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The « BarCo » project: for the promotion of barrier crops to curb the expansion of the Cocoa swollen shoot virus in Côte d'Ivoire

Régis Babin[1,8], Franck Oro[2], Mathias Tahi[3], Pierre Walet N'Guessan[3], Emmanuelle Muller[4,9], Thomas Wibaux[5,10], Alain Déron Koffi[6], Emmanuel Kassin[3], Brigitte Guiraud[3], Christian Cilas[7]

[1] CIRAD, UMR PHIM, Abidjan, Côte d'Ivoire
[2] Université Peleforo Gon Coulibaly, Korhogo, Côte d'Ivoire
[3] CNRA, Divo, Côte d'Ivoire
[4] CIRAD, UMR AGAP Institut, Montpellier, France
[5] CIRAD, UMR ABSYS, Abidjan, Côte d'Ivoire
[6] Université Félix Houphouët Boigny, Abidjan, Côte d'Ivoire
[7] CIRAD, DGDRS, Abidjan, Côte d'Ivoire
[8] PHIM Plant Health Institute, Univ Montpellier, CIRAD, INRAE, Institut Agro, IRD, Montpellier, France
[9] AGAP Institut, Univ Montpellier, CIRAD, INRAE, Institut Agro, Montpellier, France
[10] ABSYS, Univ Montpellier, CIHEAM-IAMM, CIRAD, INRAE, Institut Agro, Montpellier, France

ABSTRACT

The Cocoa swollen shoot virus disease (CSSVD) is considered as a threat in Côte d'Ivoire since the early 2000s, when serious outbreaks were reported in the Central-West region. Today the disease has reached most of the production areas, becoming a major threat for cocoa industry. Control measures currently implemented by cocoa sector are the destruction of infected cocoa trees and their closest neighbors. This strategy has proven alone ineffective, as new disease outbreaks have often been reported in the young cocoa plots. Among plant diversification strategies proposed by research, the use of barrier crops has proven effective in protecting young or mature plots from CSSV in Togo and Ghana. This strategy is based on the hypothesis that cocoa monocultures on vast and continuous areas, which were promoted in a recent past, are conducive to CSSV expansion. The virus is transmitted from an infected cocoa tree to a healthy one by mealybugs, which do not meet any obstacle to their dispersion in large monocultures. The BarCo project "Towards the use of barrier crops and biological control of vector mealybugs to curb the spread of the Cocoa Swollen Shoot Virus (CSSV) in Côte d'Ivoire" was implemented from June 2018 to December 2020, with the objective to test and promote barrier crops as a strategy to reduce the progression of CSSV in affected production areas, especially the region of Soubré (South West of Côte d'Ivoire). A living lab approach was adopted, where members of two farmer cooperatives were involved in all stages of the project. A set of fourteen 0.25 ha cocoa plots surrounded by 10 m large hedges of coffee (*Coffea robusta*) or acacia (*Acacia auriculiformis*), or without hedges (control plots), was implemented within large CSSVD outbreaks in mature cacao plots. About 330 farmers were trained on CSSVD symptoms, vector mealybugs and good planting practices and a technical sheet was distributed in 1400 copies. A survey of 300 cocoa farmers revealed a high level of comprehension and willingness to adopt the technology. However, other barrier crops were preferred by farmers, in the forefront of which oil palm, cashew and bitter cola (*Garcinia kola*). Sixteen-month observations revealed that CSSVD symptoms were not detected in the plots, whereas populations of at least four mealybug species were early recorded on young cocoa trees and coffee. The effectiveness of barrier crops in controlling the CSSVD is presented and discussed.

Keywords: plant diversification, planting pattern, vector mealybugs

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1. Context

Today, the Cocoa swollen shoot virus disease (CSSVD) is considered as the main threat to cocoa industry in Côte d'Ivoire (Aka et al., 2020). Swollen shoot is a vector-borne disease with mealybugs (Hemiptera : Pseudococcidae) as the only known vectors. Nearly a dozen mealybug species are known to be vectors of the disease in Côte d'Ivoire (N'Guessan et al., 2019). Despite decades of research, especially in Ghana, no eradication method has proven efficient and the disease is still progressing (Gyamera et al., 2022). The only recommended method to face the threat is to cut infected plants and their closest neighbors and replant with disease-tolerant plant material. In addition to the strong economic constraints it presents, this method has often proven to be ineffective, with new outbreaks appearing in young plantations. The full-sun monoculture is predominant in Côte d'Ivoire and often pointed out as a possible aggravating factor of CSSVD expansion. Sensitive to climate change, cocoa monocultures provide an ideal habitat to vector mealybugs that proliferate, and presents no barrier to the spread of the disease. Plant diversification of plantations, especially through agroforestry, seems a promising way to improve the sustainability of cocoa production systems in West Africa (Andres et al., 2018). Accordingly, the BarCo project proposed to develop and promote a CSSVD management method where new cocoa plantations are surrounded by barrier crops. Having given promising results in Ghana (Domfeh et al., 2016), barrier crops are supposed to prevent infection of new plantations through three main mechanisms: 1) hedges are physical barriers that disturb mealybug dispersion and delay plot infestation by the vectors; 2) by feeding on some CSSV non-host barrier plants (such as coffee), mealybugs get free from virus and become harmless to cocoa; 3) hedges host numerous natural enemies of mealybugs and limit their proliferation. The BarCo project "Towards the use of barrier crops and biological control of vector mealybugs to curb the spread of the Cocoa Swollen Shoot Virus (CSSV) in Côte d'Ivoire" was implemented in Côte d'Ivoire from June 2018 to December 2020 by three partners: CIRAD, CNRA and Université Peleforo Gon Coulibaly. The project was funded by « Fonds Interprofessionnel pour la Recherche et le Conseil Agricoles » (FIRCA).

2. Project objectives

The main objective of the BarCo project was to test and promote an innovative method to curb the expansion of swollen shoot in Côte d'Ivoire. This method is based on the setting up of barrier plants around young cocoa plantations when replanting after the destruction of swollen shoot outbreaks.

The 3 operational objectives of the project were as follows:

- Implement the BarCo system, consisting of cocoa plantations surrounded by barrier plants, dedicated to the experimentation and demonstration of the technology;
- Contribute to the development of the technology by improving our understanding of the barrier effect on the spread of the disease and the dynamics of the mealybug populations;
- Optimize the appropriation of the project results by cocoa farmers and create favorable interactions between actors of the cocoa industry through the "Living Laboratories" approach.

3. Main achievements of the project

3.1. BarCo technology implementation and maintenance

A total of fourteen 0.25 ha cocoa plots surrounded by 10 m large hedges of coffee (*Coffea robusta*) or acacia (*Acacia auriculiformis*), or without hedges (control plots), were implemented within large CSSVD outbreaks in mature cacao plots, in the region of Soubré/Méagui in South-West of Côte d'Ivoire (Figure 1). Plots were marked by signage panels as well as access to the plantations from main roads. The regular maintenance consisted of monthly weeding, regular fertilization and occasional insecticide applications in case of an insect outbreak. During the dry season, regular watering was carried out and some more sensitive plants were covered with oil palm leaves. Pruning was carried out when the plants reached the required development and dead plants were regularly replaced. The barriers were also

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maintained, including the pruning of acacias. Maintenance tasks were delegated to the project partner cooperatives.

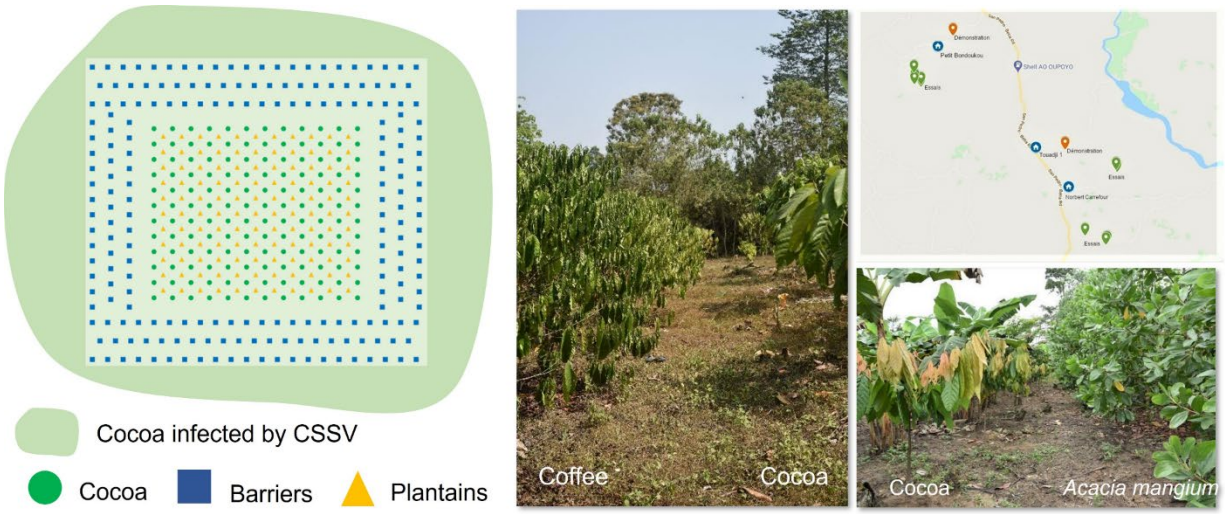

Figure 1: Illustrations of the BarCo technology implementation, with on the left, the plot diagram showing cocoa surrounded by barrier crops implemented in a CSSVD outbreak, two pictures of the cocoa/coffee and cocoa/acacia associations and on the top right, a map of the plot network

3.2. Farmer training through "Living Laboratories"

The "Living Laboratories" (LLs) approach was adopted to optimize the project's impact on cocoa farmers, who were the primary beneficiaries of the project. A collaboration platform was implemented with two partner cooperatives in the Soubré-Méagui region, Société Coopérative Agricole de Norbert Carrefour (SOCANC) and Société Coopérative Agricole de Petit Bondoukou (SCAPB), which together represent about 620 cocoa farmers. Systematic involvement of the cooperatives makes them now able to maintain and expand the technology on their own. About 330 farmers were trained on CSSVD symptoms, vector mealybugs and good planting practices in 10 sessions conducted in demonstration plots for a period of 5 days. In addition, a technical sheet covering same topics was distributed in 1400 copies (Figure 2).

3.3. Farmer survey for technology improvement

Surveys showed that 100% of trained farmers understood the importance of planting barrier plants around young plantations to protect them from swollen shoot disease. Additionally, most of them said they were willing to set up a plot with plant barriers. It is worth noting that many of trained farmers had lost all of their plantations due to swollen shoot and have already attempted to replant, which often resulted in failure. Good planting practices were rarely adopted by farmer as they were not well known. In this context, farmers seemed very open to any strategy that would renew their plantation. Another result of the survey is that nearly a quarter of the farmers said they were willing to change the planting design. Several farmers said they were willing to plant a plot with barriers on a larger surface (1 hectare instead of the 1/4-hectare plots). In addition, farmers were willing to change barrier plants, *Acacia auriculiformis* having little success among farmers who did not see a financial interest and feared that the acacia would become invasive, or sources of infestation by certain parasitic plants (Loranthaceae). In response to the question "What barrier plants would you use instead of acacia and coffee?", the answers were diverse, with preference for Oil palm (*Elaeis guineensis*), Cashew tree (*Anacardium occidentale*) and bitter cola (*Garcinia kola*) (Figure 3).

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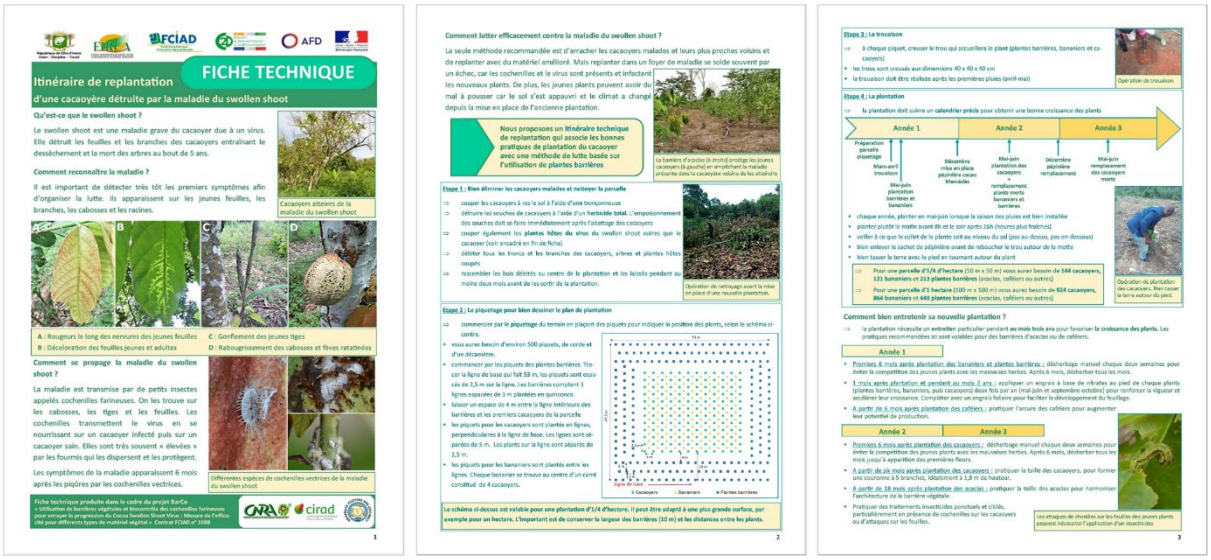

Figure 2: Extract from the technical sheet distributed to cocoa farmers in 1400 copies. The technical sheet presents CSSVD symptoms, vector mealybugs and the good practices of replanting after the destruction of disease outbreaks. The technical sheet can be downloaded on the project website (https://barco.cirad.fr/).

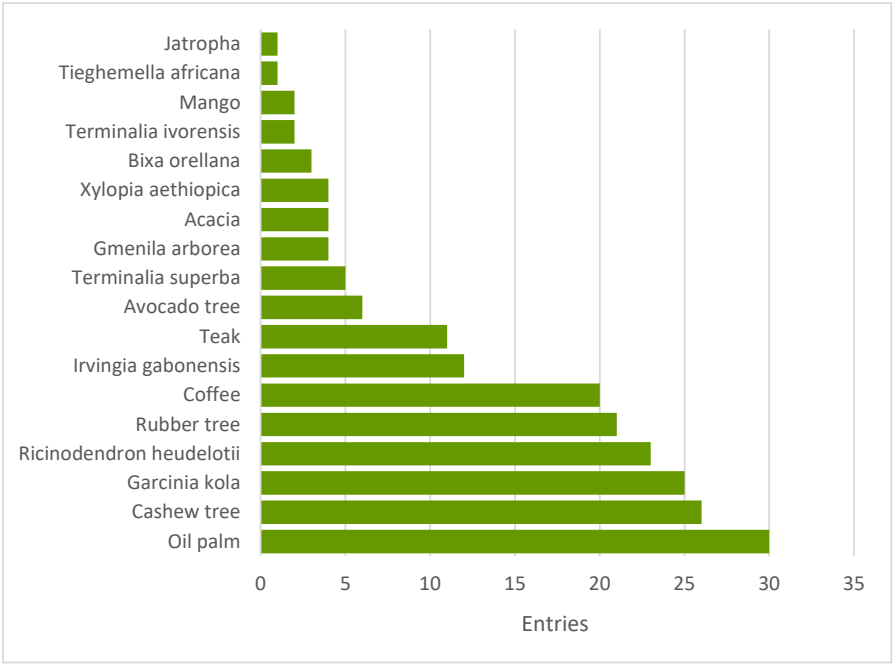

Figure 3: Cocoa farmer preferences for trees and bushes to be used as barrier crops to protect their new plantations from Swollen shoot disease

3.4. Study of barrier effect on the spread of the disease and the dynamics of the mealybug populations

Observations were carried out monthly on CSSVD symptoms and mealybug populations infesting cocoa and barrier crops. Results show that, at the end of the project, the disease did not cross barriers to enter the new plots from old infested surrounding cocoa plantations. By contrast, mealybugs from different species did early infest both cocoa and coffee from surrounding cocoa. At the end of the project, mealybug infestation was low but pests were present whatever the type of barrier crop (Figure 4), suggesting that barriers did not prevent plot from colonization by mealybugs.

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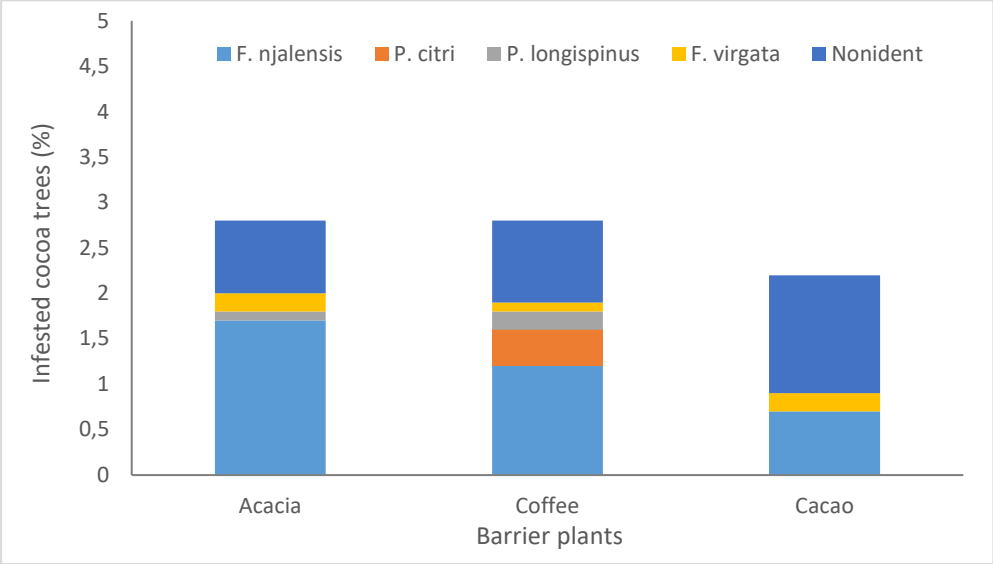

Figure 4: Infestation rate of cocoa trees in BarCo plots by different mealybug species and according to the type of barrier crop, or in control plots (cocoa). There was no significant difference between treatments.

4. Conclusion and perspectives

The BarCo project achieved most of its goals by setting up a collaboration platform with two cooperatives in the Soubré-Méagui region. This platform enabled the implementation of a network of 14 plots for experimentation and demonstration. Here, trainings and observations of swollen shoot disease and associated insects were carried out. The training allowed us to evaluate the degree of technology appropriation by cocoa farmers and also to identify their preferences in terms of associated barrier plants. Based on the project results, we were able to formulate a number of recommendations to improve the technology, based on its technical and socio-economic evaluation. Finally, the visibility of the project was greatly improved by the development of a website (https://barco.cirad.fr/) that made all project information freely available, especially numerous pictures of the symptoms of the disease and the vector mealybugs and the technical sheet that is downloadable from the site.

The perspectives of the BarCo technology are positive since the collaboration platform and the plot network will be maintained for at least two additional years under a new project, the Cocoa4Future project (EU, DeSIRA). This project will also provide additional activities such as a longer-term socio-economic evaluation of the technology, training of farmer trainers and co-conception of innovative cocoa farming systems. A new project for scaling up the technology would certainly be of interest. BarCo project results as well as ongoing Cocoa4Future project activities allow us to consider planting new plots on a larger scale from mid-2023. The collaboration platform put in place would greatly facilitate the implementation of this new project and the number of direct beneficiaries of the technology would be multiplied.

Acknowledgements

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