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Impact of Pearl Millet Farming on the Incidence of *Heliocheilus albipunctella* Joannisin Bambey Area (Senegal)

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ABSTRACT

In Senegal, *Heliocheilus albipunctella* is a real threat to the production of pearl millet with grain losses ranging from 13 to 100% during the years of heavy proliferation. After highlighting the diversity of millet farming practices in rural areas, the objective of this study is to assess their effects on the incidence of head miner *Heliocheilus albipunctella* in Bambey. To do this, agronomic surveys and entomological observations were carried out in 2015 and 2016 in 45 plots of millet selected after processing satellite images. The results revealed a great diversity of peasant cultural operations and an inadequacy of some of these practices compared to research recommendations (low fallow practice (2%), strong application of a surface preparation of the soil (71 to 100 %), distribute insufficient organic and mineral fertilization (22 and 27%)). This trend could explain the high incidence of the pest in the area (the respective infestation rates for eggs and larvae are 40 and 76% in 2015 and 50 and 73% in 2016). Contributions of knowledge and external techniques well adapted to the concrete situations of rural people are therefore necessary to be integrated with the recommendations of the research.

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INTRODUCTION

Pearl millet, *Pennisetum glaucum* (L.) R. Br. is one of the most important cultivated cereals in Senegal and is considered as the staple food for smallholders farmers. However, the production of this crop is low and has stagnated due to several factors. Among them, *H. albipunctella* of Joannis is a lepidopteran insect that attacks millet in the field and which can cause grain yield losses ranging from 13 to 100% (Thiaw and *al*., 2015). Studies on the impact of the insect in Bambey area, located in the groundnut basinagro-ecological zone have shown a high incidence ranged from 73 to 76%. (Ly, 2015; Sow, 2016; Thiaw and *al*., 2015). Several control techniques are recommended against the head miner, including cultural practices, which are interest since very few effective cultivation methods have been recommended against this insect. Our study, which is part of the strengthening of ecological regulation of pests, attempts to highlight the impact of peasant farming practices on the incidence levels of *H. albipunctella* in Bambey.

MATERIALS AND METHODS

Study area

Sampling method

A total of forty-five (45) pearl millet plots at least 2 km apart were selected over a square area of 400 km^2 (20 x 20 km) around the locality of Ndangalma (Figure 1). These plots were selected based on satellite images and following pedo-climatic criteria.

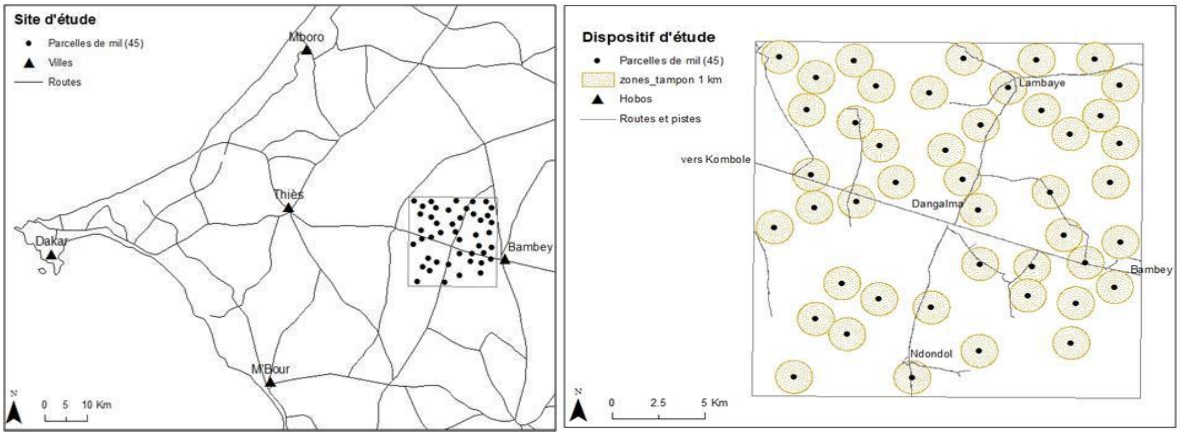

Figure 1: Presentation of study area and plots

Data collection

Data were collected during rainy seasons of 2015 and 2016. The discussions with farmers in charge of the selected plots were held in order to determine mainly the farmers' agronomic practices and major crops.

Entomological observations were also done on those selected plots. Thus, fifty (50) ears per plot were observed at the start of the heading. Samples were collected along lines which cross the entire field. On each line, the pearl millet ears were randomly selected. The Sampling always starts a little inside the field to avoid border effects. The number of eggs was counted according to a round trip on the surface of the ear using fine forceps or a needle. In addition, the selected ears were peeled to highlight all the eggs.

Larvae in the field were observed approximately two to three weeks after before heading according to the same sampling plan used for the observation of the eggs. The number of larvae was noted; in the event of visible damage and in the absence of larvae, the number of galleries is noted.

Statistical analysis

The collected data during surveys and experiments were organized in a database with the EXCEL spreadsheet. The results were presented in the form of tables and graphs. Statistical analyses were carried out using XLSTAT software version 6.1.9. The raw data were subjected to an analysis of variance (ANOVA), the means (± standard deviation) were compared using the Kruskal Wallis multiple comparison test. Student's t-test was used for the two-by-two means comparison. P values less than 5% ($P < 0.05$) were considered as significant. Agronomic practices were then correlated with incidence levels to estimate their impact on them.

RESULTS

Diversity on farming practices

Previous cultural

Crop rotation with peanut and monoculture are the two widely used methods with relative frequencies of around 67 and 27% in 2015 and 54 and 40% in 2016. The fallow and rotation with cowpea are very little used methods with cumulative frequencies of use not exceeding 6% and 5% respectively in 2015 and 2016 (Figure 2).

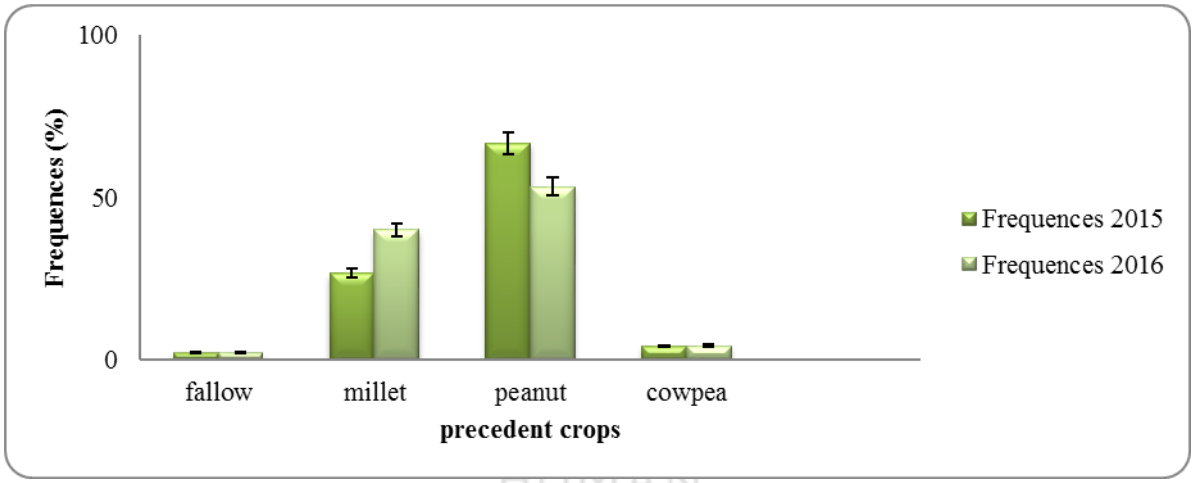

Figure 2: Diversity of precedent crops at 2015 and 2016

Soil preparation

Farmers carried out either light scraping of the soil (58%) or light cleaning followed by scorching (Figure 3). On the other hand, in 2016, soil preparation using burns was noted in 87% of the plots (71% for light cleaning followed by burns and 16% for deep work associated with burns). Also in 2016, other processes excluding burns were noted, in particular, light soil scraping scratching (4%) and deep work (plowing only: 2%). During the rainy season of 2016, we observed that the seedbed did not benefit from prior preparation (Nothing) on 7% of the plots.

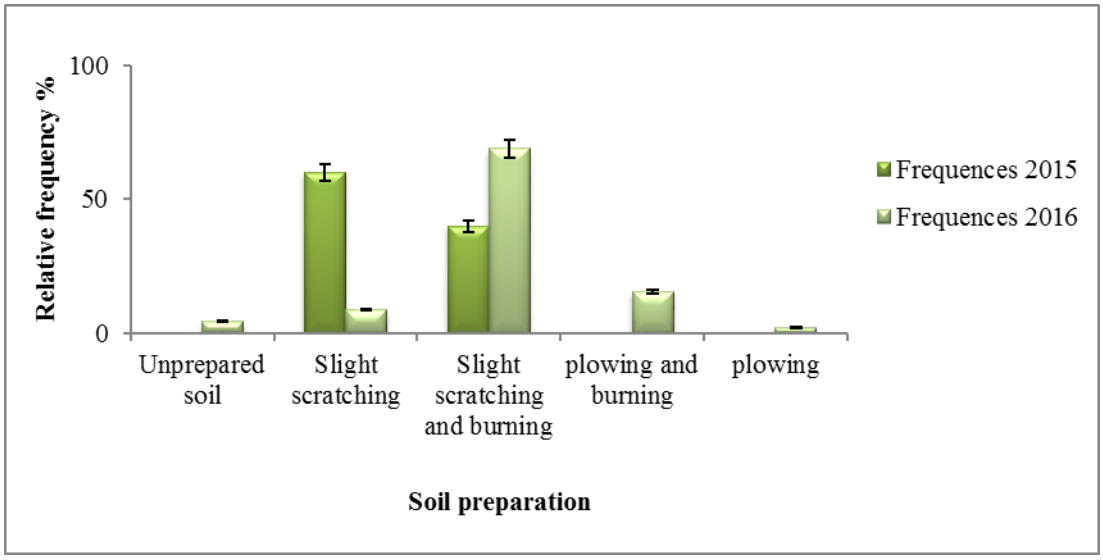

Figure 3: Diversity of soil preparation methods at 2015 and 2016

Seed treatment

Most of the farmers did not treat their seeds (Figure 4). Only 9% did it during the rainy season of 2015 while twenty two percent of the farmers treat it their seeds during the rainy season of 2016. The 2016 results also reveal a new factor: "the ignorance of farmers"; farmers who don't know if their seeds are treated or not (Figure 4).

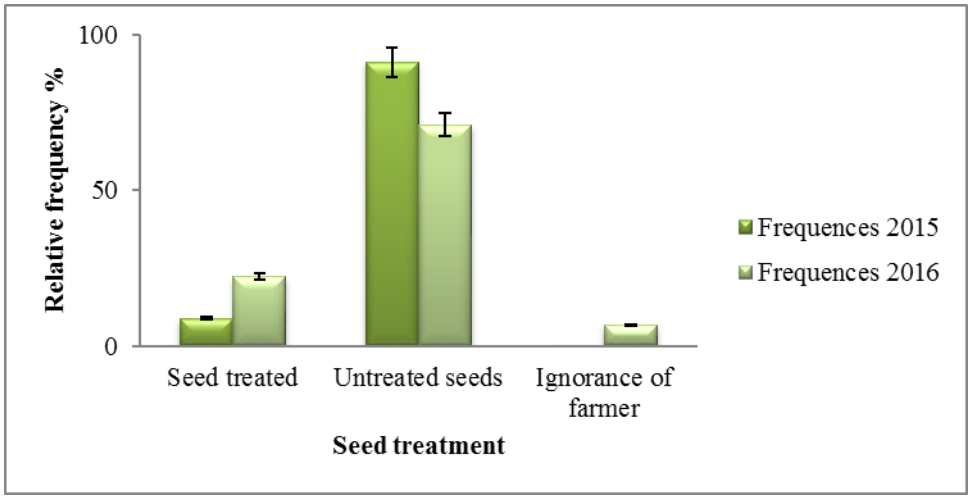

Figure 4: Frequency of application of seed treatment at 2015 and 2016

Nature of fertilization

In 2015, twenty four percent of plots were fertilized with only organic manure while sixteen percent with mineral fertilizer (Figure 5). In addition, while 38% of the plots did not benefit from fertilization, 22% benefited from the association of organic manure with mineral fertilizer.

On the other hand, in 2016, the plots having benefited from organic manure only represented 67% against 4% for those having benefited from mineral fertilizer. The two were combined on 27% of the plots and only 2% of the plots did not benefit from the supply of fertilizing elements.

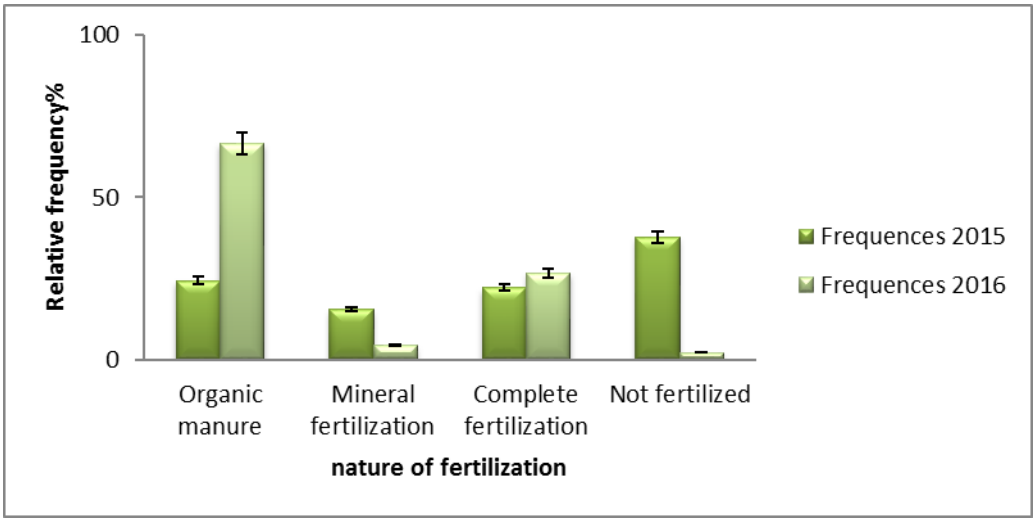

Figure 5: Diversity and frequency of fertilization methods

Number of weeding

In both 2015 and 2016, one, two or three weeding operations were carried out. However, the use of two weeding is the most common method used by farmers located in this part of the country (91% in 2015 and 60% in 2016). Which process were only carried out very slightly in 2015. Furthermore, in 2016, 25% of the plots benefited from three weeding, 13% from a single weeding and only 2% from four weeding (Figure 6).

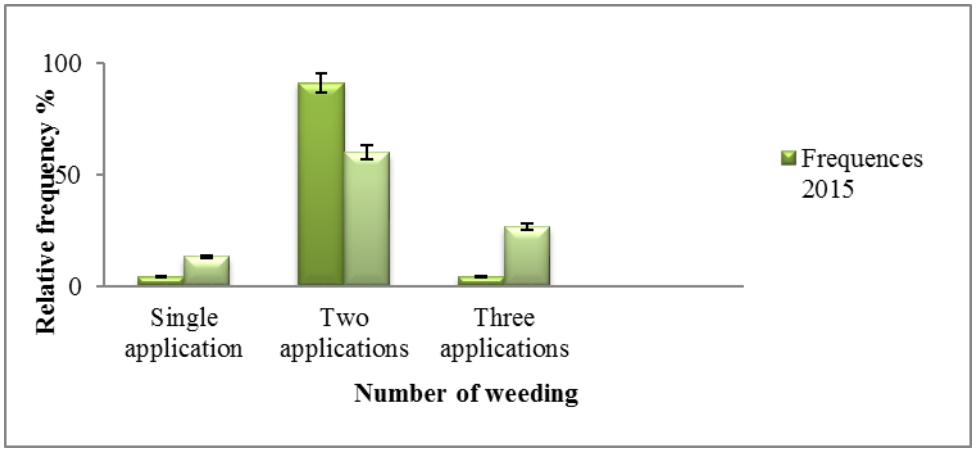

Figure 6: Diversity of weeding modalities at 2015 and 2016

Effect of cultural practices on incidence levels of *Heliocheilus albipunctella*

Previous cultural

The incidence of the *Heliocheilus albipunctella* varied according to the previous crop (Table 1). We noticed that infestation levels are relatively high from one modality to another, both for eggs (32-42% at 2015; 45-60% at 2016) and for larvae (74-77% at 2015; 60-82% at 2016). However, despite the heterogeneous distribution of the methods of the previous crop (applied in the plots), fallow land, peanut and cowpea have an ability to reduce infestations compared to general averages.

For egg infestation means averages, we noted a significant difference between the methods of previous cultivation. Indeed, fallow land and peanut recorded the lowest attack levels in 2015 (32%) and 2016 (45%), respectively. For larval attacks, the previous cowpea crop had the lowest rate in 2016 (60%).

Table 1: effect of precedent crops on the incidence at 2015 and 2016

Precedent crop	Incidence of Eggs		Incidence of Larvae	
	2015	2016	2015	2016
Peanut	40[a]	45[b]	77[a]	75[a]
Fallow land	32[b]	58[a]	74[a]	82[a]
Millet	42[a]	55[a]	74[a]	68[ab]
Cowpea	38[a]	60[a]	75[a]	60[b]

E.I = Eggs impact; I.L = Larvae incidence

Soil preparation

Table 2 shows the variations in infestation levels (in eggs and larvae) according to the soil preparation technique used.

In 2015, the differences only appear for egg infestations where “slight scratching soil” registers the lowest level (thirty-six percent).

In 2016, soil preparation methods excluding burns benefited from the lowest egg attack percentages (forty-two, forty-five and forty-six percent respectively). For the larval attacks, the lowest rates are attributed to the modalities "burn processes", "deep work only" and "deep work + burn" (71; 72 and 73 % respectively).

Table 2: effect of soil preparation methods on the incidence at 2015 and 2016

Soil Prepared	E.I		L.I	
	2015	2016	2015	2016
Slight scratching	36[b]	45[ab]	77[a]	84[a]
Slight scratching and burning	42[a]	51[a]	77[a]	71[b]
Plowing and burning		49[a]		73[b]
Plowing only		42[b]		72[b]
Unprepared soil		46[ab]		77[ab]

E.I = Eggs impact; I.L = Larvae incidence

Seed treatment

Compared to the targeted incidence parameters, the seeds treatment did not showed significantly difference in 2016. In contrast, in 2015, the multiple comparison test revealed a significant difference between seeds treatment. In fact, the treated seeds recorded the highest percentages of egg-infestation 58 % (Table 3).

Table 3: effect of seed treatment on the incidence at 2015 and 2016

Seed treatment	E.I		L.I	
	2015	2016	2015	2016
Seed treated	58[a]	42[b]	73[a]	69[a]
Untreated seeds	38[b]	53[a]	77[a]	73[a]
Ignorance of farmer		46[ab]		76[a]

E.I = Eggs impact; I.L = Larvae incidence

Nature fertilization

The results showed no significant differences on the incidence parameters (egg and larvae infestations) observed in the plots where mineral or organic fertilizer and their combination were applied (Table 4). On the other hand, the incidence parameters were higher in the plots without any fertilizer application compared to the plots where organic and/or mineral fertilizer were applied.

Table 4: effect of fertilization methods on the incidence at 2015 and 2016

Nature of fertilization	E.I		L.I	
	2015	2016	2015	2016
Organic manure	34[b]	50[ab]	76[a]	72[a]
Mineral fertilization	38[b]	48[b]	80[a]	74[a]
Organic + mineral fertilization	35[b]	48[b]	77[a]	72[a]
Not fertilized	48[a]	56[a]	74[b]	66[b]

E.I = Eggs impact; I.L = Larvae incidence

Number of weeding

The multiple comparison tests reveal a significant difference between the number of weeding on the incidence parameters (Table 5). Indeed, statistical analysis showed in 2015 that weeding carried out 3 times has the lowest attack levels for eggs (37%) and the highest for larvae (80%). In 2016, weeding three times recorded the lowest attack levels for both eggs (51%) and larvae (68%).

Table 5: effect of weeding number on the incidence at 2015 and 2016

Number of weeding	E.I		L.I	
	2015	2016	2015	2016
Single application	54[a]	61[a]	71[b]	74[a]
Two applications	40[b]	47[b]	77[ab]	74[a]
Three applications	37[b]	51[b]	80[a]	68[b]

E.I = Eggs impact; I.L = Larvae incidence

DISCUSSION

The objective of the study was to show the impact of peasant farming practices on the incidence levels of *H. albipunctella* in Bambey. The results revealed a great diversity of peasant farming practices and a heterogeneity in their application with methods which often vary from one plot to another but also from one year to another. The very diverse and complex peasant technical knowledge is based for the most part on the peasant's personal experience. It is empirical and localized knowledge unlike scientific and technical knowledge which is standardized, formalized, uniform and universal, like technical sheets. Consequently, the high incidence noted in the area could be linked to this great diversity. Concerning the methods of the previous crop, the practice of fallow land is weakly applied. This continuous cultivation of the land can cause a progressive depletion of the nutritive reserves of the soil. More, the proven adoption of the monoculture of millet noted in the area could also constitute an obstacle. This is all the more true because pupae in the ground can constitute a reserve of emerging pests if a good tillage (plowing) method is not applied before sowing. These practices combined with the increased delay in rainfall noted in recent years (case observed in 2015 with the first rains which were recorded in late June) could potentially

explain the strong presence of the pest in the area. It must be understood that rotation is very important because, if properly applied, it would separate the insect and the host plant in space and time. This interruption of the pest's biological cycle will probably make it possible to reduce its infestation and to fight against soil parasites transmitted by the soil (Stoll, 2002). Moreover, the application of cultural practices is based on the availability of appropriate tools and workforces. For most of the plots, the soil preparations methods is carried out superficially (light scraping of the soil) with rake or hilar. Thus, the preparation of the seedbed was carried out for the majority of the plots without taking into consideration the nature and the depth of the soil as recommended by the research. Moreover, the plots that benefited from plowing had the lowest incidence levels compared to the others. This is in agreement with the work of Gahukar and al. (1986) published in Ndiaye (2005) which stipulated that plowing 30 centimeter deep at the end of the rainy season destroys almost all of the leaf miner pupae. Fertilization provided, essentially a function of the peasant's financial means and income is of great importance. Indeed, it makes it possible "to nourish the ground to nourish the plant".Our results reveal that fertilization is often neglected or badly carried out with an insufficient and unbalanced supply especially in terms of organic need. This problem hides internally a social character (lack of financial income) that must be resolved to improve fertilization. This will enrich the nutrient reserves of the soil and increase the vigor of the plant not only for a better yield but also to limit the damage of some pests such as the leaf miner with the power to compensate for losses by the grains not destroyed. The study revealed that the unique contribution of manure adopted by farmers benefiting from cattle (beef, sheep, goats, horses) is also very promising. Indeed, the parking of animals around cultivated plots allows the soil to be enriched with organic elements. However, remember that functionally fertilization is a process closely linked to crop rotation and soil preparation techniques.

CONCLUSION

The high parasite pressure of Heliocheilus albipunctella in the study area despite the technical routes and control methods implemented by research remains relatively linked to the non-application of these methods by the majority of farmers. However, faced with the requirements of the plots, the inadequacy of most of the cultural practices applied was noted for most of the plots concerned. The crop rotation, soil preparation as well as the nature of fertilization are fundamental techniques in the execution of a technical route. Even if an

idealization of local knowledge is not appropriate, it would be wise to review the recommendations of research by developing preventive phytosanitary strategies. To do this, the review of local knowledge such as that made in this study is necessary in the establishment of scientific-technical knowledge. At the end of this study, it was also noted the existence of a very structured food chain involving upstream the agro-ecological parameters and the plant structure of the environment and downstream the peasant techniques that should be controlled for strengthening of ecological regulation.

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