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Diversity and distribution of sweet potato weevils (*Cylas* spp.) in southern Benin

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Diversité et distribution des charançons de la patate douce (*Cylas* spp.) dans le sud-Bénin

Résumé : Les charançons de la patate douce (PD), *Cylas* spp. sont d'importants ravageurs de la PD dans le monde et particulièrement en Afrique. Ils causent des dégâts à la culture suite à leur alimentation et à leur reproduction. Cette étude a été entreprise pour identifier les espèces de *Cylas* inféodées à la production de PD dans le sud-Bénin et pour évaluer la distribution des insectes dans les zones d'étude. Une prospection a été conduite d'Octobre à Décembre 2015 dans quinze communes des départements du Mono, du Couffo, de l'Ouémé et du Plateau dans les zones agro-écologiques 6, 7 et 8 du sud-Bénin. Les charançons adultes ont été collectés seuls en vrac mais aussi à partir de tiges et de racines tubéreuses infestées. Les tiges et les racines tubéreuses de PD ont été incubées au laboratoire pour l'émergence d'insectes adultes. Deux espèces de *Cylas* ont été identifiées: *C. puncticollis* Boheman et *C. brunneus* Schoenherr. *Cylas puncticollis* a été observé dans 82,70% du total des échantillons collectés et a été trouvé dans toutes les communes prospectées, tandis que *C. brunneus*a été observé dans 17,42% des échantillons et a été uniquement observé dans les communes d'Adjohoun, de Bopa, de Houéyogbé, d'Ifangni et de Klouékanmè. La plus grande incidence (100,00 ± 0,00%) et la plus faible incidence (0,00 ± 0,00%) ont été enregistrées avec *C. puncticollis* et *C. brunneus*, respectivement, dans les communes d'Aplahoué, de Comè, de Sakété, d'Adja-Ouèrè et de Toviklin. Tous les producteurs de PD ont utilisé uniquement des boutures de tige pour la plantation, avec 10% d'entre eux traitant le matériel de plantation avec des insecticides chimiques. Quatre-vingt pourcent des producteurs utilisent le matériel de plantation pris de leurs propres champs alors que 20% l'obtenaient de champs voisins soit gratuitement, soit par achat. Cette étude nous a donné des informations plus détaillées sur l'identité et la distribution des charançons de la patate douce au Bénin et était indispensable pour l'établissement de mesures de lutte contre eux.

Mots clés : Patate douce, *Cylas puncticollis*, *Cylas brunneus*, identification, distribution, incidence, Bénin.

Abstract: Sweet potato (SP) weevils, *Cylas* spp. are important pests of SP throughout the world and particularly in Africa. They cause damage to the crop as a result of their diet and reproduction. This study was undertaken to identify species of *Cylas* attached to SP production in southern Benin and to assess the distribution of the insects in study areas. A survey was conducted from October to December 2015 in fifteen districts of the departments of Mono, Couffo, Ouémé and Plateau in agro-ecological zones 6, 7 and 8 of Southern Benin. Weevil adults were collected alone in bulk but also along with infested vines and tuberous roots. Sweet potato vines and tuberous roots were incubated in laboratory for emergency of insect adults. Two species of *Cylas* were identified: *C. puncticollis* Boheman and *C. brunneus* Schoenherr. *Cylas puncticollis* were observed in 82.70% of total samples collected and were found in all districts prospected while *C. brunneus* were observed in 17.42% of the samples and were observed only in the districts of Adjohoun, Bopa, Houéyogbé, Ifangni and Klouékanmè. The highest incidence (100.00 ± 0.00%) and the lowest incidence (0.00 ± 0.00%) were recorded with *C. puncticollis* and *C. brunneus*, respectively, in the districts of Aplahoué, Comè, Sakété, Adja-Ouèrè and Toviklin. All SP farmers used only vine cuttings for planting, with 10% of them treating planting material with chemical insecticides. Eighty percent of farmers use planting materials taken in their own fields whereas 20% obtain them from neighboring fields either free of charge or purchase

them. This study gave use more detailed information on the identity and distribution of sweet potato weevils in Benin and was useful for the establishment of control measures against them.

Keywords: Sweet potato, *Cylas puncticollis*, *Cylas brunneus*, identification, distribution, incidence, Benin.

1. Introduction

Sweet potato (*Ipomoea batatas* [L.] Lam) is a very important crop considering its nutritional, agronomic, medicinal and other properties, but also considering the income generated by its production. It is the seventh most important and underexploited food crop in the world (Bhattarai, 2015; ELzubeir et al., 2018). In Benin, SP ranks third among root and tuber crops after yams and cassava (MAEP, 2016).

Unfortunately, the production of SP is affected by many abiotic and biotic stresses (Okonya et al., 2014; Rukarwa, 2014; Doussoh, et al., 2016). Sweet potato weevils of the genus *Cylas* are very important constraints because of the extent of damage they cause to the crop (Korada et al., 2010; Tanzubil, 2015).They are known to cause crop yield losses of up to 100% (Fuglie, 2007; Nderitu et al., 2009; Ehisianya et al., 2011; Okonya et al., 2016). Losses have been recorded in several African countries such as Uganda (Mwanga et al., 2009), Kenya (Nderitu et al., 2009), Ghana (Tanzubil, 2015), Nigeria (Tewe et al., 2003) and others (CAB International, 2005). They are able todamage every harvestable part of the plant with devastating consequences for poor farmers leading to low income and reduced food security (Magira, 2003). Attacked tuberous roots (main edible part of plant), have on their surface black spots due to the holes created by the adult female of the insect to lay its eggs. The holes are closed immediately after spawning by black excrementwhich renders the tuberous roots unfit for consumption and thereby depreciate their market value (CIP 2013; Stathers et al., 2013). An unpleasantodor and a bitter taste characterize also attacked tuberous roots in response to a defense reaction against SP weevils (Stathers et al., 2003; Varin et al., 2009). The insect larvae are the most dangerous stage of the insect. They feed by creating galleries within tuberous roots or stems depending on which part of the plant the eggs were laid on (Dhaliwal, 2017).

Several control methods have been developed against the pest around the world including cultural methods (Korada et al., 2010; Mansaray et al., 2015), host plant resistance (Stevenson et al. 2009; Korada et al., 2010; Adom et al., 2018), biological control (Korada et al., 2010; Baimey et al., 2017), biotechnological approaches, use of semiochemicals, botanical pesticides (Korada et al., 2010), chemical pesticides (Korada et al., 2010; Damalas et Eleftherohorinos, 2011) and integrated management approach that combines two or more of these methods (Tang and Cheke, 2008).The control methods identified against the insect in Benin are mainly based on cultural practices including crop rotation, fallowing and the use of healthy cuttings. Chemical control is also practiced by the use of non-homologous insecticides directed against the pests of other crops such as cotton, maize or vegetable crops.

Wolfe (1991) reported that the distribution of *Cylas* species varies with the region and Hue and Low (2015) observed variation of the degree of infestation from region to region. Proper identification of *Cylas* spp., and information on their distribution and method of dissemination are essential for a control program to be successful (van Lenteren, 2000; Tanzubil, 2015).

The two African sweet potato weevil species are *Cylas puncticollis* and *C. brunneus* (Smit and van Huis, 1998; Anyanga et al., 2013). Studies conducted in Benin reported the presence of the insect in SP fields (Zinsou et al., 2010, Baimey et al., 2017) but no published information is available on the diversity and distribution of it. This study was undertaken to survey for the species of *Cylas* attached to SP production in southern Benin, to provide information on the pests' distribution in the study zone and to determine some practices used by farmers which can explain the presence of weevils. This study will be of great importance for SP weevils' control.

2. Materials and methods

2.1. Districts prospected

In Benin, SP is cultivated countrywide but mostly in the Atlantic and Ouémé departments which alone account for more than 50% of national production (FAOSTAT, 2015). Surveys were conducted in southern Benin in the departments of Ouémé, Plateau, Mono, Couffo and Atlantic during cropping season from October to December 2015. A total of 32 sites belonging to 15districts and located in three different agro-ecological zones (the land of bar zone named Zone 6, the depression zone named Zone 7 and the fisheries zone named Zone 8) were prospected. Agro-ecological zones

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include districts which are characterized by the same constraints (PANA-Bénin, 2007). The geographical positions of the sites were recorded using a hand-held Garmin GPSMAP64s device.

2.2. Collection of sweet potato weevils in districts prospected

Sweet potato fields of sizes 0.5 ha to 2 ha were surveyed for *Cylas* spp. In each field, following the two diagonals, samples of infected SP tuberous roots and vines and also adults of *Cylas* spp. were collected at every 3 m. Sweet potato weevils were also collected in SP stores, in local markets and also at roadsides. Infested SP tuberous roots and vines presented external feeding and ovipositional punctures or black spots on the surface (Hue and Low, 2015), characteristic signs of infestation with *Cylas* spp.

At each prospective site, the samples were placed separately in clean polythene 5 L plastic boxes with pre-drilled lids in a single hole and covered with wire mesh to prevent the weevils from escaping from the boxes and to promote the air exchange. These boxes were labeled and transported to the laboratory. The incidence x of each species of the pest in each district was calculated as:

$$x = \frac{\text{number of fields infested with the pest species}}{\text{total number of fields prospected}} \text{x100}$$

2.3. Incubation of samples collected

Sweet potato tuberous root and vine samples collected during the survey were incubated in 25-L plastic boxes under laboratory conditions (Figure 1) at temperatures of 27-30°C. One box was used per sample. After emergence, insect adults were transferred into new 25-L boxes containing fresh SP tuberous roots.

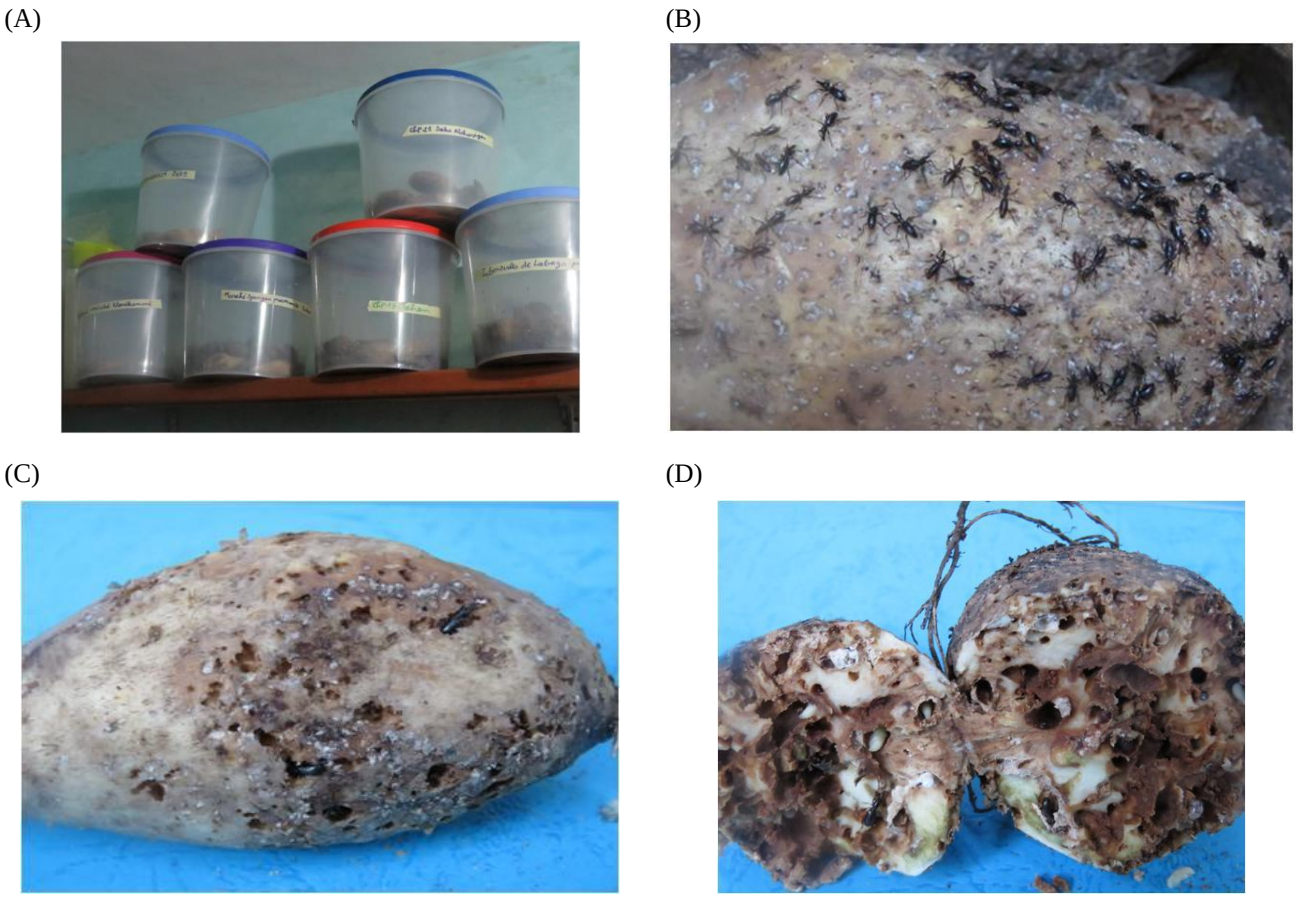

Figure 1: Incubation of infected sweet potato tuberous roots in laboratory for weevils' collection for identification: (A) incubation of infected tuberous roots, (B) Adults of weevils that emerged from tuberous roots, (C) damages on tuberous roots surface, and (D) Damages inside tuberous roots.

[Incubation des racines tubéreusesde patate douce infestées, au laboratoire, pour la collecte des charançons en vue de l'identification] : (A) incubation des racines tubéreuses infestées, (B) Adultes de charançons émergés des racines tubéreuses, (C) dégâts sur la surface des racines tubéreuses, et (D) dégâts à l'intérieur des racines tubéreuses.

2.4. Identification of sweet potato weevils collected

To identify SP weevils that emerged from the new boxes, around 19 insect adults (males and females)/sample were transferred into 25 ml-plastic vials containing 70% alcohol. In total, 13 samples of insects were obtained from samples collected in the departments of Mono (Bopa, Comè and Houéyogbé), Couffo (Aplahoué, Klouékanmè and Toviklin), Ouémé (Adjohoun) and of the Plateau (Ifangni, Sakété and Adja-Ouèrè).

The insect samples were sent to the insect museum of the International Institute of Tropical Agriculture, Cotonou station, Benin for identification to species level by Dr. Georges Goergen. The identification was done based on the morphological features of the insect adults (Figure 2) under a stereomicroscope (CETI, 40x) based onsome parameters of the insect adults: shape and size of distal antennal segment, color of body, head, thorax, elytra (Musana et al., 2016; Okonya et al., 2016).

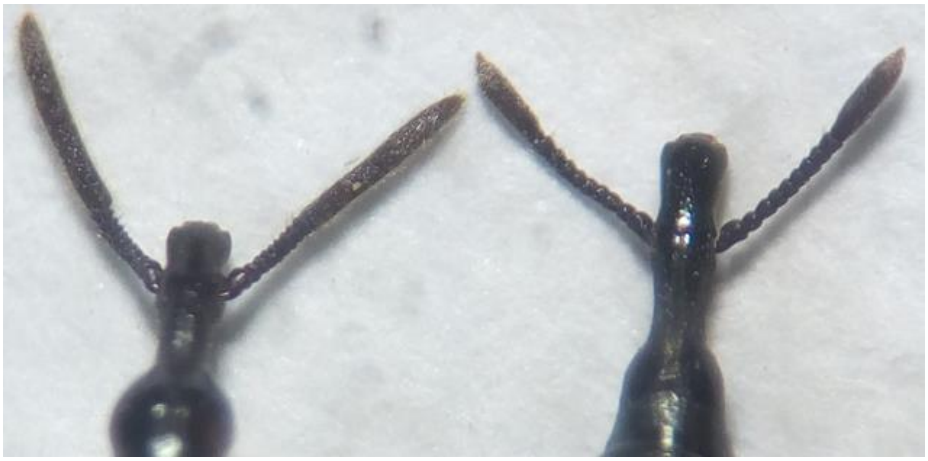

Figure 2: Distinctive feature of the male (left) and female (right) adults of *Cylas puncticollis* based on their antennae

[Caractéristique distinctive du mâle (à gauche) et de la femelle (à droite) des adultes de *Cylas puncticollis* sur la base de leurs antennes]

2.5. Some sweet potato production practices

During the survey, in each SP field, farmers were questioned on origins and types of planting

materials used, and whether the planting materials were treated or not before planting.

2.6. Statistical data analyzes

Incidence data were subjected to an analysis of variance (ANOVA) with the R software,version 3.5.1. Means were compared with the Student Newman-Keuls test at the 5% level. Figures were generated with Excel spreadsheet 2007. A distribution map of *Cylas* spp. was produced by kriging using ArcGIS Geostatistical Analyst, version 9.0.

3. Results

3.1. Sweet potato weevil species identified

Two species of SP weevils were identified from SP vines and tuberous roots and also SP weevil samples collected in southern Benin. These are: *Cylas puncticollis* Boheman and *C. brunneus* Schoenherr (Coleoptera: Brentidae). Figure 3 shows the males and females of both species.

3.2. Incidence of sweet potato weevils in southern Benin

Figure 4 shows that SP weevils were present in 10 districts out of the 15 surveyed. Significant differences ($P < 0.05$) in the insects' incidence were observed where there were present. *Cylas puncticollis* was present in all 10 districts and remained the only specie encountered in the districts of Aplahoué, Comè, Sakété, Adja-Ouèrè and Toviklin. In these districts, the lowest incidences ($0.00 \pm 0.00\%$) were recorded for *C. brunneus* while the highest incidences ($100.00 \pm 0.00\%$) were recorded for *C. puncticollis*. The lowest incidence ($14.28 \pm 0.00\%$) of *C. puncticollis* was recorded in the district of Houéyogbé as well as the highest incidence ($85.71 \pm 0.00\%$) for *C. brunneus*. The incidence of *C. brunneus* was higher ($P < 0.05$) in Bopa and Houéyogbé than that of *C. puncticollis*.

(A) (B)

(C) (D)

Figure 3: Sweet potato weevil species associated with sweet potato production in southern Benin (A and B: male and female of *C. puncticollis*, respectively. C and D: male and female of *C. brunneus*, respectively).

[Espèces de charançons de patate douce inféodées à la production de la patate douce au sud-Bénin (A et B : mâle et femelle de *C. puncticollis*, respectivement. C et D : mâle et femelle de *C. brunneus*, respectivement)]

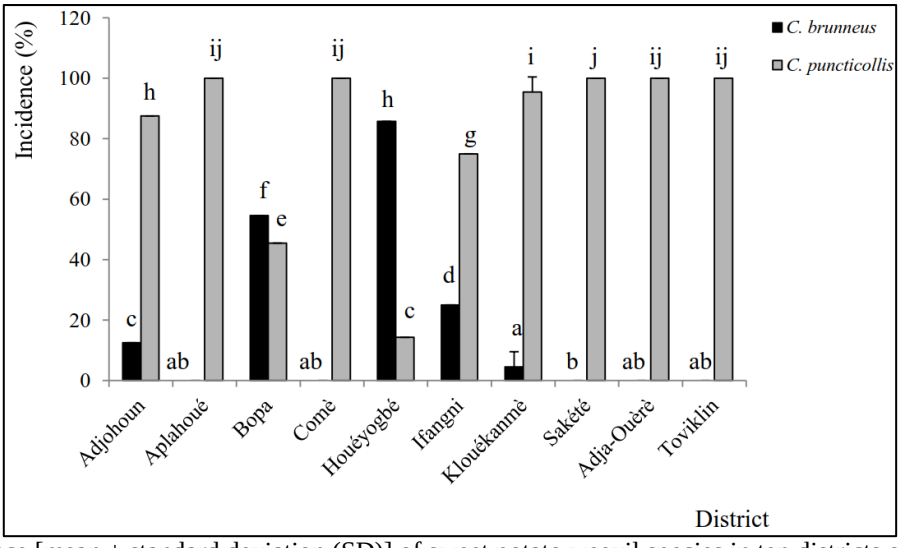

Figure 4: Incidence [mean ± standard deviation (SD)] of sweet potato weevil species in ten districts of southern Benin

[Incidence (moyenne ± erreur standard (ES)] des espèces de charançons de patate douce dans dix communes du sud-Bénin]

Figure 5 shows that *Cylas puncticollis* occurred alone in 52.46% of the 10 infected districts while the two species of SP weevils were observed together in 47.54% of those districts. In no district *C. brunneus* occurred alone.

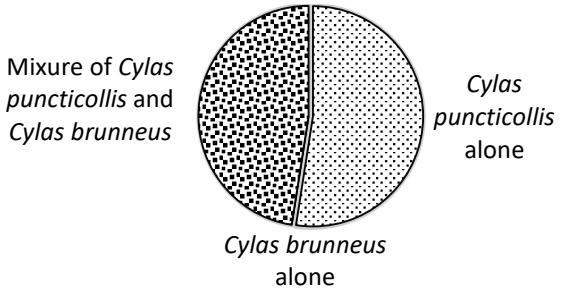

Figure 5: Proportion of sweet potato weevils species present in samples collected in Southern Benin

[Proportion des espèces de charançons de patate douce présentes dans les échantillons collectés dans le sud-Bénin]

3.3. Distribution of sweet potato weevil species in southern Benin

The figure 6 showed the distribution of *Cylas* species in the districts prospected. Each specie was specified by a color that was mentioned in legend of each map.

3.4. Results of survey information's

Figure 7A shows that samples of SP vines, tuberous roots and SP weevil adults were collected more in SP fields (85%) than at markets (7%), at roadsides (5%) and in stores (3%).

In all surveyed districts, SP vine cuttings were identified as the only planting material used by all SP farmers (data not shown). Eighty percent of farmers collected vine cuttings from their own fields on plants cropped in previous season for new planting.Twenty percent of the farmers acquired planting materials from neighboring fields either for free or purchase them (Figure 7B). Sweet potato vine cuttings were treated with insecticides [Lambda Super 2,5 EC (active ingredient: Lamda-cyhalothrine), Cyperforce(active ingredient: Cyperméthrine10 EC) or Aldrine] directed against insect pests of other crops, before planting by only 10% of farmers (Figure 7C).

4. Discussion

The results of our investigations showed that *C. puncticollis* and *C. brunneus* are the two species of SP weevils present in the SP production areas of southern Benin. This is the first report of *C. brunneus* in Benin as *C. puncticollis* was reported earlier by Baimey et al. (2017). Muyinza et al. (2012), Hue and Low (2015) and ELzubeir et al. (2018) reported that *C. puncticollis* and *C. brunneus* are African species of SP weevils and are confined to Africa. On the other hand, according to Rukarwa (2014), *C. formicarius* (Fabricius), is also present but rare in Africa.

Our study showed that of both species of SP weevils identified, *C. puncticollis* was the most widespread and could be found alone in SP fields whereas *C. brunneus* was not observed alone in any field. Capinera (2001) reported that different subspecies of SP weevils can be found in different geographical locations. *Cylas puncticollis* was recorded in 24 African countries (Burundi, Cape Verde, Cameroon, Chad, Congo, Central African Republic, DR Congo, Ethiopia, Ghana, Ivory Coast, Kenya, Madagascar, Malawi, Mali, Mozambique, Nigeria, Senegal, Sierra Leone, Somalia, Sudan, Tanzania, Uganda, Rwanda and Zambia) (Musana et al., 2016). According to the same authors, *C. brunneus* was recorded in nine African countries (Uganda, Kenya, Rwanda, Burundi, Nigeria, Ghana, Ivory Coast, Sierra Leone and Togo).

Benin is now part of the countries where the species are present. The difference in the distribution of the species in the districts prospected could be related to the susceptibility of the sweet potato accessions cultivated in each commune (= preference of accessions by the pest) or to the transfer of planting material from one district to another (= passive transfer of the pest from one district). Musana et al. (2016) reported that *C. puncticollis* has a much larger range than *C.brunneus* which female has shorter life duration (92±12 days) and develops faster (32–41 days from egg to adult) than *C. puncticollis* (141 ± 10 days; 20–28 days from egg to adult, respectively) (Smith and van Huis, 1998). In our study, the two species have sometimes been identified on the same growing area, which means that they can cohabit. According to Muyinza et al. (2012), both *C. puncticollis* and *C. brunneus* have some differences in their biology, but their ecological interactions in the field are similar and they may co-exist in the same tuberous roots.

Female adults of *Cylas* species can spawn in SP vines (Hue et Low, 2015) which were identified as the main source of planting material. Thus, untreated vine cuttings, which are used continuously by farmers for SP planting, can therefore contribute to a proliferation of *Cylas* species in the fields or stores. The aerial biomass (several leaves and long vines) of SP plant is important (Djinet et al., 2016). So, it is easier and more profitable for farmers to use own material from previous crops than to buy them. Mvumi et al. (2018) explained the choice of vine cuttings as planting material by the fact that this part of the plant regenerate faster than the use of tuberous roots. This is also the reason why SP farmers in southern Benin adopted vine cuttings for production on different scales of sweet potato.

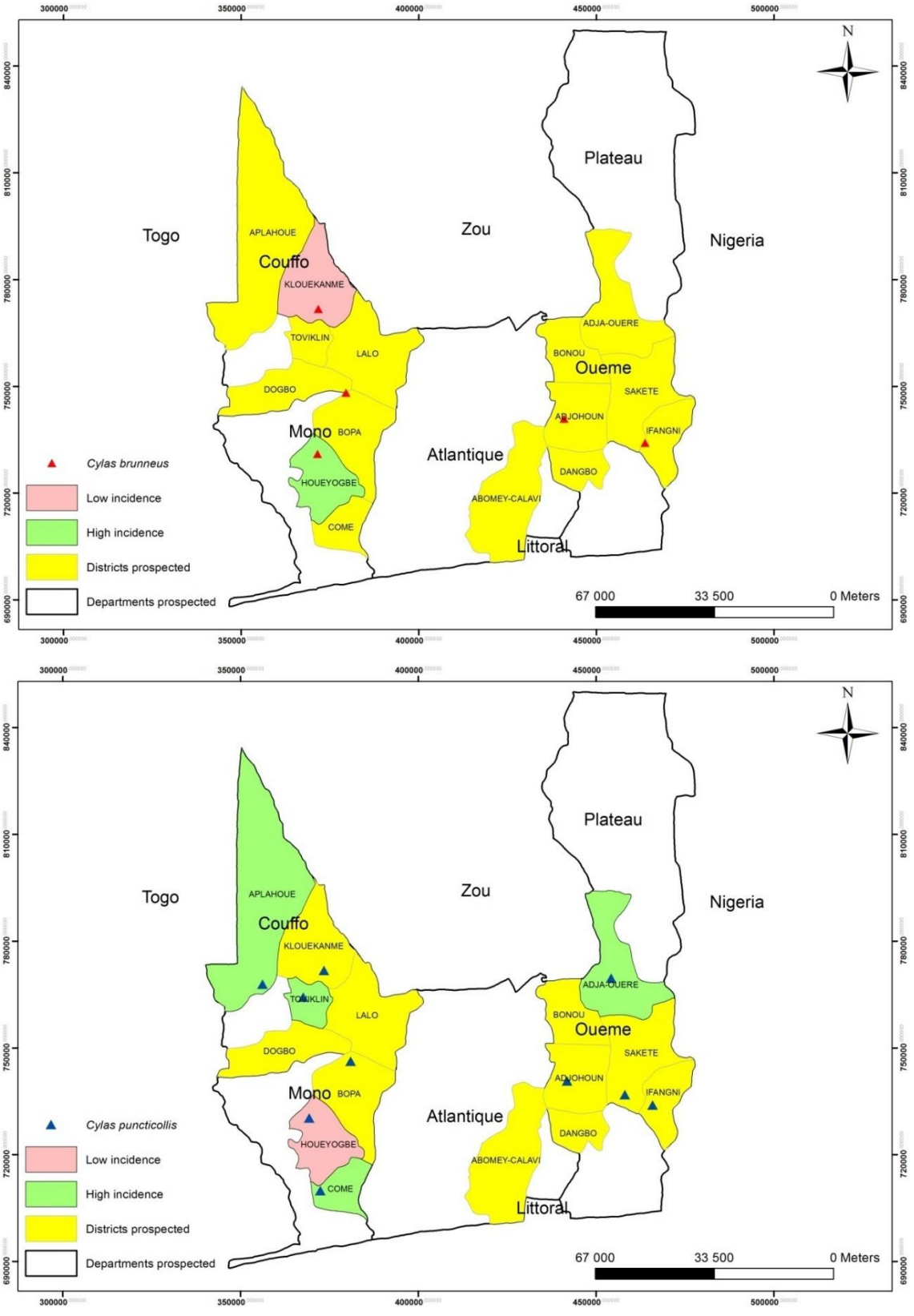

Figure 6: Maps showing sweet potato weevils species (*C. brunneus* [top] and *C. puncticollis* [bottom]) distribution in southern Benin with high and low incidences zones per species

[Cartes montrant la distribution des espèces de charançons de patate douce (*C. brunneus* [en haut] and *C. puncticollis* [en bas]) dans le sud-Bénin avec les zones de forte et faible incidences par espèce]

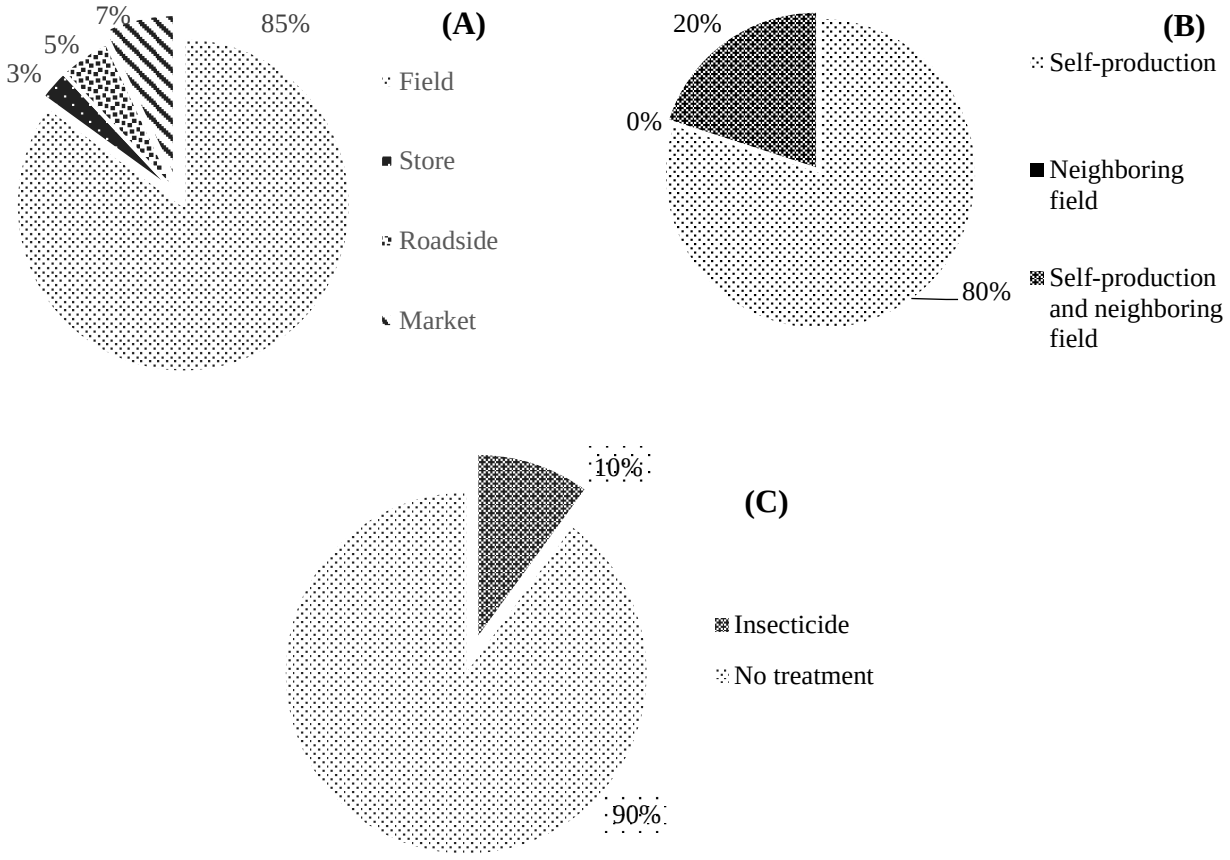

Figure 7: Some data on the survey conducted in southern Benin for *Cylas* spp.: Place of samples' collection (A), Origin of planting material (B), and Treatment of planting material (C).

[Quelques informations de la prospection conduite dans le sud-Bénin pour *Cylas* spp. : Lieu de collecte des échantillons (A), Origine du matériel de plantation (B), et Traitement du matériel de plantation (C)].

It then becomes important to identify methods to effectively control *Cylas* spp. Compliance with certain prophylactic measures, such as the use of healthy planting material, can help reduce the insect population in the field. However, a sustainable, effective, less expensive and environmentally and humanly friendly control such as the use of entomopathogenic nematodes and varietal resistance may be a priority for successful control of *Cylas* spp.

5. Conclusion

This study gave information on the distribution of SP weevils, *C. puncticollis* and *C. brunneus* in southern-Benin. These two species of *Cylas* are distributed in different agro-ecological zones of Benin with *C.puncticollis* being the most widespread. Sweet potato vines which are the preferred planting materials are treated by only 10% of farmers questioned and therefore might constitute the main means of spreading of the pests.Control methods are to be taken against the pests to guarantee highest yield and quality sweet potato in Benin.

CONFLICT OF INTEREST

The authors did not declare any conflict of interest.

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