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Ethnobotanical survey to evaluate the endogenous knowledge and consequences of Taro Leaf Blight (TLB) in Sudanian climatic zone of Burkina Faso

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Leaf blight caused by *Phytophthora colocasiae* poses a significant threat to taro production in the Sudanian climatic zone of Burkina Faso. This study aims to assess producers' knowledge about the disease, its consequences, and field management practices. An ethnobotanical survey was conducted among taro producers between June and July 2021. Data were collected using a semi-structured questionnaire and analyzed through descriptive statistics, frequency calculations, relative citation frequencies (RCF), and Spearman correlation. The results revealed that the major constraint faced by producers is Taro Leaf Blight. Although surveyed producers have good knowledge of the symptoms (RCF=79.67%), they have limited knowledge about the source of infestation, dissemination factors, and none of them associate it with a pathogen. Consequences of the disease on the plant include a decrease in corm yield and its denaturation. In terms of local livelihoods, the disease leads to food insecurity, poverty, and indebtedness of producers. Furthermore, the respondents are not aware of any effective control methods for the disease. The study highlights the real threat that the disease poses to taro production in the Sudanian climatic zone of Burkina Faso, emphasizing the urgency of developing an integrated control strategy.

Key words: Food security, taro leaf blight, endogenous knowledge, *Phytophtora colocasiae*, Burkina Faso.

INTRODUCTION

Taro (*Colocasia esculenta* (L.) Schott) is globally the fourth most consumed tuber crop, yet it belongs to the category of underutilized food plants known as orphan crops, receiving relatively little research and development attention (Legesse and Bekele, 2021). These crops, essential for global food and nutrition, can contribute to resilient food systems under climate change (Mabhaudhi et al., 2019). Taro serves as a vital staple in the diets of many Pacific islands, certain regions of Africa, Asia, and the Caribbean, providing both food and income for farmers in some of the world's poorest regions (Ebert, 2014).

Taro is an herbaceous plant of the Araceae family, a tropical monocotyledonous, vegetatively propagated,

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perennial crop grown primarily for its starchy corm or underground stem. Richer in carbohydrates than potatoes, it also contains 11% protein by dry weight and is abundant in minerals, vitamin C, thiamine, riboflavin, and niacin (Melese and Negussie, 2015; Gupta et al., 2019). Taro is nutritionally superior to many cereals, such as rice, wheat, and sorghum, in terms of vitamins C and E, and potassium (USDA, 2022). All parts of the plant are consumed, and besides its nutritional value, taro has medicinal properties, used to treat tuberculosis, ulcers, pulmonary congestion, and fungal infections (Misra and Sriram, 2002; Brow et al., 2004; Sharma et al., 2008). Additionally, taro corms are used in various industries for the preparation of syrup and alcohol (Misra et al., 2008), making it a crucial socio-economic crop, especially in Africa where food insecurity prevails. While Burkina Faso is not among the taro-producing countries in Africa (FAOSTAT, 2022), taro plays a significant role in the diet of rural households, particularly in the western part of the country (Traoré, 2014). Taro cultivation could potentially contribute to food security and the improvement of financial income for rural populations if adequately valorized. However, the emergence of Taro Leaf Blight (TLB) in West Africa in 2009 has posed challenges to taro production, consumption, and marketing (Onyeka, 2021). It has caused yield reductions of up to 50-100%, dietary changes, and a shift of producers to other crops in Cameroon, Ghana, and Nigeria (Bandyopadhyay and Sharma, 2011; Omane et al., 2012; Tsopmbeng et al., 2014). TLB has been considered responsible for economic losses exceeding $1.4 billion annually, significantly impacting the erosion of the taro gene pool (Onyeka, 2021). *Phytophthora colocasiae* is identified as the only pathogen responsible for this disease (Erwin and Ribeiro, 1996; Drenth and Sendall, 2004). The disease poses a threat to taro cultivation in several producing countries, including Nigeria, Ghana, Cameroon, and Samoa (Bandyopadhyay et al., 2011; Omane et al., 2012; Tsopmbeng et al., 2014; Alexandra et al., 2020). In Nigeria, losses due to the disease could reach 70% in extremely severe cases (Bandyopadhyay et al., 2011). In Cameroon, yield losses range from 50 to 100% in most taro-producing regions (Fokunang et al., 2016). In 1993, the disease caused yield losses of around 100% in the Samoan Islands (Alexandra et al., 2020).

Unfortunately, TBL is believed to be present in the Sudanian taro production zone in Burkina Faso since 2015. However, to date, there is no literature on the presence of the disease in the country. This disease could be a real constraint to taro cultivation in the country, as it is in other West African countries where it is prevalent.

The use of control practices or new technologies by farmers depends on both their local knowledge and researchers' advice (Kaup, 2008). Furthermore, disease control techniques and strategies often fail because they were developed without considering farmers' knowledge, practices, and needs (Trutmann et al., 1996). The effective management of a crop disease and the adoption of control methods by farmers must consider their knowledge of the disease. Surveys to assess producers' knowledge are therefore available for potato leaf disease (Baral et al., 1997; Nyankanga et al., 2004; Tafesse et al., 2018), maize ear rot (Bentley, 1990), and bean disease (Trutmann et al., 1996). Unfortunately, information on farmers' knowledge of TLB is not available in Burkina Faso. The purpose of this study is to document farmers' knowledge and experience in the management of TLB in the Sudanian zone of Burkina Faso. This will allow the incorporation of this knowledge into the research process for controlling the disease in Burkina Faso.The specific objectives are to: (i) list the different constraints on taro production encountered by producers; (ii) assess producers' knowledge of the symptoms of the disease, the sources of infestation, and the modes of dissemination; (iii) identify the different local control methods; and (iv) determine the consequences generated by this disease in the Sudanian zone of Burkina Faso.

MATERIALS AND METHODS

Study area

The study was conducted from June to July 2021 in the Sudanian climatic zone of Burkina Faso. The selection of provinces took into account the range of taro growing areas, the significance of the crop in these areas (Traoré, 2014), and the climatic conditions favorable to the development of the pathogen responsible for Taro Leaf Blight (Cabi, 2016; Benzohra et al., 2018). A North-South transect was considered for sampling to encompass provinces with high taro production. Consequently, the provinces of Houet and Kénédougou in the Upper-Basins region, and Comoé in the Waterfalls region, were sampled. The climatic conditions in the study area are the most clement in Burkina Faso, marked by low thermal amplitudes and relatively high rainfall. Two seasons alternate during the year: a dry season (November-March) and a rainy season (April-October) (Table 1).

Sampling and data collection

Eight taro production localities were selected, with two in each of the provinces of Houet and Comoé and four in the province of Kénédougou (Table 2). These localities were chosen based on a preliminary survey of the geographic distribution of taro cultivation in the Sudanian climatic zone of Burkina Faso. In these localities, 123 taro producers were randomly selected. Data were collected through a questionnaire and an individual semi-structured interview guide. Information covered socio-demographic characteristics of the respondents (age, gender, literacy level, and professional activities), the importance of taro production (production area, varieties grown, experience in cultivation, yield, and benefits related to production), various constraints faced, knowledge of TLB (symptoms, date of emergence, source of infestation, mode of spread), and control methods used. The questionnaire was pretested with 30 people and revised for the surveys. On average, the interview took approximately 30 min with each producer.

Table 1. Environmental characteristics of the Sudanian climate zone of Burkina Faso.

Parameter	Characteristics
Rainy season	April-October
Rainfall	>1100 mm
Temperature	20-25°C
Hydrographic system	Comoé River and its affluent the Leraba
Types of soil	Hydromorphic, ferrallitic
Types of vegetation	Savanes, open forests, gallery forests

Sources: Climatic variables: (Thiombiano and Kampmann, 2010); Hydromorphic system (BUNASOLS, 2004); Vegetation (Fontès and Guinko, 1995).

Table 2. Growing taro localities sampled.

Regions	Provinces	Localities
Upper-Basins	Houet	Bama Karangasso-Sambla
	Kénédougou	Kourinion Samorogouan Samogohiri Kangala
Waterfalls	Comoé	Bérégadougou Séréfédougou

Data analysis

The survey forms were processed and the data were statistically analyzed using descriptive and frequency calculations. Respondents were grouped by age category and literacy level. The age distribution was as follows: young (age ≤ 30 years); adult (30 < age < 60); old (age ≥ 60 years) as described by Assogbadjo et al. (2008). Only one respondent was female and therefore the analysis did not involve the gender parameter. To assess respondents' knowledge of the disease, relative citation frequencies (RCF) by type of symptoms, type of organs subject to infestation, type of sources of infestations, and modes of disease spread were calculated using the following formula:

$$RCF = S/N \times 100$$

where S = number of people who cited the information and N = total number of people interviewed. Excel software was used to calculate frequencies and to illustrate the results in diagrams. A Spearman correlation was performed to assess the relationship between the different types of symptoms listed by the interviewees, the experience in the crop and the period of observation of the disease in the Sudanian climatic zone. This analysis was done with R software version 4.1.0 (R Core Team, 2020).

RESULTS

Socio-demographic characteristics of the respondents

A striking majority of the surveyed producers, accounting for 99.18%, were male (Table 3). In terms of age distribution, 73.2% were adults, 14.6% were young, and 12.1% were categorized as old. The educational level of the respondents was predominantly low, with 73.98% being non-literate. The experience in taro cultivation varied from 1 to 47 years, with an average of 18.24 years. Notably, a significant proportion (69.10%) had over 10 years of experience in taro cultivation.

Production areas and benefits of taro

Taro emerges as a cash crop primarily cultivated on small areas, in contrast to other crops (Figure 1). The majority (66.67%) of the production area is less than 0.5 ha. Yields ranged from 0.4 to 60 tonnes (Figure 2). The prevalent varieties across all three provinces in the Sudanian climatic zone are the local variety Tabouchi and the exotic variety BL/SM/120.

Regarding the significance of taro in this zone, all respondents (100%) deemed taro as "very important" and even "indispensable" for their well-being. Producers highlighted that taro serves as a crucial source of income and plays a pivotal role in food production during the hunger season (Figure 3). Income from taro sales is primarily used to meet essential household needs (92% of respondents), including medical care, acquiring other foodstuffs (maize, millet, sorghum, etc.), constructing

Table 3. Socio-demographic profile of respondents.

Parameter	Modalities	Comoe		Kenedougou		Houet		Total
		M	W	M	W	M	W	
Age (years)	A<30	18	0	0	0	0	0	18
	30≤A<60	18	1	56	0	21	0	96
	A≥60	0	0	9	0	0	0	9
Education level	Alphabetized	7	0	22	0	2	0	31
	Not alphabetized	29	1	43	0	19	0	92
	Total	36	1	65	0	21	0	123

M: Man; W: woman.

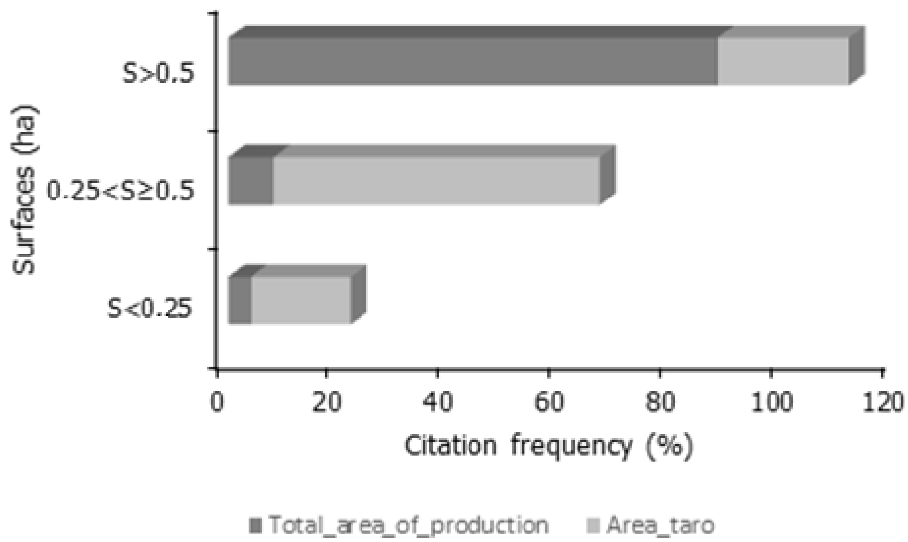

Figure 1. Production areas.

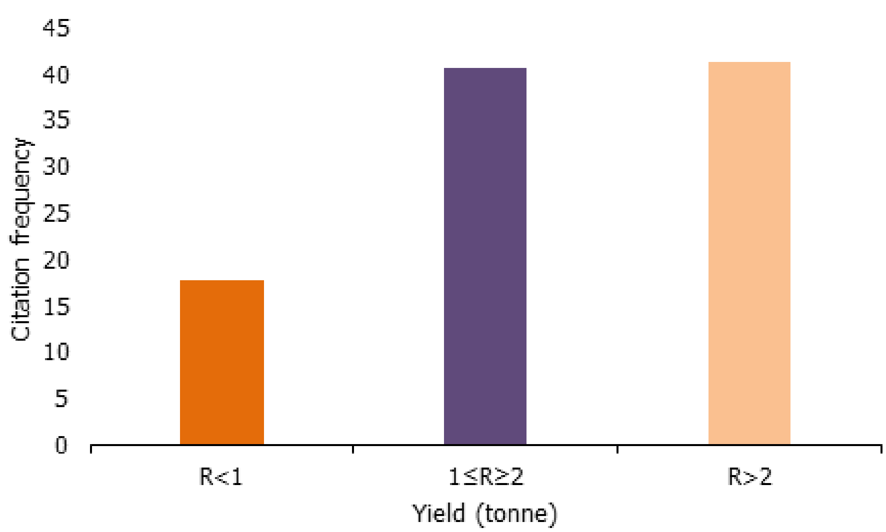

Figure 2. Yield of taro.

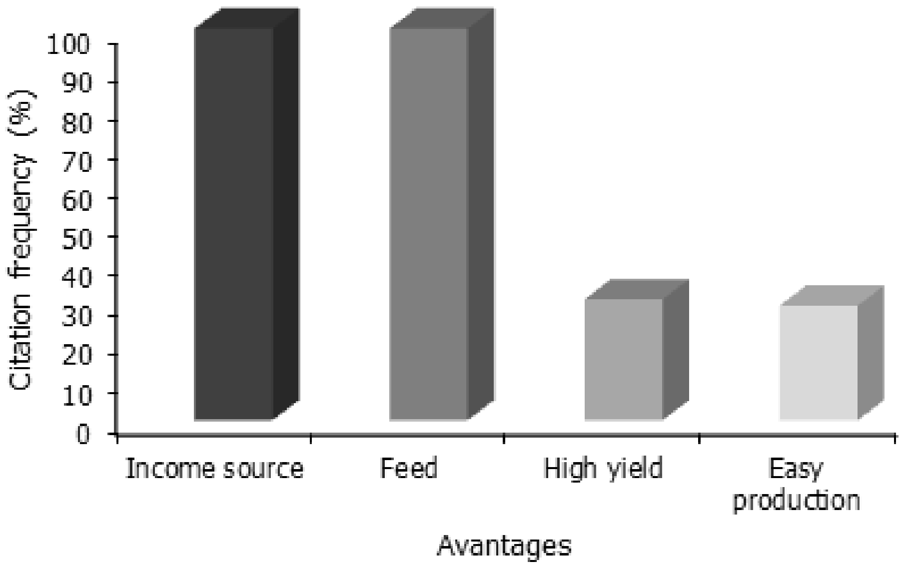

Figure 3. Benefits of taro production.

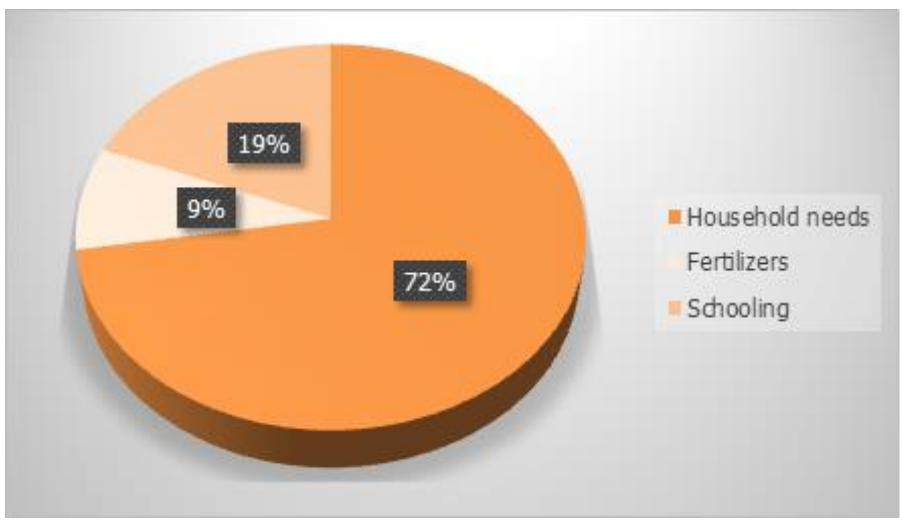

Figure 4. Distribution of income generated from the sale of taro.

houses, and celebrating social events such as naming ceremonies. Additionally, this income is allocated to children's education (24% of respondents) and purchasing fertilizer (11% of respondents) for maintaining other crops (Figure 4).

Constraints of taro cultivation in the Sudanian climatic zone of Burkina Faso

The findings underscore a significant decline in taro cultivation in the Sudanian climatic zone of Burkina Faso, with 100% of respondents acknowledging this trend. Various constraints were identified as contributing factors to this decline (Figure 5). Leaf blight emerged as the predominant and most impactful constraint, with a relative citation frequency (RCF) of 99.18%.

History and time of occurrence of TLB

Respondents' accounts regarding the onset of TLB in the zone varied (Figure 6). The majority (74.80%) estimated the appearance to be between 2 and 6 years, while a minority attributed it to over 10 years. June was identified by most growers as the month when TLB symptoms first

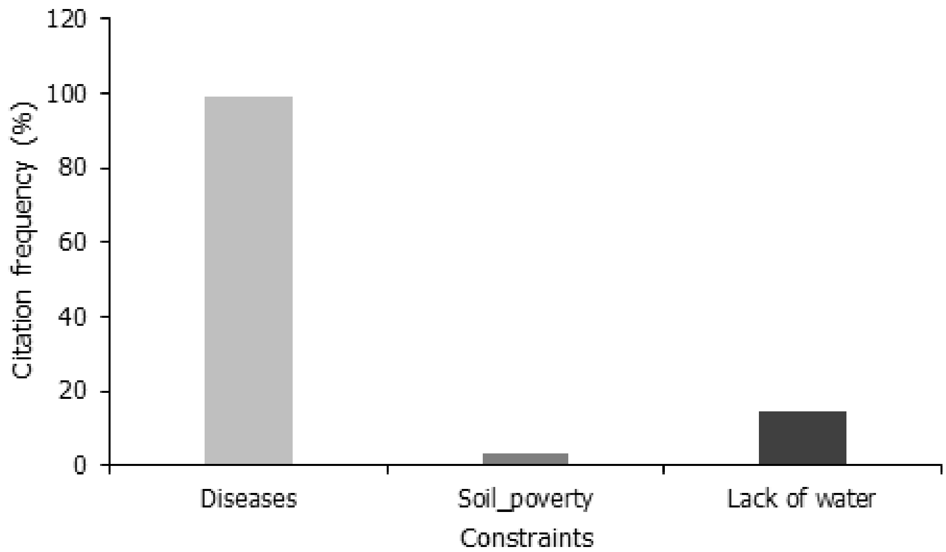

Figure 5. Constraints of taro cultivation.

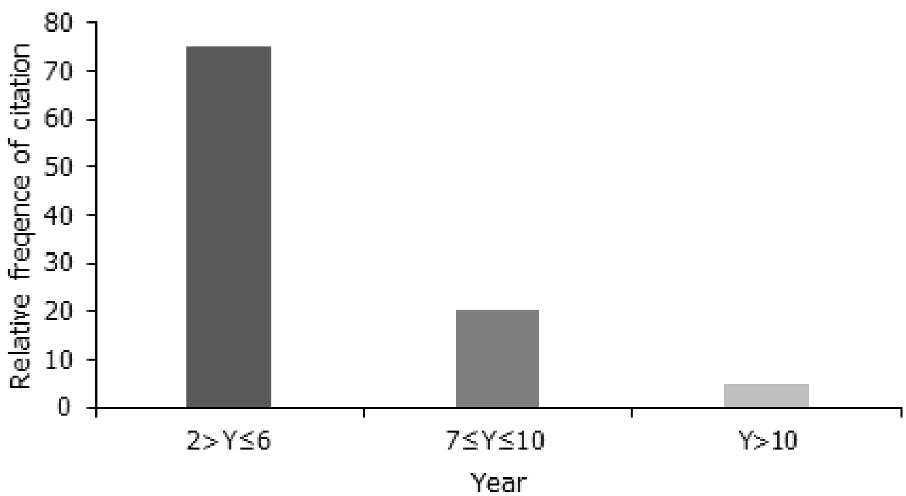

Figure 6. Start of the presence of the disease.

appeared in the fields (Figure 7). However, there was significant variation in the exact timing reported by growers, spanning from March to July.

Social and economic consequences of TLB

TLB affects both the production of the plant and the living conditions of the producers (Figure 8). At the plant level, the producers mainly notice a considerable decrease in yield (100%). Damage to the corms includes denaturation and reduction in size. Socially, the disease leads to food insufficiency, declining income, poverty, and indebtedness. The foliar disease affects the development of taro cultivation in the Sudanian climatic zone of Burkina Faso. As a consequence, the majority of producers (64%) stated that they would abandon taro production (Figure 9) in favor of market garden crops like cassava, sweet potatoes, rice, or gold panning, despite its highly competitive profitability in the absence of the disease.

Producers' knowledge on TLB symptoms noticed

Surveyed producers cited several symptoms of the disease on the leaf and corms (Table 4). The main symptoms reported were burn and black spots on the leaf blight (53.66%), petiole rot (49.59%), corm denaturation

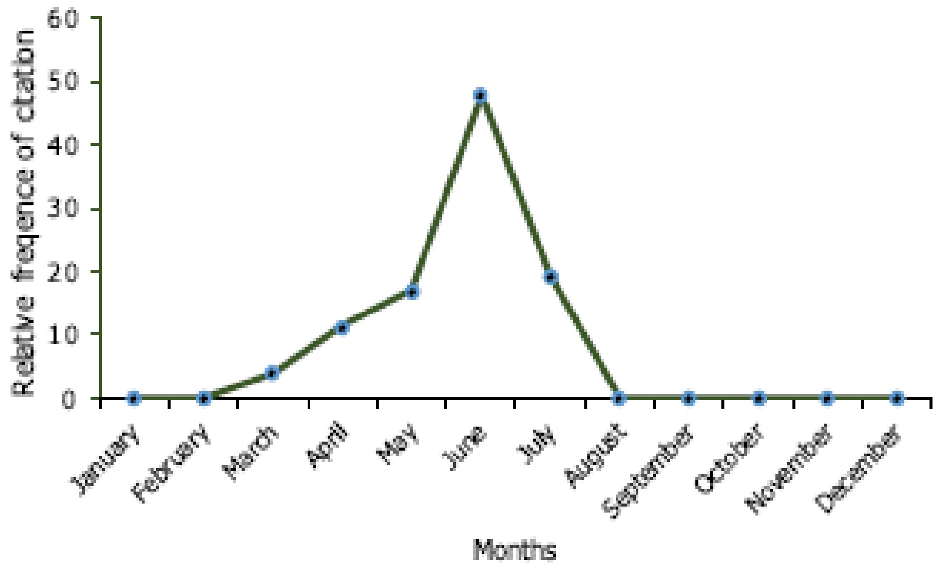

Figure 7. Month beginning symptoms.

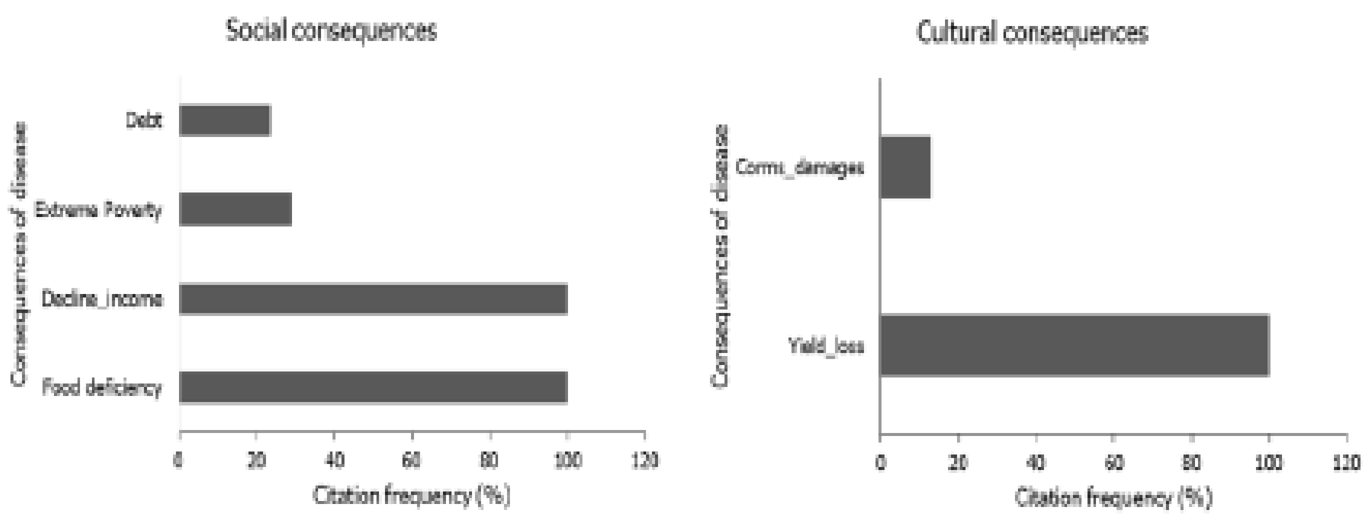

Figure 8. Consequences of taro leaf blight.

marked by the presence of unpleasant odor, loss of flavor and poor storage time (67.48% of respondents). All parts of the plant are affected by the disease regardless of the stage of the plant's development, according to 65.04% of respondents. On the average, the disease would appear 5 months after the plant was put into cultivation with a minimum of three months and a maximum of eight months. These values depend on whether or not each farmer planted taro before the rainy season.

Spearman's correlation test performed on the symptoms cited by the growers shows positive correlations between the symptoms burn spots, black spots, holes on the leaf blade and the symptoms petiole rot and corm denaturation. Strong negative correlations were observed between the symptoms burn spot, petiole rot and the symptom leaf yellowing (Figure 10). Leaf yellowing was cited as the only leaf blight symptom by only 8.13% of the surveyed population.

Source of infestation and dissemination factor

Responses of surveyed producers on the sources of infestation and modes of dissemination are controversial. They gave several sources of disease infestation. Nearly half (45.53%) of them did not know the potential sources

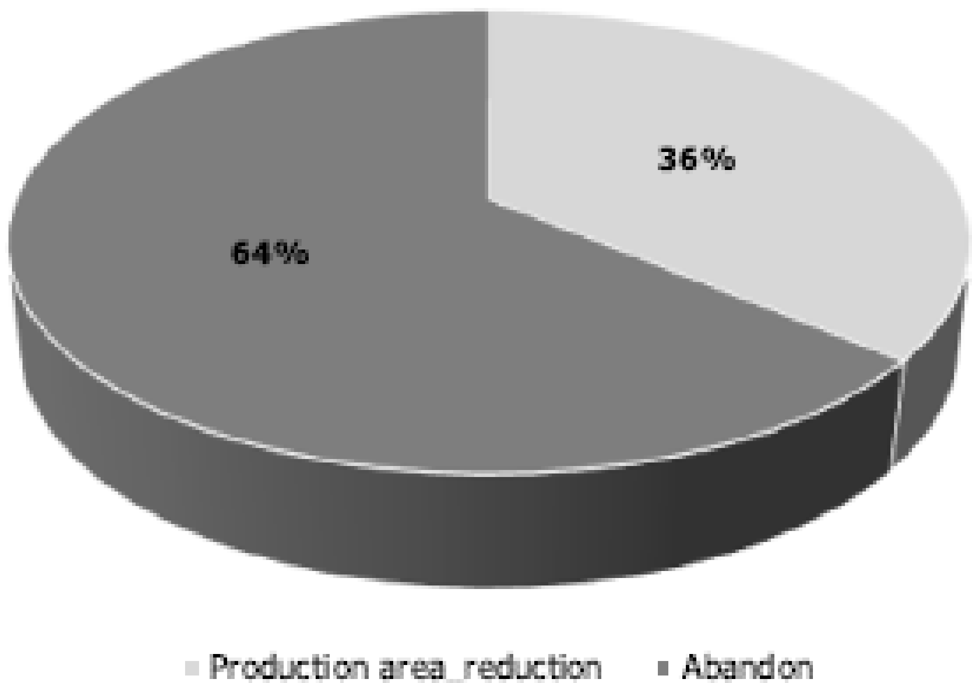

Figure 9. Future views on taro cultivation in the context of leaf blight.

Table 4. Respondents' knowledge on symptoms and infected organs.

Characteristics	Modalities	RCF (%)
Symptoms	Burns	79.67
	Black spots	53.66
	Holes on the limbs	10.57
	Yellowing of the limbs	24.39
	Petiole rot	49.59
	Denaturation of corms	67.48
Organs	Leaves	34.96
	Leaves and corms	65.04

RCF: Relative citation frequency.

Figure 11). Many growers recognized the symptoms of the disease but did not associate it with a known pathogen. Producers also reported different ways in which the disease can spread. The most cited factor of dissemination was runoff water (57.72%) (Figure 12). In addition, 32.52% of the respondents did not know the pathogen dissemination factors.

Disease management practices

The majority of the producers surveyed (75.60%) do not know any control practices against TLB. Of the ones who do know, 50% use cultural control (staggering of planting, pulling up infected plants) while the others use pesticides (Figure 13). However, these control methods do not provide adequate control of the disease. For this reason, most producers (85.37%) requested the establishment of effective control strategies, the development of resistant varieties and assistance from the authorities in order to continue production of this plant with high economic and social potential.

Ethics approval and consent to participate

Informed prior consent was obtained from all respondents before commencement of the interview.

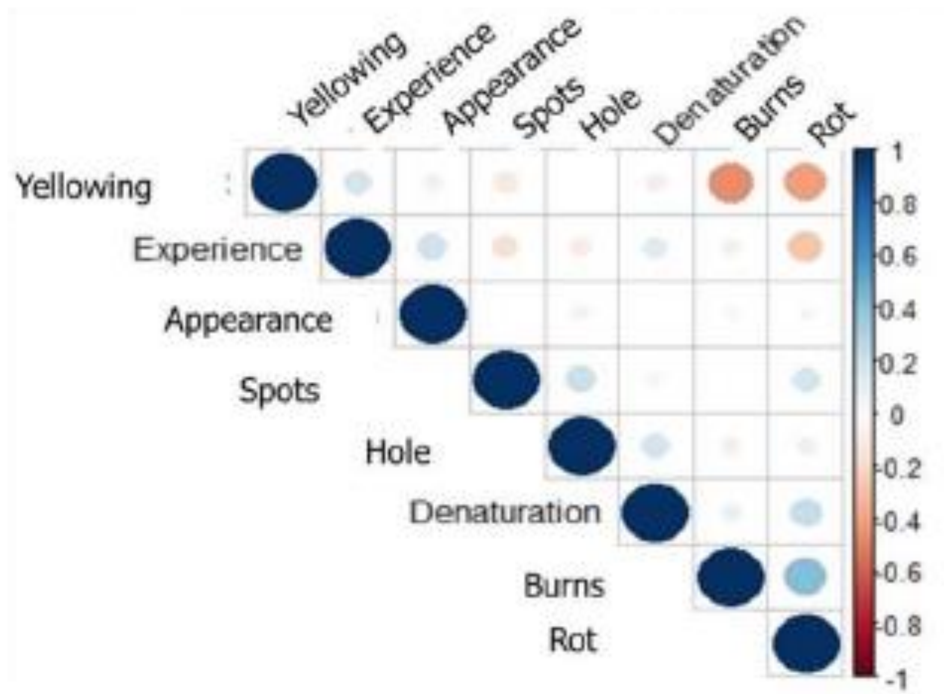

Figure 10. Spearman's correlation test on disease symptoms reported by producers.

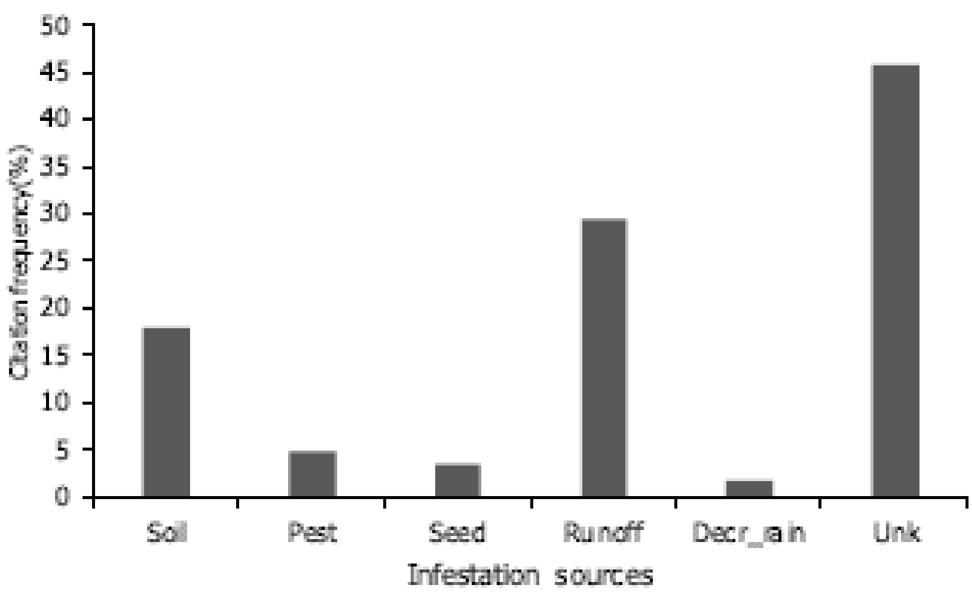

Figure 11. Infesting sources of taro leaf blight. Pest: Pesticide; Decr_rain: decrease in rainfall; Unk: unknown.

DISCUSSION

Strategies developed for farmers failed with negative social consequences mostly because the research was conduct without their participation or their own knowledge on disease. This study is the first step of development of management of TLB in Burkina Faso.

In the Sudanian climatic zone of Burkina Faso, this research shows that taro cultivation is practiced mainly by men and generates significant financial income. Indeed,

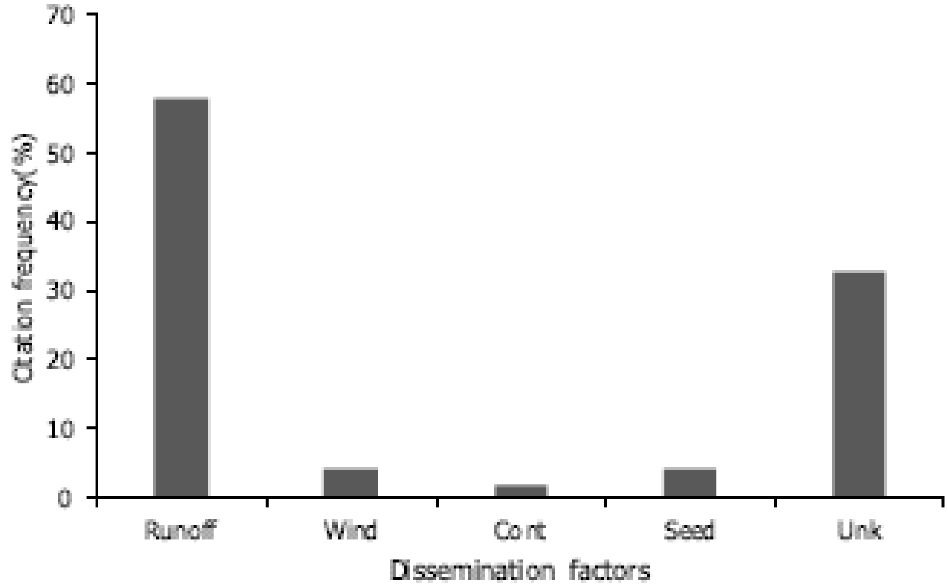

Figure 12. Dissemination factors of taro leaf blight. Cont: Contact with infected plants; Unk: unknown.

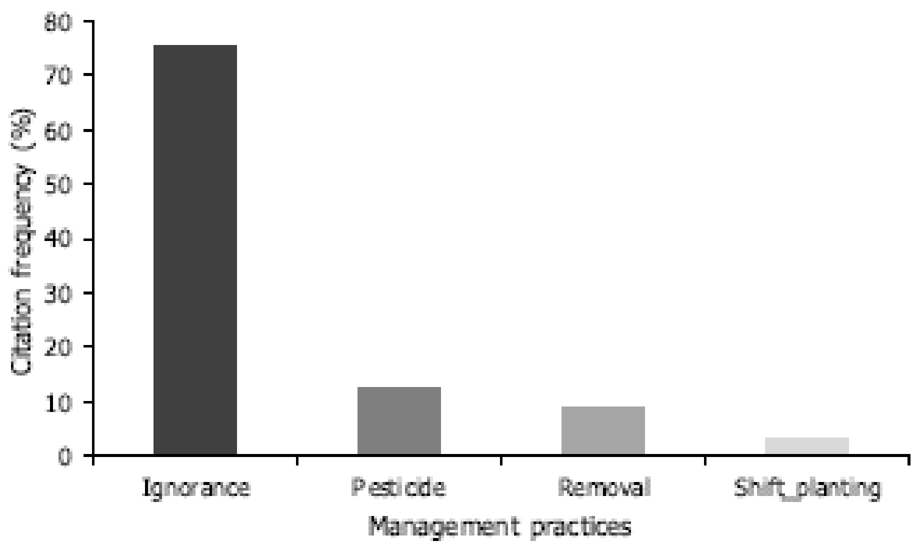

Figure 13. Control methods against taro leaf blight.

taro is produced primarily for commercial purposes, but also for household consumption. The rural populations attach great importance to taro cultivation in view of its many advantages. All this shows the importance of the plant in this area. Similar benefits of taro cultivation have been identified in Cameroon (Takor et al., 2020) and Nigeria (Ugbajah, 2013). Nevertheless, various studies have shown that taro is mainly produced by women in the Sudano-Sahelian climatic zone of Burkina Faso (Traoré, 2014) and in several other West African countries (Azeez and Madukwe, 2010; Quaye et al., 2010; Adisa and Okunede, 2011; Ugbajah, 2013).

Despite its importance, taro production in the study area is done on small areas of 0.5 ha or less. In addition, only two varieties were identified in the study area: a local variety (*Tabouchi*) that is produced by the majority of producers (88.62%) and an exotic variety (*BL/SM/120*). An increase in the number of varieties was noticed because Traoré (2014) had found only one variety produced in the zone during his ethnobotany studies.

Indeed, the exotic variety comes from the Samoan Islands and was introduced in the area in 2011 as part of Adapting clonally propagated crops to climatic and commercial changes (ACPCCC) project of the International Network for Edible Aroids (INEA). The predominance of the local variety *Tabouchi* in the area, testifies the attachment of the producers to it. In fact, the variety is adapted to the climate and growing conditions of the Sudanian zone. In addition, it is highly prized by consumers. The use of small areas for the production of these varieties could be explained by the lack of available floodable land, the absence of irrigation systems and the difficulty of post-harvest management of the crop. Indeed, in this area, the predominantly produced taro variety (*Tabouchi*) is water demanding, growing in low-lying areas and on depression land (Traoré, 2014). Thus, the men who are generally heads of household prioritize these areas for taro production, which is very competitive in economic terms compared to other crops. Traoré (2014) also reported similar results through ethnobotanical surveys. In Côte d'Ivoire, Benin, Ghana, Nigeria, Central African Republic, Togo, Liberia, Cameroon, and Chad, taro is also mostly produced on smallholder farms whose primary concern is to ensure their own subsistence (Koffi et al., 2018; FAOSTAT, 2007).

The major constraint affecting taro production in the Sudanian climatic zone of Burkina Faso reported by almost all producers is leaf blight. It has drastically reduced the cultivation of the plant in the zone. The disease was also reported in Ghana by a large majority of producers as the major factor limiting taro cultivation (Asraku, 2010). Thus, since its appearance in West Africa in 2009 (Onyeka, 2021), the disease has been a threat to taro cultivation in several producing countries including Nigeria, Ghana, Cameroon, and Samoa (Bandyopadhyay et al., 2011; Omane et al., 2012; Tsopmbeng et al., 2014; Alexandra et al., 2020).

Assessment of respondents' knowledge on TLB shows that the majority have good knowledge of disease symptoms regardless of their experience in the crop or their education level. This could be explained by the fact that symptoms are easily observables. Indeed, according to Bentley (1992), in general, farmers have a good knowledge of easily observable phenomena. The symptoms cited by producers are also described in literature as TLB symptoms (Hunter et al., 1998). However, a minority of farmers cited leaf yellowing as the only disease symptom. This apparent lack of knowledge of the disease symptom may be explained by the fact that the disease is not yet present in the locality.

The yellowing and necrosis of the leaves reported by these producers could be rather the result of an abiotic stress such as a deficiency in mineral elements. According to Prevel (1978), a nitrogen deficiency can cause yellowing and necrosis of old leaves. The first symptoms of taro leaf disease were observed between 2 and 6 years ago, according to the majority of respondents. This period depends on the experience of the producers in the cultivation of taro. Symptoms would begin to appear in the fields after the first rains, generally in the months of May to July. According to Cabi (2016), TBL is epidemic under high rainfall conditions. Studies have shown that growers in Nigeria (Bandyopadhyay et al., 2011), Cameroon (Fontem and Mbong, 2011) and Ghana (Omane et al., 2012) also locate the onset of disease symptoms during the rainy season.

Despite their good knowledge on the Taro Leaf Blight symptoms prevalent in their fields, growers have limited knowledge about the sources of infestation and the disease's spread factors. None of the respondents associated the disease with a known pathogen. In addition, almost half of the respondents ignored the potential sources of infestation of plants in the field. The same finding was reported in Ghana (Asraku, 2010) where 80% of the farmers did not know the source of Taro Leaf Blight despite their good knowledge of symptoms. In Kenya, Nyankanga et al. (2004) reported similar results for potato where the majority of growers (81%) did not associate the plant's foliar disease with a pathogen. This is because growers rarely know the causes of plant diseases (Bentley, 1992, 1993). Concerning the disease spread factors, growers cited several. Nevertheless, 32.52% of them are ignorant. In addition, they do not have effective control methods against the disease. This is probably because producers do not know the cause of the disease. The respondents' low knowledge of the source of the infestation, factors of spread, and disease management methods could be explained in part by the fact that most of them are non-literate. The social and demographic characteristics of the interviewees show that the majority of them (75.61%) are non-literate. This explanation agrees with Abang et al. (2014) who reported that low level of education among vegetable farmers in Nigeria was the cause of their low level of knowledge on vegetable pests, diseases, and control methods. In Ethiopia, Tafesse et al. (2018) also found that most growers have limited knowledge on the mode of spread as well as management methods on potato disease.

The general consequences of TLB in the Sudanian zone of Burkina Faso are drastic. Respondents reported significant yield losses and poor-quality corms on the plant. This shows the gravity of the disease when it occurs in an area. Indeed, in Nigeria, a study showed that losses due to the disease could attain 70% in extremely severe cases (Bandyopadhyay et al., 2011). In Cameroon, yield losses range from 50 to 100% in most taro producing regions (Fokunang et al., 2016). In 1993, the disease caused yield losses of around 100% in the Samoan Islands (Alexandra et al., 2020). Where, local taro varieties are highly susceptible to TLB. This has led to considerable genetic erosion of the plant in the country (Hunter et al., 1998). The genetic diversity of taro is already low in Burkina Faso and mainly in this area (Traoré, 2014). Growing only one variety of taro in a disease context poses a high risk of complete production loss. TLB poses a serious threat to taro production and biodiversity, which is already low in Burkina Faso. Socially, the consequences of the disease are equally disastrous. It is believed to be the cause of the gradual abandonment of the crop in the Sudanian climatic zone of Burkina Faso. Similar social consequences have been reported in Cameroon (Takor et al., 2020), Ghana (Adomako et al., 2016), and several regions in the Pacific (Jackson, 1993). The impact of leaf disease in the countries in which it occurs clearly demonstrates the potential threat that the disease poses to food security, nutrition, and income generation.

Conclusion

The ethnobotanical study conducted in the Sudanian climatic zone of Burkina Faso has shed light on the significance of taro cultivation for rural households' economic development. However, the study also identified TLB as a major constraint faced by producers. While the producers demonstrated good knowledge of TLB symptoms, there is a notable gap in their understanding of the disease's source of infestation, dissemination factors, and effective control methods.The importance of taro cultivation for local producers is emphasized, serving as a foundation for the development of control strategies against TLB. Urgent measures are required to preserve taro cultivation and enhance its production in the Sudanian climatic zone of Burkina Faso.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

The authors appreciate the individuals who participated in the study for their cooperation.

ABBREVIATIONS

RCF, the relative frequency of citation; **ACPCCC,** adapting clonally propagated crops to climatic and commercial changes; **INEA,** International Network for Edible Aroids; **BL/SM/120,** name of a variety from Samoa.

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