

Endemicity of Fall Armyworm, *Spodoptera frugiperda* (Lepidoptera : Noctuidae), and its damages to maize in South Benin (West Africa)

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Abstract

The present work is aimed at determining the presence of *S. frugiperda* and its damages to maize leaves and ears throughout the seasons in South Benin (West Africa). Five trials were carried out on different plots and dates throughout 2021 year, beginning from April. For data collection, maize plants were frequently observed immediately after emergence to identify symptoms showing the presence of armyworms in the field, and the percentage of injured plants was determined. Also, harvested ears were peeled and the percentage of ears injured by *S. frugiperda* was determined. Globally, results indicated that *S. frugiperda* is endemic to the district of Abomey-Calavi, in South Benin, West Africa. Nevertheless, damages caused to the plants and ears varied according to the planting dates. When sown in April, the plants and ears were slightly damaged. When sown on May 1, damages caused to the plants and ears slightly increased compared to plants sown about 2 weeks before. In contrast, plants sown on May 15 as well as those sown on July 4, were severely injured. Finally, when the seeds were sown on October 11, damages to the ears were not severe. In view of these results, it is obvious that the armyworms were highly harmful to maize plants when they are sown in the time period from mid-May to July. This time corresponds to late-season plantings in South Benin. Research efforts should be directed on the Integrated Management of *S. frugiperda* that includes non-chemical solutions such as planting date.

Keywords : Maize, *Spodoptera frugiperda*, Crop loss.

Introduction

Spodoptera frugiperda is native to tropical and subtropical regions of the Americas. The fall armyworm is a strong flier, and disperses long distances annually (Capinera, 2021 ; Hruska, 2019 ; Mitchell *et al.*, 1991).

This species seemingly displays a very wide host range, with over 80 plants recorded, but clearly prefers grasses. The most frequently consumed plants are field corn and

sweet corn, sorghum, and grass weeds. When the larvae are very numerous, they defoliate the preferred plants, acquire an "armyworm" habit and disperse in large numbers, consuming nearly all vegetation in their path. Field crops are frequently injured, including cotton, maize, millet, peanut, rice, sorghum, soybean, sugarcane, etc. (Capinera, 2021). Larvae cause damage by consuming foliage. Young larvae initially consume leaf tissue from one side, leaving the opposite epidermal layer intact. By the second or third instar,

larvae begin to make holes in leaves, and eat from the edge of the leaves inward. Feeding in the whorl of corn often produces a characteristic row of perforations in the leaves (Capinera, 2021). Larval densities are usually reduced to one to two per plant when larvae feed in close proximity to one another, due to cannibalistic behavior. Older larvae cause extensive defoliation, often leaving only the ribs and stalks of corn plants, or a ragged, torn appearance (Capinera, 2021). It was noted that mean densities of 0,2 to 0,8 larvae per plant during the late whorl stage could reduce yield by 5 to 20 percent (Marenco *et al.*, 1992).

In the last few years, *S. frugiperda* rapidly spread in Africa, and had been encountered in every sub-Saharan African country. It was first reported in 2016 in West African countries such as Benin (Hruska, 2019 ; Goergen *et al.*, 2016). *S. frugiperda* moths are typically attracted to fields of late-maturing maize to lay their eggs. The development of economically damaging populations depends on a number of factors such as cropping practices, date of planting, insect migration patterns, parasites and predators, weather conditions, etc... (Anonyme, 2021).

The present work is aimed at determining the presence of *S. frugiperda* and its damages to maize leaves and ears throughout the seasons in South Benin (West Africa). For that, maize fields have been planted 5 times at different dates in year 2021.

Materials and Methods

The experiments have been carried out in the District of Abomey-Calavi, South Benin, West Africa. The climate of this commune is of the subequatorial type with two rainy seasons and two dry seasons. The rainy and dry seasons are approximately distributed as follows: A long rainy season from mid-March to mid-July, a short dry season from mid-July to mid-September, a short rainy season from mid-September to mid-December, and a long dry season from mid-December to mid-March. The climatic data of the region over the year are shown on Appendix 1 and 2. Yellow maize variety called 'Sammaz 39', produced by the International Institute of Tropical Agriculture was used.

Sowing was carried out with a spacing of 0, 80 meter between rows and 0, 40 meter between pockets. Thinning to one plant per pocket was done after emergence.

Fifteen days after sowing, the first dose of mineral fertilizer (NPK) was applied, and the second dose, 45 days after sowing. For fertilization, about 4g of NPK granules were introduced into the soil about 10 centimeters from each plant. The weeding of the experimental plots was done frequently.

For data collection, maize plants were frequently observed immediately after emergence to identify symptoms showing the presence of armyworms in the field, and the percentage of injured plants was determined. Also, harvested ears were peeled and the percentage of ears injured by *S. frugiperda* was determined. Five trials were carried out on different plots and dates throughout 2021 year, beginning from April.

Experiment 1 :

Trial 1 was installed on the campus of the University of Abomey-Calavi over an area of 52,7 square meters. Sowing took place on April 19, 2021. During the first weeks of this trial, the rains were very rare ; the field was therefore frequently watered in order to avoid water stress to the plants. To determine the presence and damage of the armyworms, all the plants in the plot were carefully examined from day 24 after sowing. These observations were made once a week. The harvest took place on June 29, 2021. All the ears were harvested and peeled, and the number of ears injured by the armyworms was determined.

Experiment 2 :

Trial 2 was installed in Ouèdo, Commune of Abomey-Calavi, over an area of 50 square meters. Sowing took place on May 1, 2021. During the first weeks of this trial, the rains were sporadic ; the field was therefore watered from time to time, in order to avoid water stress to the plants. On day 56 after sowing, all maize plants were examined and the number of injured plants was determined. The harvest took place on July 14, 2021. All the ears were harvested and peeled, and the number of ears injured by the armyworms was determined.

Experiment 3 :

Trial 3 was installed in Ouèdo, Commune of Abomey-Calavi, on another area of 50 square meters. Sowing took place on May 15, 2021. During this trial, the rainy season set in, but there were periods of drought. The watering of the field was therefore done whenever the need arose. To determine armyworms damages, all plants were observed on day 42 after sowing. The harvest was made on August 08, 2021. All harvested ears were peeled and the number of injured ears was determined.

Experiment 4 :

This trial was carried out on the campus of the University of Abomey-Calavi. Sowing took place on July 4, 2021, over the area of 52,7 square meters. During the first weeks of this trial, the rains were abundant, but later they were rare. So, the field was often watered during the second half of the trial. During this trial, armyworms damages was assessed twice, respectively on day15 and 37 after sowing. All the plants in the plot were observed as in the previous trials. The harvest took place on September 18, 2021. All the ears harvested were peeled and the number of injured ones was determined.

Experiment 5 :

The trial 5 was carried out on the campus of the University of Abomey-Calavi. The sowing took place on October 11, 2021, on the area of 52,7 square meters. During the first weeks of this trial, the rains were also abundant, but later

they were scarce. The field was therefore often watered during the last three weeks of the trial to avoid water stress to the plants. During this trial, armyworms damages was assessed twice, respectively on day 18 and 53 after sowing. All plants in the plot were observed as in the previous experiments. The harvest took place on December 24, 2021. Here also, all the ears were harvested and peeled, and the number of injured ones was determined.

Results

Experiment 1 :

The results showed that during trial 1, the number of injured plants gradually increased during maize growing season (Table 1), but the symptoms of attacks were not severe on the leaves. About 41% of harvested ears (Fig. 1) were slightly injured by the armyworms (Photo 1).

Table 1 : Percent of injured plants in experiment 1

Days after sowing	Percent of plants (%)
24	13,27
31	19,28
38	30,20
45	33,93
52	48,51
54	50,64

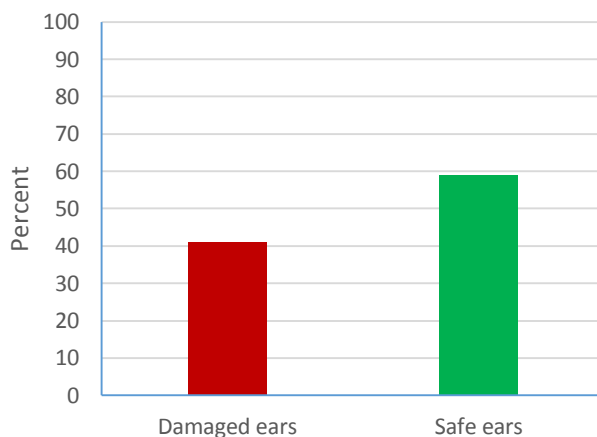


Figure 1 : Percentage of ears injured during trial 1



Photo 1 : An ear of maize harvested during experiment 1, showing the armyworm and its damage

Experiment 2 :

On day 56 after sowing, 38% of maize plants were injured by *S. frugiperda* (Figure 2.a). On the day of harvest, 68% of

the ears were injured by the armyworms (Figure 2.b). Damages to ears in experiment 2 was greater compared to that observed in experiment 1 (Photo 2).

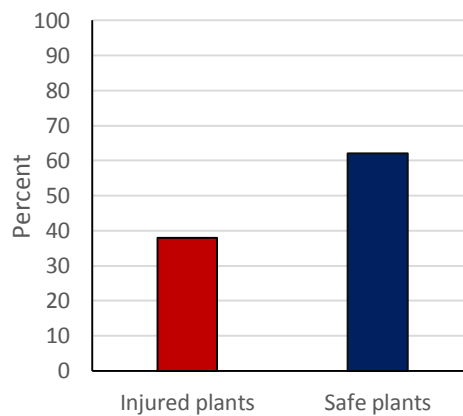


Figure 2.a: Percentage of maize plants injured in experiment 2

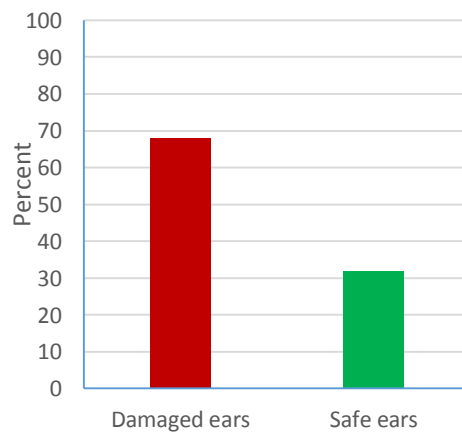


Figure 2.b : Percentage of maize ears injured in experiment 2



Photo 2 : Ears harvested during experiment 2, showing the armyworm and its damage

Experiment 3 :

On day 42 after sowing, 88% of maize plants were injured (Figure 3.a) ; the plants were severely damaged (Photo 3).

And on the harvest day, 86,50% of harvested ears have been injured by the armyworms (Figure 3.b).



Figure 3.a : Percentage of maize plants injured in experiment 3

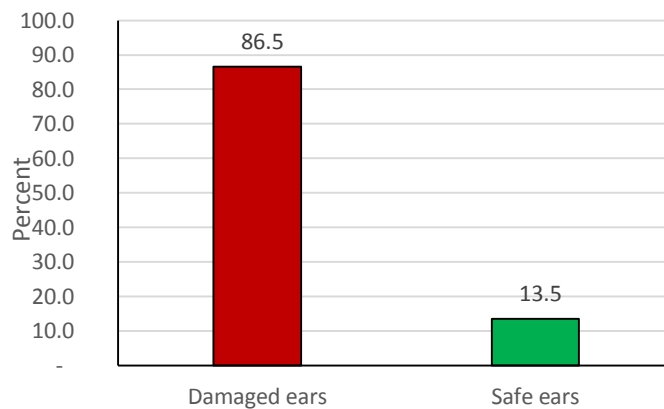


Figure 3.b : Percentage of maize ears injured in experiment 3



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Photo 3 : Injured maize plants during experiment 3

Experiment 4 :

Observations from experiment 4 revealed that 54% of the plants were injured by the armyworms on day 15 after sowing ; and on day 37, this rate reached 99% (Figure 4.a).

Regarding harvested ears, 95% of them have been damaged by the armyworms (Figure 4.b). The damages caused to the ears during experiment 4 were very severe (Photo 4).

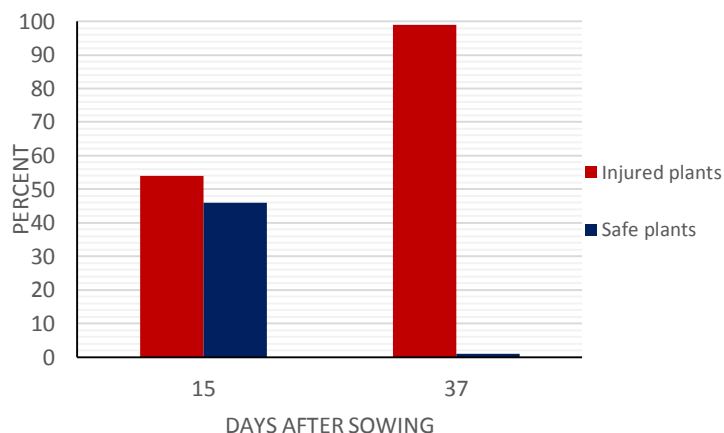


Fig. 4.a: Percentage of maize plants injured by *S. frugiperda* during experiment 4

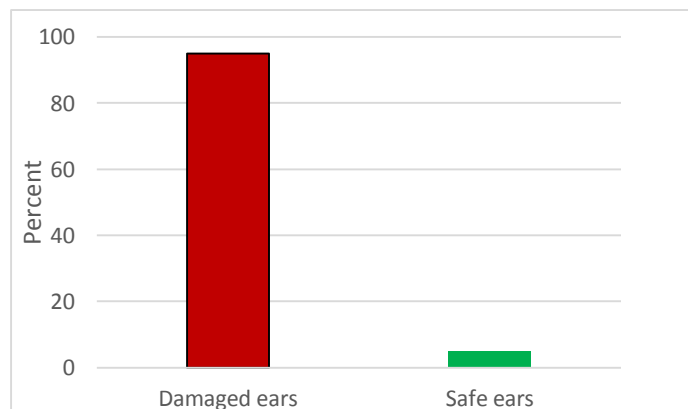


Fig. 4.b : Percentage of maize ears injured by *S. frugiperda* during experiment 4



Photo 4 : Maize ears harvested during experiment 4, showing armyworms damages

Experiment 5 :

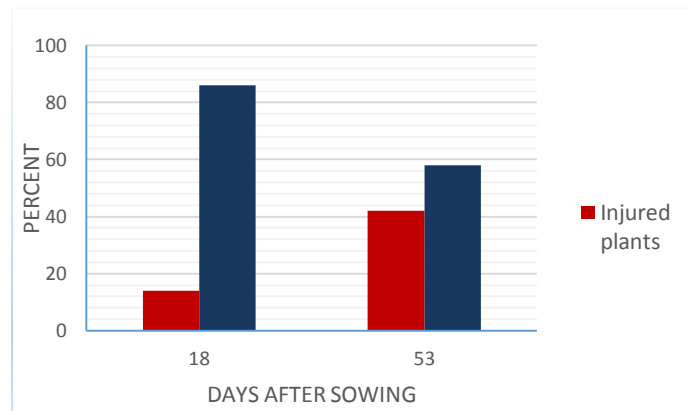


Fig. 5.a: Percentage of maize plants injured by *S. frugiperda* during experiment 5

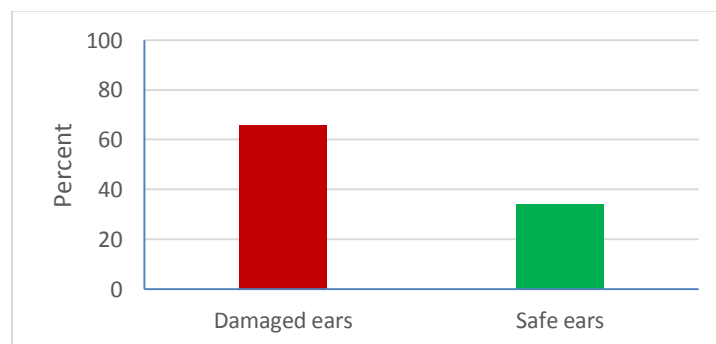


Fig. 5.b : Percentage of ears damaged by *S. spodoptera* during experiment 5

Observations from experiment 5 revealed that 14% of the plants were injured by the armyworms on day 18 after sowing ; and on day 53, this rate reached 42% (Figure 5.a). In this experiment, 66% of the harvested ears were damaged by the armyworms (Figure 5.b). Damages to the

ears were not severe during experiment 5, and were similar to those observed in experiment 1.

Discussions

In the present study, we cultivated maize five times from April to December 2021, in different areas. Globally, results indicated that *S. frugiperda* is endemic to the district of Abomey-Calavi, in South Benin, West Africa. Nevertheless, damages caused to the plants and ears varied according to the planting dates. When sown in April, the plants and ears were slightly damaged. In this district, the month of April correspond to the beginning of the big rainy season. When sown on May 1, damages caused to the plants and ears slightly increased compared to plants sown about 2 weeks before. In contrast, plants sown on May 15 as well as those sown on July 4, were severely injured. These dates correspond to late and very late planting dates respectively. Finally, when the seeds were sown on October 11, damages to the ears were not severe (were similar to those registered for the plants sown at the beginning of the big rainy season). The month of October is a part of the small rainy season which begins about mid-September, and ends about mid-December. In view of these results, it is obvious that the armyworms were highly harmful to maize plants when they are sown in the time period from mid-May to July. This time corresponds to late- season plantings in South Benin.

Ayala et al. (2013) have assessed the attack rates and level of damages by the fall armyworm, affecting corn-crops in Argentina ; they found that the sowing date affected the infestation levels and early seeding avoided high armyworm densities that develop later in the season. *S. frugiperda* is a polyphagous insect that attacks many crops in the Americas (Ashley et al. 1989). In the southeastern United States, the insect possess a serious threat to maize production, especially to late-season plantings (Scott et al. 1977). The fall armyworm often attack late season plantings of maize from seedling to mature stages of growth.

In regards to the results of the present study as well as published papers, we may suggest that the planting date may play an important role in the management of *S. frugiperda* in West Africa.

The prevalence of maize and other crops on which this highly polyphagous pest feeds, associated with agroecological conditions suitable for *S. frugiperda* in much of the region, makes it a serious (and most certainly perennial) threat to food security in sub-Saharan Africa (Day et al., 2017). The continued destruction by the Fall Armyworm, leading to reduced yields, would aggravate the already precarious conditions of millions Africans living below the poverty line.

Research efforts should be directed on the Integrated Management of *S. frugiperda* that includes non-chemical solutions such as planting date, resistant varieties, etc.

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Disclosure statement

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Public interest statement

The Fall Armyworm, *Spodoptera frugiperda*, is native to tropical and subtropical regions of the Americas. But in the last few years, *S. frugiperda* rapidly spread in Africa, and had been encountered in every sub-saharan African country. The present work has determined the injury rates of this polyphagous insect pest to maize leaves and ears throughout the seasons, in South Benin (West Africa). The results point out the continued destruction by the Fall Armyworm, leading to reduced yields, which would aggravate the already precarious conditions of millions Africans living below the poverty line.

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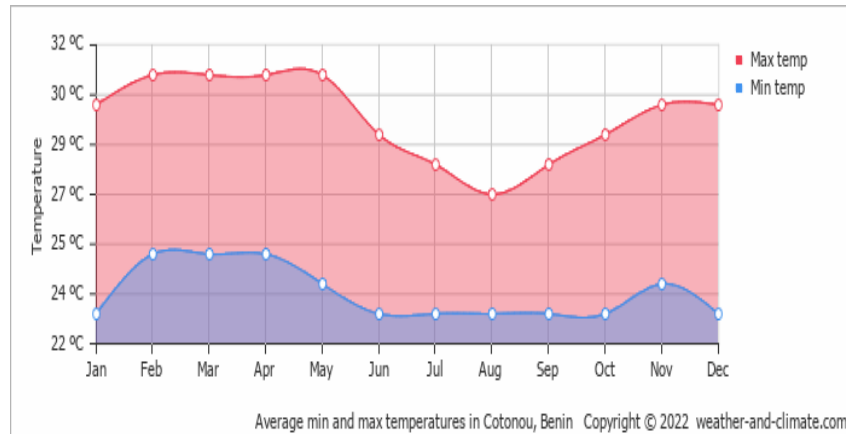
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References

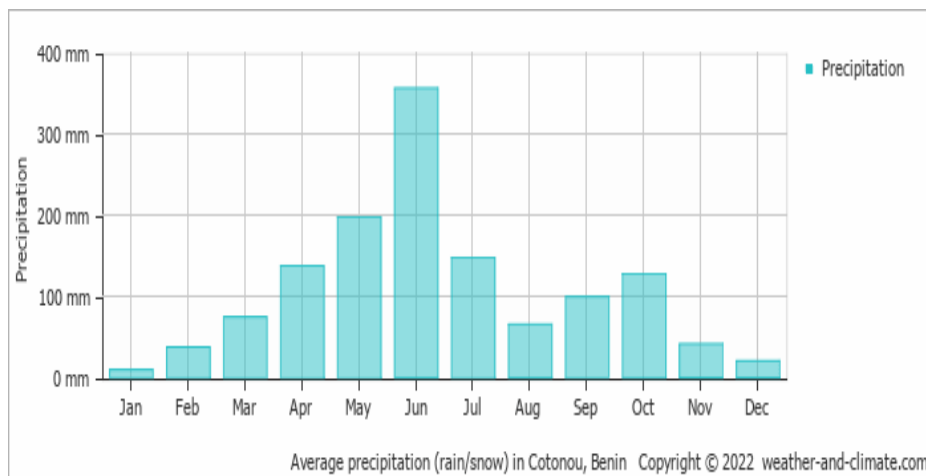
- Anonyme, Purdue University (2021). Corn Crop Management : Fall Armyworm ; Available from : URL : <https://extension.entm.purdue.edu/fieldcropsipm/insects/fall-armyworm.php> (last accessed 11 October 2021)
- Ayala Oscar R, Fernando Navarro, Eduardo G. Virla (2013). Evaluation of the attack rates and level of damages by the fall armyworm, *Spodoptera frugiperda* (Lepidoptera : Noctuidae), affecting corn-crops in the northeast of Argentina. Rev. FCA UNCUIYO 45(2) : 1-12.
- Ashley, T. R., B. R. Wiseman, F. M. Davis, and K. L. Andrews. (1989). The fall armyworm : A bibliography. Florida Entomologist 72 : 150-202.

- Capinera J L (2021) Fall Armyworm, *Spodoptera frugiperda* (J.E. Smith) (Insecta : Lepidoptera : Noctuidae). University of Florida, IFAS Extension. Available at <https://edis.ifas.ufl.edu/publication/IN255> (Last accessed 11 October 2021)
- Day, R., Abrahams, P., Bateman, M., Beale, T., Clotey, V., Cock, M., Colmenarez, Y., Corniani, N., Early, R., Godwin, J., Gomez, J., Moreno, P.G., Murphy, S.T., Oppong- Mensah, B., Phiri, N., Pratt, C., Richards, G., Silvestri, S., Witt, A. (2017). Fall armyworm : impacts and implications for Africa. *Outlooks Pest management* 28, 196–201. <https://doi.org/10.1564/v28>.
- Goergen G, Kumar PL, Sankung SB, Togola A, Tamo M. (2016) First report of outbreaks of the fall armyworm *Spodoptera frugiperda* (J E Smith) (Lepidoptera, Noctuidae), a new alien invasive pest in West and Central Africa. *PLOS ONE* 2016 ;11 :1–9. Available from : URL : <https://doi.org/10.1371/journal.pone.0165632>.
- Hruska A. J. (2019) Fall armyworm (*Spodoptera frugiperda*) management by smallholders. *CAB Reviews* 14, No. 043 :1-11. Doi : 10.1079/PAVSNNR201914043
- Marenco, R.J., Foster R.E., and Sanchez C.A. (1992). Sweet corn response to fall armyworm (Lepidoptera : Noctuidae) damage during vegetative growth. *Journal of Economic Entomology* 85 :1285-1292.
- Mitchell ER, McNeil JN, Westbrook JK, Silvain JF, Lalanne-Cassou RB, Chalfant SD, et al. (1991) Seasonal periodicity of fall armyworm, (Lepidoptera : Noctuidae) in the Caribbean basin and northward to Canada. *Journal of Entomological Science* ; 26 :39–50.
- Scott, G. E., F. M. Davis, G. L. Beland, W. P. Williams, And S. B. King. 1977. Host plant resistance is necessary for late-planted corn. *Mississippi Agric. and Forestry. Exp. Stn. Res. Rpt.* 13. 4 pp.

Appendix



Appendix 1 : The mean minimum and maximum temperatures over the year in Abomey-Calavi, South Benin, West Africa <https://weather-and-climate.com/average-monthly-min-max-Temperature,abomey-calavi-bj,Benin> (Consulted on January 19, 2022)



Appendix 2 : Average monthly rainfall in Abomey-Calavi, South Benin, West Africa <https://weather-and-climate.com/average-monthly-precipitation-Rainfall,abomey-calavi-bj,Benin> (Consulted on January 19, 2022)