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CONSTRAINTS TO PRODUCTION AND PREFERRED TRAITS FOR TARO (*COLOCASIA ESCULENTA*) AND NEW COCOYAM (*XANTHOSOMA MAFAFFA*) IN TOGO, WEST AFRICA

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ABSTRACT

Taro (*Colocasia esculenta* L. Schott) and tannia (new cocoyam) (*Xanthosoma mafaffa* L. Schott) are food crops cultivated in tropical and subtropical regions of Asia, Africa and Latin America. In cultivation, they are always vegetatively propagated and their production faces many constraints. Their corm is an important source of carbohydrates and leaves eaten as vegetable provide important minerals and vitamins. In Togo, although these crops are among the most important food crops in some rural areas, they appear at the country level as neglected and underutilized species (NUS) and should be promoted. However, adequate information related to production, constraints, farmers' preferred traits and utilisation is lacking for the development of efficient breeding schemes and their sustainable preservation and use in Togo. In this paper, a focus group survey was conducted in all five ecological zones of the country to document farmers' perceptions regarding constraints for production of these two crops and their preferred traits for production and utilization. Collected data were analysed through descriptive statistics (frequencies, percentages and means) using the Statistical Package for Social Scientists (SPSS 20) and Excel spreadsheets. Rainfall irregularity (or shortage of rainy seasons) (68.4% of responses), soil infertility (61.5% of responses) and inefficient marketing (58.7% of responses) were the most common production constraints reported. Farmers preferred early-maturity (73% of responses) and high-yield (65% of responses) as crop traits. Men are more involved in production of these crops in Togo (79% of respondents). However, the constraints and preferences reported were not gender dependent. This study showed that production of taro and tania faces many challenges in Togo. Morphological and molecular characterization of grown varieties is highly recommended to help select suitable varieties for breeding programmes. Improvements in food processing and accessibility of credit should be prioritized to generate more income for farmers and encourage production in Togo.

Key words: Agriculture, *Colocasia esculenta,* constraints, farmers, preferences, production, Togo, *Xanthosoma mafaffa*

INTRODUCTION

In 2005, FAO estimated that 852 million persons, particularly in developing countries suffer from chronic malnutrition. For example, in Togo, the annual mean growth of food supply is 3.1 % for an annual growth of population of 3% [1]. As a result, diet deficits have been nearly permanent. Across the world, many plant species that are cultivated for food are neglected and underutilized despite having a crucial role in food security, nutrition and income generation of the rural poor [2, 3, 4]. Taro (*Colocasia esculenta* L. Schott) and new cocoyam or tannia (*Xanthosoma mafaffa* L. Schott) are two of these species and are the most important food crops in family Araceae [5, 6].

Taro is considered an ancient food crop with uncertain genetic and geographical origins in Southeast Asia [7]. It is of particular significance in many Pacific Island countries where it forms part of the staple diet and serves as an export commodity [8]. The young leaves of taro are eaten as vegetable and are an important source of folic acid, vitamin A, vitamin C, riboflavin and minerals such as iron [9]. Roots (corms) are consumed boiled, roasted or fried and are an important source of carbohydrates while the corn flour has been reported to have 70–80 % starch content with small granules, which results in high digestibility [10, 11]. In Africa, Darkwa and Darkwa [12] reported that cake and chips prepared from a combination of taro flour and cereals such as maize/corn, rice and wheat are well accepted by Ghanaian people. Bamidele *et al*. [13] showed that co processing of cassava and taro improved the nutritional quality of *gari*, a traditional cassava food product that is often eaten in West Africa. The combination was met with a high level of acceptance. According to Igbabul *et al.* [14], fermentation of taro corms before flour extraction helps to increase nutrients, reduce anti-nutritional factors, improve functional properties and enhance utilization of taro flour in different food systems.

Although *C. esculenta* is polymorphic, two varieties have been recognized among cultivated forms: *C. esculenta* var. *esculenta* (also known as *dasheen*) and *C. esculenta* var. *antiquorum* (also known as *eddoe*) [6]. *Dasheen* types have a larger main corm with smaller side corms (cormels) and are usually diploids, whereas e*ddoe* types have a relatively smaller central corm with well-developed side corms (cormels) and are triploids [6, 15]. Cultivars are differentiated mainly by leaf pigmentation, plant size, cormel shape and number, cormel tip shape and pigmentation, spatial arrangement of cormels and cormel flesh pigmentation [6]. In Togo, Brunel *et al.* [16] described taro as an introduced and cultivated species, more or less naturalized. However, taro is known and grown as food crop by only a small proportion of farmers. In the north, (ecological zone II), taro is mainly grown by the Kabyè tribe and locally named *kpèkpèou* or *kpèkping*. The cultivated form is an *eddoe* type that requires long cooking due to corm acridity. In the south, the cultivated form is a *dasheen* type. It is grown very often in home gardens, along the boundary with Ghana and is locally named *aborbe* or *mancanikokoo* (ecological zones IV). It is also found wild along the southern rivers.

The genus *Xanthosoma* has about 40 species, some of which are grown as ornamental or food crops originating in the American continent [17]. Young leaves of *X. mafaffa* (tannia, yautia) are used as a vegetable and are an important source of proteins and vitamins [18]. In Togo and elsewhere in Africa, corms are consumed boiled, roasted or fried and are a source of carbohydrate. The high viscosity of some varieties makes them

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the preferred choice for preparation of *pounded fufu*, a traditional dish often consumed in West Africa [19]. Cultivars are differentiated mainly by leaf pigmentation, plant size, cormel shape and number, cormel tip shape and pigmentation, spatial arrangement of cormels, and cormel flesh pigmentation [6]. In Togo, tannia is locally named *mancani* or *bancani*. Brunel *et al*. [16] describe tannia as an introduced and cultivated species, more or less naturalized in Togo. Tannia is very common and is more often traded commercially than taro. It is mostly grown in areas with high rainfall and mainly in intercropping system.

These two crops contribute to food security in the lives of many and have rich economic and socio-cultural connotations in Africa [12, 20, 21]. However, according to FAOSTAT [22] and DSID [23], taro and tannia produce the lowest average yields (5.4 tonnes/ha for the world and 1.2 tonnes/ha for Togo, respectively) of all reported root crops. Pests and diseases such as taro Leaf Blight (TLB) disease [24] and root rot diseases, caused by *Pythiummyriotylum*, have been reported as important constraints for producing tannia [25]. Other constraints include: weeds, labour requirements, scarcity of land, scarcity of planting material, lack of improved varieties, inefficient marketing, limited research and limited extension services [5]. Common constraints to their production in West Africa are erratic rainfall, pests and diseases, limited allocation of resources, increased dependence on cereals for dietary energy, unfavourable competition of taro and tannia against other root crops, inefficient marketing and limited and uncoordinated research [26].

In Togo, these two species are listed among neglected and underutilized crops [3]. Data on production and productivity for taro is not mentioned in agricultural statistics for the country. Recorded national productions of tannia were 20,165 tonnes, 20,407 tonnes and 11,337 tonnes in 2011, 2012 and 2013 respectively [22, 23]. Specific information on the main constraints, in Togo, has not been reported. In this paper, a survey of indigenous knowledge related to constraints for production is reported. A constraint in this study is defined as a factor (biotic or abiotic) that reduces production of taro and tannia or a trait of these crops that is not desired by farmers, and that may lead them to not being grown. Also, identified and analysed were the agro-morphological and culinary traits or related factors that are more interesting to farmers and that may encourage them to grow these crops; these traits and factors may be also referred as “preferred traits” or “preference criteria”.

MATERIALS AND METHODS

Study Area

The Republic of Togo is a West African country between Burkina Faso in the North, the Atlantic Ocean in the South, Ghana in the West and Benin in the East. It has a total land area of 56,600 km² and a population of about 5.8 million [27]. There are five ecological zones recognized (I- V) from north to south [28] with Zone I corresponding to the northern part of the country. The main type of vegetation is the Sudanian savannah where remain a few fragments of gallery forests along the banks of the river Oti. Zone II, the mountain zone of the north, is characterized by dense forests, clear forests and grassy savannas. The zone III corresponds to the large areas of the centre of the country with altitudes between 200 and 400 meters. It is dominated by Guinean wooded savannas,

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clear forests and discontinuous forests along the main rivers. Ecological zone IV is the southern part and corresponds to the humid and semi-deciduous forests zone of Togo. Zone V is located at the extreme south of the country with fallow land, thickets, bushes, derived savannas and coastal grassland savannas [29, 30]. These lie within two climatic zones: in the south, a sub-equatorial climate with two rainy seasons (April to July and September to November) and two dry seasons (November to March and July to August); in the North, a Sudan climate with one rainy season (May to October) and one dry season (November to April). In the south, rainfall is between 1200 and 1400 mm per year; in the north, it is between 800 and 1000 mm. The country's mean annual temperatures range from 26°C to 28°C and may exceptionally reach 35°C to 40°C in far northern localities [30]. In 2016, forty-five villages were randomly selected across all ecological zones of Togo (Figure 1).

Methodology

Focus group discussions were conducted in villages of zones I-V: I (9 villages), II (6 villages), III (12 villages), IV (11 villages) and V (7 villages) following the method described by Dansi *et al.* [31]. Data were collected through direct observation and group discussions using a questionnaire and following the procedures of Dansi *et al.* [31] and Kombo *et al.* [32]. In each village, interviews were conducted with the help of a local translator. Group surveys involved 8 to 40 tannia and taro producers of both sexes and of different ages. The respondents were identified and assembled with the help of village chiefs who facilitated the organization of meetings and collection of data. Information was collected after giving a detailed presentation of the research objectives to the farmers. Following a pre-tested questionnaire, each group was asked to first, list all the factors (biotic and abiotic) that reduce taro and tannia production and to identify unwanted traits in these crops. All the listed items were ranked in order of decreasing importance from first to last. All these items are referred as constraints to production and the constraint ranked as number one in a village, was the most important constraint reported there. Secondly, farmers were asked to list all the morphological and culinary traits that could interest them and motivate them to continue growing taro and tannia, as preferred traits or criteria. All these traits were also ranked from most to least important. All the answers for both tannia and taro were reported on same questionnaire in each village surveyed and respondents did not always distinguish the two crops. Farmers referred Tannia and taro in some villages as taro. The discussions were free, open-ended and without a time limit being set. The information provided by the focus group discussion in each village surveyed was noted as one interview: the number of interviews in each ecological zone was equal to the number of villages surveyed. The surveys were conducted during rainy season (May to September 2016), to help gather further information through farm visit and samples collection.

The Statistical Package for Social Scientists (SPSS) was used to check the normal distribution of the data and generate frequencies, percentages and means. Histograms were generated using Ms-Excel program. Percentages were calculated as follows:

$$\mathbf{Pi} = \frac{\mathbf{ni}}{\mathbf{N}} \times 100$$

; Percentage of interviews (N) in which the i constraint or preference was reported

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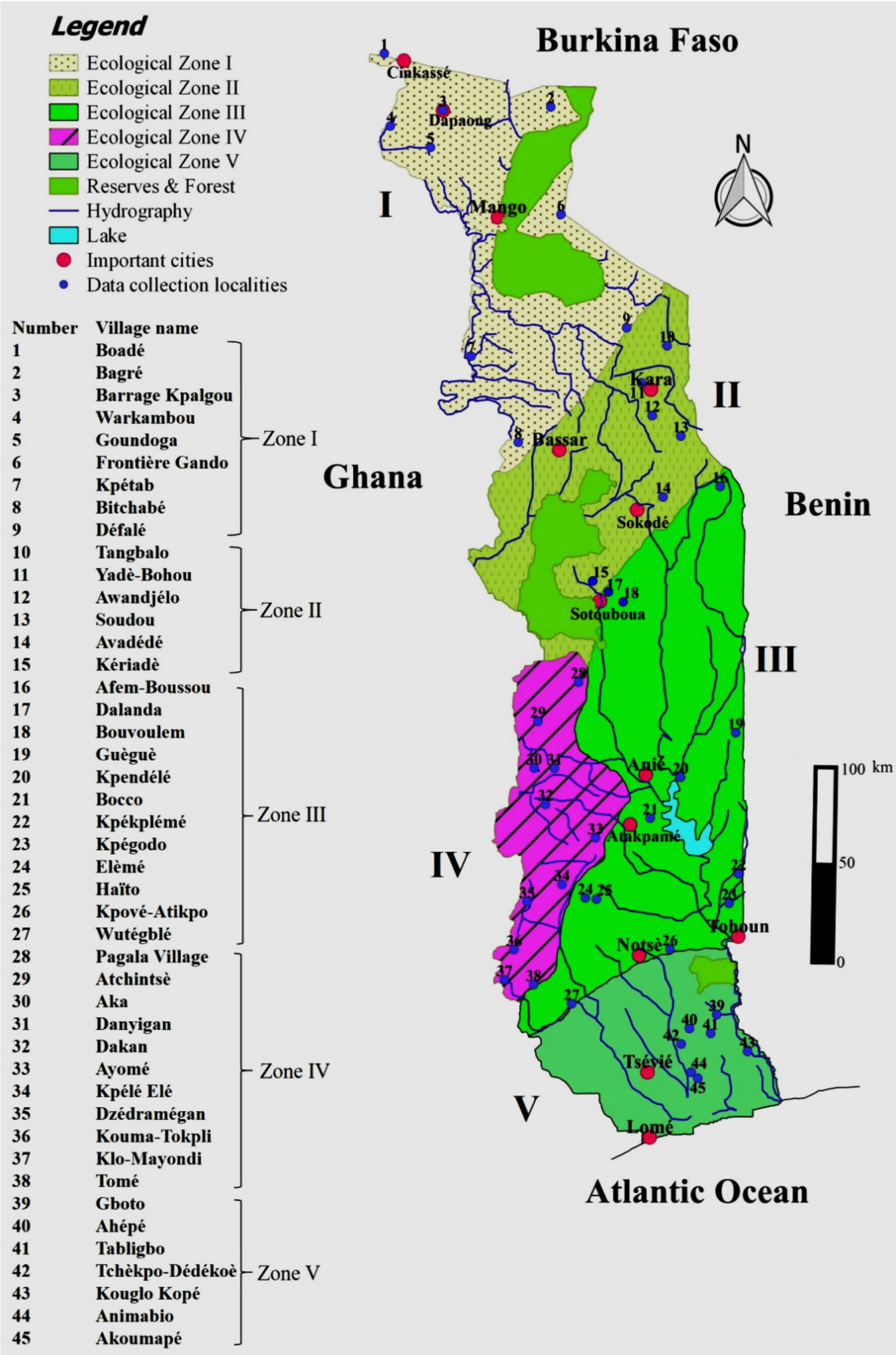

Figure 1: Map of Togo showing villages surveyed in 2016 and ecological zones (Base map from IGN France, 1990)

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RESULTS AND DISCUSSION

A majority (79%) of the farmers who attended the focus group discussion were male while 21% were female. About 90% of the respondents were the heads of their households. The respondents were aged between 15 and 85 with a mean of 46 years.

A high involvement of men in taro and tannia production was also previously reported in Ghana [33, 34], in Ekiti state of Nigeria [35] and in Uganda [36]. The contrary was found in South-East of Nigeria where tannia was mostly grown by women [37]. The generally large involvement of men can be explained by better access to land for men and the fact that these crops contribute not only to subsistence but also cash income for the households [34, 35, 36].

Twenty-five constraints were identified overall and can be grouped into four main categories: abiotic (3), biotic (6), technological and agronomic (10) and socio-economic (6) (Table 1). Among abiotic constraints, the most important were rainfall irregularity (68.4% of interviews) and soil infertility (61.5%). Among biotic constraints, sensitivity to weeds (26 %) and side-effect of herbicide use on weeds (11.3%) were the most important. Among agronomic constraints, the most frequently reported were scarcity of planting materials (34.7%), late maturity (32.0%) and post-harvest loss (20.9%). Among socio-economic constraints, inefficient marketing (58.7%) and dietary habits (18.4%) were the most frequently reported (Figure 2).

Overall, rainfall irregularity was most frequently reported as a primary constraint, followed by soil infertility, inefficient marketing and scarcity of planting materials. Other constraints identified as primary by at least one focus group, were credit availability, grazing, haemorrhoid risk, herbicide use, shortage of cropland, post-harvest loss, theft and urbanisation, lack of extension services, forest fire and dietary habits (Table 1, Figure 2).

Other studies in Ghana, Nigeria and Uganda reported that production of tannia and taro is challenged by the lack of extension services, scarcity of land, land ownership and credit availability [34, 35, 36]. Land scarcity and land ownership were not clearly stated in this survey. However, these constraints lead young farmers from the northern part of the country to migrate to the south (zones III and IV) where they can rent land and this influences the cropping system and the variety they decide to grow. Further to this, farmers' migration allows the introduction of varieties from the north of the country to the south and vice versa. The low reporting of credit availability in our study suggests that credit is rarely allocated to farmers by Department of Agriculture or other organisations in Togo.

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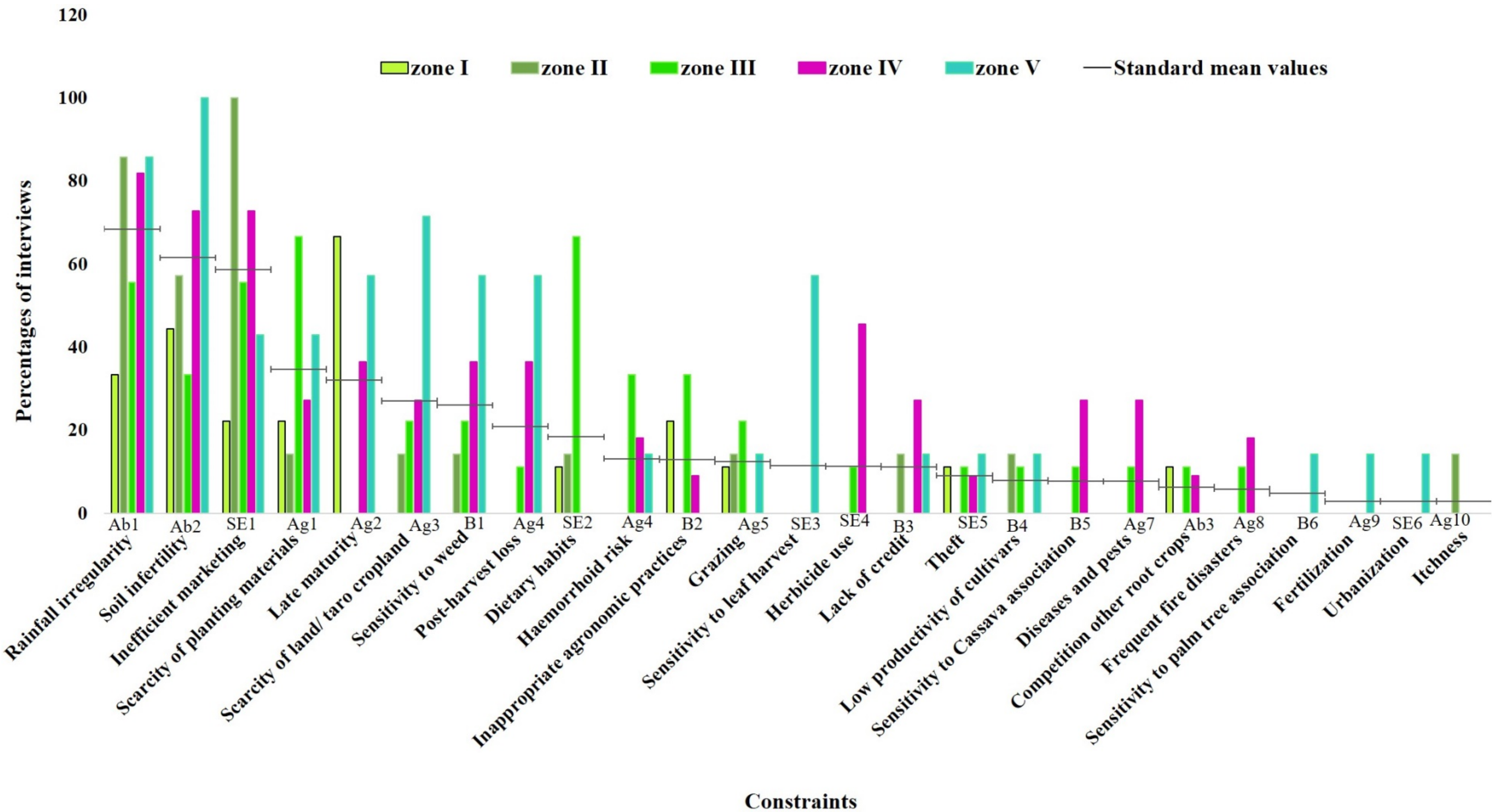

Figure 2: Reported constraints for the production of edible aroids (taro and new cocoyam) in Togo: Percentage of interviews in which each constraint was mentioned, in each ecological zone. ***Ab = Abiotic constraint; Ag = Agronomic constraint; B= biotic constraint; SE= Socio-economic constraint*** **(Field survey, 2016)**

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Rainfall shortages arise through long dry seasons and short rainy seasons. Irregular rainfall was reported to affect the production of taro more in ecological zone IV where the dasheen type is grown more. This species requires more water for growing than new cocoyam. The challenge of soil infertility could be the result of over-exploitation and can be linked to the financial constraint, which limits the application of fertilizers, and other inputs required for soil maintenance [35]. These abiotic constraints are a common problem for Togolese and African agriculture in general [26, 38]. Inefficient marketing may be both the cause and effect of low demand and low prices for these crops. Historically, taro and new cocoyam are crops of secondary importance in Togo and generally in West Africa [39]. Land scarcity is a general problem in Togo, due to population increase [27]. The water requirement for planting limits the area of suitable farmland since both crops are restricted to wetter areas and the competition for water with the grazing animals population is increasing [35, 36]. In other areas, they are intercropped with plantation crops, but long dry seasons and increasing frequency of fire, more reported by farmers in ecological zone III, (5.9% of interviews) have restricted their area. Rainfall irregularity and fire frequency are phenomena that may reflect cyclic or general changes in climate.

Scarcity of planting materials for taro was reported throughout the country because this crop is not abundant. Farmers reported that they have more constraints to storing this crop, so the lack of appropriate storage technique can lead to the loss of large amount of planting material before the next planting season. Moreover, there were no statistical data for this crop in the database of Department of Agriculture. Thus, there is no breeding program that can provide seed for farmers. Quaye *et al.* [34] also reported such scarcity in Ghana. For new cocoyam, planting materials scarcity was mostly reported in areas where the plant was recently introduced or where it has been abandoned due to unfavourable competition with other root crops (yams and cassava particularly) or where consumption of new cocoyam was regarded by 13.2% of the respondents as a haemorrhoid (piles) risk leading to abandonment of the crop. Late maturity was mostly reported in relation to new cocoyam. Post-harvest losses are due to lack of suitable storage techniques. In the past, new cocoyam was stored after harvest in a pit silo (hole located in a field and covered with straw, with corms placed horizontally or vertically inside) or by stacking (corms laid on a layer of straw in shade of a tree and covered with straw). These are also traditional techniques for yam storage. However, with the risk of theft, 9.1% of the respondents in this study noted that these techniques are not generally used. Interior storage (cormels in bags or on ground) and in-ground storage (cormels not harvested) are now the main methods used particularly for new cocoyam. Farmers reported more difficulty in storing taro than new cocoyam, due to root rot. Taro has been reported to be more sensitive to rot than new cocoyam [40].

Weeds have been reported elsewhere as a constraint for production of both taro and new cocoyam [34, 36]. Herbicide use, even if its percentage share of reports seems low, is a real threat to new cocoyam especially in ecological zone IV, the most humid zone of Togo and main zone of maize, cocoa and coffee production. Herbicides are easily imported from Ghana and are available in the villages. After clearing and burning of fallows, new cocoyam sprouts vigorously but wherever farmers spray herbicide, it disappears. Full wilting (Figure 3) follows yellowing of leaves.

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The results concerning socio-economic constraints (Table 1) suggest that traits related to food processing should be prioritized in breeding programmes to ease market access for farmers growing these species in Togo. New cocoyam is more often grown in the ecological zones III and IV while taro is more often grown in the ecological zones II and IV. Data on taro production are not available in statistics provided by the Department of Agriculture [23]. Production was assessed in this survey in an approximate manner through the abundance of visible gardens and from the general discussion with focus groups. Sensitivity to leaf harvest was reported only in ecological zone V. Tannia is more eaten as vegetable than taro in all the ecological zones but the effect of drought restricts growth and regrowth of the leaves. Zone V has a low rainfall compared to zones III and IV. In zone I and II, where rainfall is less than zone V, tannia growing is restricted to wetlands and home gardens.

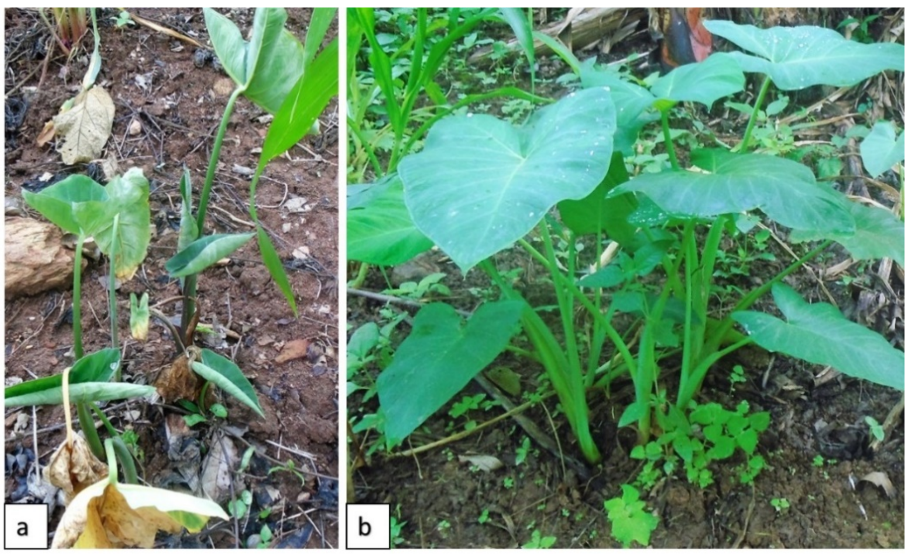

Figure 3: *Xanthosoma mafaffa* (a) with symptoms of herbicide damage, and (b) normal plant (Kpélé Elé, Togo. 2016)

Farmers identified fourteen preferred traits across the areas surveyed and among these, eight were of agronomic nature (A1-A8), five were related to culinary and technological characteristics (C1-C5) and one was economic (E) (Table 2). The most reported agronomic traits were early-maturity (73% of interviews), high-yield (65%), tolerance to soil infertility (27%) and resistance to root rot (21%). Among preferred culinary traits, good taste (39%) and suitability for *pounded fufu* (17%) were the more preferred (Figure 4).

Farmers reported early-maturity and high-yield varieties as main preferred traits (Figure 4). Similar preferences were reported in Ghana [34] and Uganda [36]. The culinary preferences reported were mostly related to new cocoyam. For *pounded fufu*, farmers reported that the white fleshed variety of new cocoyam has a poor consistency when pounded. This leads to low demand for this variety in the market and negative selection by farmers on some farms where this variety is simply discarded.

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Most of preferred traits reported are linked to constraints encountered by farmers. The strong preference of farmers for early-maturity varieties, for example, is due to the late maturity of available varieties and rainfall irregularity, shortening the effective length of rainy seasons, when most vegetative growth takes place. The low productivity of the available cultivars (under present conditions) was a reported constraint (Figure 2) and is reflected as a preference for high-yield varieties (Figure 4).

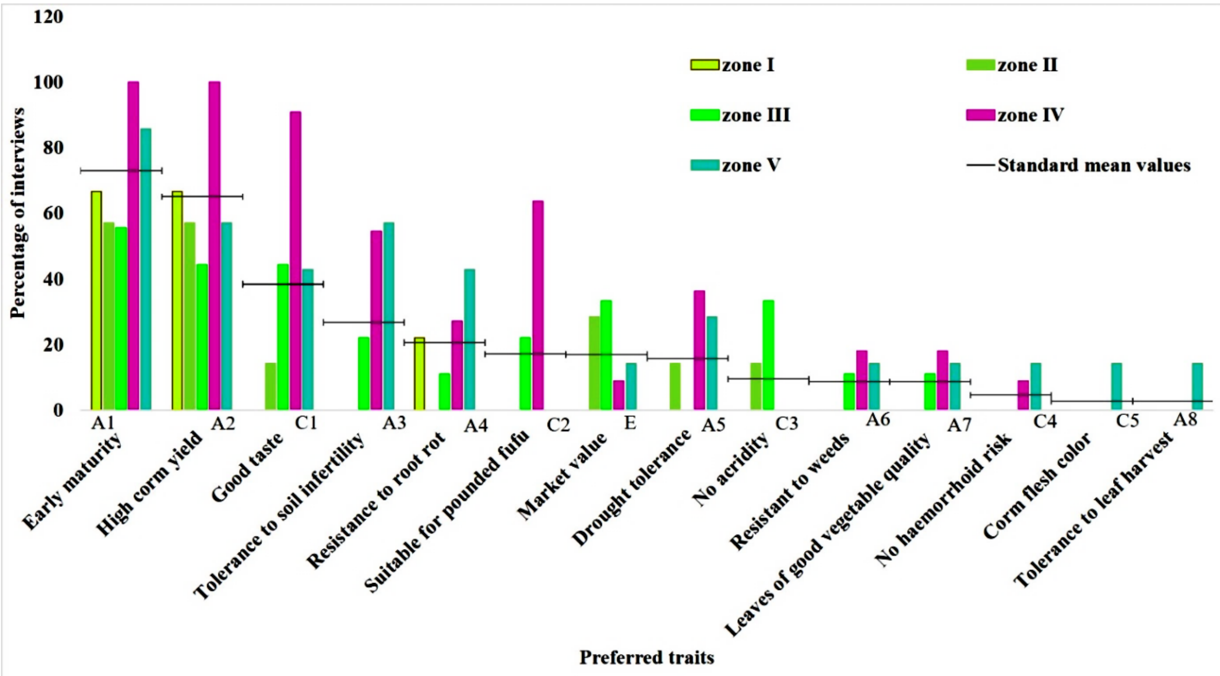

Figure 4: Preferred traits reported for the production of edible aroids (taro and new cocoyam) in Togo: Percentage of interviews in which each preferred trait was mentioned, in each ecological zone. ***A = Agronomic trait; C = culinary trait, E= economic trait*****. (Field survey, 2016)**

CONCLUSION

In Togo, new cocoyam and taro production faces many challenges. Among these, the most common that significantly affect this production are rainfall irregularity (due to shortened rainy seasons), soil infertility and inefficient marketing. The preferred traits reported by farmers are mainly, early-maturity (almost all the available varieties have cycle of 8 to 24 months) and high-yield.

The study of morphological and molecular characters is recommended to help select suitable varieties for a breeding program with these species in Togo. Morphological and chemical traits that may affect food processing should be investigated. Irrigation facilities and fertilizer should also be provided for intensive management practices and commercial production of these crops. Further research into food processing and preservation techniques is needed to enhance production and marketing of these crops in Togo.

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Table 1: Categories of reported constraints across ecologic zones (Field survey, 2016)

Categories	Constraints	Overall percentages for all interview (N=45)
Abiotic	Rainfall irregularity	68.4
	Soil infertility	61.5
	Frequent fire disasters	5.9
Technological and agronomic	Scarcity of planting materials	34.7
	Late maturity	32.0
	Scarcity of land/ taro cropland	27.0
	Post-harvest loss	20.9
	Hemorrhoid risk	13.2
	Inappropriate agronomic practices	12.9
	Low productivity of cultivars	7.9
	Unfavourable competition with other root crops	6.3
	Acridity (itchiness)	2.9
	Fertilization	2.9
Biotic	Sensitivity to weed	26
	Sensitivity to leaf harvest	11.4
	Herbicide use	11.3
	Sensitivity to cassava association	7.7
	Diseases and pests	7.7
	Sensitivity to palm tree association	4.8
Socio-economic	Inefficient marketing	58.7
	Dietary habits	18.4
	Grazing	12.4
	Lack of credit	11.2
	Theft	9.1
	Urbanization	2.9

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Table 2: Preferred traits reported as of greatest interest (percentage of all interviews, 2016)

Categories	**Traits**	**Percentage of all interviews (N=45)**
Agronomic traits	Early maturity	73.02
	High corm yield	65.08
	Tolerance to soil infertility	26.78
	Resistance to root rot	20.69
	Tolerance to drought stress	15.84
	Resistant to weeds	8.72
	Leaves of good vegetable quality	8.72
	Tolerance to leaf harvest	2.86
Culinary and technological traits	Good taste	38.50
	Suitability for *pounded fufu*	17.17
	No acridity (itchiness)	9.52
	No haemorrhoid risk	4.68
	Corm flesh colour	2.86
Economic trait	Market value	17.06

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