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Evaluation of the Maize - *False basil* Cultural Association in the Fight against the Fall Armyworm *Spodoptera frugiperda* (Lepidoptera: Noctuidae)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In Ivory Coast, maize (*Zea mays* L.) is the second most cultivated cereal after rice. Despite this, maize cultivation is limited by pest pressures. Apart from the usual pests, a new enemy has arrived on the continent, the fall armyworm, *Spodoptera frugiperda*. To control this pest, farmers use pesticides, which are not only expensive, but also pose risks to human health and the environment. The objective of this study is to find an alternative solution to chemical control through the cultivation of maize-*Ocimum gratissimum* (False basil) in two ways. The first consisted in planting *False basil* around the maize plot as a barrier plant (P_1). The second consisted of alternating maize plants with *False basil* plants (P_2). The experimental design used was a one-factor randomized FISHER block with three treatments. The efficacy of the two association modalities was compared to that of control which was maize crop only. The results showed better control of fall armyworm in the combination than control. Of the two combination treatments, it was the P_1 treatment that was effective against *S. frugiperda* compared to the P_2 treatment and the control. Thus the infestation rate of treatment P_1 (33 %) was lower than that of treatment P_2 (50 %) followed by the control (70 %). In addition, it was the P_1 treatment that harbored fewer armyworms (8 larvae) compared to the P_2 treatment (22 larvae) and the control (35 larvae). The maize-*False basil* crop combination therefore appears to be beneficial than pure crops as it significantly reduces the infestation rate, damage level and harbors less fall armyworm population.

Keywords: Cultural association; fall armyworm; maize (Zea mays L.); Ocimum gratissimum (False basil); Spodoptera frugiperda.

1. INTRODUCTION

In Côte d'Ivoire, the cultivation of maize (*Zea mays L.*), originally concentrated in the north, has extended to the entire national territory for around thirty years. Maize is the second most cultivated cereal in the country after rice [1]. The area of maize cultivation is estimated in Côte d'Ivoire at nearly 350 000 ha with an average annual production estimated at 600 000 ton, 60 % of which is provided by the savanna region with a yield of 1.9 ton per hectare [2]. Maize is the staple food of many Ivorians, especially those in the north. It is also used in animal feed [3].

Despite the importance of maize in the country, its cultivation is increasingly threatened by the introduction of a new pest to the African continent in 2016 [4]. In Côte d'Ivoire, it was reported in October 2016 by maize producers in the center of the country [5]. The fall armyworm, *Spodoptera frugiperda* is a polyphagous pest with over 80 host plant species [6] causing considerable economic damage to crops such as maize, sorghum, rice, cotton, etc. In Africa, the pest prefers maize more. It feeds on the young leaves of whorls, ears and even male flowers, which seriously limits maize yield [7]. To combat this pest, farmers use chemical pesticides, which are not only expensive but pose risks to human health and environment.

Studies have shown that combining maize with other crops reduces pest infestation [8,9]. The use of the cultural association to prevent or reduce the infestation of *S. frugiperda* on maize is well documented both in Africa [10,11] and in other regions of the world [7]. Therefore, crop association constitutes a promising avenue for the sustainable management of the fall armyworm. The objective of this study is to find an alternative solution to chemical control through the maize – *False basil* cultural association.

2. MATERIALS AND METHODS

2.1 Plant Materials

The plant material consists of a variety of maize (improved seed) whose commercial name is N'GUOACHIA and Ocimum gratissimum (*False basil).*

2.2 Study Site

The study was carried out on an experimental plot within the botanical garden of the Peleforo GON COULIBALY University of Korhogo. The locality belongs to the dry tropical climate regime of the Sudano-Sahelian type whose rhythm of seasons is regulated by the movement of the Intertropical Front [12]. The average annual rainfall varies between 1100 mm and 1600 mm and the annual temperature varies between 25 and 35°C [13]. The soil is moderately desaturated ferralitic with shrub savanna type vegetation.

2.3 Setting up and Maintaining the Test

The experimental design was a single-factor randomized FISCHER block with 3 repetitions, therefore 3 blocks. Each block measures 15.35 m in length and 4 m in width and the distance between each block is 3 m. Each block contains 3 elementary plots, each elementary plot measuring 3.75 m in length by 3 m in width (i.e. an area of 11.25 m²) and contains 20 plants. Each elementary plot corresponds to a treatment and each block contains a total of 60 plants. Each elementary plot contains 5 lines of plants and each line contains 4 pockets. The distance between each line is 75 cm (0.75 m) and the distance between each pocket is 50 cm (0.50 m). Three treatments were carried out:

P_1: treatment where *False basil* constitutes a barrier around the maize. For this, a row of *False basil* was planted around the maize plot.

P_2: treatment where maize stalks alternate with *False basil*

T: control containing only maize plants.

False basil plants obtained in the nursery and two weeks old were transplanted to the elementary plots depending on the treatment. Two weeks after transplanting, maize sowing was carried out at a rate of 3 grains per pocket with a depth of 3 to 5 cm. A first weeding took place 15 days after sowing and manual weeding was carried out for the maize and made it possible to maintain one plant per pocket after emergence. Maintenance work was undertaken as necessary following field observations. The maize plants were fertilized with synthetic fertilizers at a dose of 200 kg / ha of NPK 15 - 15 - 15 and 100 kg / ha of urea respectively 15 and 45 days after sowing. A weeding operation was carried out at the same time as the spreading of urea in order to support the plants against the wind and keep humidity at the base of the plants.

2.4 Collection of Data

Observations were made on maize plants and focused on the search for clusters of eggs, live larvae or fresh droppings. Therefore, maize plants are inspected by observing the different parts, mainly the upper and lower surfaces of the leaves, the whorl and the ears. The foliar damage caused by the caterpillar is evaluated on the maize plants per elementary plot every two days from the 30th day after sowing until the maize matures. The data collected made it possible to determine: Number of live fall armyworm larvae, rate of infestation of maize plants by the fall armyworm and fall armyworm damage level.

2.4.1 Number of live fall armyworm larvae

The number of live larvae and egg masses was counted in each elementary plot. Counting was done according to the length of the stem, leaves and ears. During our observations, we mechanically destroyed the clusters of eggs and live larvae observed in order to avoid their propagation throughout the experimental plot.

2.4.2 Rate of infestation of maize plants by the fall armyworm

A plant is considered infested when we notice the presence of clusters of eggs, live larvae, fresh droppings and / or characteristic damage on the plant. Thus, per elementary plot, the infestation rate was calculated in relation to the plants surveyed. This rate was determined according to the formula:

Infestation rate = (Number of infested plants / Total number of plants) X 100

2.4.3 Fall armyworm damage level

The damage estimate was made only on leaves and ears. To do this, the percentage of attacked leaves relative to the total number of leaves per plant was calculated. A leaf was considered infested when characteristic damage was observed on the leaf. The level of leaf damage was calculated using the following formula:

Damage level = (Number of infested leaves / Total number of leaves per plant) X 100

Furthermore, the percentage of infected ears compared to the total number of ears harvested was calculated. An ear was considered infested if live larvae were present on the ear. The level of damage to the ears was calculated according to the following formula:

Damage level = (Number of infested ears / Total number of ears harvested) X 100

2.5 Statistical Analyzes

The results were analyzed using Microsoft Office Excel and Statistica 7.1 software. Microsoft

Office Excel was used to calculate percentages and graph representation. As for the Statistica software, it was used to calculate the average numbers of live larvae, the infestation rate and the level of fall armyworm damage in the experimental plot.

3. RESULTS AND DISCUSSION

3.1 RESULTS

3.1.1 Effect of treatments on the number of live larvae of *S. frugiperda*

Fig. 1, shows the number of live *S. frugiperda* larvae per treatment. The number of live larvae varies from 8 to 35 larvae depending on the treatments. The highest number is noted on the control plot (35 larvae), followed by treatment P_2 where the maize plants alternate with *False basil* (22 larvae) and treatment P_1 where *False basil* constitutes a barrier around maize (8 larvae). The lowest value of the number of live larvae was observed at treatment P_1 (8 larvae). Furthermore, no larvae were observed on *False basil* plants.

3.1.2 Effect of treatments on the rate of infestation of maize plants by *S. frugiperda*

Fig. 2, shows the infestation rate according to the treatments. This rate varied from 33% to 70% depending on the treatments. The highest infestation rate was recorded on the control plot (70 %), followed by treatment P_2 (50 %) and treatment P_1 (33 %). The lowest rate was recorded in treatment P_1 (33 %). No infestation was observed on *False basil* plants.

3.1.3 Effect of treatments on the level of damage of *S. frugiperda*

Fig. 3, shows the level of leaf damage depending on the treatments. The proportion varied from 25% to 58% depending on the treatments. The highest level of damage was observed in the control plot (58%), followed by treatment P_2 (42%) and treatment P_1 (25%). The lowest level of damage was observed by treatment P_1 (25%).

The level of damage to the harvested ears according to the treatments was presented in Fig. 4. The level of damage to the harvested ears varied from 44% to 68% depending on the treatments. The highest proportion was recorded at the control plot (68%), followed by treatment P_2 (53%) and treatment P_1 (44%). The lowest value was recorded at treatment P_1 (44%). It was observed that the ears were more attacked by the fall armyworm compared to the leaves. There was no damage to *False basil* plants.

3.2 Discussion

The results showed a reduction in the number of live larvae, infestation rate and damage level in the intercropping system compared to the control. This reduction can be explained

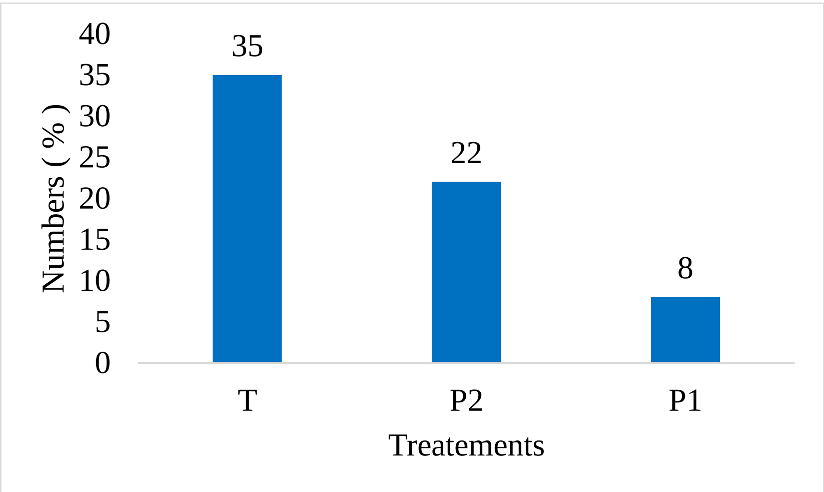

Fig. 1. Number of live *S. frugiperda* larvae per treatment
P1: treatment where false basil constitutes a barrier around the maize
P2: treatment where maize plants alternate with false basil
T: control containing only maize plants

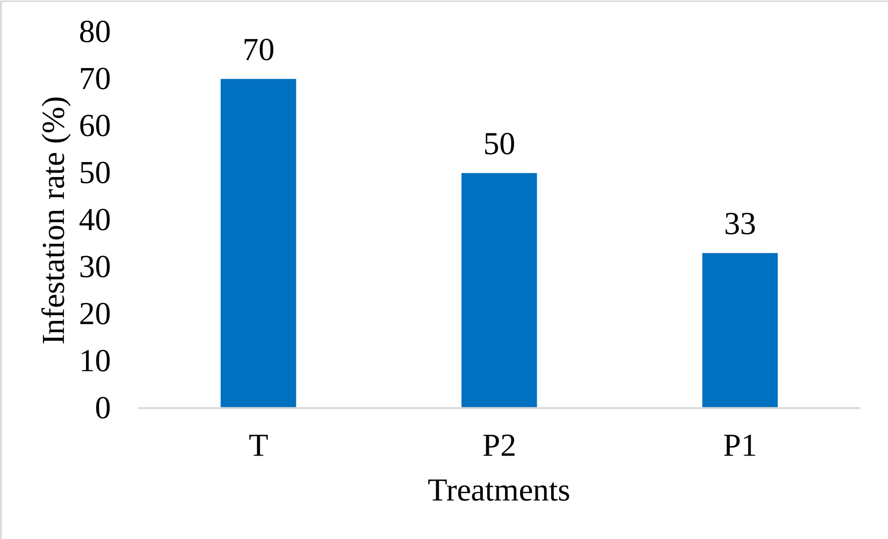

Fig. 2. Infestation rate according to treatments
P1: treatment where False basil constitutes a barrier around the maize
P2: treatment where maize plants alternate with False basil
T: control containing only maize plants

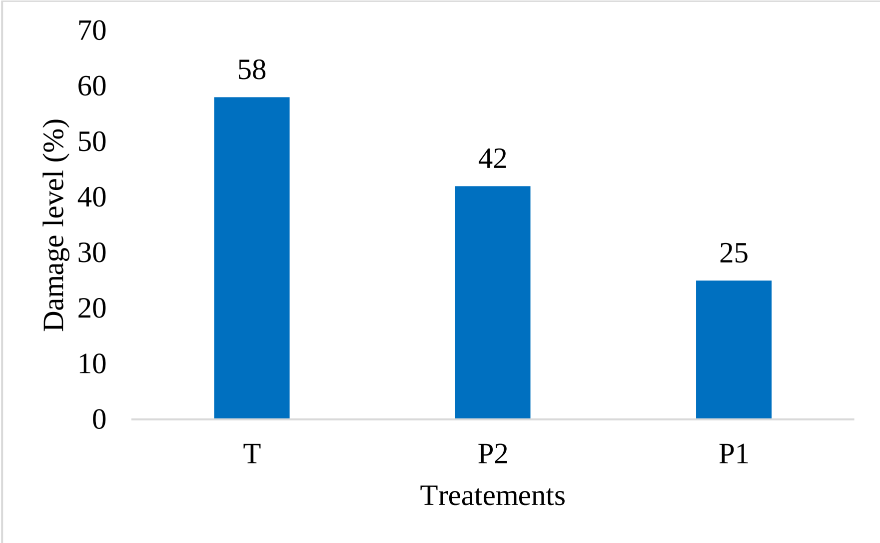

Fig. 3. Level of leaf damage depending on treatments
P1: treatment where False basil constitutes a barrier around the maize
P2: treatment where maize plants alternate with False basil
T: control containing only maize plants

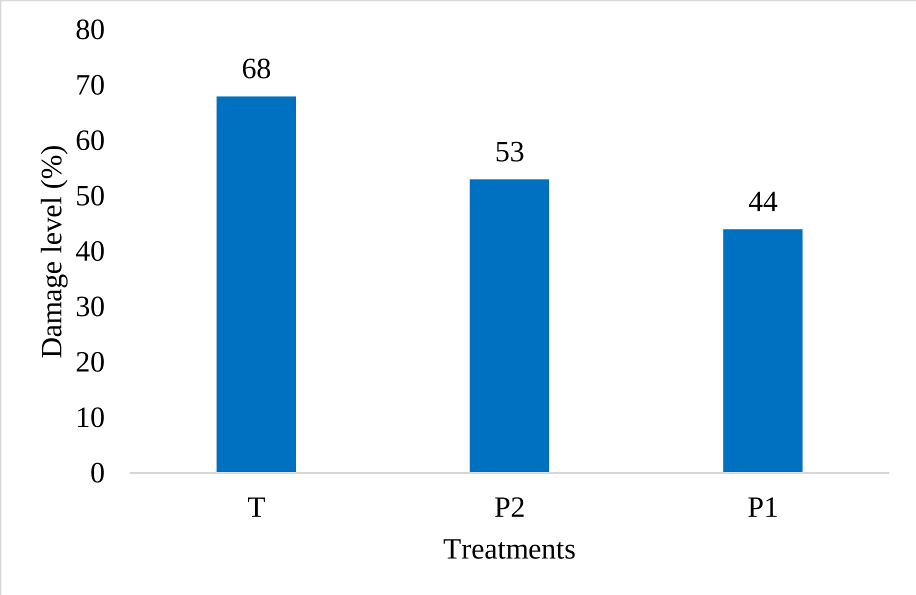

Fig. 4. Level of damage of harvested ears according to treatments

P1: treatment where False basil constitutes a barrier around the maize
P2: treatment where maize plants alternate with False basil
T: control containing only maize plants

according to Tchegueni et al. [14] by the fact that the association of crops offers various species which hide the host plant. These results are similar to those of Midega et al. [10] and [11]. Indeed, [10] showed an effective reduction in fall armyworm infestation and damage levels on maize using the push-pull system in some East African countries. Furthermore [11] showed that the intercropping of beans and maize reduced the rate of infestation by the fall armyworm.

The analysis of the effect of the treatments on the number of *S. frugiperda* larvae showed that the combination treatments made it possible to reduce the pest population compared to the control. This low number of larvae in the crop association treatments could be explained by the fact that the crop combined with maize, *False basil*, constitutes a chemical barrier. Indeed, the odor of the associated *False basil* could disrupt the attraction of *S. frugiperda* for maize, reducing the activity of *S. frugiperda* at the time of egg laying. These results confirm those obtained by studies carried out on the repellent effect of *Ocimum Spp*. against pests in associated crop plots. Indeed [15] proved that the intercropping of *False basil* with cabbage reduces the populations of cabbage pests in the association plots compared to the control. Houadakpode et al. [16] also showed that plots of nightshade associated with *Ocimum basilicum* harbored fewer pests overall than controls. The repellent effect of aromatic plants on insects is generally attributed to their volatile organic compounds [17]. Indeed, the volatile organic compounds emitted by aromatic plants greatly influence the process of localization of host plants by pests according to certain authors [18,19]. Furthermore, several studies have shown the repellent effect of aromatic plants, notably Ocimum species, on various arthropods [20-22].

Furthermore, there were no larvae on the *False basil* plants, which confirms the hypothesis according to which maize is the host plant par excellence for the fall armyworm [23].

Regarding the infestation rate, the results showed a low infestation rate in the associated crop plots compared to the control, particularly for treatment P_1 where *False basil* constituted a barrier. This could be explained by the phenomenon of obstruction of *False basil* plants which, thanks to their biomass and their odor, constitute a screen against the movement of first stage larvae, which are often mobile and move from one maize plant to another under the action of the wind thanks to their silks [14]. Similar results were obtained by [24,25] in a maize-bean association system on the same pest. The low infestation rate in the associated plots would also be due to the reduced population of larvae in these plots.

Furthermore, a low level of damage was observed on the leaves and ears of maize plants in intercropping than in pure maize cultivation. This is explained by the fact that in plots of associated crops, the extent of damage is strongly influenced by the repellent effect of *False basil* plants on the pest. Indeed, the volatile organic compounds emitted by this aromatic plant greatly influence the process of localization of host plants by pests [18]; [19]. These results are in agreement with those of [26], which according to him, *Hellula undalis* Fabricius causes less damage to cabbage when the cabbage is grown in association with pepper or onion. Furthermore, the reduced larva population and the low infestation rate in the associated plots could also justify the low level of damage observed in these plots. Indeed, the larvae constitute the voracious development stage of the Fall armyworm (FAW), so the more numerous they are in a plot, the more severe the attack.

4. CONCLUSION

The present study was carried out with the aim of contributing to the sustainable management of the armyworm through cultural methods. At the end of this study, it appears that the maize - *False basil* crop combination is effective in controlling *S. frugiperda* and reducing its damage on maize compared to the control. Precisely, the association where *False basil* constitutes a barrier around maize plants. This type of association can be considered as a sustainable management strategy for *S. frugiperda* in the maize fields in Côte d'Ivoire. Taking this conclusion into account, work could be carried out to associate the practice of the aqueous extract of *False basil* with the cultural association to evaluate its effect on *S. frugiperda*.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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