Int.J.Curr.Microbiol.App.Sci (2025) *14*(06): 123-146

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 14 Number 6 (2025)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2025.1406.012

Adaptive Strategies of Togolese Farmers for Sustainable *Phaseolus spp.* Production Amidst Climate Variability in West Africa

Ame Mensah Espère HOUNGO[1,2], Atti TCHABI[1,2], Koffi Kibalou PALANGA[1,2], Komi AGBOKA[3,4,5], Essohouna Modom BANLA[6], Kpatcha KAMDE[1,2] and Moustakimou SIBABI[1,2]

Laboratoire des Sciences Agronomiques et Biologiques Appliquées (LaSABA), Université de Kara, Kara, Togo
[2]Institut Supérieur des Métiers de l'Agriculture (ISMA), Université de Kara, Kara, Togo
[3]Laboratoire de Recherche sur les Agroressources et la Santé Environnementale (LaRASE), Université de Lomé, Lomé, Togo
[4]École Supérieure d'Agronomie (ESA), Université de Lomé, Lomé, Togo
[5]West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL), Université de Lomé, Lomé, Togo
[6]Centre de Recherche Agronomique Savanes Sèche-Institut Togolais de Recherche Agronomique (CRASS-ITRA), Kara, Togo

**Corresponding author*

Keywords

Phaseolus, snowball sampling, cultural practices, production constraints, climate change

Article Info

Received:
11 April 2025
Accepted:
28 May 2025
Available Online:
10 June 2025

ABSTRACT

Beans of the *Phaseolus* genus are among the neglected and underutilized species, exposing them to a high risk of genetic erosion and extinction. This study aimed to identify production areas and producers, document cultural practices, analyze production constraints, explore suitable solutions, and assess the effects of climate change on *Phaseolus* cultivation. The methodology employed was based on the snowball sampling technique, implemented after a preliminary identification of villages and potential producers, conducted in collaboration with agents from the Institut de Conseil et d'Appui Technique (ICAT) in Togo. Data were collected through surveys of producers. The results indicate that the surveyed producers, with an average age of 45.87 ± 0.43 years, have accumulated 13.96 ± 0.47 years of experience in bean cultivation. Women predominantly manage production on average arable areas of 5.96 ± 0.44 hectares, of which 3.67 ± 0.17 hectares are actively cultivated. Beans are often grown in intercropping systems under trees, primarily dry trees (521) or under palms (*Elaeis guineensis*). Most producers (41.36%) began cultivation using seeds received as donations, while seeds for the following planting season are mainly derived from previous harvests (97.35% of producers). The results also reveal that corn (citation frequency: 98.9%; Smith index: 0.7418), cassava (70.1%; 0.4150), and cowpea (66.4%; 0.3514) are most frequently associated with *Phaseolus* spp.. Sowing periods vary by region but generally occur in May and July (61.47%), with harvesting between January and February (65.42%), depending on the varieties cultivated for an average cycle length of more than 210 days (69.80% of producers). The main constraints identified include pest infestations, notably field caterpillars (185 producers), storage pests (130 producers), and bean weevils (*Acanthoscelides obtectus*) during storage (69 producers), as well as a lack of trees for staking plants.

Introduction

Legumes are indispensable for providing protein-rich food products and introducing nitrogen into cropping systems (Julier and Louarn, 2022). Agronomically, legumes are uniquely capable of utilizing atmospheric nitrogen through symbiotic fixation, allowing them to grow independently of soil nitrogen, unlike most other crops (Bernard, 2016). They play a critical role in maintaining soil fertility by converting atmospheric nitrogen into plant-usable compounds, thus improving soil health (Fao, 2016). Additionally, legumes enhance agricultural ecosystems by supporting biomass production and vital microbial activity in soils (Fao, 2016).

Among legumes, *Phaseolus* beans, comprising 80 species, include five domesticated ones: *Phaseolus acutifolius* A. Gray, *Phaseolus coccineus* L., *Phaseolus dumosus* Macfad, *Phaseolus lunatus* L., and *Phaseolus vulgaris* (Baudoin, 2004; Fagbédji *et al.,* 2022). Of these, *Phaseolus lunatus* and *Phaseolus vulgaris* are the most widely cultivated in tropical Africa. These beans are essential crops for many farming communities worldwide, providing a significant source of proteins and nutrients for rural families, particularly the poorest and most vulnerable (Brink and Belay, 2006; Missihoun *et al.,* 2017; Estelle *et al.,* 2018; Fagbédji *et al.,* 2022). Their consumption offers multiple health benefits, including managing chronic conditions such as diabetes and cancer, as well as treating other ailments like edema, gout, and tumors (Baudoin, 2004).

In Togo, *Phaseolus* beans are cultivated nationwide, though on marginal areas, primarily for household consumption. Production is constrained by abiotic factors such as climate change effects (e.g., drought and high temperatures) (Bayuelo-Jiménez *et al.,* 2003; Mansouri, 2021), biotic factors like fungal, bacterial, and viral diseases (Mahuku *et al.,* 2002; Milognon *et al.,* 2020; Caixeta *et al.,* 2023), and storage pest infestations (Estelle *et al.,* 2018). Recognizing these constraints is vital for developing technologies and knowledge to enhance yields and improve farmers' incomes (Rodríguez De Luque and Creamer, 2015; Estelle *et al.,* 2018). Moreover, an effective conservation strategy requires evaluating genetic diversity and analyzing farming practices.

Studies from other countries, such as Benin, reveal that *Phaseolus* beans are often intercropped with other plants (Milognon *et al.,* 2020), grown in home gardens, or along fences (Missihoun *et al.,* 2017). Most producers associate *Phaseolus* cultivation with other erect crops, including cassava (*Manihot esculenta* Crantz), maize (*Zea mays* L.), pigeon pea (*Cajanus cajan*), juvenile oil palms (*Elaeis guineensis*), or yam (*Dioscorea* spp.), which also require staking (Missihoun *et al.,* 2017).

However, limited knowledge of the farming practices adopted by *Phaseolus* bean producers in Togo, along with the challenges they face and mitigation measures, poses a significant obstacle to promoting the crop's adoption (Ayenan and Danquah *et al.,* 2017). This study seeks to identify *Phaseolus* production areas and producers, document traditional farming practices, assess production constraints, explore potential solutions, and evaluate the impact of climate change on *Phaseolus* cultivation to ensure sustainable production and resilience

Materials and Methods

Study Area

This study was conducted across the five regions of Togo, a country in West Africa with a narrow 50 km coastline along the Atlantic Ocean to the south. Togo is bordered to the north by Burkina Faso, to the east by Benin, and to the west by Ghana. Covering an area of 56,600 km², the country stretches 660 km from north to south between latitudes 6° and 11°N, with a maximum width of 150 km, spanning longitudes 0°14’W to 1°40’E (CCNUCC, 2022). From a pedological perspective, Togo comprises tropical ferruginous soils, ferralitic soils, weakly developed soils, hydromorphic soils, and vertisols (Da Costa *et al.,* 2015).

Togo enjoys a tropical climate with two variations. In the southern region, a Guinean-type climate with four seasons is observed:

a. A major rainy season (March/April to July), peaking in June.
b. A minor rainy season (September to November), peaking in October.
c. A short dry season in August.
d. A long dry season from November to February.

Annual rainfall in the south averages between 1200 and 1600 mm (Djan’na *et al.,* 2019). However, southern Togo experiences a climatic anomaly resulting in reduced rainfall compared to other countries along the coastal belt.

North of the 8th parallel, a Sudanian-type tropical climate prevails with two seasons: (i) a rainy season from April to October, peaking in August/September, (ii) a dry season from November to March. Annual rainfall averages range between 850- and 1350-mm. Thermal conditions indicate an annual mean temperature of 27.1 °C. Temperatures vary with altitude, latitude, and land use. In plains, temperatures range from 19 °C to 34 °C, while forested and mountainous areas exhibit a narrower range of 18 °C to 29 °C. Overall, Togo's climate shows global warming trends, with national meteorological data from 1961 to 2018 revealing temperature increases of 0.8 °C to 1.2 °C and rainfall declines between -15.4 mm and -97.8 mm over the same period (Djan'na *et al.,* 2019).

Data Collection

Data were collected in all villages (Appendix 1) where *Phaseolus* bean production occurs in Togo (Figure 1). As *Phaseolus* beans are minor crops typically cultivated by smallholder farmers, the study targeted producers with at least one *Phaseolus* plant in their fields or around their homes.

Ethnobotanical Surveys and Data Collection

Data collection in each village utilized two main methods: (i) Village and Farmer Pre-Identification**:** This involved identifying villages and *Phaseolus* bean farmers with the assistance of agents from ICAT (Institute of Advice and Technical Support) in Togo, (ii) Snowball Sampling: Following the method described by (Biernacki and Waldorf, 1981), this approach involved interviewing previously surveyed farmers to identify other villages and producers. Farmers were asked about the sources of their initial seeds, their knowledge of other *Phaseolus* bean farmers, and whether they had provided seeds to others (Laboratory of Genetic Resources and Molecular Breeding, Department of Genetic and Biotechnology, Faculty of Sciences and Techniques, University of Abomey-Calavi, BP 1947 Abomey-Calavi, Benin Republic. *et al.,* 2019).

Two types of questionnaires were administered:

Group Questionnaires: Designed to gather community-level data.

Individual Questionnaires: Focused on personal farming practices and experiences (Ayenan, Danquah, *et al.,* 2017).

Questionnaires were conducted in local languages with the help of interpreters (Fagbédji *et al.,* 2022) selected from among the farmers. Before starting the surveys, the study's objectives were explained to each participant, and their consent was obtained.

Data collected were categorized into four main sections (Ayenan, Ofori, *et al.,* 2017):

a. **Sociodemographic Information:** Gender, age, household size, education level, ethnicity, cultivable land size, area allocated to *Phaseolus* beans, and farming experience with *Phaseolus* beans.
b. **Farming Systems:** Agricultural operations, crops associated with *Phaseolus* beans, production constraints, and mitigation measures.
c. **Gender Roles in *Phaseolus* Bean Production and Marketing:** Exploring the involvement of different household members.
d. **Post-Harvest Management:** Practices related to *Phaseolus* bean grain storage and handling.

Producers

This study identified 937 *Phaseolus* bean producers across Togo, with 55.71% being women and 44.29% men. The average age of respondents was 45.87 ± 0.43 years. These producers have been cultivating *Phaseolus* beans for an average of 13.96 ± 0.47 years, with over 77.59% having between 1 and 20 years of experience in this activity.

The average cultivable land per household was 5.96 ± 0.44 hectares, with 3.67 ± 0.17 hectares being effectively cultivated. However, none of the surveyed producers allocated a specific portion of their cultivated land solely to *Phaseolus* bean farming (Table 1).

Data Analysis

The study analyzed the farming practices of *Phaseolus* bean producers to understand their production methods, associated constraints, and possible solutions. The constraints were categorized for each region based on the average of three indicators:

1. **NTV (Number of Total Villages):** Villages reporting the constraint.
2. **MAC (Major or Priority Constraint):** Villages where the constraint is deemed significant.
3. **PCO (Principal Constraint):** Villages ranking the constraint among their top five.

The **Constraint Importance Index (IMC)** was calculated using the formula proposed by (Dansi *et al.,* 2013):

$$\mathbf{IMC} = \frac{\mathbf{NTV+MAC+PCO}}{\mathbf{3}}$$

This approach enabled a clear ranking of constraints within each region.

Data were analyzed using statistical methods, including a**nalysis of Variance (ANOVA)** to assess variations in farming practices across regions. Qualitative data were interpreted using diagrams and dendrograms. All analyses were performed using R software (version 4.3.1)

Crops associated with Phaseolus spp. were classified according to the order in which they were cited by producers, then the frequency, average citation rank, and Smith index were calculated for each species, in accordance with the methodology described by (Sarr *et al.,* 2022).

The Smith index is calculated as the weighted average of the inverse of the rank of each item in the free lists, normalized by the length of the lists. It reflects both the frequency and the priority given to each item by respondents (Smith and Borgatti, 1997; Marsha, 2005).

$$S = \frac{1}{N}\sum_{j=1}^{N} \frac{Lj - rij + 1}{Lj}$$

where:

S= Smith index

N = number of lists,

Lj= length of list j,

rij= rank of element i in list j.

Results and Discussion

Seed Management

The initial seeds used by Phaseolus bean producers in Togo predominantly come from gifts, especially in the Plateaux-Est and Plateaux-Ouest regions. Although less significant in quantity, other sources of seeds include inheritance and local market purchases, depending on the region.

Analysis in Figure 2 shows that the majority of Phaseolus bean producers in Togo started cultivation with seeds received as gifts (41.36% of the producers), typically from family, friends, or neighboring countries such as Ghana, Benin, and Nigeria. Another group of producers (32.91% of the producers) began production with seeds inherited from their parents, while 16.49% of the producers purchased their seeds from local markets. A small fraction of producers (5.65% of the producers) started by combining seed purchases from the market with gifts from relatives. Additionally, a few producers (3.59% of the producers) received part of their seeds through inheritance and part as gifts, although the inherited, purchased, or gifted varieties are not necessarily the same.

For the following season's planting, most producers (97.35%) across all regions obtain their seeds from the previous harvest.

Sowing and Harvesting

Analysis of sowing periods revealed significant variation across regions ($\chi^2 = 18.618$; df = 10; $p < 0.001$). Most respondents (61.47%) sow between May and June, with a high concentration in the East Plateaus (307 producers) and West Plateaus (134 producers) regions. The March–April period accounts for 30.42% of sowing activities, predominantly in the Maritime (53 producers), West Plateaus (97 producers), and East Plateaus (123 producers) regions. In contrast, sowing during July–August is marginal (8.11%), mainly observed in the East Plateaus (20 producers) and Kara (17 producers) regions, and entirely absent in the Savannahs region.

Harvest periods also exhibited significant regional variation ($\chi^2 = 5.345$; df = 5; $p < 0.001$). Most producers (65.42%) harvest in January–February, predominantly in the East Plateaus (336 producers) and West Plateaus (125 producers). Although less frequent (34.58%), the November–December harvest period remains notable in the West Plateaus (117 producers) and Central region (38 producers), whereas the Savannahs and Kara regions contribute minimally to this period.

The duration of the crop cycle varied markedly among the studied areas (χ^2 = 134.861; df = 10; p < 0.001). A large majority of respondents (69.80%) reported crop cycles exceeding 210 days, particularly in the East Plateaus (320 producers) and West Plateaus (204 producers). Intermediate cycles, ranging from 180 to 209 days, accounted for 18.36% of producers, with a higher prevalence in the Kara (29 producers) and Maritime (29 producers) regions. Short cycles of less than 180 days were rare (11.85%) and primarily concentrated in the East Plateaus (50 producers) and West Plateaus (22 producers) (Table 2).

The cultivation system of *Phaseolus* beans in Togo relies on simultaneous polyculture, combining beans with other crops. Since no specific area is exclusively dedicated to Phaseolus beans, producers sow them alongside other crops. Agricultural practices are diverse, and a single producer may employ one to four cultivation techniques. Generally, sowing is done either under dry trees present in the fields (521 producers), around palm trees (473 producers), on the same stakes as yams, or along house fences.

By region, distinct practices are observed. In the Maritime region, 82 producers sow on palm trees, 17 sow on house fences, and 6 sow on all trees in their fields. In the Plateaux-Ouest (P.O.), sowing on palm trees is also dominant (274 producers), but a significant number of producers (139) sow on dry trees, and 82 use stakes after sowing. In Plateaux-Est (P.E.), the practice of sowing on palm trees is widespread (274 producers), and many producers (116) also sow on dry trees, with 77 sowing in fields of yams. In the Central region, sowing is less frequent on trees, with 19 producers using house fences, 6 sowing on all trees, and 4 employing staking. The Kara region shows a marked preference for sowing on palm trees (11 producers) and on dry trees (32 producers). In the Savanes region, the practices are less diverse, with 3 producers sowing on all trees and one sowing under ronier (*Borassus flabellifer*) trees (Table 2).

The following table presents the plant species cited by respondents, along with their citation frequency, mean rank, and three ethnobotanical importance indices: Smith's index, Sutrop's index, and the B.Score, which assess the relative cultural significance of the species. The results indicate that maize (*Zea mays* L.), cassava (*Manihot esculenta* Crantz), cowpea (*Vigna unguiculata*), and common bean (*Phaseolus* spp.) rank highest in local preferences, exhibiting the highest index values.

For example, maize is the most frequently cited species with a citation frequency of 98.9% and a Smith's index of 0.7418, followed by cassava (70.1%, Smith = 0.4150) and common bean (59.8%, Smith = 0.5416). Cowpea, meanwhile, shows a mean rank of 4.386, reflecting its strong presence, though slightly less prioritized.

Conversely, certain species such as roselle (*Hibiscus sabdariffa*), proso millet (*Panicum miliaceum*), and shea tree (*Vitellaria paradoxa*) present very low index values (Table 3).

Post-harvest Seed Management

Post-harvest seed management practices vary across regions in Togo. However, in all regions, plastic containers are commonly used for storing harvested beans. Bags and sachets are also used in all regions except the Savanes. In the maritime, Plateaux, and Central regions, beans are sometimes stored in pods or sachets. Specific containers for seed storage for the next season include gourds, ceramic jugs (canari), and pesticide containers. The gourd is used in both Plateaux regions and the Kara region, while the canari and pesticide containers are exclusively used in the Plateaux regions (Figure 4).

Generally, producers do not use preservation products (920 producers). However, a small proportion of producers use substances like ash, cotton pesticides, or cockroach insecticides to preserve the seeds. (17 producers) (Figure 7). In the Kara region, producers do not systematically use any preservation products, whereas in the Savanes region, a large proportion of producer's resort to preservation products (Figure 5).

Role of Gender in the Production Chain of Phaseolus Beans in Togo

From plot selection to commercialization, women, men, and even children are involved in the production chain, though to varying degrees. Overall, women are more involved than men at each stage of the Phaseolus bean production chain in Togo. Stages such as variety selection (522 women vs. 415 men), plot selection (523 women vs. 414 men), and plot preparation (528 women vs. 409 men) show a higher participation of women compared to men. On the other hand, crop management (539 women vs. 339 men), harvesting (559 women vs. 378 men), and sales participation (232 women vs. 88 men) show a more marked difference, with significantly fewer men involved compared to women (Table 4).

Constraints Related to Phaseolus Bean Cultivation

Several constraints hinder large-scale production of Phaseolus beans in Togo. Among these, the most significant are insect pest attacks, both in the field and during seed storage (IMC = 79.33), lack of trees to expand production (IMC = 60.33), and lack of market opportunities for the harvested seeds (IMC = 47.33). However, 27.31% of the villages surveyed report encounter no constraints related to production.

Other constraints, although less frequent, include issues like lack of flowering in beans imported from the south to the north of Togo, excessive leaf production at the expense of pods, cattle attacks, flower drop, empty pods, difficulty in harvesting, long production cycles, squirrel attacks on pods, lack of technical guidance, and the need to plant under trees (IMC < 6). The level of importance of these constraints varies by region. The Central and Kara regions exhibit similar rankings of constraints, while the Maritime, Plateaux-Est, and Plateaux-Ouest regions face prevalent issues such as insect attacks, lack of trees for sowing, and market absence. Certain constraints, such as flower drop, dry pockets, excessive leaf production, planting under trees, lack of technical itineraries, long cycles, difficult harvesting, and squirrel and rat attacks on pods, are specific to certain regions (Table 5).

To address these constraints, villagers adopt various practices, such as the use of insecticidal treatments to control pests and flower drop (40% of producers). They also carry out planting on palm trees (20% of producers), in yam fields (7.06% of producers), or on maize and sorghum stalks (1.18% of producers), and employ staking after sowing (3.53% of producers) to compensate for the lack of available trees. In the absence of buyers for the harvested products, some producers cultivate solely for family consumption (44.71% of producers) (Table 6).

Main Pests Associated with Bean Cultivation

Pests constitute a significant portion of the constraints related to the cultivation of Phaseolus beans in Togo. Among the most common are caterpillars, which cause damage both in the field (185 producers) and during storage (130 producers), as well as the bean weevil *Acanthoscelides obtectus* (69 producers), which attacks seeds in storage. Caterpillars damage either the leaves (94 producers), the pods (254 producers), or the seeds (130 producers). Aphids and whiteflies feed on the sap of young leaves (58 producers), pods (59 producers), and flowers (46 producers), while locusts feed on the leaves (14 producers) and pods (9 producers) (Figures 6 and 7).

Although caterpillars are most cited as causing the most damage to Phaseolus beans, the majority of respondents (165) assessed these damages as generally low. A significant portion (106) considered the damage to be moderate, while only a few (14) viewed the damage as high. Regarding aphids and whiteflies, the number of people who considered the damage to be low (28) is roughly equal to those who assessed it as moderate (31), with only 5 producers considering the damage from these pests to be very high. Weevils were also mentioned as pests causing generally low (42 producers) to moderate (23 producers) damage, with some (5 producers) deeming the damage high. Other pests, such as locusts, rats, and termites, were considered to cause damage generally seen as low by the producers.

Perception of Climate Change, Impacts, and Mitigation Measures

The majority of respondents report not perceiving any impacts of climate change, with particularly high numbers in the Plateaux-Est (359) and Plateaux-Ouest (175) regions, while the numbers are notably low in the Savanes region (3). Conversely, fewer respondents report perceiving impacts, though these are more notable in the Maritime (63), Plateaux-Ouest (67), and Plateaux-Est (91) regions, whereas recognition is minimal in the Centrale (6) and Kara (5) regions.

The most frequently cited manifestations of climate change in each region include irregular rainfall (Plateaux-Est: 17 producers, Maritime: 14 producers) and drought pockets (Plateaux-Est: 16 producers, Plateaux-Ouest: 9 producers). Impacts on bean cultivation are also reported, particularly reduced production (Plateaux-

Ouest: 11 producers, Maritime: 3 producers) and pod formation issues, such as pods without seeds (Maritime: 13 producers, Plateaux-Est: 5 producers), which are more pronounced in these regions.

Although adaptation measures such as reforestation (Centrale: 1 producer, Plateaux-Ouest: 2 producers) and adjustments to planting schedules are mentioned, their adoption remains limited. A majority of respondents report taking no measures (Plateaux-Est: 66 producers, Plateaux-Ouest: 47 producers). When measures are implemented, they are often deemed ineffective, particularly in the Plateaux-Est (69 producers) and Plateaux-Ouest (52 producers) (Table 7).

Sociodemographic Characteristics of Surveyed Producers

This study on the cultivation practices of beans from the *Phaseolus* genus in Togo revealed that only a small number of individuals are engaged in this activity, with a total of 937 producers identified nationwide. Women play a predominant role in this sector, representing 55.71% of the producers. This proportion is significantly higher than those reported in similar studies conducted in other countries by (Estelle *et al.,* 2018; Loko *et al.,* 2018; Milognon *et al.,* 2020; Fagbédji *et al.,* 2022), who documented lower percentages of female participation. These findings highlight the critical role of women in sustaining the cultivation of *Phaseolus* beans.

However, the limited number of producers (937) points to a potential threat to the survival of this crop. Despite this, the average experience of producers, estimated at 13.96 ± 0.47 years, suggests a resurgence in production in recent years, as the majority (77.59%) have less than 20 years of experience. Nonetheless, the area dedicated to bean cultivation remains negligible. While the average arable land per producer is 5.96 ± 0.44 hectares, the actual area allocated to bean cultivation is only 3.67 ± 0.17 hectares. Previous studies have demonstrated that the land area allocated to neglected species, including beans, is generally much smaller compared to areas devoted to non-neglected crops (Loko *et al.,* 2018).

Seed Management

A significant proportion (66.38%) of the surveyed producers began cultivating *Phaseolus* beans with seeds obtained as gifts. Subsequently, seeds for the following years are generally sourced from the previous year's harvest. However, in rare instances where the entire harvest is lost, producers resort to purchasing seeds or requesting them from other farmers. Missihoun *et al.,* (2017) reported that most producers reserve a portion of their harvests for use as seeds in the next planting season.

Our findings reveal the complete absence of a formal seed system for *Phaseolus* beans. This situation encourages seed exchanges between farmers and villages, facilitating the introduction of new varieties and the dissemination of existing cultivars (Almekinders and Louwaars, 1999; Mula, 2014; Ayenan, Ofori, *et al.,* 2017). The transmission of seeds from parents to descendants, combined with the lack of improved varieties, could mitigate the risks of genetic erosion (Missihoun *et al.,* 2017). Similar observations have been documented for other local crops, such as fonio (Adoukonou-Sagbadja *et al.,* 2006; Dansi, Adoukonou-Sagbadja and Vodouhè, 2010), millet (Geiger *et al.,* 2003; Kinhoégbè *et al.,* 2020), and sorghum (Polycarpe Kayode *et al.,* 2005; Missihoun *et al.,* 2012), as well as for *Phaseolus* beans (Missihoun *et al.,* 2017).

Sowing Practices

In general, sowing aligns with the climatic specificities of each region and takes place between March and June across the country. Sowing is typically carried out after the planting of major crops, as bean cultivation is considered secondary. In all regions, producers commonly interplant *Phaseolus* beans with maize, cassava, cowpea, palm, sorghum, vegetables, and other crops. Some of these crops, such as cassava, sorghum, and maize, also serve as natural supports for the beans. Sowing primarily occurs under dry trees or oil palms found in the farmers' fields. These practices have previously been documented by Missihoun *et al.,* (2017).

Harvesting generally takes place between December and January, after the main crops have been collected. The timing of sowing and harvesting reflects the climatic variability of the country. Southern regions experience two peaks for sowing and harvesting, while northern regions exhibit only one peak for each activity.

Beans from the *Phaseolus* genus are frequently used as a supplementary food source and are often harvested during the lean season when food reserves, particularly cereals, are scarce (Missihoun *et al.,* 2017).

Gender Roles in the *Phaseolus* Bean Production Chain in Togo

The choice of varieties and plots dedicated to bean cultivation is proportional to the number of individuals surveyed in each category. Contrary to findings by (Kinhoégbè *et al.,* 2020) on *Cajanus cajan*, women are more actively involved in the production chain of *Phaseolus* beans, from selecting accessions to harvesting and marketing. This can be attributed to the higher number of women cultivating these beans. While land ownership typically rests with household heads (men), women usually decide where to plant *Phaseolus* beans. They take advantage of existing trees in their husbands' or their own fields to plant the beans. These results contrast with findings from (Missihoun *et al.,* 2017; Estelle *et al.,* 2018; Milognon *et al.,* 2020), who observed a higher number of men involved in *Phaseolus* bean production in Benin.

Phaseolus Spp. are often grown in association with other staple crops such as maize (*Zea mays* L.), cassava (*Manihot esculenta Crantz*) and cowpea (*Vigna unguiculata*), which have the highest indices of ethnobotanical importance, confirming their central role in local food systems, as highlighted by (Munialo *et al.,* 2025). The high frequency of citation and the high Smith index for these species reflect their cultural and economic importance, in line with the observations of (Sarr *et al.,* 2022; Matos *et al.,* 2024) on the predominance of food crops in West Africa. Conversely, species such as shea (*Vitellaria paradoxa* C.F. Gaertn.) and bissap (*Hibiscus sabdariffa* L.) show very low indices, which is in line with the conclusions of (Pei *et al.,* 2020; Duche-Pérez *et al.,* 2024) who report their marginal role in daily subsistence despite their ecological presence.

Also, the moderate importance of crops such as groundnut (*Arachis hypogaea* L.) and sesame (*Sesamum indicum* L.) suggests their function as secondary or cash crops, a pattern also observed by (Brooke, 1958) in similar agroecological contexts.

Constraints

The low production of *Phaseolus* beans in Togo can be partially attributed to several production challenges. This study revealed that insect pests are the main threat to *Phaseolus* bean cultivation. Unlike the findings of (Gichangi *et al.,* 2012; Musoni *et al.,* 2014; Ruganzu *et al.,* 2014; Missihoun *et al.,* 2017; Estelle *et al.,* 2018; Milognon *et al.,* 2020), who identified staking materials as the primary constraint, the damage caused by insects can be explained by the absence of a formal cultivation protocol. This could lead to genetic erosion due to the destruction of seeds by *Acanthoscelides obtectus* weevils. Among the most significant pests are the *A. obtectus* weevils (during storage), caterpillars (in the field and during storage), aphids, and whiteflies (in the field). Similar findings have been reported in Benin (Estelle *et al.,* 2018), Asia (Thakur, 2012), America (Quentin *et al.,* 1991; Silva *et al.,* 2015; Baldin *et al.,* 2017), Africa (Rugumamu, 2014), and Oceania ('Evaluation of protectants for control of Acanthoscelides obtectus (Say) (Coleoptera: Bruchidae) in navybeans (*Phaseolus vulgaris* (L.))', 1993).

The reliance of *Phaseolus* beans on trees for growth, particularly dry trees, poses a significant challenge as such trees are becoming increasingly rare. Farmers also face the need to preserve their environments.

The scarcity of staking materials remains one of the biggest obstacles for farmers, potentially hindering production (Estelle *et al.,* 2018). Other authors, such as (Gichangi *et al.,* 2012; Musoni *et al.,* 2014; Ruganzu *et al.,* 2014), reached similar conclusions. According to (Estelle *et al.,* 2018) and (Ntukamazina *et al.,* 2014), the reduction in tree plantations, combined with the high cost of staking materials, explains the unavailability of suitable poles for staking. Milognon *et al.,* (2020); (Missihoun *et al.,* 2017) attributed this challenge to the increasing degradation of forests and savannahs in production areas, making it difficult to obtain appropriate wooden stakes.

Table.1 Sociodemographic Characteristics of Phaseolus Bean Producers in Togo

Sociodemographic Variables	Minimum	Maximum	Mean ± SD
Age of respondents (years)	15	100	45.87 ± 0.43
Arable land area (hectares)	0.12	250	5.96 ± 0.44
Cultivated area (hectares)	0.12	62	3.67 ± 0.17
Phaseolus bean harvested area (hectares)	--	--	--
Experience in Phaseolus production (years)	1	85	13.96 ± 0.47

Table.2 Distribution of sowing dates, harvest dates and cycle duration for Phaseolus beans by region

Features	Month	Centrale	Kara	Maritime	Plateaux_Ouest	Plateaux_Est	Savanes	Total	%	Khi²	ddl	p-value
Sowing date	Juillet-Août	9	17	19	11	20	0	76	8.11	18.618	10	< 0.001
	Mai-Juin	90	27	15	134	307	3	576	61.47			
	Mars-Avril	12	0	53	97	123	0	285	30.42			
Total		**111**	**44**	**87**	**242**	**450**	**3**	**937**	**100**			
Harvest date	Janvier-Février	73	17	61	125	336	1	613	65.42	5.345	5	< 0.001
	Novembre-Décembre	38	27	26	117	114	2	324	34.58			
Total		**111**	**44**	**87**	**242**	**450**	**3**	**937**	**100**			
Cycle	< 180 jours	11	11	17	22	50	0	111	11.85	134.861	10	< 0.001
	≥ 210 jours	82	4	41	204	320	3	654	69.80			
	180–209 jours	18	29	29	16	80	0	172	18.36			
Total		**111**	**44**	**87**	**242**	**450**	**3**	**937**	**100**			

Table.3 Significance of Cultivation Practices for Phaseolus Beans in Togo

Cultural Practices	Maritime	P.O	P.E	Centrale	Kara	Savanes	Total
Sowing on all trees in my fields	6	82	116	6	32	3	245
Sowing on dry trees in my fields	8	139	279	86	9	0	521
Sowing only on palm trees	82	100	274	6	11	0	473
Sowing in pure and staking after	13	22	0	4	3	0	42
Sowing only in yam fields	1	10	77	19	9	0	116
Sowing under the ronier tree (*Borassus flabellifer*)	0	0	0	0	0	3	3
Sowing on house fences	17	1	1	19	12	0	50
Grills	0	0	0	0	1	0	1
Sowing on cassava stems	1	1	0	7	0	0	9
Sowing on specific bait	1	0	0	0	0	0	1
Sowing under sorghum plants	0	0	5	0	0	0	5
Sowing under the *Cajanus cajan* weight	0	0	2	0	0	0	2
Sowing on maize stems	0	0	5	1	0	0	6
Sowing on banana trees	1	0	0	0	0	0	1
Sowing on avocado trees	0	1	0	0	0	0	1
P-value	<0.00	<0.00	<0.00	<0.00	<0.00	<0.00	<0.00

PO= Plateaux-Ouest and PE=Plateaux-Est

Table.4 Crops Grown by Phaseolus Bean Producers in Togo

Cited items	Latin name	N	Frequency	Mean rank	Smith's index	Sutrop index	B. score
Ananas	*Ananas comosus (L.) Merr.*	6	0,006	1,000	0,0064	0,0064	0,0064
Anarcardier	*Anacardium occidentale L.*	73	0,078	2,233	0,0646	0,0349	0,0521
Arachide	*Arachis hypogaea L.*	322	0,344	1,096	0,3391	0,3135	0,3282
Aubergine	*Solanum melongena L.*	3	0,003	1,000	0,0032	0,0032	0,0032
Avocatier	*Persea americana Mill.*	11	0,012	1,091	0,0116	0,0108	0,0112
Banane plantin	*Musa paradisiaca L.*	39	0,042	1,564	0,0384	0,0266	0,0333
Bissape	*Hibiscus sabdariffa L.*	1	0,001	1,000	0,0011	0,0011	0,0011
Blé	*Triticum aestivum L.*	1	0,001	11,000	-0,0004	0,0001	0,0003
Cacao	*Theobroma cacao L.*	17	0,018	1,588	0,0167	0,0114	0,0144
Café	*Coffea spp. L.*	76	0,081	1,553	0,0749	0,0522	0,0651
Cane à suicre	*Saccharum officinarum L.*	1	0,001	4,000	0,0006	0,0003	0,0005
Césame	*Sesamum indicum L.*	54	0,058	1,111	0,0567	0,0519	0,0547
Colatier	*Cola spp. Schott & Endl.*	17	0,018	2,235	0,0150	0,0081	0,0121
Coton	*Gossypium spp. L.*	47	0,050	1,128	0,0493	0,0445	0,0472
Cultures maraîchère		34	0,036	1,971	0,0314	0,0184	0,0258

Curcuma	*Curcuma longa L.*	12	0,013	2,250	0,0106	0,0057	0,0085
Fonio	*Digitaria exilis (Kippist) Stapf*	10	0,011	2,100	0,0090	0,0051	0,0074
Gingembre	*Zingiber officinale Roscoe*	42	0,045	2,643	0,0346	0,0170	0,0276
Gombo	*Abelmoschus esculentus (L.) Moench*	7	0,007	1,571	0,0069	0,0048	0,0060
Haricot	*Phaseolus spp*	560	0,598	1,675	0,5416	0,3568	0,4618
Igname	*Dioscorea spp. L.*	470	0,502	1,928	0,4369	0,2602	0,3613
Karité	*Vitellaria paradoxa C.F. Gaertn.*	1	0,001	8,000	0,0000	0,0001	0,0004
Lantille de terre	*Arachis hypogaea L. (même que arachide)*	47	0,050	2,830	0,0374	0,0177	0,0298
Légume		203	0,217	2,374	0,1753	0,0912	0,1406
Maïs	*Zea mays L.*	927	0,989	2,799	0,7418	0,3534	0,5913
Manioc	*Manihot esculenta Crantz*	657	0,701	3,936	0,4150	0,1781	0,3534
mil	*Pennisetum glaucum (L.) R.Br.*	13	0,014	3,462	0,0091	0,0040	0,0075
Monodora (Ayikou)	*Monodora myristica (Gaertn.) Dunal*	1	0,001	7,000	0,0002	0,0002	0,0004
Niébé	*Vigna unguiculata (L.) Walp.*	622	0,664	4,386	0,3514	0,1514	0,3170
Palmeraie	*Elaeis guineensis Jacq.*	80	0,085	5,000	0,0379	0,0171	0,0382
Patate douce	*Ipomoea batatas (L.) Lam.*	53	0,057	5,604	0,0204	0,0101	0,0239
petit mil	*Panicum miliaceum L.*	1	0,001	4,000	0,0006	0,0003	0,0005
Piment	*Capsicum spp. L.*	11	0,012	1,091	0,0116	0,0108	0,0112
poids d'engole	*Cajanus cajan (L.) Millsp.*	148	0,158	6,034	0,0474	0,0262	0,0643
riz	*Oryza sativa L.*	241	0,257	5,776	0,0864	0,0445	0,1070
Soja	*Glycine max (L.) Merr.*	545	0,582	6,081	0,1708	0,0957	0,2359
sorgho	*Sorghum bicolor (L.) Moench*	318	0,339	6,673	0,0717	0,0509	0,1314
Taro	*Colocasia esculenta (L.) Schott*	59	0,063	7,254	0,0082	0,0087	0,0234
Tomate	*Solanum lycopersicum L.*	136	0,145	7,603	0,0119	0,0191	0,0526
Voandzou	*Vigna subterranea (L.) Verdc.*	130	0,139	8,646	-0,0087	0,0160	0,0472
Xylépia (Etcho)	*Xylopia aethiopica (Dunal) A. Rich.*	1	0,001	8,000	0,0000	0,0001	0,0004

Table.5 Role of gender in cultivation practices for Phaseolus beans grown in Togo

Implication	Femele	Male	Femele	Male
Accession selection	522	415	+++	++
Plot selection	523	414	+++	++
Plot preparation	528	409	+++	++
Crop management	539	398	+++	+
Harvest	559	378	+++	+
Sales	232	88	+++	+

Table.6 Constraints Related to Phaseolus Bean Cultivation in Togo

Constraints	NTV	MAC	PCO	IMC	Rank	Centrale	Kara	Maritime	Plateaux-Ouest	Plateaux-Est	Savanes
Insect Attacks	97	44	97	79.33	1	3	3	1	1	1	--
Lack of Trees for Sowing	77	27	77	60.33	2	1	1	--	3	3	1
No Market	65	12	65	47.33	3	2	2	6	2	2	2
Empty Pods	7	3	7	5.67	4	--	--	2	--	--	--
Cattle Attacks	5	2	5	4.00	5	4	--	4	--	--	--
Flower Drop	5	2	5	4.00	5	--	--	3	--	--	--
Drought Pockets	3	2	3	2.67	7	--	--	5	4	--	--
Excessive Leaves without Pods	2	1	2	1.67	8	--	--	5	--	--	--
Need to Plant Under a Tree	2	1	2	1.67	8	--	--	--	4	--	--
Lack of Technical Itinerary	2	0	2	1.33	10	--	--	--	--	--	--
Imported from the South but Does Not Produce	1	1	1	1.00	11	--	4	--	--	--	--
Difficult to Cook	1	1	1	1.00	11	--	--	--	5	--	--
Long Cycle	1	1	1	1.00	11	--	--	--	5	--	--
Difficult Harvesting	1	1	1	1.00	11	--	--	--	--	5	--
Pod Attacks by Squirrels	1	1	1	1.00	11	--	--	--	--	6	--
Rat Attacks	1	0	1	0.67	16	--	--	--	5	--	--

Table.7 Mitigation measures for constraints related to the cultivation of Phaseolus beans in Togo.

Constraints	Mitigation Measures
Insect Attacks	Nothing (65.98%), Insecticidal treatment (15.46%), Production for consumption (18.56%)
Lack of Trees for Sowing	Nothing (20%), Production for consumption (44.71%), Sowing and staking afterward (3.53%), Sowing in yam fields (7.06%), Abandoning cultivation (1.18%), Sowing on house fences (1.18%), Sowing on palm trees (20%), Sowing on living trees (1.18%), Sowing on sorghum stalks (1.18%), Sowing on baited areas (1.18%), Sowing on bamboo (1.18%), Sowing on maize stalks (1.18%)
No Market	Nothing (19.40%), Production for consumption (80.60%)
Drought Pockets	Nothing (100%)
Import from the South but Not Producing Locally	Nothing (100%)
Too Many Leaves, No Seeds	Nothing (100%)
Oxen Attacks	Nothing (60%), Insecticidal treatment (40%)
Flower Drop	Nothing (60%), Insecticidal treatment (40%)
Pods Without Seeds	Nothing (71.43%), Insecticidal treatment (28.57%)
Difficult Harvest	Sowing on palm trees (100%)
Too Long a Growth Cycle	Nothing
Pods Attacked by Squirrels	Nothing (100%)
Lack of Technical Itinerary	Nothing (100%)
Obligation to Sow Under a Tree	Production for consumption (100%)
Difficult Cooking	Production for consumption (50%), Soaking in water before cooking (50%), Use of potash for cooking (50%)

Figure.1 Map of the study areas

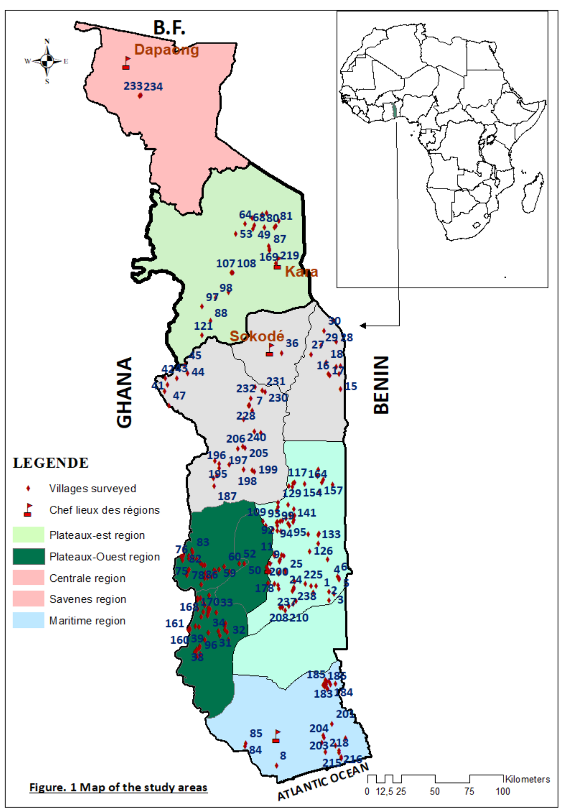


Table.8 Perception of Climate Change Among Surveyed Producers

Variables	Centrale	Kara	Maritime	Plateaux-Ouest	Plateaux-Est	Savanes	Significance Level
Climate Change Impact							
No	105	39	24	175	359	3	***
Yes	6	5	63	67	91	NA	**
Years of Impact Observed							
Moins de 10 ans	4	3	5	43	67	NA	NS
entre 10 et 20 ans	3	NA	37	22	23	NA	*
≥20 ans	NA	NA	21	3	NA	NA	*
Manifestation of Climate Change							
Irregular rainfall	2	1	14	13	17	NA	**
Late rains	1	1	15	1	13	NA	*
Pockets of drought	2	1	2	9	16	NA	NS
Excess rainfall	NA				6	NA	NS
Effects on Bean Crops							
Reduced production	NA	NA	3	11	1	NA	*
Pods without seeds	2	NA	13	3	5	NA	*
Early drying of pods	NA	NA	1	NA	NA	NA	NS
Adaptation Measures							
Reforestation	1	NA		2	1	NA	NS
Early planting	NA	NA	2	NA	2	NA	NS
Late planting	NA	NA	4	1	NA	NA	NS
No adaptation	3	2	43	47	66	NA	**
Effectiveness of Measures							
Effective	3	1	17	12	20	NA	**
Not effective	4	2	46	52	69	NA	**

Figure.2 Source of Seeds for Phaseolus Bean Cultivated in Togo

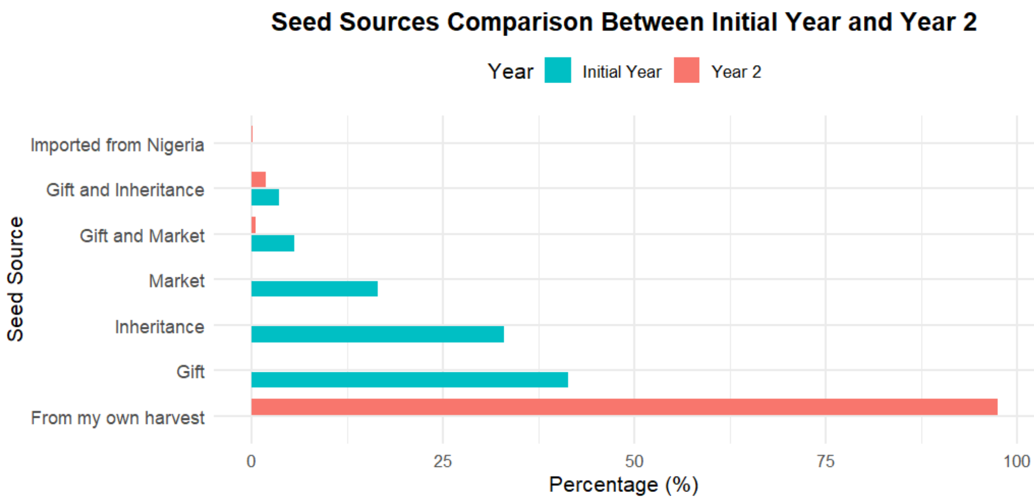


Figure.3 Storage Methods by Region

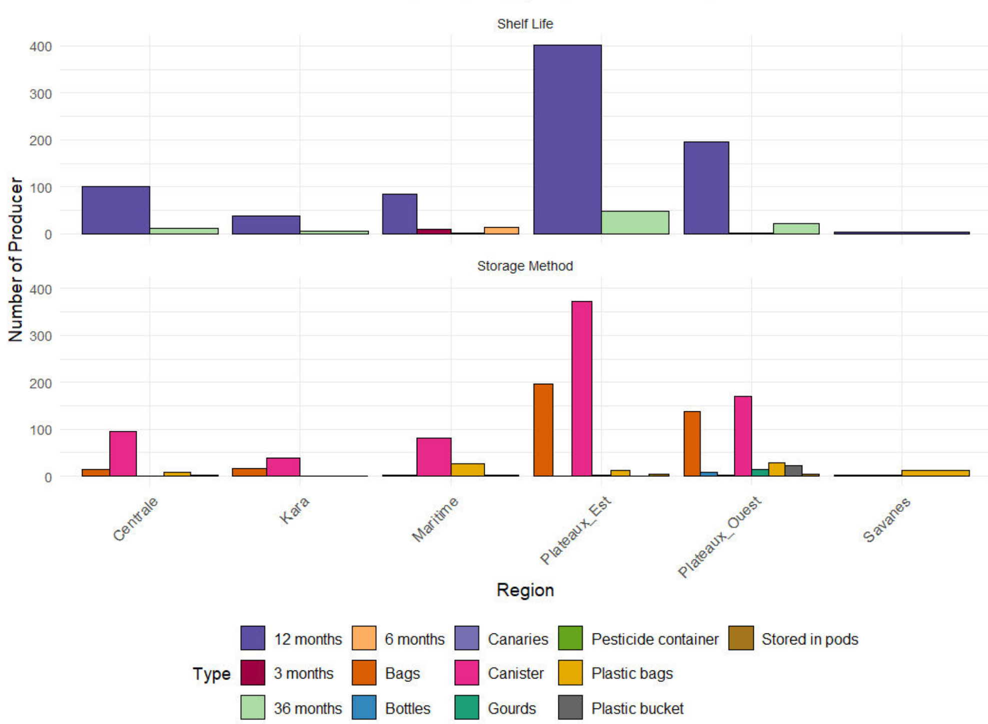


Figure.4 Usage ou non de produits de conservation par les producteurs du haricot du genre Phaseolus cultivé au Togo

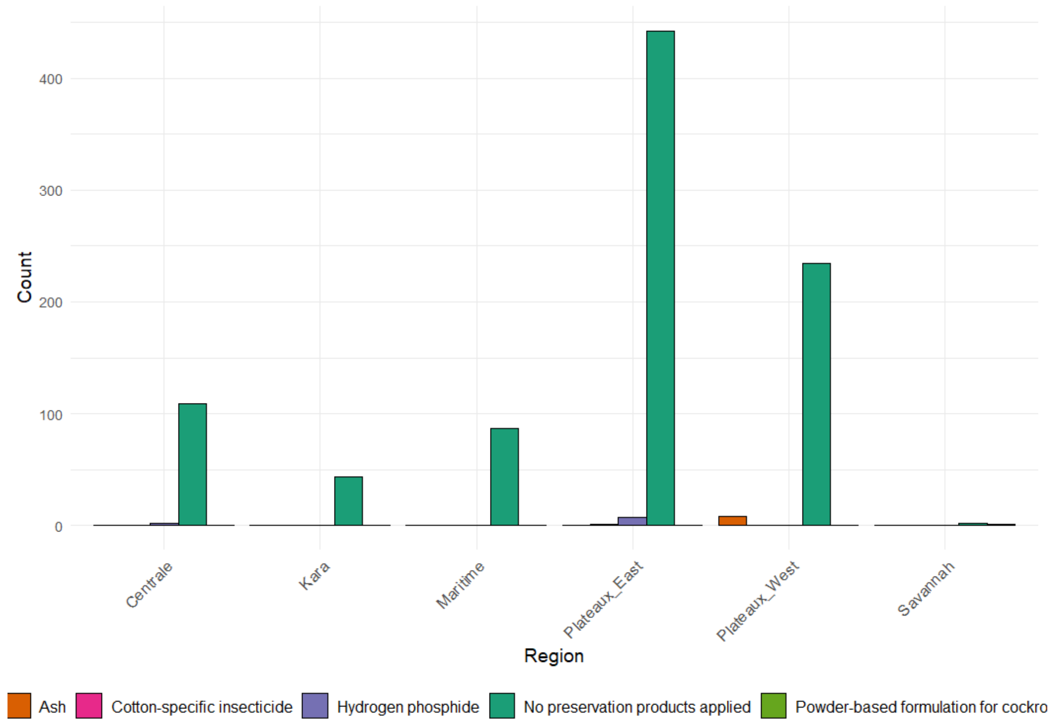


Figure.5 Insect Pests of Phaseolus Beans Grown in Togo

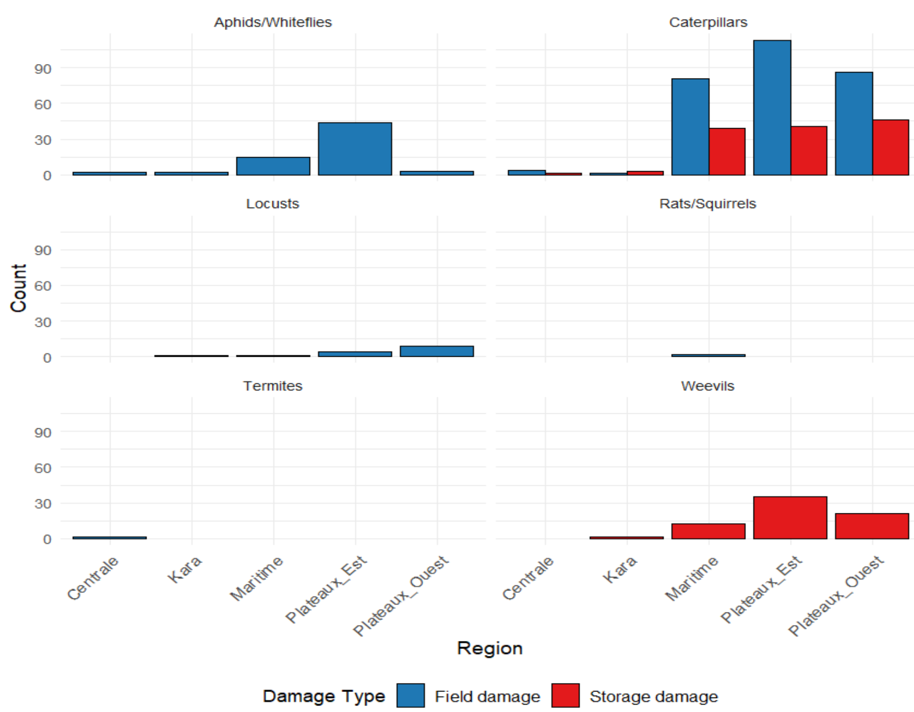


Figure.6 Plant parts consumed by insect pests of Phaseolus beans grown in Togo

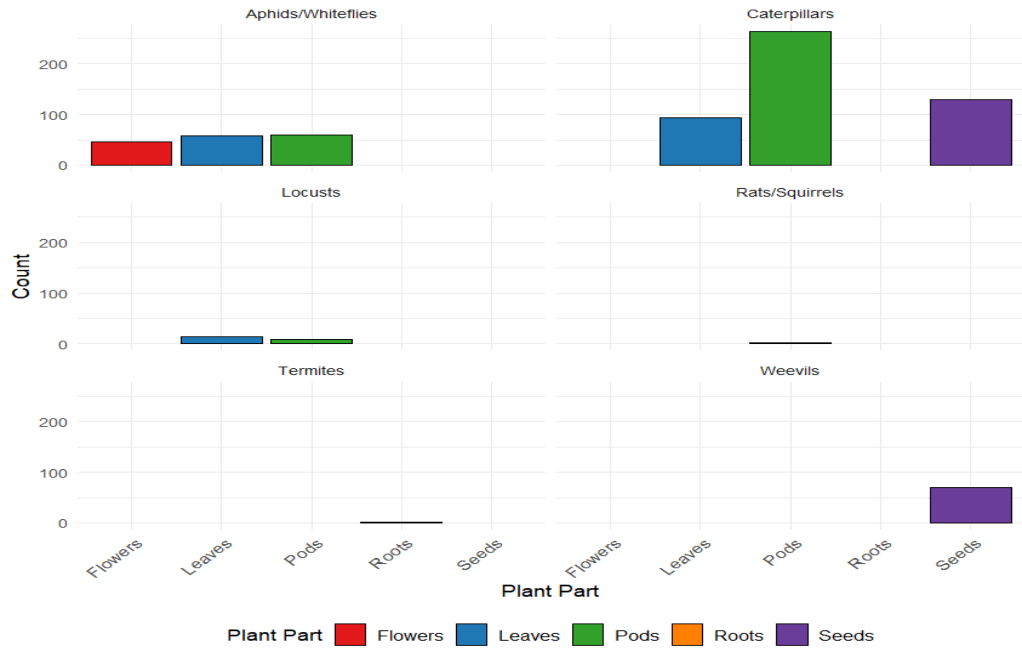
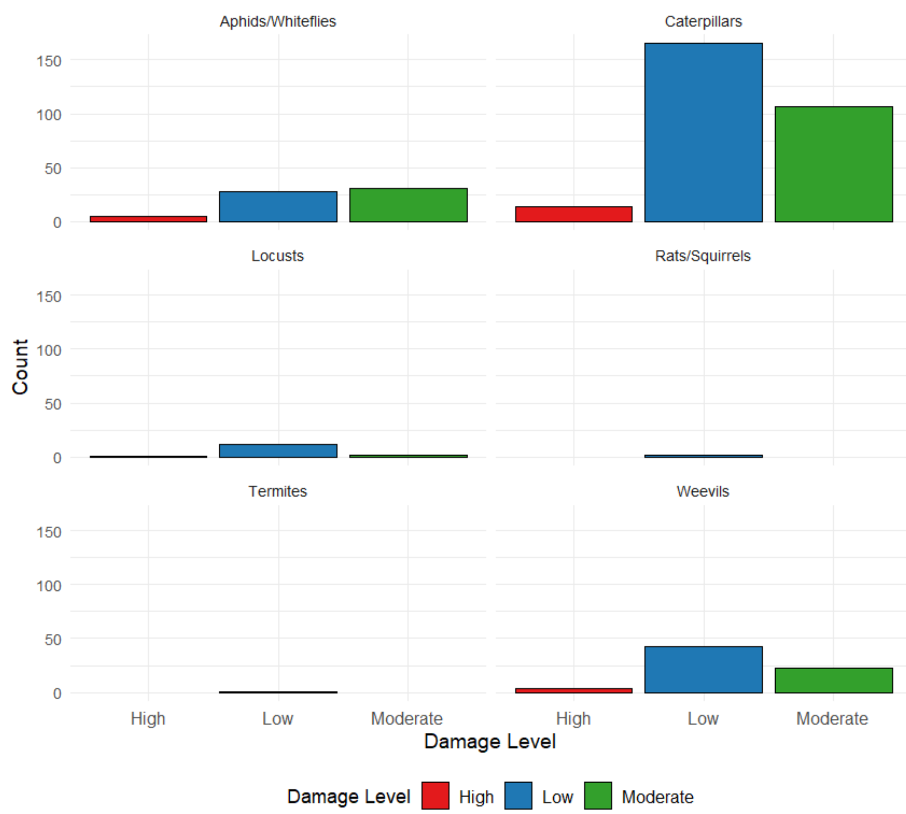
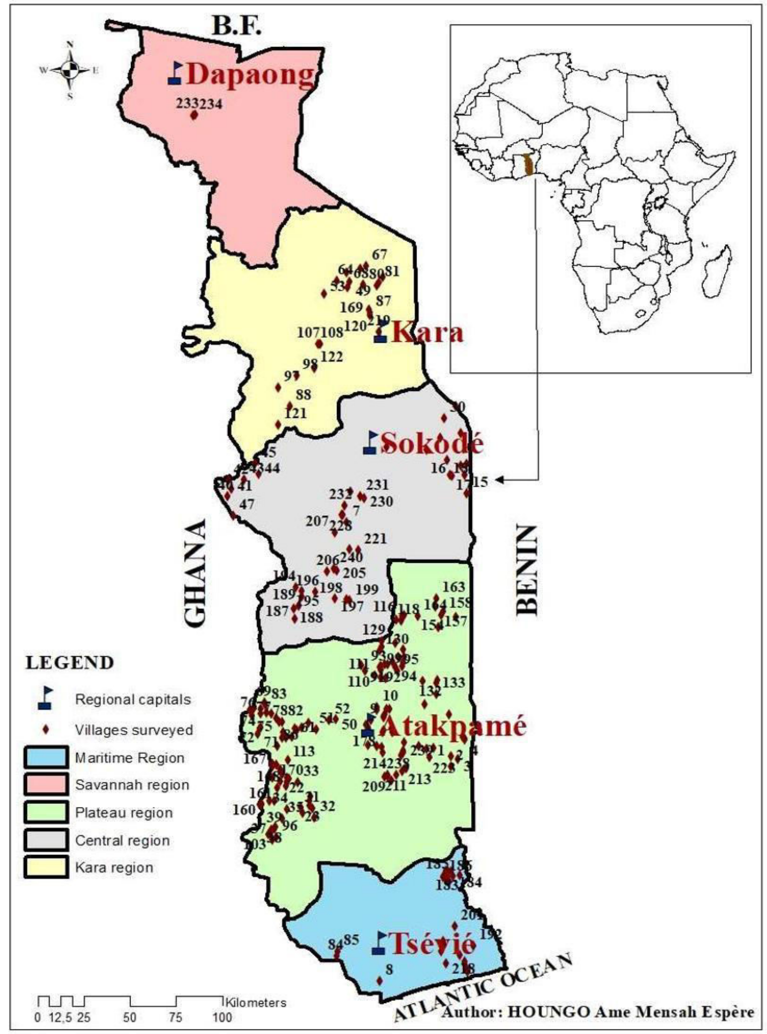


Figure.7 Level of damage caused by insect pests of Phaseolus beans grown in Togo



Appendix.1 Villages surveyed

1	Atomé	51	Alossonou copé	101	Woumé	151	Edigbalé	201	Mome-hagou
2	Tokotchikoé	52	Imoussa	102	Kpimé-séva	152	Tadi copé	202	Afédoko
3	Ountivou	53	Bourkou	103	Kpimé-tomégbé	153	Kamina	203	Kossidamé
4	Ayihoé	54	Gbadi N'kougna	104	Ataké	154	Fangodo	204	Ativé
5	Azovou	55	Kouma Konta	105	Kondo copé	155	Kakpa	205	Blitta
6	Gbétan	56	Enawoè	106	Karoué copé	156	N'digbé	206	Amaklé
7	Déréboua	57	Gbadi Gaodo	107	Sanda Kagbanda	157	Ogou-alah	207	Kpètè-kpèté
8	Marché Kpélé	58	Agadja	108	Gnadéyo	158	Lauran copé	208	Tchéla
9	Démadéli	59	Gobé	109	Pallakoko	159	Dzigbé	209	Atakpara
10	Djérouhouyè	60	Gonobé	110	Akabassim	160	Anyigbé	210	Sama-copé
11	Blakpa	61	Ona	111	Konigbo	161	Yikpa-Dafo	211	Bourè
12	Balanka	62	N'taré copé	112	Babahouè	162	Ilèkohan	212	Kpalagban
13	Afélé	63	Tchoré	113	Kpévé	163	Okouta	213	Odoli
14	Alougba	64	Kadjala	114	Elavanyo	164	Nangbéto-Afidégnigban	214	Atakpara 2
15	Agbansikiti	65	Kessibo	115	Kpéssi	165	Bogo	215	Folivi-joe
16	Lawarè	66	Défalé-lao	116	Alou copé	166	Denou	216	Kouto
17	Anacoridè	67	Kpaha	117	Kpoguédjé	167	Awounadjassi	217	Atsoukopé
18	N'kogno	68	Samaragou	118	Gado kpodji	168	Atigba-todomé	218	Klétchigan
19	Amidou-copé	69	Abrewanko-Todji	119	Landa	169	Pya-Akéï	219	Dongoyo
20	Azionou	70	Tomégbé	120	Lohou	170	Mépassèm	220	Bodjondè
21	Avégamé 1	71	Ouméou	121	Baghan	171	Iko-akpa	221	Pouda
22	Avovlè	72	Akloa	122	Léguélégué	172	Maromi-Iba	222	Nangbéto 1
23	Avégbadjè	73	Dentey copé	123	Djitoyi	173	Bocco-Holoboè	223	Albarka
24	Akomégni	74	Abouabo	124	Wanou copé	174	Akpaka 1	224	Findigue
25	Ilama	75	Dantékoko copé	125	Glito	175	Loto	225	Yao copé
26	N'djakpo	76	Badou djidjolé	126	Ayorè	176	Okpodjivé	226	Kaniaboua
27	Alibi 1	77	Zogbégan Lomnava	127	Afiadényigba	177	Awokou copé	227	Kédéinzi
28	N'tchourou-mango	78	Adossou	128	Gaougblé	178	Atcha copé	228	Daoudè
29	Dantcho	79	Borga	129	Alinmodji	179	Atchavé	229	Aouda
30	Affem carefour	80	Konfaga	130	Akakpo copé	180	Zouvi	230	Haloukpaboudou
31	Dawoxeta	81	Koukou	131	Odin	181	Dossouhoé	231	Tabouga
32	Kpoglo	82	Todomé	132	Akpaka copé	182	Tométi-kondji	232	Adjengré
33	Kpélé-agave	83	Abranko outima	133	Hounto	183	Sédomé	233	Pimpengou
34	Kpele-toutu	84	Dokplala	134	Agbofon	184	Korohoé	234	Madiaré
35	Akata-adamé	85	Sossouvi copé	135	Lakpa marché	185	Agodomé	235	Kèlèkpè N'taré
36	Nima	86	Ovlawlou	136	Djeyi kopé	186	Houglo	236	Abodji
37	Yokélé	87	Pya-Lao	137	Djeyi kopé2	187	Koflo	237	Gbénou
38	Adéklékpoé	88	Kpalou	138	Gbokopé	188	N'kengbé	238	Oga copé
39	Kélindji	89	Komlan copé	139	Afadi copé	189	Lalamila	239	Abotchi copé
40	Kandjo	90	Felema	140	Gbadjahè	190	Abalo kondji	240	Sontou-copé
41	Sakou N'gbaladama	91	Yiboe kopé	141	Yovo copé	191	Afanvi kondji		
42	Solidè	92	Niamtougou copé	142	Bodjè	192	Atitongo-mawussi		
43	Sabomdè	93	Tchamgbssou copé	143	Akao-copé	193	Tchifama		
44	Kpangamdè	94	Wilikè	144	Avloumé	194	M'poti		
45	Bolkatanga	95	Dotè copé	145	Kpéto	195	Tadja		
46	Totamé	96	Kpimé-kopégan	146	Hihéatro	196	Pangala village		
47	Saibou	97	Sankpali	147	Tonota-CPFA	197	Pagala-gare		
48	Anima	98	Dakpandé	148	Koyo copé	198	Tchanié 2		
49	Wia	99	Arouna copé	149	Kossi kiti	199	Yéloum		
50	Ounabè	100	Kpassa copé	150	Lomnava Bas	200	Akpaka abalèdjo		



The use of trees as staking materials limits bean production, as not all farmers own trees in their fields (Ayenan, Danquah, *et al.,* 2017). The lack of trees for sowing may lead farmers to clear new land, resulting in deforestation and environmental degradation (Gichangi *et al.,* 2012; Musoni *et al.,* 2014; Estelle *et al.,* 2018). To address this, farmers use alternative staking systems, including maize and sorghum stalks (Gichangi *et al.,* 2012; Takusewanya *et al.,* 2017; Estelle *et al.,* 2018), oil palms (*Elaeis guineensis*) (Missihoun *et al.,* 2017; Milognon *et al.,* 2020), *Cajanus cajan*, yam (*Dioscorea spp.*), avocado trees, raffia palms, cassava, bananas, household fences, and other staking materials. Some farmers prefer monocropping with dedicated stakes, a dominant system in Rwanda that is more productive than intercropping systems (Ruganzu *et al.,* 2014). The use of strings as staking materials (Mazina *et al.,* 2014) is another alternative.

Additionally, the long cooking time and bitter taste of some varieties, as reported by (Milognon *et al.,* 2020) and (Missihoun *et al.,* 2017), alongside market challenges and the lack of trees for planting, discourage *Phaseolus* bean production. As a result, this crop is under threat of extinction if no action is taken. Similar studies in Benin revealed that *Phaseolus* beans are also at risk due to biotic, abiotic, and anthropogenic constraints (Missihoun *et al.,* 2017; Milognon *et al.,* 2020). In Rwanda, constraints such as the lack of staking materials, improved seeds, fertilizers, and pesticides, as well as pest and disease pressures, were identified in climbing bean systems (Ruganzu *et al.,* 2014). According to (Dansi *et al.,* 2012) agronomic constraints are predominant and stem from a lack of or insufficient scientific research.

The main pests associated with bean cultivation

The results reveal significant disparities in the perception and manifestations of climate change across different regions. They indicate that most respondents, particularly in the Plateaux-Est and Plateaux-Ouest regions, do not perceive any impact of climate change. This contrasts with a notable minority in the Maritime and Plateaux-Ouest regions. The perception of no impact of climate change on beans in these regions could be due to these regions being the main production zones for Phaseolus beans in Togo. The most frequently cited manifestations of climate change include irregular rainfall and drought pockets, consistent with the observations of (Gbetibouo *et al.,* 2010; Gbetibouo *et al.,* 2010). Impacts on bean crops, such as reduced yields and pod sterility, are particularly pronounced in the Maritime and Plateaux-Ouest regions, corroborating the findings of (Lobell *et al.,* 2008). Similar results were obtained by (Layou *et al.,* 2023), who highlighted that shortened rainy seasons, combined with irregular and excessive rainfall, significantly affect bean yields.

Despite the recognition of these impacts, few adaptation measures, such as reforestation, adjustments to planting schedules, or the selection of short-cycle varieties (Mfewou *et al.,* 2022), are implemented, often considered ineffective by producers. This tendency to choose short-cycle varieties to mitigate the effects of climate change exposes long-cycle varieties to genetic erosion (Egah *et al.,* 2013).

Perception of climate change, impacts, and mitigation measures

The results highlight contrasting perceptions of the impact of climate change among respondents, revealing significant disparities across regions. Most producers in the Plateaux-Est and Plateaux-Ouest regions perceive no impact of climate change on their agricultural activities, despite findings by (Adewi *et al.,* 2010) showing that the area between Kanté and Atakpamé has experienced premature cessation of growing seasons since 1970. These authors' findings also reveal disparities both between and within regions, which may explain the contrasting perceptions of climate change impacts among respondents.

Climatic manifestations, such as irregular rainfall and drought pockets (Ayedegue and Yabi, 2021), are recurrent in the Plateaux-Est and Maritime regions, highlighting disruptions in rainfall patterns critical to agriculture. These phenomena appear to directly affect bean crops, as evidenced by reduced yields and the presence of sterile pods (Porch *et al.,* 2010), particularly in the Plateaux-Ouest and Maritime regions. These observations suggest that climate change is beginning to impact key crops in certain regions, even if its full extent is not yet uniformly perceived.

Despite these challenges, adaptation responses remain marginal. Across all regions, most producers have adopted no measures, likely due to a lack of awareness or resources to implement solutions. Mentioned initiatives, such as reforestation or adjustments to planting schedules (Kouassi, 2022; Yovo and Lantomey, 2023), are uncommon and often deemed ineffective. This reflects either insufficient technical support or a lack of relevance of proposed solutions to local realities.

Phaseolus beans occupy a significant role in the diet of populations in rural cultivation areas. For their optimal development, they require staking and are thus predominantly cultivated on trees, particularly dead trees, oil palms (*Elaeis guineensis*), pigeon peas (*Cajanus cajan*), sometimes on other grasses (maize and sorghum), and finally on household fences. This crop, mainly managed by women from cultivar selection to harvest and commercialization, is threatened by both biotic and abiotic constraints, notably climatic variability (high temperatures, drought pockets, and excessive rainfall). These constraints cause leaf, flower, and pod drop, and sometimes result in seedless pods. Additionally, pest infestations (caterpillars, aphids, whiteflies, and weevils) are also responsible for yield decline and reduced seed germination capacity.

Although producers have developed strategies such as planting beans alongside palm trees and grasses, and using ash or chemical pesticides to preserve seeds, several challenges remain. These include the need for proper staking techniques, agronomic characterization, and evaluation of the nutritional qualities of each cultivar. Moreover, further scientific research is required to establish a technical guide for the cultivation of *Phaseolus* beans in Togo to enable their broader dissemination in the future.

Funding

This document has been produced with the financial assistance of the European Union (Grant no. DCI-PANAF/2020/420-028), through the African Research Initiative for Scientific Excellence (ARISE), pilot program. ARISE is implemented by the African Academy of Sciences with support from the European Commission and the African Union Commission. The contents of this document are the sole responsibility of the authors and can under no circumstances be regarded as reflecting the position of the European Union, the African Academy of Sciences, and the African Union Commission.

Author Contributions

Ame Mensah Espère Houngo: Investigation, formal analysis, writing—original draft. Atti Tchabi: Validation, methodology, writing—reviewing. Koffi Kibalou Palanga:—Formal analysis, writing—review and editing. Komi Agboka: Investigation, writing—reviewing. Essohouna Modom Banla: Resources, investigation writing—reviewing. Kpatcha Kamde: Validation, formal analysis, writing—reviewing. Moustakimou Sibabi: Conceptualization, methodology, data curation, supervision, writing—reviewing the final version of the manuscript.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate Prior to data collection, the objectives of the study were clearly explained to all participants. Informed consent was obtained from each participant before the commencement of the surveys. The study did not involve any invasive procedures, and participation was entirely voluntary

Consent to Publish We, the authors, consent to the publication of this article, confirm that it is original, approved by all co-authors, and not under consideration by any other journal.

Conflict of Interest The authors declare no competing interests.

References

Adewi, E., Badameli, K.M.S. and Dubreuil, V. (2010) ‘Evolution des saisons des pluies potentiellement utiles au Togo de 1950 a 2000’, *Climatologie*, 7, pp. 89–107 https://doi.org/10.4267/climatologie.489.

Adoukonou-Sagbadja, H. *et al.,* (2006) ‘Indigenous knowledge and traditional conservation of fonio millet (Digitaria exilis, Digitaria iburua) in Togo’, *Biodiversity and Conservation*, 15(8), pp. 2379–2395. https://doi.org/10.1007/s10531-004-2938-3.

Almekinders, C.J.M. and Louwaars, N.P. (1999) *Farmers’ seed production : New approaches and practices*. London: Intermediate Technology Publications, p. (Accessed: 6 July 2024).

Ayedegue, O.I. and Yabi, J.A. (2021) ‘Analyse des paquets d'adaptation au changement climatique au Nord Est du Bénin'.

Ayenan, M.A.T., Ofori, K., *et al.,* (2017) 'Pigeonpea [(*Cajanus cajan* (L.) Millsp.)] production system, farmers' preferred traits and implications for variety development and introduction in Benin', *Agriculture & Food Security*, 6(1), p. 48. Available at: https://doi.org/10.1186/s40066-017-0129-1.

Ayenan, M.A.T., Danquah, A., *et al.,* (2017) 'Utilization and farmers' knowledge on pigeonpea diversity in Benin, West Africa', *Journal of Ethnobiology and Ethnomedicine*, 13(1), p. 37. https://doi.org/10.1186/s13002-017-0164-9.

Baldin, E.L.L. *et al.,* (2017) 'Characterization of resistance to the bean weevil Acanthoscelides obtectus Say, 1831 (Coleoptera: Bruchidae) in common bean genotypes', *Arthropod-Plant Interactions*, 11(6), pp. 861–870. Available at: https://doi.org/10.1007/s11829-017-9540-6.

Baudoin, J-P., ; Rocha, O.;. Degreef, J.;. Maquet, A.;. Guarino, L. (2004) *Ecogeography, demography, diversity and conservation of Phaseolus lunatus L. in the Central Valley of Costa Rica*. International Plant Genetic Resources Institute, Rome, Italy.

Bayuelo-Jiménez, J.S., Debouck, D.G. and Lynch, J.P. (2003) 'Croissance, échanges gazeux, relations avec l'eau et composition ionique de *Phaseolus*espèces cultivées dans des conditions salines', *Field Crops Research*, 80(3), pp. 207–222. https://doi.org/10.1016/S0378-4290(02)00179-X.

Bernard, J. (2016) 'Les légumineuses, une composante essentielle des systèmes de production durables', *Recherche Agronomique Suisse*, 7 (3), p. 119.

Biernacki, P. and Waldorf, D. (1981) 'Snowball Sampling: Problems and Techniques of Chain Referral Sampling', *Sociological Methods & Research*, 10(2), pp. 141–163. Available at: https://doi.org/10.1177/004912418101000205.

Brink, M. and Belay, G.M. (2006) *Céréales et légumes secs*. PROTA.

Brooke, C.H. (1958) 'The durra complex in the central highlands of Ethiopia', *Economic Botany*, 12, pp. 192–204. Available at: https://doi.org/10.1007/BF02862775.

Caixeta ET, Borém A, Azevedo Fagundes S, Niestche S, Barros EG, Moreira MA (2023) 'Inheritance of angular leaf spot resistance in common bean line BAT 332 and identification of RAPD marker linked to the resistance gene', *Euphytica*. 134th edn, pp. 297-303.

CCNUCC (2022) *Quatrième Communication Nationale sur les Changements Climatiques*. Togo. .

Da Costa, P.Y. *et al.,* (2015) 'Old landscapes, pre-weathered materials, and pedogenesis in tropical Africa: How can the time factor of soil formation be assessed in these regions?', *Quaternary International*, 376, pp. 47–74. http://dx.doi.org/10.1016/j.quaint.2014.04.062

Dansi, A. *et al.,* (2012) 'Diversity of the Neglected and Underutilized Crop Species of Importance in Benin', *The Scientific World Journal*, 2012, p. e932947. https://doi.org/10.1100/2012/932947.

Dansi, A. *et al.,* (2013) 'Varietal diversity and genetic erosion of cultivated yams (Dioscorea cayenensis Poir-D. rotundata Lam complex and D. alata L.) in Togo', *Int. J. Biodivers. Conserv*, 5(2), pp. 223–239. https://doi.org/10.5897/IJBC12.124

Dansi, A., Adoukonou-Sagbadja, H. and Vodouhè, R. (2010) 'Diversity, conservation and related wild species of Fonio millet (Digitaria spp.) in the northwest of Benin', *Genetic Resources and Crop Evolution*, 57(6), pp. 827–839. https://doi.org/10.1007/s10722-009-9522-3.

Djan'na, H.K. *et al.,* (2019) 'Trend analysis of hydroclimatic historical data and future scenarios of climate extreme indices over Mono River Basin in West Africa'. Available at: https://www.preprints.org/manuscript/201906.0267 (Accessed: 15 January 2025).

Duche-Pérez, A. *et al.,* (2024) 'Systematic review of ethnomedicinal knowledge: Documentation, evaluation, and conservation of medicinal plants and their therapeutic applications', *F1000Research* [Preprint]. https://doi.org/10.12688/f1000research.157960.1

Egah, J. *et al.,* (2013) 'Les paysans maintiennent-ils la biodiversite dans un contexte de changement climatique ? Une etude de cas de l'igname au Nord-Benin', *Agronomie Africaine*, 25(3), pp. 285–297.

Estelle, L.Y.L. *et al.,* (2018) 'Farmers traditional practices and management methods of stored common bean (*Phaseolus vulgaris* L.) insect pests in the central region of Benin Republic', *Journal of Horticulture and Forestry*, 10(8), pp. 113–126. https://doi.org/10.5897/JHF2018.0555.

'Evaluation of protectants for control of Acanthoscelides obtectus (Say) (Coleoptera: Bruchidae) in navybeans (*Phaseolus vulgaris* (L.))' (1993) *Journal of Stored Products Research*, 29(3), pp. 215–219. https://doi.org/10.1016/0022-474X(93)90003-M.

Fagbédji, R.F. *et al.,* (2022) 'Parataxonomie des taxons considérés comme des variétés locales de Phaseolus lunatus cultivées au Bénin: Parataxonomy of taxa considered as folk local varieties of Phaseolus lunatus grown in Benin', *International Journal of Biological and Chemical Sciences*, 16(6), pp. 2621–2640. https://doi.org/10.4314/ijbcs.v16i6.14.

Fao (2016) *Les légumineuse et la bidiversité*, p. 2. Available at: https://www.fao.org/fileadmin/user_upload/pulses-2016/docs/factsheets/Biodiversity_FR_PRINT.pdf.

Gbetibouo, G.A., Hassan, R.M. and Ringler, C. (2010) 'Modelling farmers' adaptation strategies for climate change and variability: The case of the Limpopo Basin, South Africa', *Agrekon*, 49(2), pp. 217–234. Available at: https://doi.org/10.1080/03031853.2010.491294.

Gbetibouo, G.A., Ringler, C. and Hassan, R. (2010) 'Vulnerability of the South African farming sector to climate change and variability: An indicator approach: Vulnerability of the South African farming sector to climate change and variability', *Natural Resources Forum*, 34(3), pp. 175–187. https://doi.org/10.1111/j.1477-8947.2010.01302.x.

Geiger, H. *et al.,* (2003) 'Farmers' Seed Systems and Management Practices Determine Pearl Millet Genetic Diversity Patterns in Semiarid Regions of India', *Crop Science*. Wiley Online Library. Available at: https://acsess.onlinelibrary.wiley.com/doi/abs/10.2135/cropsci2003.1680 (Accessed: 12 July 2024).

Gichangi A, Maobe SN, Karanja D, Getabu A, Macharia CN, Ogecha JO, Nyang'au MK, Basweti E, Kitonga L (2012) 'Évaluation de la production et de la commercialisation de haricots grimpants par les petits exploitants agricoles de la région de Nyanza, au Kenya.', *Journal mondial des sciences agricoles*. 8th edn, pp. 293–302.

Julier, B. and Louarn, G. (2022) 'Rôle des légumineuses pérennes dans une agriculture agroécologique', *Fourrages*, 251, pp. 17–25.

Kinhoégbè, G. *et al.,* (2020) 'On-farm management and participatory evaluation of pigeonpea (*Cajanus cajan* [L.] Millspaugh) diversity across the agro-ecological zones of the Republic of Benin', *Journal of Ethnobiology and Ethnomedicine*, 16(1), p. 24. https://doi.org/10.1186/s13002-020-00378-0.

Kouassi, K.G. (2022) 'Changement Climatique En Côte D'ivoire : Impact Sur Les Systèmes Culturaux Et Résilience Paysanne (1970 À La Fin Des Années 1990)', *es Editions Francophones Universitaires d'Afrique* [Preprint].

Laboratory of Genetic Resources and Molecular Breeding, Department of Genetic and Biotechnology, Faculty of Sciences and Techniques, University of Abomey-Calavi, BP 1947 Abomey-Calavi, Benin Republic. *et al.,* (2019) 'A Pigeon pea [*Cajanus cajan* (L.) Millsp] cultivation, its major constraints and ethnobotanical status in Southern Benin', *Journal of Agricultural and Crop Research*, 7(6), pp. 95–105. https://doi.org/10.33495/jacr_v7i6.19.131.

Layou, A.M. *et al.,* (2023) 'Perceptions et réactions des producteurs du haricot commun face aux incidences pluviométriques à FOUMBOT (LOUEST-CAMEROUN)', *Espace Géographique et Société Marocaine*, 1(77–78). https://revues.imist.ma/index.php/EGSM/article/download/43920/22365 (Accessed: 31 December 2024).

Lobell, D.B. *et al.,* (2008) 'Prioritizing Climate Change Adaptation Needs for Food Security in 2030', *Science*, 319(5863), pp. 607–610. : https://doi.org/10.1126/science.1152339.

Loko, L.E.Y. *et al.,* (2018) 'Folk taxonomy and traditional uses of common bean (*Phaseolus vulgaris* L.) landraces by the sociolinguistic groups in the central region of the Republic of Benin', *Journal of Ethnobiology and Ethnomedicine*, 14(1), p. 52. https://doi.org/10.1186/s13002-018-0251-6.

Mahuku GS, Jara CE, Cajiao C, Beebe S. (2002) 'Sources of resistance to Colletotrichum lindemuthianum in the secondary gene pool of *Phaseolus vulgaris* and in crosses of primary and secondary gene pools.', *Plant Disease*. 86th edn, pp. 1383–1387. https://doi.org/10.1094/pdis.2002.86.12.1383

Mansouri, L.M. (2021) 'Etude des effets des facteurs biotiques et abiotiques sur la nodulation chez le haricot (PhaseolusvulgarisL.)'.

Marsha, Q. (2005) *Considérations pour la collecte de listes libres sur le terrain : exemples d'éthobotanique*. https://journals.sagepub.com/doi/10.1177/1525822X05277460 (Accessed: 12 June 2025).

Matos, G.C. da S. *et al.,* (2024) 'Report of Practical Class In Agricultural Area With The Bachelor Class In Agronomy In The Municipality of Tracuateua-Pa', *Journal of Interdisciplinary Debates* https://doi.org/10.51249/jid.v5i04.2267.

Mazina, N., Ruraduma, C. and Ntibashirwa, S. (2014) 'Relative performance of staking techniques on yield of climbing bean in highlands of Burundi', *African Crop Science Journal*, 22, pp. 997–1001.

Mfewou, A., Nfor, J.T. and Nadji, P. (2022) 'Variabilité climatique au Tchad : Perception et stratégie d'adaptation paysanne à Kélo (Tchad)', *VertigO - la revue électronique en sciences de l'environnement* [Preprint], (22–1). https://doi.org/10.4000/vertigo.35399.

Milognon, H. *et al.,* (2020) 'Connaissances endogènes et contraintes biotiques de production des haricots cultivés du genre Phaseolus au Centre et Sud Bénin (Afrique de l'Ouest', *Journal of Applied Biosciences*, 145, pp. 14938–14954. https://doi.org/10.35759/JABs.v145.9.

Missihoun, A.A. *et al.,* (2012) 'Impacts des pratiques culturales sur l'organisation génétique des sorghos cultivés par les Lokpa au Nord-Ouest du Bénin révélés par les marqueurs SSRs', *J. Appl. Biosci*, 60, pp. 4394–4409.

Missihoun, A.A. *et al.,* (2017) 'Diversité variétale et gestion paysanne des haricots cultivés du genre Phaseolus cultivés au Centre et au Sud Bénin (en Afrique de l'Ouest)'.

Mula, M.G. (2014) 'Seed System Institutionalization for Pulses: A Must in the Philippines', in. *1st Philippine Pigeonpea Congress*, Mariano Marcos State University (MMSU), Batac, Ilocos Norte, Philippines, pp. 1–6. Available at: https://oar.icrisat.org/8791/ (Accessed: 6 July 2024).

Munialo, S. *et al.,* (2025) 'Comparative Analysis of Five African Traditional Multipurpose Crops Using a Food Systems Approach', *Food Reviews International*, 0(0), pp. 1–37. https://doi.org/10.1080/87559129.2025.2481449.

Musoni, A. *et al.,* (2014) 'Innovations to Overcome Staking Challenges to Growing Climbing Beans by Smallholders in Rwanda', in B. Vanlauwe, P. van Asten, and G. Blomme (eds) *Challenges and Opportunities for Agricultural Intensification of the Humid Highland Systems of Sub-Saharan Africa*. Cham: Springer International Publishing, pp. 129–136. https://doi.org/10.1007/978-3-319-07662-1_11.

Ntukamazina N, Ruraduma C, Ntibashirwa (2014) 'Performance relative des techniques de tuteurage sur le rendement du haricot grimpant dans les hauts plateaux du Burundi.', *Journal africain des sciences des cultures*. 22nd edn, pp. 997–1001.

Pei, S., Alan, H. and Wang, Y. (2020) 'Vital roles for ethnobotany in conservation and sustainable development', *Plant Diversity*, 42, pp. 399–400. https://doi.org/10.1016/j.pld.2020.12.001.

Polycarpe Kayode, A.P. *et al.,* (2005) 'Quality of Farmers' Varieties of Sorghum and Derived Foods as Perceived by Consumers in Benin', *Ecology of Food and Nutrition*, 44(4), pp. 271–294. https://doi.org/10.1080/03670240500187302.

Porch, T.G. *et al.,* (2010) 'TARS-HT1 and TARS-HT2 Heat-tolerant Dry Bean Germplasm'. https://doi.org/10.21273/HORTSCI.45.8.1278.

Quentin, M.E., Spencer, J.L. and Miller, J.R. (1991) 'Bean tumbling as a control measure for the common bean weevil, *Acanthoscelides obtectus*', *Entomologia Experimentalis et Applicata*, 60(2), pp. 105–109. https://doi.org/10.1111/j.1570-7458.1991.tb01529.x.

Rodríguez De Luque, J.J. and Creamer, B. (2015) 'Replication Data for: Major constraints and trends for common bean production and commercialization; establishing priorities for future research'.

Ruganzu, V. *et al.,* (2014) 'Farmers' Knowledge and Perception of Climbing Beans-Based Cropping Systems in Rwanda', in B. Vanlauwe, P. van Asten, and G. Blomme (eds) *Challenges and Opportunities for Agricultural Intensification of the Humid Highland Systems of Sub-Saharan Africa*. Cham: Springer International Publishing, pp. 39–49. Available at: https://doi.org/10.1007/978-3-319-07662-1_4.

Rugumamu, C.P. (2014) 'Potency of Traditional Insecticide Materials against Stored Bean Weevil, Acanthoscelides Obtectus (Coleoptera: Bruchidae) in Tanzania', *Huria: Journal of the Open University of Tanzania*, 16, pp. 126–139.

Sarr, A. *et al.,* (2022) 'Ethnobotanical study of cowpea

(*Vigna unguiculata* (L.) Walp.) in Senegal', *Journal of Ethnobiology and Ethnomedicine*, 18(1), p. 6. https://doi.org/10.1186/s13002-022-00506-y.

Silva, V.B.D. *et al.,* (2015) 'Genetic diversity and promising crosses indication in lima bean (*Phaseolus lunatus*) accessions', *Semina: Ciências Agrárias*, 36(2), p. 683. https://doi.org/10.5433/1679-0359.2015v36n2p683.

Smith, J.J. and Borgatti, S.P. (1997) 'Salience Counts—And So Does Accuracy: Correcting and Updating a Measure for Free-List-Item Salience', *Journal of Linguistic Anthropology*, 7(2), pp. 208–209. https://doi.org/10.1525/jlin.1997.7.2.208.

Takusewanya R, Namayanja A, Bwogi GV, Mwine J, Odong TL (2017) 'Évaluation du jalonnement dans un système de production de haricots grimpants tel que pratiqué par les petits agriculteurs en Ouganda.', *2*. Journal des sciences des cultures et de l'agronomie, pp. 018–027.

Thakur, D. (2012) 'Taxonomy, Distribution and Pest Status of Indian Biotypes of Acanthoscelides obtectus (Coleoptera: Chrysomelidae: Bruchinae) - A New Record', *Pakistan Journal of Zoology*, 44.

Yovo, K. and Lantomey, K.E. (2023) 'Stratégies d'adaptation au changement climatique et production agricole dans la région maritime au Togo', *Économie rurale*, (385), pp. 101–118. https://doi.org/10.4000/economierurale.11783

How to cite this article:

Ame Mensah Espère Houngo, Atti Tchabi, Koffi Kibalou Palanga, Komi Agboka, Essohouna Modom Banla, Kpatcha Kamde and Moustakimou Sibabi. 2025. Adaptive Strategies of Togolese Farmers for Sustainable *Phaseolus* spp. Production Amidst Climate Variability in West Africa. *Int.J.Curr.Microbiol.App.Sci.* 14(06): 123-146.
doi: https://doi.org/10.20546/ijcmas.2025.1406.012