppings. The use of beef droppings is linked to their richness in nutrients [18] and their ability to raise the water retention necessary for the development of plants and microorganisms [19] and [20].

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The quantity of dry matter per unit area was 2.5 kg, which corresponds to 22.104 t/ha of fertilizer [21]. The manure was deposited on the determined surface and then mixed with the soil with a hoe at a depth of 10 to 15 cm before sowing. Spreading was done on the same day for all sowing points. The Number of Fruit per Plant (NbFp) and the Seed Weight per fruit (SW) were evaluated.

To this, is added the Yield per Plant (YP) which represents the weight of the seeds of a plant, calculated according to the following formula:

$$YP = SW \times NbFp$$

Yield Gain (YG) represented the difference in yield between the different treatments applied to an accession. It was determined according to the formula:

$$YP = \frac{YPM - YPC}{YPC} \times 100$$

YPM: Yield of the plot with manure; YPC: Yield of the control plot

2.5. Statistical Analysis

One-way Variance of Analysis (ANOVA 1) was used to compare the level of foliar damage accessions (PDF and SeDa) for each cropping cycle. When there were significant differences between accessions, means were separated using the Student Newman Keul Test (SNK).

In order to evaluate impact of organic manure on agronomic parameters of *L. siceraria* Student's *t* test was also used. All tests were performed using the SAS version 9.1 [22].

3. Result

3.1. Evaluation of Proportion and Severity Foliar Damage on Accessions

Comparison of accessions within each cropping cycle using Analysis test indicated that there was a significant difference between accessions for all cropping cycles **(Table 2)**.

NI227, NI219, and NI180 accessions were proportion damage foliar greater than 80% at first, second, and third cropping cycles. However NI185, NI174, NI252, NI354, NI421 and NI429 accessions exceeded this threshold only at the third cropping cycles. In contrast, only NI431 accession was proportion damage foliar below 50% during the three cropping cycles.

Table 2: Mean values of Proportion Damage Foliar (PDF) and Severity of Damage (SeDa) per cropping cycle

Accessions	Phyllophagous damage on Lagenaria siceraria					
	First cropping cycle		Second cropping cycle		Third cropping cycle	
	PDF	SeDa	PDF	SeDa	PDF	SeDa
NI252	75.426±9.265b	3.666±0.577b	65.443±7.760fgh	3.000±0.000c	90.883±1.247ab	3.333±0.577c
NI219	93.203±1.114a	5.000±0.000a	94.353±1.369a	5.000±0.000a	93.077±8.471a	4.750±0.500ab
NI185	68.200±6.116bcd	3.000±0.000c	64.746±8.083gh	3.000±0.000c	82.123±0.272abc	3.000±0.000c
NI174	75.716±6.806b	3.666±0.577b	60.217±9.988h	3.000±0.000c	89.026±4.992ab	4.000±0.000bc
NI106	64.060±6.715cd	2.333±0.577d	66.960±8.062fgh	3.000±0.000c	-	-

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NI227	94.07±1.14a	5.00±0.00a	90.01±1.30ab	4.66±0.57a	93.04±6.52a	4.750±0.500b
NI304	72.373±6.940bc	2.000±0.000d	58.560±13.269h	2.000±0.000e	77.183±15.449abc	3.000±1.000c
NI347	61.150±12.198de	2.000±0.000d	59.363±9.189h	2.000±0.000e	72.407±15.406bc	3.250±0.500c
NI354	52.963±2.710ef	1.333±0.577e	61.900±8.031h	1.250±0.500fg	82.250±10.196abc	4.000±1.000bc
NI180	94.986±1.806a	5.000±0.000a	88.003±2.769abc	5.000±0.000a	82.345±2.149abc	5.000±0.000a
NI359	75.203±5.348b	2.333±0.577d	56.992±3.429h	2.000±0.000e	65.350±16.016cd	2.666±0.577c
NI420	77.070±7.259b	2.666±0.577d	78.516±5.080bcde	2.333±0.577de	43.253±4.890d	1.666±0.577d
NI421	69.783±3.22bcd	2.333±0.577d	74.816±5.635defg	3.000±0.000c	81.820±2.722abc	3.000±0.000c
NI425	69.513±1.890bcd	2.000±0.000d	68.970±2.763efg	3.000±0.000c	63.773±17.419cd	2.666±0.577c
NI429	69.703±8.575bcd	2.000±0.000d	75.676±5.554defg	3.000±0.000c	82.486±1.226abc	3.000±1.000c
NI430	75.376±6.272b	2.000±0.000d	83.010±9.880abcd	3.000±0.000b	82.383±2.614abc	3.000±0.000c
NI431	44.946±3.015f	1.000±0.000e	42.806±3.029i	1.000±0.000g	48.097±1.378d	1.500±0.577d
NI432	69.420±13.508bcd	1.333±0.577e	61.556±0.642h	1.333±0.577fg	76.963±16.383abc	3.000±0.000c
NI434	69.406±5.007bcd	2.000±0.000d	76.686±8.631cdef	1.666±0.577ef	73.226±6.864bc	3.000±0.000c
F	10.640	32.990	10.910	51.180	3.210	9.070
P	<0.001	<0.001	<0.001	<0.001	0.002	0.001

: absent

The degree of severity on leaves estimated on different accessions of *Lagenaria siceraria* over the three cropping cycles varied from 1 to 5. NI431 and NI432 were less 25% of leaf area destroyed respectively for all cropping cycle and the two cropping cycle.

On the other side, the degree of damage of NI80, NI227 and NI219 presented more than 75% to the three cropping cycles. And finally, the 13 other accessions presented between 25 and 75% of leaf area destroyed **(Table 2).**

3.2. Effect of Organic Manure on Foliar Damage Intensity of NI227 and NI431

A significant difference was observed between the treatments for the two accessions NI227 and NI431 to Proportion Damage Foliar. For both accessions, the proportion damage leaf was greater on the non-fertilized plots. In contrast, a significant difference was observed only in the NI227 accession (P <0.001) for the Severity of Damage **(Table 3)**. The extent of foliar damage was lower on the fertilized plots.

Table 3: Evaluation of leaves damage of NI227 and NI431

Parameters		**Fertilizer application**		***t***	**ANOVA results**
	Accessions	**Treated**	**Untreated**		***P***
PDF	NI227	86.62±5.67	94.12±3.81	8.103	<0.001
	NI431	72.82±11.40	79.31±7.62	18.60	<0.001
SeDa	NI227	2.32±0.67	3.72±0.65	25.08	<0.001
	NI431	1.17±0.38	1.035±0.18	7.56	0.55

3.3. Impact of Organic Manure on Yield Parameters

The Student's *t* test between the manure plots and the controls revealed that a significant difference was observed for the yield per plant the NI227 accession. The yield was higher on manure plots. In contrast to NI227, the yield per plant of NI431 was identical between manure-treated plots and the controls revealed. Also, mean values of Fruit Number (NbFp). Fruit Weight (FW) and Seed Weight (SW) were higher on the fertilized plot for NI227 accession. These three parameters are statistically identical on both treatments for the NI431 accession (**Table 4**). The yield gain

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comparison between the plot treated and the untreated plot was 33.53% for the NI227 accession while it was only 0.78% for NI431.

Table 4: Incidence of fertilizer input on NI227 and NI431 accessions performance parameters

Accessions	**Parameters**	**Fertilizer application**		**Statistics**	
		Treated	**Untreated**	***t***	***P***
NI227	**NbFp**	2.42±0.96	1.72±0.65	9.02	0.004
	FW (g)	791.12±202.34	645.12±220.79	5.36	0.025
	SW (g)	31.06±9.11	21.40±5.02	22.40	<0.001
	ReP (g)	75.16±30.14	37.15±19.33	24.81	<0.001
	YP (kg/ha)	49.609	37.153	-	-
	YG (%)	33.51			
NI431	**NbFp**	1.00±0	1.31±0	0.03	0.713
	FW (g)	2101.47±895.21	2203.85±1046.39	0.17	0.685
	SW (g)	54.63±18.93	54.20±23.31	0.01	0.938
	ReP (g)	54.63±18.93	54.20±23.31	0.01	0.938
	YP (kg/ha)	64.49	63.99	-	-
	YG (%)	0.78	-	-	

4. Discussion

Capacity defensive of *L. siceraria* was the start on program of the defense mechanism to pests. Visual leaf damage used to evaluate reaction of *L. siceraria* accessions to insects in this study was also used to others [23] and [24]. A wide range of reaction to insects was observed at all plants screened. Three groups of accessions were formed based on the reaction of these accessions to insect pests. In fact, Proportion of Damage Leaf and Severity of the Damage are more increased for the first group such as NI227, NI219 and NI180. NI431 is the only accession to the second group with a low foliar damage. The 15 other accessions were an intermediate reaction to damage insects. Indeed, herbivorous insects preferred leave of the accessions of the first group more than those of the other two groups. Similar observations have been reported by [25]. These authors attested that only any genotypes of *Cucurbita pepo* were preferred by beetles. In this experiment an emphasis was placed on leaf morphology in order to explain the results obtained. Observations on leaf size during the three cropping cycles revealed that NI431 accession was large leaves unlike NI227 and NI219 [26]. The leaf size was also used by [27] to evaluate the resistance of three species of Cucurbitaceae to *Cerotoma trifurcata.*

NI227 and NI431 accessions with contrasting foliar damage levels were used to evaluate the effect of organic manure on the intensity of insect damage. Indeed certain environmental factors such as soil fertility affect reaction of plants to insects. Beef droppings significantly decreased Proportion of Damage Leaf and the Severity of Damage of NI227. Cattle manure fertilizer reduced leaf damage of NI227. Similar results have been observed in Guatemala by [28] at *Cucurbita maxima* and *Cucurbita pepo* after using chicken manure fertilizer. In fact, the organic fertilization increased the microbial activity of soil and gradually released nutrients to plants and this caused a good reaction of these plants to damage insects.

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Contrarily to NI227, Leaf Damage Severity was the same for both NI431 accession treatments. Cattle manure fertilizer did not seem to play any role in the extent of foliar damage to NI431. This result confirmed the idea that NI431 accession would be tolerant of insect pest and that this tolerance is related to genetic and non-nutritional factors of soil. In fact, genes have been identified as positive plant defense regulators to pests in tomatoes [29], maize [30], chilli [31] and in rice [32]. The search for genes involved in the variation of tolerance to NI431 to insect damage would be necessary. Cattle manure fertilizer also improved the yield of NI227. On the other hand the yield per plant of NI431 accession plants from the manure plots from the non-fertilized plots was identical. The difference yield of NI227 between the two treatments (fertilized and unfertilized) was 33.53%. These results showed that it is possible to improve the productivity of NI227 accession through the use of organic manure. Numerous studies carried out on various plants have shown the beneficial effect of the organic manure input on the production of crops such as sorghum in Burkina [33], cassava in Côte d'Ivoire [34] and potatoes in Rwanda [35]. The improvement in the yield of NI227 would be attributed to cattle manure fertilizer on the improvement of the physical and biological conditions of the soil. Beef droppings could be used as fertilizer in a program to increase the yield of this accession.

5. Conclusion

During the three-cropping cycle, NI180, NI227 and NI219 were regularly destroyed (75%). The results showed that only one accession NI431 during the three cropping cycles showed less than 25% of the leaf area destroyed. The study also showed that organic fertilizer input improves yield and reduces foliar damage in NI227. Thus, organic fertilization has emerged as an effective means of controlling insect damage of *L. siceraria* susceptible accessions.

Further studies have been necessary to determine whether the tolerance of NI431 to insect is controlled by genetic effects.

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