agronomy

MDPI

Review

Taro in West Africa: Status, Challenges, and Opportunities

Joy Jesumeda Oladimeji [1,2], P. Lava Kumar [2], Ayodeji Abe [3], Ramesh Raju Vetukuri [4] and Ranjana Bhattacharjee [2,*]

[1] Department of Plant Breeding, Pan African University Life and Earth Sciences Institute (Including Health and Agriculture), Ibadan 200284, Nigeria
[2] International Institute of Tropical Agriculture, Ibadan PMB 5320, Nigeria
[3] Department of Agronomy, University of Ibadan, Appleton Road, Ibadan 200132, Nigeria
[4] Department of Plant Breeding, Swedish University of Agricultural Sciences, Alnarp, SE-234 22 Lomma, Sweden
* Correspondence: r.bhattacharjee@cgiar.org

Abstract: Taro is an ancient nutritional and medicinal crop woven into the fabric of the socio-economic life of those living in the tropics and sub-tropics. However, West Africa (WA), which has been a major producer of the crop for several decades, is experiencing a significant decline in production as a result of taro leaf blight (TLB), a disease caused by *Phytophthora colocasiae* Raciborski. A lack of research on taro in WA means that available innovative technologies have not been fully utilized to provide solutions to inherent challenges and enhance the status of the crop. Improvement through plant breeding remains the most economically and environmentally sustainable means of increasing the productivity of taro in WA. With this review, we provide insights into the importance of the taro crop in WA, evaluate taro research to date, and suggest how to address research gaps in order to promote taro sustainability in the region.

Keywords: taro; taro leaf blight; *Phytophthora colocasiae*; taro improvement; West Africa

Citation: Oladimeji, J.J.; Kumar, P.L.; Abe, A.; Vetukuri, R.R.; Bhattacharjee, R. Taro in West Africa: Status, Challenges, and Opportunities. *Agronomy* **2022**, *12*, 2094. https://doi.org/10.3390/agronomy12092094

Academic Editors: Isabel Marques and David Draper Munt

Received: 19 June 2022
Accepted: 29 August 2022
Published: 1 September 2022

1. Introduction

Taro [*Colocasia esculenta* (L.) Schott] is the most commonly cultivated species in genus *Colocasia* [1] and is the fourth most consumed tuber crop globally [2]. It is a member of family Araceae, sub-family Aroideae, and is a tropical monocotyledonous, vegetatively propagated, perennial crop grown primarily for its starchy corm or underground stem. Taro is one of the world's oldest food crops, with its domestication dating back over 9000 years [3]. It was probably first domesticated in Southeast Asia and thereafter spread across the world, to become one of the most important staple food crops in the Pacific Islands. It is widely distributed across Africa, Oceania, Asia, and the Americas [4,5]. The crop has been largely maintained by smallholder farmers, and the species' genetic resources have remained largely within local communities [3]. In many societies, taro is considered a sacred plant of strong cultural importance and is used in religious festivals, domestic and agricultural rituals, and as bride price [3,6].

Taro is an important food crop for millions of people in many parts of Africa, where it is widely grown as a backyard crop and an intercrop [6–10]. It is also used as an ornamental plant [11]. It is a staple food for millions of people in West Africa (WA) and can be found in virtually all countries in the region [12]. Taro contains about 35 g of total carbohydrate per 100 g of the corm, which is twice that of potatoes [13]. It also contains 11% protein by dry weight and is rich in minerals, vitamin C, thiamine, riboflavin, and niacin [14]. Taro is nutritionally better than many kinds of cereals, such as rice, wheat and sorghum, in terms of vitamins C and E, and potassium [13]. Besides its nutritional value, it is also often used as a traditional medicinal plant, providing bioactive compounds with important properties [15]. In 2020, more than 12.8 million tons of taro were produced worldwide

from 1.8 million hectares [16]. According to the Food and Agricultural Organization (FAO) of the United Nations production data for 2020, Nigeria was the largest producer of taro, with a global share of 25%, followed by Ethiopia, China, Cameroon, Ghana, and Papua New Guinea [16]. In WA, taro is reported to be present in all countries [9,12,17,18] except for Mauritania, where there is a paucity of information on its production. However, taro production in WA has been severely affected by the emergence of taro leaf blight (TLB), caused by *Phytophthora colocasiae* Raciborski [19–21]. Since its outbreak in WA, TLB has accounted for an economic loss of more than USD 1.4 billion annually, leading to the genetic erosion of the crop in this region [19].

This article presents a review of the origin, domestication, and dispersal of taro and evaluates current research on taro in WA. To address the identified gaps in taro research, recommendations are made that can contribute to a revival in taro production, to meet the region's nutritional demands, and to contribute to the food and income security of smallholder farmers.

2. Origin, Domestication, and Dispersal of Taro

Taro is believed to have originated in the tropics, extending from India to Indonesia [22]. It is still found in the wild, with the greatest diversity of wild *Colocasia* species apparently extending from northeast India to southern China. The occurrence of taro wildtypes is, however, unclear, because the location of its first use by humans is unknown, and in some areas, it is difficult to distinguish between wild and cultivated taro [7].

As a food, medicinal, ornamental, or fodder plant, the geographical range of wildtype taro has been extended by humans, with or without cultivation. It is thought to be one of the world's oldest cultivated crops and was present 28,000 years ago in the Solomon Islands [23]. Based on the high genetic diversity reported for the Indian germplasm, it may be that taro was domesticated in India and then spread to countries in the Asia-Pacific region. This is supported by the work of Chair et al. [8], who reported a higher genetic diversity among genotypes collected from Asia than among those from the Pacific, Africa, and the Americas. A secondary domestication of taro may have occurred in New Guinea [24]. Ivancic and Lebot [24] have suggested that all cultivars in the Pacific are diploids, produce flowers, and are naturally pollinated by insects, contributing to their higher genetic diversity and clonal richness.

Taro is presumed to have reached WA as a result of human introduction, and most cultivars are probably of Indian origin [8]. It is likely that taro was introduced to Africa together with bananas and the greater yam (*Dioscorea alata* L.) [25]. Clonal propagation combined with natural mutations probably then led to taro diversification in Africa.

3. Genetic Diversity of Germplasm Resources for Improvement

Taro belongs to the Araceae family, which is a large, ancient, monocotyledonous plant family characterized by high morphological diversity [26]. Taro is suspected to have originated from the Indo-Malayan region, based on its enormous varietal diversity there [27]. The number of species in genus *Colocasia* ranges from 5 to 10, with taro (*C. esculenta*) being the most widely cultivated species, with over 10,000 landraces worldwide [24]. Taro is highly polymorphic, and two widely cultivated types are *C. esculenta* var. *esculenta*, called the "dasheen" type, which has a large cylindrical corm with few or no cormels, and *C. esculenta* var. *antiquorium*, called the "eddoe" type, which has usually a small globular corm with several cormels [28]. Most taro cultivated in Asia and the Pacific is of the dasheen type. Typically, *C. esculenta* is propagated by asexual reproduction, but it can also reproduce sexually through its protogynous flowers, with the aid of insect pollinators or mechanical means [18]. It has a high adaptive plasticity and can thus be found in varying environments, ranging from full sunlight to deeply shaded regions and from dry soils to saline and flooded soils [29]. The crop, overall, has high diversity, which probably accounts for its resilience to variable environmental conditions [30,31]. It is believed that there are at least two main evolutionary lineages in taro, and it is likely that the hybridization between

these two lineages added to the overall diversity of cultivated forms [22]. There is much to be learned through the analysis of both the plastid and nuclear genomes, together with systematic morphological evaluation and characterization.

Although the genetic base of taro as an introduced crop in Africa and the Americas is likely to be narrow [8,30,32], this can be broadened by the introduction of new germplasm, improving the crop's ability to withstand the vagaries of climate variability and associated biotic and abiotic stresses [30]. It is, therefore, necessary to understand and assess the extent of taro's genetic diversity within a region, to identify gaps that can inform the collection of additional germplasm and the introduction of new germplasm [3].

Several studies documenting the genetic diversity of taro from Asia and Oceania have revealed greater variation in Asia. A global experiment including taro cultivars and improved hybrids across 14 countries in Asia, Africa, America, and the Pacific revealed that the introduced genotypes were readily adopted by farmers if they met their needs [30]. In this cited study, 50 introduced genotypes were compared with local cultivars using a participatory approach, to strengthen the smallholder farmers' capacity to adapt to climate change and to broaden the genetic base of the crop to cope with climate variability.

The majority of taro cultivars found in WA are believed to have originated in India, and Indian cultivars are reported to be cytogenetically variable, with varying chromosome numbers and ploidy levels (diploids and triploids) [8]. Several studies on genetic diversity in taro have grouped the majority of cultivars as diploids, with 2n = 2x = 28 chromosomes, and triploids, with 2n = 3x = 42 chromosomes, whereas tetraploids (2n = 4x = 56) are rare [8]. There are also reports of cultivars with a basic chromosome number of n = x = 12 [32]. This difference in ploidy levels among cultivars (diploids and triploids) impedes hybridization and gene flow among cultivars, thus reducing the extent of genetic diversity in WA [8].

4. Taro Production in Africa

The current distribution of taro as a cultivated food crop extends from southern to northern Africa [6,33], western Asia to eastern Asia, across Southeast Asia and the Pacific Islands, and through the Americas, from the USA to Brazil [34]. The root crops that have an important role in many African countries are potato, cassava, sweet potato, yam, taro, and the new cocoyam [35]. Within Africa, four countries, Nigeria, Ethiopia, Ghana, and Cameroon, accounted for about 67% of total production in 2020 [16]. Numerous taro cultivars are found across WA and occupy an important role in local agriculture and traditions, indicating a long history of the crop in the region. Grimaldi [36] produced a taro distribution map for the period between 1849 and 2012 based on several reports and academic articles on taro cultivation at specific locations and region in African countries. Figure 1 shows the distribution of African countries where taro was cultivated between 1961 and 2020, indicating that it is grown in hot, humid areas with high rainfall, such as the tropical sub-Saharan region, but that it can also be grown in drier regions along streams, such as in Egypt, Algeria, and Libya. Taro can thrive under diverse agro-ecological and soil conditions and is referred to as an ecologically friendly crop [37]. The crop optimally grows at altitudes extending from 60 to 1850 m above sea level in the tropics and temperate zones [7,38,39]. However, despite its wide geographical presence, there are limited research effort and funding for the large-scale assessment of the production, trade, and usage of this crop. Changes in the environment and agricultural systems in Africa have also led to a decline in taro production.

Traditionally, taro is propagated using corms, cormels, suckers, and tops (huli, a Hawaiian vernacular term used to describe a plant part). The use of tops and suckers is preferred because the growing season from planting to harvest is shorter than that of cormels, corms, or corm pieces (setts), although cultivars with many suckers produce smaller corms [37]. The yield of taro is optimized when the soil is appropriately managed and agronomic practices are carried out well [3]. On average, taro requires a well-drained sandy loam soil with good water retention capacity, and benefits from the application of NPK fertilizers [18,40]. Quality organic materials and bio-fertilizers (Mycorrhizae,

Azotobacter, and Phosphorine) can also be used via furrow placement and split application, respectively [3].

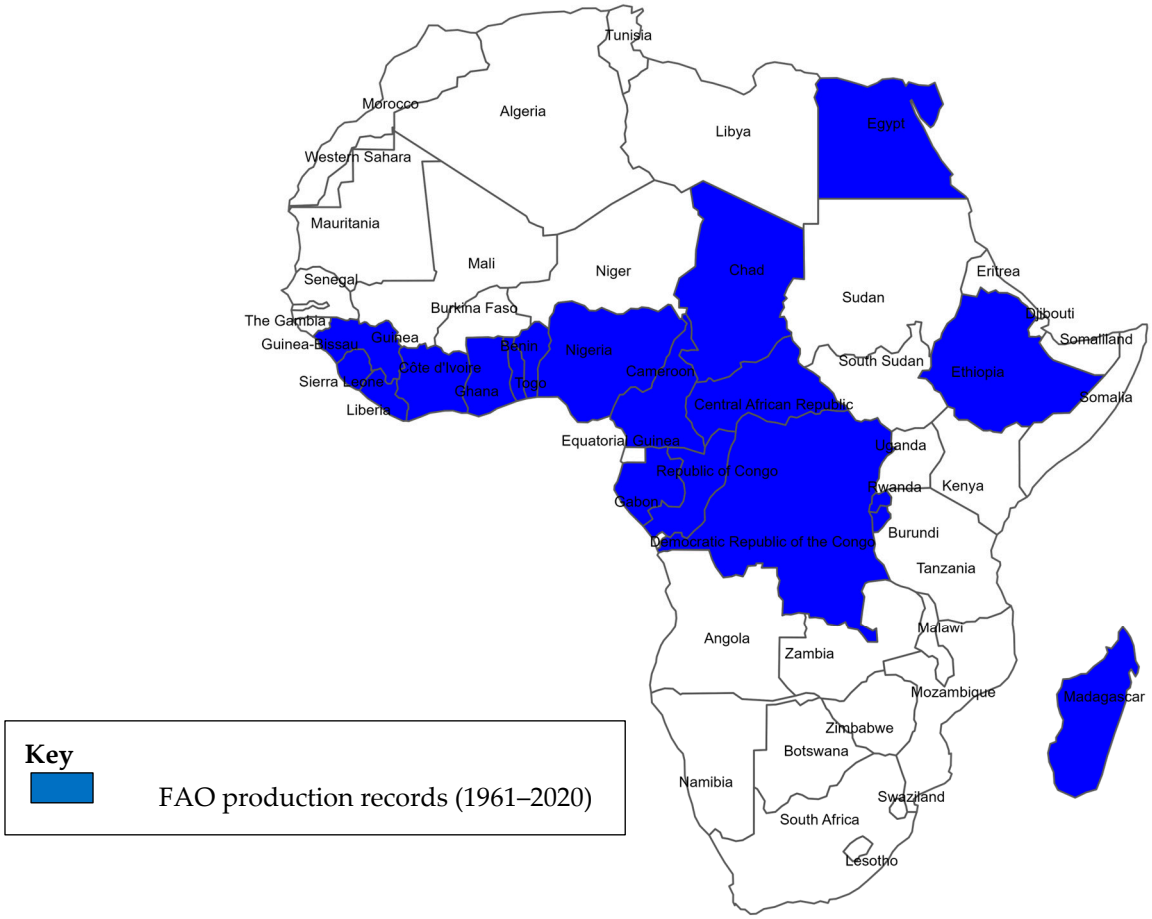

Figure 1. Map of taro production in Africa based on FAOSTAT data from 1961 to 2020.

5. Taro Production Trends

Data on taro production and consumption are limited. The FAO Crop Production Statistics (FAOSTAT) includes data for 47 major taro-producing countries globally [16]. However, production data in several countries where more taro is consumed as a traditional food crop are not accounted for in FAO global statistics, as most production is either in backyards or as an intercrop [41,42].

Globally, taro ranks 5th among root and tubers and 17th among staple crops, representing about 12 million tons of production from about 2 million hectares, with an average yield of 7 tons/ha [16]. Taro production in terms of total harvested area has substantially increased in the last two decades. Most of the global production comes from developing countries characterized by smallholder production systems relying on minimum resource inputs [43]. Based on FAOSTAT [16], Africa has consistently contributed more than 70% of taro production worldwide for the past two decades, accounting for about 76% in 2000. Despite declining yields per unit area since 2009, Africa provided about 77% (9.3 million tons) of world production in 2019 (the highest in two decades). This increased production in Africa has largely been achieved by increased area for taro production rather than increased yield per hectare [19]. The average yield per land area (tons/ha) in Africa is relatively low (Figure 2) and fell from 6.60 tons/ha in 2000 to 5.80 tons/ha in 2019, while Nigeria, the leading taro producer, experienced a decline from 6.62 tons/ha in 2000 to 3.91 tons/ha in 2019 [16]. Africa recorded the lowest taro yield per land area in 2020 compared with other regions, such as Asia (16.3 tons/ha), America (11.0 tons/ha), and Oceania (9.0 tons/ha).

This yield difference in Africa can be attributed to limited input use, taro cultivation on marginal lands, and the emergence of TLB in WA in 2009 [19].

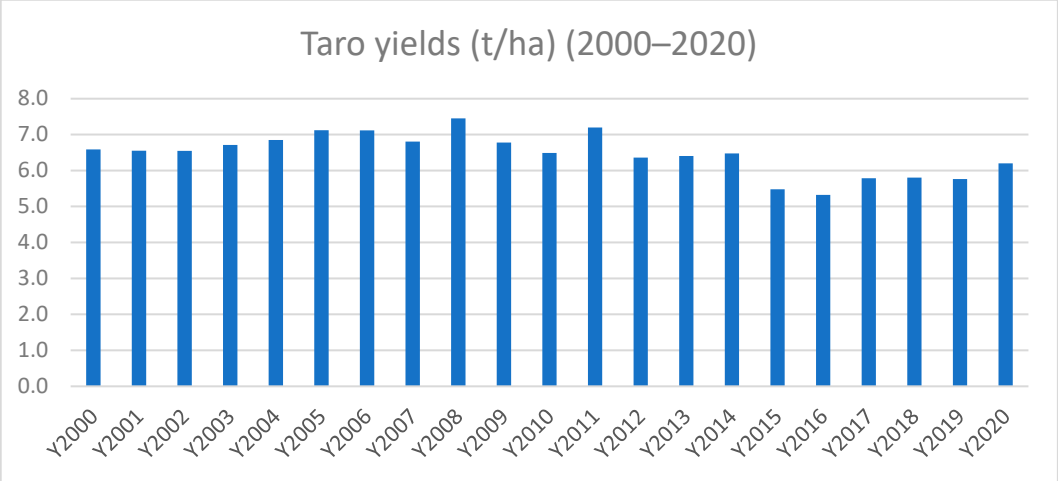

Figure 2. Taro yield in Africa from 2000 to 2020 (FAOSTAT, 2022).

6. Taro Production Constraints in Africa

The major biotic stress for taro is TLB, a disease caused by *P. colocasiae*; it is an oomycete disease with highly devastating effects [44]. *Phytophthora colocasiae* was first reported in Java by Raciborski [45] and has now spread all over the tropics [46,47]. The disease thrives where day and night temperatures range between 25–28 °C and 20–22 °C, respectively, and can assume epidemic proportions all year round under favorable conditions [48]. TLB was not known in WA before 2009, when there were simultaneous outbreaks in Nigeria, Cameroon, Ghana, and other neighboring countries [20,21]. It is estimated that TLB in WA accounts for an economic loss of about USD 1.4 billion annually [19].

Phytophthora colocasiae reproduces asexually during rainy seasons, with the production of sporangia from sporangiophores at the extremity of lesions in infected leaves. Sporangia leave the pedicel during rain fall and germinate to produce motile zoospores that can swim for short distances in water and encyst to form germ tubes that can penetrate the host. This can happen within two hours at a favorable temperature of 20 °C and a minimum humidity of 90%. At an ideal temperature of 24–27 °C, symptoms present 2–4 days after penetration of the germ tube [46,47]. *Phytophthora colocasiae* is heterothallic with two mating types, A1 and A2, and can produce oospores via sexual reproduction [49].

In the field, *P. colocasiae* is spread mainly by zoospores and sporangia. The propagules are short-lived in the infected leaves and tissues and are carried by water to a host through rain splashes [47,50]. Taro corms are, however, rarely harvested from the field and can sustain the pathogen. Usually, planting is carried out within a short time frame after harvesting; any infected tissue debris left in the field is, therefore, a source of inoculum for subsequent infection of new plants [49,50]. An entire field can become symptomatic of the disease within seven days when conditions are favorable [19,48]. A symptomatic plant initially displays water-soaked lesions with a diameter of 1.5 cm around the leaf edges; the fluid exudates from the lesions are of bright-yellow to dark-purple colors when dried. As the disease progresses, the lesions enlarge, developing a zonate appearance characterized by brownish to purplish-brown colors. White fuzz also appears on both sides of the leaves, indicating sporangia, which continues to develop until the leaves are completely covered [46,48]. The white fuzz of sporangia around lesions is a characteristic symptom of *P. colocasiae* infection [46]. The infected leaf tissues collapse after 20 days, unlike healthy leaves, which last 40 days before senescence [50]. TLB also affects the corms, causing them to rot, and yield losses as a result of this disease can be as high as 70–100% [46,48,51].

TLB is usually controlled with the use of copper fungicides at a rate of 38 Lha^{-1}, using 2.24 kg of copper oxychloride as the active ingredient. Fungicide applications start from four months after planting (MAPs) and continue until nine MAPs, weekly during rainfall periods and bi-weekly when conditions are dry. Dithane M-45 can also be used, at a rate of 1.68–2.25 kilograms in 189.3–378.5 liters of water per hectare. This application can be weekly or bi-weekly, depending on the severity of the disease, but should not exceed 25 applications and cannot be used once the crop is nine months old [48]. Metalaxyl fungicides have also been effectively used to control TLB [49]. In Hawaii, planting distance has been used as a control measure, with a decrease in disease incidence achieved by increasing the planting distance from 46 cm to 75 cm. In the Solomon Islands, improved sanitation, via pruning and removing infected leaves on a bi-weekly basis, has also reduced disease incidence.

The use of resistant and immune varieties is the most viable control measure for TLB in terms of environmental impact and sustainability [43,52–57]. However, the use of resistant varieties has been limited by a lack of crop improvement programs and a lack of desirable economic market value traits in resistant genotypes. This is compounded by a lack of understanding of the genetic structure of pathogen populations [56]. Compared with other species of *Phytophthora*, very little attention has been paid to *P. colocasiae*, either globally or at a regional level. Some research has been carried out on screening for disease-resistance genotypes and their adaptability in WA and beyond. For example, Ackah et al. [58] evaluated taro genotypes from Ghana for resistance to TLB and found all the genotypes to be susceptible to varying degrees. Similarly, Amadi et al. [58] characterized some local and exotic collections of taro for yield, local adaptation, and TLB resistance in Nigeria and found some promising genotypes, although no single genotype combined all the desired traits.

Additional major taro diseases are caused by viruses and other microorganisms that are specific to the Pacific [41]. These reduce corm size and quality, with yield losses of up to 20%. For example, the co-infection of taro with taro bacilliform virus (TaBV) and Colocasia bobone disease virus (CBDV) is thought to be lethal to the crop. TaBV, along with taro bacilliform CH virus (TaBCHV) diseases [59] and dasheen mosaic virus disease [10], has been reported in Africa. Several other taro viruses have also been found in the Pacific, which currently restricts international movement of germplasm; thus, many countries do not have access to agronomically elite genotypes and selected traditional cultivars. Taro diseases reported in the Pacific include taro soft rot, caused by several species of *Pythium*, sclerotium rot, caused by *Sclerotium rolfsii*, and cladosporium leaf spot, caused by *Cladosporium colocasiae* [41]. Taro soft root rot and cladosporium leaf spot have been reported in Africa [19,60].

7. Botany and Uses of Taro

Taro is a perennial herbaceous plant that grows to a height of 1–2 m. The plant consists of a central corm (lying below the soil surface) from which leaves grow upwards and roots grow downwards, while cormels and runners (stolons) grow laterally. The leaves are simple peltate in shape, arranged spirally in a rosette. The petioles can reach about 1 m in length, each having a distinct sheath, a cordate blade of about 85 cm by 60 cm with rounded basal lobes and long anterior lobe. The central veins of each lobe and primary lateral veins (ribs) are raised, and the tertiary venation of the lamina is reticulated (net-veined). The inflorescence is composed of an outer spathe and inner spadix borne on a peduncle (Figure 3). The inflorescence is protogynous because the female flowers (on the lower spadix) mature before the male flowers (upper spadix). Each fruit is a berry consisting of numerous seeds, the shape of which ranges from ovoid to ellipsoid, about 2 mm in length, with an extensive endosperm. Pollination in taro and its wild relatives is primarily by insects (drosophilid flies in genus *Colocasiomyia*) [61]. Fruit set and seed production only occasionally occur under natural conditions. For production purposes, the crop is considered mature when the mother corm is fully expanded. The average time to maturity for taro ranges between 6 months and 12 months [18,30,62]. Corm formation starts about

three months after planting, while cormel formation follows soon afterward. In the dasheen types, the corm is cylindrical and large (Figure 4). The plant can grow up to 30 cm long and 15 cm in diameter and constitutes the main edible part of the plant. In eddoe types, the corm is small, globoid, and surrounded by several cormels (stem tubers) (Figure 4). Corms and cormels are similar in their internal structure, with the outmost layer being a thick brownish periderm (Figure 4).

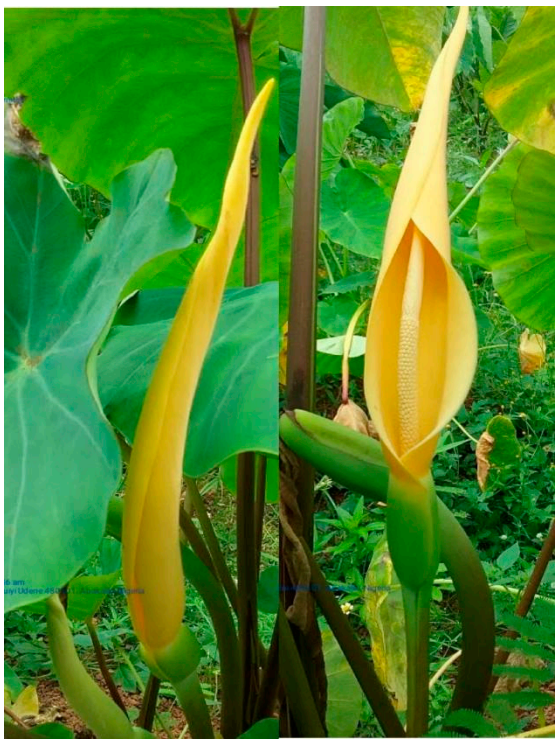

Figure 3. Inflorescence of *C. esculenta*. Photographed by the first author on 9 September 2021 during a visit to a farmer's field in Agbaja azumili, Abakaliki, Ebonyi State, Nigeria. The taro cultivar is popularly known as "Ede ofe".

The main economic parts of a taro plant are the corms and cormels, as well as the leaves. Taro corms are an essential food in the African diet, eaten in a variety of ways (boiled, fried, roasted, and porridge) and used as a food additive [63]. The leaves are used as a vegetable and are a good source of vitamins, especially folic acid. They contain 23% protein by dry weight and are a rich source of calcium, phosphorus, iron, vitamin C, thiamine, riboflavin, and niacin [64]. The inflorescence is a delicacy in some food cultures of Asia and the Pacific. The corms and leaves are also used for medicinal purposes. They are used as a curative for arterial hypertension, liver infections, rheumatism, and snake bites [28,64,65], and the mucilage serves as a good carrier for drug administration [66]. As a fermented product, taro is rich in probiotics, which can be used to help to ameliorate the symptoms of gastroenteritis, Crohn's disease, depressed immune function, and inadequate lactose digestion [64]. Taro is a good source of calcium for children who cannot take milk as a result of lactose intolerance [5,28] and is gluten-free, making it suitable for people with gluten intolerance. The starch grains are minute, making it highly digestible (99%).

The resilience of taro makes it a good alternative crop when other crops fail under extreme weather conditions [40,67]. Taro is used as an ornamental plant [15,64]. The peels and wastes of taro plant can be used as animal feed [29]; the crop can be used to produce biofuel [68,69] and biodegradable plastics [70], and the corm can be used to prepare nutrient media for nematode growth [71].

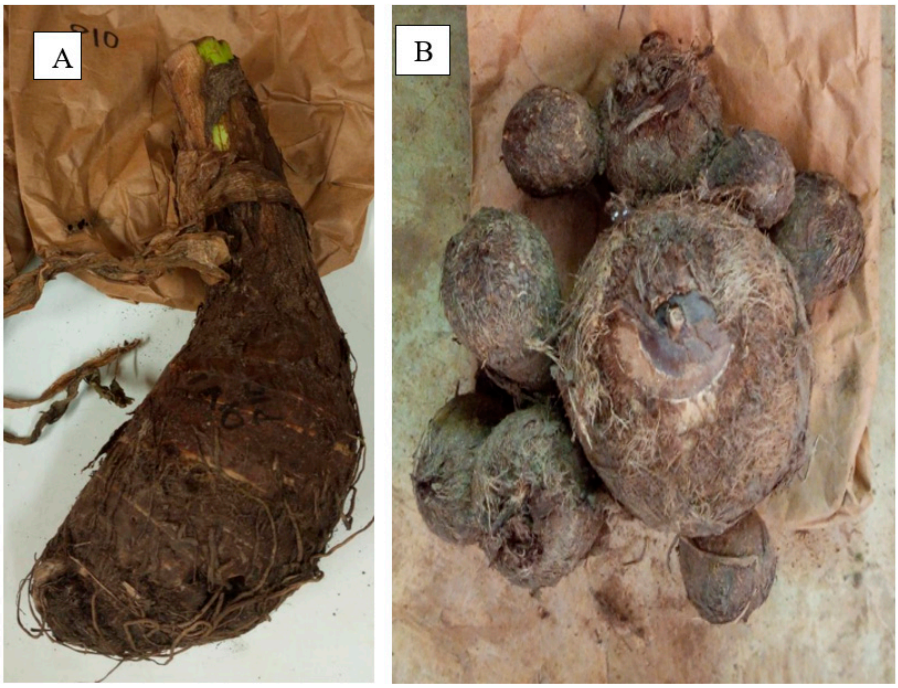

Figure 4. Corm of *C. esculenta*. (**A**): dasheen type; (**B**): eddoe type. Photographed by the first author on 25 December 2021 (**A**) and 15 January 2022 (**B**) during a visit to a farm in Sabo, Ogbomoso North, Oyo State, and Ilasa, Ekiti East, Ekiti State, Nigeria, respectively. The corm type shown in (**A**) is popularly known as "Kokooghana", while that in (**B**) is popularly known as "Eposo".

8. Taro Improvement

Taro is an important crop in several cultures in Asia, the Pacific, and Africa but still lacks international recognition [3,63,72,73]. The crop is understudied compared with other staple crops such as maize, wheat, rice, cassava, and potato. While there is ongoing research on taro in the Pacific region, Oceania, and Asia, which has led to the release of varieties with improved disease resistance and good agronomic and culinary attributes [3,27,55], there is a need to establish national and regional interest in the crop in WA. The focus should be on germplasm collection, conservation, maintenance, and characterization and on the initiation of breeding programs to facilitate the development and release of improved cultivars and revive taro production in WA.

The success of taro improvement heavily depends on the genetic resources that are maintained in the farmers' fields. Taro is a vegetatively propagated crop, and the expected genetic diversity of existing germplasm in farmers' fields greatly varies in different regions and has not been systematically compared across Asia, Africa, Oceania, and Americas. Because of the lack of characterization data and the absence of a centrally located database, it is difficult to estimate the full extent of available genetic material. The main challenge for breeders is sourcing genetic resources specific to traits such as resistance/tolerance to pests and diseases, morphology, and quality. Current breeding programs are generally led by national institutes, and international collaboration among breeders and a standard procedure for germplasm exchange has not been fully established. Similarly, taro germplasm is usually maintained by national institutes with limited facilities that face several challenges, with no international centers.

While taro is widely cultivated by resource-poor farmers in different ecological habitats of tropical and sub-tropical regions across the world, the largest area of cultivation is WA, which accounts for the majority of output [37,74]. Taro breeding in WA has not progressed beyond conventional means [18,57,58,73,75]. Some information on germplasm characterization is available, and promising genotypes have been identified for resistance to TLB disease and adaptability to the local environment. However, the major constraints in

WA are a lack of concerted interest in the crop by plant breeders, inadequate funding from national or international agencies, and inadequate research infrastructure [76]. In addition, the complexity of the flowering biology of taro, such as protogyny, variation in ploidy, little or no flowering, and natural pollination, restricts progress in improving disease resistance and agronomic performance [18,30,32]. Several factors are necessary for taro improvement, as outlined below.

8.1. Taro Germplasm Collection and Conservation

Germplasm collection and documentation are necessary for the effective conservation, management, and utilization of plant genetic resources. It is well known that many genotypes/landraces of taro are scattered across diverse environments, and their conservation, genetic diversity status and genetic improvement are not fully documented. More needs to be known about the genetic variability of existing germplasm to then develop conservation and breeding strategies for further the improvement and utilization of the genetic resources. In Southeast Asia and the Pacific, several germplasm collections have been established and characterized using internationally standard morphological descriptors [77], which provide information on the extent of genetic diversity within that geographical region [78]. In addition, South Pacific Commission (SPC) Centre for Pacific Crops and Trees (CePaCT) currently maintains the largest taro collection (1136 accessions), comprising germplasm mainly from the Pacific and Southeast Asia [79,80]. This germplasm has been used in breeding experiments to produce TLB-resistant varieties. Similarly, the World Information and Early Warning System (WIEWS) on Plant Genetic Resources for Food and Agriculture has a total of 1685 taro (*Colocasia* spp.) accessions that were conserved ex situ in 2017 by 14 institutes, including some from a few countries in Africa (Table 1) [81]. While taro germplasm collection and genetic diversity have been documented at country and regional levels in Asia and the Pacific, few reports of such germplasm collection and maintenance are available from Africa.

Table 1. Global taro (*Colocasia* spp.) genetic resources conserved ex situ in 2017, based on the WIEWS.

Country	Holding Institute Code	No. of Accessions	Mode of Conservation
Cuba	CUB006	112	Field
Ecuador	ECU023	18	Field
Ethiopia	ETH085	138	Field
Fiji	FJI049	1165	In vitro
Guyana	GUY021	8	Field
Japan	JPN183	29	Field
Malawi	MW1041	111	Field
Malaysia	MYS220	47	Field + in vitro
Panama	PAN172	1	In vitro
Peru	PER045	6	Field
South Africa	ZAF062	35	Field[a]
Spain	ESP172	3	Field
Swaziland	SWZ015	11	Field
Taiwan	TWN001	1	Seed
Total		1685	

The role of gene banks for breeding improved cultivars with targeted traits such as disease resistance, quality traits, etc., cannot be over-emphasized. Between 2011 and 2018, CePaCT distributed taro germplasm, including TLB-resistant lines, worldwide, and several countries in Africa were recipients [79]. In addition, SPC-CePaCT distributed 50 virus-indexed taro genotypes to 15 countries in Africa, including Nigeria, Ghana, Burkina Faso, and Kenya, in response to the TLB outbreak and spread in WA [80]. These recipient countries further characterized the introduced taro germplasm and released cultivars to

farmers; for example, 9 genotypes were released in Nigeria [18], 30 genotypes in Ghana [75], and 22 in Burkina Faso [82].

As vegetative propagation and the fixation of somatic mutations are common in taro, cultivars/genotypes can be distinct in morphotype even with the same genetic background [83]. This characteristic of taro means it is essential that landraces from countries within West and Central Africa (Nigeria, Ghana, and Cameroon) and other countries in Africa are collected, characterized, and conserved for further utilization and improvement.

8.2. Taro Germplasm Characterization

There is some information available on taro germplasm characterization using morphological traits and molecular markers. As a species, taro is highly polymorphic [84] for phenotypic traits such as the size of corms and the number of cormels. Singh et al. [85] reported high variability among 859 taro accessions from Papua New Guinea using 10 quantitative and 20 qualitative traits. High morphological variability has also been reported among taro accessions from Southeast Asia and Oceania [86,87]. Similar agro-morphological variability was observed among 2,298 taro accessions collected within the TaroGen project [88]. In Ethiopia, morphological variability has been observed among taro accessions [89], while limited variability has been reported among five taro cultivars in Nigeria [90]. Several molecular techniques have been used for the characterization of taro in the Pacific and Asia, such as isozymes [3], amplified fragment-length polymorphisms (AFLPs) [5], microsatellites [8,91], and inter-simple sequence repeats (ISSRs) [54]. Chaïr et al. [8] reported variability among 357 taro cultivars from 19 countries in Asia, the Pacific, America, and Africa using microsatellites and suggested that most taro genotypes grown in WA originated from India. Although high morphological variability was observed among 2298 taro accessions collected from seven countries within the *TaroGen* project, Lebot et al. [88] reported a narrow genetic base among these accessions based on isozymes and AFLP fingerprinting. The genetic diversity of a clonally propagated crop such as taro is expected to be narrow, especially in countries where it was introduced through vegetative propagules. This narrow genetic base not only makes the crop extremely susceptible to biotic stresses such as TLB but also to abiotic stresses. Collecting and conserving the existing wild and cultivated genetic diversity in the countries of origin and sharing this diversity with producer countries in other parts of the world, such as Africa, the Americas, and the Caribbean, is strongly recommended.

9. Opportunities for Improved Taro Production in WA

Among root crops, taro currently has the lowest average yield (5.4 tons/ha globally) [92]. WA countries dominate as the major producers of taro globally, producing 4.9 million tons of the estimated 12.0 million tons of taro produced in the world [79]. In the same year, Nigeria, the world's largest producer of taro, harvested approximately 3.2 million tons from 0.8 million hectares, followed by Ghana with 1.68 million tons [81]. Currently, there is no taro germplasm repository in WA responsible for preserving, characterizing, and distributing taro germplasm. The International Institute of Tropical Agriculture (IITA) in collaboration with the National Root Crop Research Institute of Nigeria (NRCRI) had collected and preserved taro landraces. However, this collection was lost during the outbreak of TLB in West and Central Africa, including Nigeria [20], Ghana [21], and Cameroon [93]. Breeding resistant cultivars offers the best long-term control of TLB disease in most production systems; thus, urgent and collaborative efforts among research groups and donors are needed to combat the TLB epidemic and prevent taro from going extinct in the region.

In recent years, scientists in WA and beyond have been gathering information, developing strategies, and evaluating stress factors to help to improve the taro crop [8,18,19,58,64,94–98]. Two of the improvements achieved to date are outlined as follows:

i. *Standardized collection protocols*: Dansi [95] has outlined a collection procedure for root and tuber crops, including taro. The methodology is based on synthesized information from the publications of international bodies such as Biodiversity International, World

Conservation Union (IUCN), FAO, and United Nations Environment Programme (UNEP). This helps to ensure that collection programs are executed using international standard procedures;

ii. *Characterization of local and exotic germplasm for agro-morphological traits, disease resistance, and nutritional qualities, to be used as the basis for taro improvement*: Several authors have used morphological characterization to evaluate taro cultivars, including agro-morphological traits, diseases, and flowering ability [58,75,90,97]. This has helped the classification of taro into different morphotypes, which can then be used in taro improvement programs.

There is still more to be done with taro in WA, however. There is a scarcity of information on the use of molecular techniques in the characterization of taro, which would facilitate the understanding of the genetic phylogeny of local accessions and fast-track the improvement of the crop. In addition, there is a need to raise awareness among different stakeholders, including producers and consumers, about the crop's potential contribution to food security, health, and economics, so that the improved production of the crop is prioritized at regional and country levels.

10. Breeding Efforts in Taro

Taro breeding efforts should focus on traits that are important for both producers and consumers, such as yield, pest and disease resistance, nutritional quality, shelf life, plant architecture, maturity, and culinary characteristics [99]. Breeding programs involving different stakeholders can be used to gather more information and adopt new technologies. For example, there is a need to assess the acridity levels of different cultivars so that consumers can develop suitable cooking methods for increased edibility.

Taro breeding was initiated in the late 1970s, and varieties were released in Fiji (1978), Samoa (1982; 1996), Solomon Islands (1978; 1992), Papua New Guinea (1993), and India (1995) [100,101]. The first successful controlled hybridization of taro in Nigeria was reported in 2015 [18]. Breeding schemes such as bi-parental crossing and recurrent selection were used at an early stage of plant development for traits such as taro corm flesh and corm fiber colors, which were correlated with the color of different petiole zones [102]. There have been several efforts in Papua New Guinea towards resistance breeding, but one of the difficulties is getting rid of deleterious traits from wild types. Breeding programs have been initiated in Hawaii for agronomic traits, and pests and disease resistance, to develop improved varieties for the restaurant and landscape trades [103].

The major objectives of taro breeding so far have been to improve plant architecture (such as optimal number of suckers, absence of stolons, optimal number of leaves, etc.), corm yield, resistance/tolerance to diseases such as TLB, and quality traits (such as dry-matter content, low levels of phenolic compounds causing irritation, etc.) [104]. Breeding activities with parents from a diverse genetic base could result in improved targeted traits. However, taro is usually propagated through vegetative means, seldom through flowers; the flowers are protogynous, making conventional breeding methods difficult [32]. Taro breeding has been initiated in many countries within the South Pacific under two major programs, TaroGen and TANSAO [105]. These programs have focused on hybridization to develop new cultivars with higher yields, better taste, and improved resistance to TLB [106,107]. Hybridization in taro is promising, but it is labor intensive and lengthy in terms of the induction of flowering (although gibberellic acid has been used to induce flowering in taro [18,47,75]), pollination, and seed harvesting. It takes 10 years or more from pollination for a new improved cultivar to be developed [108]. There is a scarcity of reports on taro breeding in WA, and the majority of the work is limited to the agro-morphological characterization or evaluation of local landraces. Amadi et al. [18] did achieve 109 crosses using 15 exotic taro cultivars and 4 local Nigerian cultivars, of which only 20 crosses (18.3%) were successful, with 9 crosses reaching maturity and producing seeds. The limited success with taro breeding can be linked to the weak institutional capacities of most national institutes engaged in breeding, coupled with a lack of genetic

resources and funding for establishing a sustainable taro breeding program in WA. The work of existing national, regional, and international networks should also be consolidated to optimize breeding methodologies.

The application of biotechnological techniques for the disease-free clonal propagation of taro plants is another viable option. Tuia [109] developed an efficient taro multiplication protocol and reported that it was possible to eliminate viruses using meristem cultures. There are also reports of somatic embryogenesis in taro [110–112], but the regeneration rate is low. Similarly, Fukino et al. [113] reported transformation in taro (*C. esculenta* var. *antiquorum*) calluses by particle bombardment, but only two putative transgenic plants were obtained. Transformation in *Colocasia esculenta* var. *esculenta* via microprojectile bombardment [114] and *Agrobacterium tumefaciens* [115,116] was also reported. These efforts show that using biotechnology to generate taro plantlets is a possibility, but there is a need to validate the vigor of plants in terms of growth rate, pest and disease resistance, and corm characteristics, in addition to extensive field trials to record the frequency of somaclonal variations [112].

11. Constraints to Taro Breeding

11.1. Variation in Ploidy and Chromosome Number

Cytological studies of taro indicate confusion over the basic chromosome number. Various cytotypes have been observed, with 2n = 28 (diploid) and 42 (triploid) forms and a basic chromosome number of 14 [117]. It has been suggested that the chromosomes are prone to unpredictable behavior during cell division; thus, the chromosome number per cell may not be uniform [118,119]. From a breeding perspective, the occurrence of polyploidy in taro may result in changes in cellular structures, leading to irregular meiosis. Therefore, the viability of gametes and zygotes is very low [120].

11.2. Poor Flowering

Taro genotypes rarely flower, and flowering is strongly influenced by environmental, physiological, genetic, and developmental conditions [121]. Cultivars or landraces are not stable regarding flowering and may have abnormalities in the inflorescence structure, which is the main limiting factor for conventional hybridization. Additionally, the flowering ability of diploid cultivars is poorly understood, although some may flower easily when allowed to reach reproductive maturity [24].

11.3. Sexual Crossing and Seed Set

Sexual crossing is labor intensive and takes time in terms of field preparation, the planting of parents, the induction of flowering using gibberellic acid (GA), pollination, the development and maturation of fruits, and seed harvesting [122]. In addition, the development of new, improved cultivars takes 10 years or more after successful pollination. There are reports of taro plants producing viable seeds under natural conditions; however, the germination of seeds is affected by genotype, environment, harvesting and storage conditions, and germination protocols [107].

11.4. Narrow Genetic Base

Taro production is extremely low in comparison with other root and tuber crops, such as cassava, sweet potato, and yams, in WA. The limiting factors include the low genetic base maintained in farmers' fields, the lack of improved varieties, the lack of planting material, the presence of pests and diseases, and limited research and information on available taro germplasm in the region compared with other regions, such as the Pacific. The introduction and evaluation of cultivars from other countries for adaptation to local production systems has potential to increase the local variability, diversity, and improvement of taro. In addition, large scale, commercial production systems tend to focus on few popular cultivars. There is a need for maintaining or developing commercial production systems that embrace cultivar diversity.

11.5. Availability of Uniform Planting Materials

The productivity of crops, and taro in particular, in farmers' fields depends on several factors, including the type of planting material, the size of planting material, population density, etc. The use of different types of planting material or propagules, such as stolons/suckers, corms, and cormels, results in a higher intra-clonal variation in the growth rate, although plants from stolons usually grow faster [30]. For uniformity in growth and production in farmers' fields, uniform planting materials and population densities are required.

11.6. Limited Knowledge on Genetic/Genomic Resources for Accelerated Breeding

The breeding of improved cultivars is a complex process that requires adequate knowledge and experience, in addition to the availability of genetic resources, reliable characterization data for morphological traits, and an understanding of the effects of biotic and abiotic stresses on quality traits. In the case of taro, there are currently limited knowledge and experience, as well as limited available information, for use in an accelerated breeding program.

12. Taro Genome and Relevance to Its Improvement

Recent developments in genomics have resulted in an increased understanding of the genome as well as specific pathways in different crop plants. In this context, the availability of a high-quality chromosome-level genome of taro is an important goal [31]. A popular taro diploid cultivar, "Longxianggyu", from Jiangsu, China, has a basic chromosome number of 14. Its assembled genome size is 2.41 Gb, with a contig N50 of 400 kb and a scaffold N50 of 159.4 Mb. Using a phylogenetic tree based on 769 genes, it has been suggested that taro and *Spirodela polyrhiza* (duckweed) are on the same branch that diverged approximately 73.23 million years ago and that there have been at least two whole-genome duplication events in taro's history, separated by a relatively short gap. Similarly, a de novo taro genome assembly has been carried out for the Hawaiian landrace "Moi", which is a grandparent to cultivars used in TLB-resistant mapping populations and is used for its agronomic qualities [55]. Its haploid assembly is 2.45 Gb with a contig length of 38 Mb and scaffold N50 of 317,420 bp. The sequenced data from the TLB-resistant mapping population revealed 16 major linkage groups, with 520 markers and 10 quantitative trait loci (QTLs) being significantly associated with TLB disease resistance.

This sequencing information has already helped researchers to understand how different traits are regulated in taro. Transcriptome sequencing in taro has revealed the mechanism of purple-pigment formation [123] and the development of EST-SSR [124] and SSR [125] markers. In addition, the deep sequencing of the taro transcriptome has revealed major metabolic pathways of starch synthesis and has helped to identify the mRNAs and genes that are expressed for starch biosynthesis in taro corms [126]. Similarly, Dong et al. [127] have conducted comprehensive whole transcriptome sequencing of taro corms aged 1, 2, 3, 4, 5, and 8 months to assess the starch and sucrose biosynthesis pathways. This study provides a valuable resource for the future exploration of the molecular and physiological mechanisms behind the starch and sucrose properties of taro corms.

Genomic-assisted breeding (GAP) programs for taro could be improved with access to molecular information. The availability of the taro genome could inform studies on the origin, evolutionary history, and breeding of this crop. This could also improve the understanding of the molecular mechanisms underlying some of the key traits, including disease susceptibility and quality. The QTLs identified for TLB disease can be further investigated to identify genes that contribute to resistance, and flanking markers can be used in marker-assisted breeding. Most importantly, SSRs and SNPs can be identified for routine genotyping for parental identification, the assessment of genetic diversity, the identification of duplicate genotypes, linkage mapping, QTL identification, and other genomic-assisted studies.

13. Future Perspectives for Taro in WA

Taro is an important food and income-security crop for millions of farmers in WA, particularly in Nigeria. One of the major challenges facing sustainable crop production is the genetic erosion of germplasm as a result of several factors, such as climate change, pests and diseases, etc. In the case of taro, most of the germplasm is held in farmers' fields, as well as in the wild. In the absence of a regional conservation strategy for taro, there is a high risk of loss of valuable genetic resources and thus future sustainability. There is a need to explore, collect, and safeguard the existing genetic diversity, as well as define production zones to ensure a better sustainability of the crop. Germplasm collection, coupled with effective conservation and utilization, is a prerequisite for the success of taro breeding programs. There is a need to establish regional and international networks to strengthen the work of NARS breeding programs in different countries regarding germplasm conservation, utilization, and exchange. Obtaining and evaluating a larger sample of genetic diversity from Asia, the Pacific, and Latin America, utilizing germplasm exchange protocols, would mean that different gene pools could be effectively combined to develop heterotic populations [128]. Such an approach is already being applied to cassava and maize breeding programs in Africa, where germplasm from Latin America has been successfully introgressed into African germplasm [129]. Conventional taro breeding programs should target available regional genetic resources, use them as parents to improve traits such as disease resistance, quality, etc., and ensure that the selected genotypes flower naturally or respond to the induction of flowering through GA application. In addition, newly developed cultivars should be tested under different conditions to take into account the genotype-by-environment (G $\times$ E) effect to develop the large marginal non-optimal areas where taro is generally grown for optimum yield performance. Participatory breeding programs would also provide a good platform for identifying superior cultivars, increasing farmers' access to those cultivars and broadening the genetic base for taro improvement. This needs to be coupled with seed system strategies to increase the quantity of disease-free planting material, facilitate safe germplasm exchange, and provide a better distribution system for the dissemination of improved cultivars for the sustainable production of taro.

So far, there has been limited application of genomics to taro improvement in WA, and there is a need to use molecular and genetic tools, such as tissue culture and micropropagation, as well as genotyping using SSRs or SNPs, to assess genetic diversity, marker-assisted selection, and genome-wide associations and define a set of markers for cultivar identification. Future breeding programs should add value by including organoleptic characteristics and nutritional properties, and export markets could be widened by generating value-added products, diversifying uses, and promoting taro consumption.

Most importantly, there is a need to develop a database of cultivars present in farmers' fields at national and regional levels. This kind of a modern, curated, and interactive database would help farmers and extension officers to understand the value and potential of locally available cultivars and to learn from the experiences of other people who grow similar varieties in other regions. The database would also help farmers to compare their local varieties with newly available varieties. In addition, taro agro-ecological production zones need to be defined at a country level while safeguarding indigenous local knowledge using a participatory approach. A multi-disciplinary approach should be applied to taro improvement; its potential for better productivity needs to be exploited through the multi-environment evaluation of the different agro-ecologies within each country.

Global initiatives such as the African Orphan Crops Consortium (AOCC) have listed taro among the 101 traditional orphan or neglected crops of Africa that are important for food and nutritional security [130]. This consortium, established in 2011, aims to sequence, assemble, and annotate the genomes of 101 targeted crops to explore in-depth genetic diversity and facilitate their genetic improvement. The crops have been prioritized based on input from scientists, development practitioners, consumers, and producers to support the diets of African consumers and farmers' incomes. The genomic information generated by the AOCC is to be deposited in the public domain for use by breeders and

other researchers, so that the information can be used to develop improved varieties and cultivars, which can then be released to farmers. So far, the AOCC has completed the genome sequencing of eight crop species, but the genome sequencing of taro is still pending.

Taro has been neglected as a research crop, and there is a need to prioritize it as a crop of importance at regional and country levels and to effectively invest research funds to guarantee its future development.

Author Contributions: Conceptualization, R.B., P.L.K., A.A. and R.R.V.; J.J.O. prepared the first draft of the manuscript; All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Swedish Research Council, including open access publication (2019-04270); Pan African University Life and Earth Sciences Institute (Including Health and Agriculture) (PAULESI), Ibadan; and International Institute of Tropical Agriculture (IITA).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: This work was supported by the Swedish Research Council (2019-04270); Pan African University Life and Earth Sciences Institute (Including Health and Agriculture) (PAULESI), Ibadan; International Institute of Tropical Agriculture (IITA), Ibadan; and Swedish University of Agricultural Sciences (SLU), Sweden. IITA acknowledges funding support for roots and tuber crops from the donors of the CGIAR Trust Fund.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Nelson, S.C. Dasheen mosaic of edible and ornamental aroids. *Pl. Dis.* **2008**, *44*, 1–9.
2. Legesse, T.; Bekele, T. Evaluation of improved taro (*Colocasia esculenta* L.) Schott genotypes on growth and yield performance in north-bench woreda of Bench-Sheko zone, South-Western Ethiopia. *Heliyon* **2021**, *7*, e08630. [CrossRef] [PubMed]
3. Rao, R.V.; Peter, M.J.; Pablo, E.B.; Hunter, D. *The Global Diversity of Taro: Ethnobotany and Conservation*; Bioversity International: Rome, Italy, 2010.
4. Lee, W. Taro (*Colocasia esculenta*). Ethnobotanical Leaflets. 1999. Available online: http://opensiuc.lib.siu.edu/ebl/vol1999/iss1/4. (accessed on 3 May 2022).
5. Kreike, C.M.; van Eck, H.J.; Lebot, V. Genetic diversity of taro, *Colocasia esculenta* (L.) Schott, in Southeast Asia and the Pacific. *Theor. Appl. Genet.* **2004**, *109*, 761–768. [CrossRef]
6. Grimaldi, I.M.; van Andel, T.R. Food and medicine by what name? The ethnobotanical and linguistic diversity of Taro in Africa. *Econ. Bot.* **2018**, *72*, 217–228. [CrossRef]
7. Matthews, P.J.; Ghanem, M.E. Perception gaps that may explain the status of taro (*Colocasia esculenta*) as an "orphan crop". *Plants People Planet* **2021**, *3*, 99–112. [CrossRef]
8. Chaïr, H.; Traore, R.E.; Duval, M.F.; Rivallan, R.; Mukherjee, A.; Aboagye, L.M.; Van Rensburg, W.J.; Andrianavalona, V.; Pinheiro de Carvalho, M.A.A.; Saborio, F.; et al. Genetic Diversification and Dispersal of Taro (*Colocasia esculenta* (L.) Schott. *PLoS ONE* **2016**, *11*, e0157712. [CrossRef]
9. FAOSTAT. 2020. Available online: http://www.fao.org/faostat/en/#data/QC (accessed on 29 January 2021).
10. Kidanemariam, D.B.; Sukal, A.C.; Abraham, A.D.; Njuguna, J.N.; Stomeo, F.; Dale, J.L.; James, A.P.; Harding, R.M. Incidence of RNA viruses infecting taro and tannia in East Africa and molecular characterisation of dasheen mosaic virus isolates. *Ann. Appl. Biol.* **2021**, *180*, 211–223. [CrossRef] [PubMed]
11. Foxcroft, L.C.; Richardson, D.M.; Wilson, J.R. Ornamental plants as invasive aliens: Problems and solutions in Kruger National Park, South Africa. *Environ. Manag.* **2008**, *41*, 32–51. [CrossRef]
12. Bricas, N. Les Enjeux de L'urbanisation pour la Durabilité des Systèmes Alimentaires. In *Construire des Politiques Alimentaires Urbaines*; [Designing Urban Food Policies]; Brand, C., Bricas, N., Conaré, D., Daviron, B., Debru, J., Michel, L., Soulard, T., Eds.; Éditions Quae: Versailles, France, 2017; pp. 19–42.
13. USDA Food Composition Databases. Revised in May 2016. Available online: https://fdc.nal.usda.gov/fdc-app.html#/food-details/169308/nutrients (accessed on 9 March 2022).
14. Melese, T.; Negussie, R. Nutritional Potential, Health and Food Security Benefits of Taro *Colocasia esculenta* (L.): A review. *FSQM* **2015**, *36*, 23–30.
15. Pereira, H.F.; Puiatti, M.; Finger, F.L. Ornamental potential of taro [*Colocasia esculenta* (L.) Schott] accessions. *5th Int. Symp. New Floric. Crops* **2005**, *683*, 307–312. [CrossRef]

16. FAOSTAT. FAO Statistical Database. 2022. Available online: https://www.fao.org/faostat/en/#data/QCL (accessed on 8 April 2022).
17. Annegers, J.F. Ecology of dietary patterns and nutritional status in West Africa. 1. Distribution of starchy staples. *Ecol. Food Nutri.* **1973**, *2*, 107–119. [CrossRef]
18. Amadi, C.O.; Onyeka, J.; Chukwu, G.O.; Okoye, B.C. Hybridization and Seed Germination of Taro (*Colocasia esculenta*) in Nigeria. *J. Crop. Improv.* **2015**, *29*, 106–116. [CrossRef]
19. Onyeka, J. Status of Cocoyam (*Colocasia esculenta* and *Xanthosoma* spp.) in West and Central Africa: Production, Household Importance and the Threat from Leaf Blight. Lima (Peru). *CGIAR Res. Program Roots Tubers Banan. (RTB)* **2014**, *39*, 1–39.
20. Bandyopadhyay, R.; Sharma, K.; Onyeka, T.J.; Aregbesola, A.; Kumar, P.L. First Report of Taro (*Colocasia esculenta*) Leaf Blight Caused by *Phytophthora colocasiae* in Nigeria. *Plant Dis.* **2011**, *95*, 618. [CrossRef] [PubMed]
21. Omane, E.; Oduro, K.A.; Cornelius, E.W.; Akrofi, A.Y.; Asare, E.K.; Adongo, B.A. Improvement in the Management of Leaf Blight Disease of Taro (*Colocasia esculenta*) with Copper and Metalaxyl Fungicides. *J. Exp. Agric. Int.* **2020**, *42*, 127–136. [CrossRef]
22. Ahmed, I.; Lockhart, P.J.; Agoo, E.M.; Naing, K.W.; Nguyen, D.V.; Medhi, D.K.; Matthews, P.J. Evolutionary origins of taro (*Colocasia esculenta*) in Southeast Asia. *Ecol. Evol.* **2020**, *10*, 13530–13543. [CrossRef]
23. Loy, T.H.; Spriggs, M.; Wickler, S. Direct evidence for human use of plants 28,000 years ago: Starch residues on stone artefacts from the northern Solomon Islands. *Antiquity.* **1992**, *66*, 898–912. [CrossRef]
24. Ivancic, A.; Lebot, V. *The Genetics and Breeding of Taro*; CIRAD Publication Series: Cirad, France, 2000.
25. Blench, R. Bananas and plantains in Africa: Re-interpreting the linguistic evidence. *Ethnobot. Res. App.* **2009**, *7*, 363–380. [CrossRef]
26. Henriquez, C.L.; Arias, T.; Pires, J.C.; Croat, T.B.; Schaal, B.A. Phylogenomics of the plant family Araceae. *Mol. Phylogenet. Evol.* **2014**, *75*, 91–102. [CrossRef]
27. Helmkampf, M.; Wolfgruber, T.K.; Bellinger, M.R.; Paudel, R.; Kantar, M.B.; Miyasaka, S.C.; Kimball, H.L.; Brown, A.; Veillet, A.; Read, A.; et al. Phylogenetic relationships, breeding implications, and cultivation history of Hawaiian taro (*Colocasia esculenta*) through genome-wide SNP genotyping. *J. Hered.* **2017**, *109*, 272–282. [CrossRef]
28. Safo-Kantanka, O. *Colocasia esculenta* (L.) Schott. Record from PROTA4U. In *PROTA (Plant Resources of Tropical Africa/Ressources Végétales de l'Afrique Tropicale)*; Grubben, G.J.H., Denton, O.A., Eds.; Wageningen, The Netherlands, 2004; Available online: https://uses.plantnet-project.org/en/Colocasia_esculenta_(PROTA) (accessed on 10 February 2021).
29. CABI. Invasive Species Compendium: Datasheet Report for *Colocasia esculenta* (taro). 2019. Available online: https://www.cabi.org/isc/datasheetreport/17221 (accessed on 10 February 2021).
30. Lebot, V.; Tuia, V.; Ivancic, A.; Jackson, G.V.H.; Saborio, F.; Reyes, G.; Rodriguez, S.; Robin, G.; Traore, R.; Aboagye, L.; et al. Adapting clonally propagated crops to climatic changes: A global approach for taro (*Colocasia esculenta* (L.) Schott). *Genet. Resour. Crop. Evol.* **2017**, *65*, 591–606. [CrossRef]
31. Yin, J.; Jiang, L.; Wang, L.; Han, X.; Guo, W.; Li, C.; Zhou, Y.; Denton, M.; Zhang, P. A high-quality genome of taro (*Colocasia esculenta* (L.) Schott), one of the world's oldest crops. *Mol. Ecol. Resour.* **2021**, *21*, 68–77. [CrossRef] [PubMed]
32. Amadi, C.O.; Mbanaso, E.N.A.; Chukwu, G.O. A Review Cocoyam Breeding in Nigeria: Achievements, Challenges and Prospects. *Niger. Agric. J.* **2012**, *43*, 72–80.
33. Grimaldi, I.M.; Leke, W.; Borokini, I.; Wanjama, D.; Van Andel, T.R. From landraces to modern cultivars: Field observations on taro *Colocasia esculenta* (L.) Schott in sub-Saharan Africa. *Genet. Resour. Crop. Evol.* **2018**, *65*, 1809–1828. [CrossRef]
34. Matthews, P.J. Written Records of Taro in the Eastern Mediterranean. In *Ethnobotany: At the junction of the continents and the disciplines, Proceedings of the IVth International Congress of Ethnobotany, ICEB, Istanbul, Turkey, 21–26 August 2006*; Ertug, Z.F., Ed.; Istanbul Yayinlari: İstanbul, Turkey, 2006; pp. 419–426.
35. FAOSTAT. FAO Statistical Database. 2017. Available online: https://www.fao.org/faostat/en/#data/QCL/visualize (accessed on 8 December 2021).
36. Grimaldi, I.M. Taro across the Oceans, journeys of one of our oldest crops. In *News from the past, Progress in African Archaeobotany, Proceedings of the Seventh International Workshop on African Archaeobotany, Vienna, Austria, 2–5 July 2012*; Advances in Archaeobotany 3; Barkhuis: Groningen, The Netherlands, 2016; pp. 67–81.
37. Onwueme, I. Taro cultivation in Asia and the Pacific. *RAP Publ.* **1999**, *16*, 1–60. Available online: https://www.sciencedirect.com/science/article/pii/S240584402102733X-bbib18 (accessed on 9 September 2021).
38. Dagne, Y.; Mulualem, T.; Kifle, A. Development of high yielding Taro (*Colocasia esculenta* L.) Variety for mid altitude growing areas of Southern Ethiopia. *J. Plant Sci.* **2014**, *2*, 50–54.
39. Maretta, D.; Sobir, S.; Helianti, I.; Purwono, P.; Santosa, E. Genetic diversity in Eddoe Taro (*Colocasia esculenta* var. antiquorum) from Indonesia based on morphological and nutritional characteristics. *Biodiversitas.* **2020**, *21*, 3525–3533. Available online: https://smujo.id/biodiv/article/view/5930 (accessed on 10 February 2021).
40. Terry, E.R.; Oduro, K.A.; Caveness, F.E. Cocoyam Farming Systems in Nigeria. In *Tropical root crops: Research Strategies for the 1980s, Proceedings of the First Triennial Root Crops Symposium of the International Society for Tropical Root Crops—Africa Branch, Ibadan, Nigeria, 8–12 September 1980*; International Development Research Centre: Ottawa, Canada, 1981.
41. Reddy, P.P. Taro, *Colocasia esculenta*. In *Plant Protection in Tropical Root and Tuber Crops*; Springer: New Delhi, India, 2015.
42. Bricas, N.; Tchamda, C. *Sub-Saharan Africa's Significant Changes in Food Consumption Patterns*; CIRAD: Montpellier, France, 2017; p. 4.
43. Singh, D.; Jackson, G.; Hunter, D.; Fullerton, R.; Lebot, V.; Taylor, M.; Iosefa, T.; Okpul, T.; Tyson, J. Taro Leaf Blight—A Threat to Food Security. *Agriculture* **2012**, *2*, 182–203. [CrossRef]

44. Vetukuri, R.R.; Kushwaha, S.K.; Sen, D.; Whisson, S.C.; Lamour, K.H.; Grenville-Briggs, L.J. Genome Sequence Resource for the Oomycete Taro Pathogen *Phytophthora colocasiae*. *Mol. Plant Microbe Interact.* **2018**, *31*, 903–905. [CrossRef]
45. Raciborski, M. Parasitic algae and fungi. *Java. Batavia Bull. N. Y. State Mus.* **1900**, *19*, 189.
46. Mbong, G.; Fokunang, C.; Manju, E.; Njukeng, A.; Tembe-Fokunang, E.; Hanna, R. Mycelia Growth and Sporulation of *Phytophthora colocasiae* Isolates under Selected Conditions. *Am. J. Exp. Agric.* **2015**, *8*, 193–201. [CrossRef]
47. Padmaja, G.; Uma Devi, G.; Kanaka Mahalakshmi, B.; Sridevi, D. Characterization of Isolates of *Phytophthora colocasiae* Collected from Andhra Pradesh and Telangana Causing Leaf Blight of Taro. *Int. J. Curr. Microbiol Appl. Sci.* **2017**, *6*, 1901–1912. [CrossRef]
48. Ooka, J.J. Taro Diseases. Research-Extension-Series. *Hawai Inst. Trop. Agricul. Hum. Res.* **1990**, *114*, 51–59.
49. Misra, R.S.; Mishra, A.K.; Sharma, K.; Jeeva, M.L.; Hegde, V. Characterisation of *Phytophthora colocasiae* isolates associated with leaf blight of taro in India. *Arch. Phytopathol. Pflanzenschutz* **2011**, *44*, 581–591. [CrossRef]
50. Jackson, G.V.H.; Gollifer, D.E. Disease and Pest Problems of Taro (*Colocasia esculenta* L. Schott) in the British Solomon Islands. *PANS Pest. Artic. News Summ.* **1975**, *21*, 45–53. [CrossRef]
51. Indrani Devi, Y.; Sahoo, M.R.; Mandal, J.; Dasgupta, M.; Prakash, N. Correlations between antioxidative enzyme activities and resistance to *Phytophthora* leaf blight in taro. *J. Crop. Improv.* **2020**, *35*, 250–263. [CrossRef]
52. Ganança, J.F.T.; Freitas, J.G.F.; Nóbrega, H.G.M.; Rodrigues, V.; Antunes, G.; Rodrigues, M.; Carvalho, M.Â.A.P.; Lebot, V. Screening of Elite and Local Taro (*Colocasia esculenta*) Cultivars for Drought Tolerance. *Procedia Environ. Sci.* **2015**, *29*, 41–42. [CrossRef]
53. Anjitha Nair, U.M.; Devi, A.A.; Veena, S.S.; Krishnan, B.S.P.; Arya, R.S. Genetic Diversity Analysis of Leaf Blight Resistant and Susceptible Taro [*Colocasia esculenta* (L.) Schott] Genotypes Using ISSR Markers. *J. Root Crops* **2018**, *44*, 44–52.
54. Ganança, J.F.T.; Freitas, J.G.R.; Nóbrega, H.G.M.; Rodrigues, V.; Antunes, G.; Gouveia, C.S.S.; Rodrigues, M.; de Carvalho, M.A.P.; Lebot, V. Screening for Drought Tolerance in Thirty Three Taro Cultivars. *Not. Bot. Horti. Agrobot. Cluj Napoca* **2018**, *46*, 65–74. [CrossRef]
55. Bellinger, M.R.; Paudel, R.; Starnes, S.; Kambic, L.; Kantar, M.B.; Wolfgruber, T.; Lamour, K.; Geib, S.; Sim, S.; Miyasaka, S.C.; et al. Taro Genome Assembly and Linkage Map Reveal QTLs for Resistance to Taro Leaf Blight. *G3* **2020**, *10*, 13. [CrossRef]
56. Martin, F.N.; English, J.T. Population genetics of soil-borne fungal plant pathogens. *Phytopathology* **1997**, *87*, 446–447. [CrossRef] [PubMed]
57. Ackah, F.K.; van der Puije, G.C.; Moses, E. First evaluation of taro (*Colocasia esculenta*) genotypes against leaf blight (*Phytophthora colocasiae*) in Ghana. *HRS* **2014**, *3*, 390–391.
58. Amadi, C.O.; Onyeka, J.; Okoye, B.C.; Ezeji, L.; Ezigbo, E.C. Evaluation of Exotic Genotypes of Taro (*Colocasia esculenta*) in Nigeria. *Niger. Agric. J.* **2015**, *46*, 36–42.
59. Kidanemariam, D.B.; Sukal, A.C.; Abraham, A.D.; Stomeo, F.; Dale, J.L.; James, A.P.; Harding, R.M. Identification and molecular characterization of Taro bacilliform virus and Taro bacilliform CH virus from East Africa. *Plant Pathol.* **2018**, *67*, 1977–1986. [CrossRef]
60. Awuah, R.T. Leafspot of taro (*Colocasia esculenta* (L.) Schott) in Ghana and suppression of symptom development with Thiophanate methyl. *Afr. Crop. Sci. J.* **1995**, *3*, 519–523. [CrossRef]
61. Sultana, F.; Hu, Y.-G.; Toda, M.J.; Takano, K.T.; Yafuso, M. Phylogeny and classification of *Colocasiomyia* (Diptera, Drosophilidae), and its evolution of pollination mutualism with aroid plants. *Syst. Entomol.* **2006**, *31*, 684702. [CrossRef]
62. Vaurasi, V.; Kant, R. Effects of Salinity and Plant Growth Media on in Vitro Growth and Development of Taro (*Colocasia esculenta* L.) Varieties. *Acta Hortic. Regiotect.* **2016**, *19*, 17–20. [CrossRef]
63. Ubalua, A.O.; Ewa, F.; Okeagu, O.D. Potentials and challenges of sustainable taro (*Colocasia esculenta*) production in Nigeria. *J. Appl. Biol. Biotechnol.* **2016**, *4*, 53–59. Available online: http://jabonline.in/abstract.php?article_id=118 (accessed on 10 February 2021).
64. Rashmi, D.R.; Raghu, N.; Gopenath, T.S.; Palanisamy, P.; Bakthavatchalam, P.; Karthikeyan, M.; Gnanasekaran, A.; Ranjith, M.S.; Chandrashekrappa, G.K.; Basalingappa, K.M. Taro (*Colocasia esculenta*): An overview. *J. Med. Plants Stud.* **2018**, *6*, 156–161.
65. Saxby, S.M. The Potential of Taro (*Colocasia esculenta*) as a Dietary Prebiotic Source for the Prevention of Colorectal Cancer. Ph.D. Thesis, University of Hawai'i at Manoa, Honolulu, HI, USA, 2020.
66. Ribeiro Pereira, P.; Bertozzi de Aquino Mattos, É.; Nitzsche Teixeira Fernandes Corrêa, A.C.; Afonso Vericimo, M.; Margaret Flosi Paschoalin, V. Anticancer and Immunomodulatory Benefits of Taro (*Colocasia esculenta*) Corms, an Underexploited Tuber Crop. *Int. J. Mol. Sci.* **2020**, *22*, 265. [CrossRef]
67. Esfeld, K.; Uauy, C.; Tadele, Z. Application of TILLING for Orphan Crop Improvement. In *Biotechnology of Neglected and Underutilized Crops*; Jain, S.M., Gupta, S.D., Eds.; Springer Science Business Media Dordrecht: Dordrecht, The Netherlands, 2013; pp. 83–113.
68. Ogali, R.E.; Ofodile, S.E.; Eze, C. Comparison of Bioethanol Yield from Four Cocoyam Species in Nigeria. *J. Med. Plants Stud.* **2016**, *41*, 5.
69. Praputri, E.; Sundari, E. Production of Bioethanol from *Colocasia esculenta* (L.) Schott (Talas Liar) by Hydrolysis Process. *IOP Conf. Ser. Mater. Sci. Eng.* **2019**, *543*, 012056. [CrossRef]
70. Briones, M.F.; Jazmin, P.F.; Pajarillaga, B.E.; Juvinal, J.G.; Leon, A.A.D.; Rustia, J.M.; Tuates, A.M., Jr. Biodegradable film from wild taro *Colocasia esculenta* (L.) Schott starch. *Agric. Eng. Int. CIGR J.* **2020**, *22*, 4.
71. Oduori, C.A.; Atandi, J.; Kisaakye, J.; Coyne, D. Cocoyam (*Colocasia esculenta*) provides an effective monoxenic culture media for Radopholus similis. *Nematology* **2021**, *23*, 597–599. [CrossRef]

72. Tadele, Z. Orphan crops: Their importance and the urgency of improvement. *Planta* **2019**, *250*, 677–694. [CrossRef]
73. Bammite, D.; Matthews, P.J.; Dagnon, D.Y.; Agbogan, A.; Odah, K.; Dansi, A.; Tozo, K. Constraints to production and preferred traits for taro (*Colocasia esculenta*) and new cocoyam (*Xanthosoma mafaffa*) in Togo, West Africa. *Afr. J. Food Agric. Nutr. Dev.* **2018**, *18*, 13389–13407. [CrossRef]
74. Kuswara, T.; Prana, M.S. *Trade Pattern of Taro (Colacasia esculenta L.)*; Unpublished Report; West Java: Bogor, Indonesia, 2003; pp. 71–79.
75. Boampong, R.; Aboagye, L.M.; Nyadanu, D.; Esilfie, M. Agro-morphological characterization of some taro (*Colocasia esculenta* (L.) Schott.) germplasms in Ghana. *J. Plant Breed. Crop Sci.* **2018**, *10*, 191–202.
76. Phillip, D.; Nkonya, E.; Pender, J.; Oni, O.A. Constraints to Increasing Agricultural Productivity in Nigeria: A Review. *Int. Food Policy Res. Inst.* **2009**, *6*, 1–72.
77. IPGRI (International Plant Genetic Resources Institute). *Descriptors for Taro (Colocasia esculenta)*; IPGRI: Rome, Italy, 1999.
78. Lebot, V.; Hartati, S.; Hue, N.T.; Viet, N.V.; Nghia, N.H.; Okpul, T.; Pardales, J.; Prana, M.S.; Prana, T.K.; Thongjiem, M.; et al. Genetic variation taro (*Colocasia esculenta*) in South East Asia and Oceania. In Proceedings of the Twelfth Symposium of the International Society for Tropical Root Crops (ISTRC), Tsukuba, Japan, 10–16 September 2000.
79. Alexandra, S.; Jamora, N.; Smale, M.; Ghanem, M.E. The tale of taro leaf blight: A global effort to safeguard the genetic diversity of taro in the Pacific. *Food Secur.* **2020**, *12*, 1005–1016. [CrossRef]
80. Ebert, A.; Waqainabete, L.M. Conserving and sharing taro genetic resources for the benefit of global taro cultivation: A core contribution of the Centre for Pacific crops and trees. *Biopreserv Biobank.* **2018**, *16*, 361–367. [CrossRef]
81. Food and Agriculture Organization of the United Nations (FAO). *The State of Food Security and Nutrition in the World. Building Climate Resilience for Food Security and Nutrition*; FAO: Rome, Italy, 2018.
82. Ouedraogo, N.; Traore, R.E.; Bationo/Kando, P.; Sawadogo, M.; Zongo, J.-D. Agro-morphological diversity of exotic taro varieties (*Colocasia esculenta* L. Schott) introduced in Burkina Faso. *J. Exptl. Biol. Agricul. Scien.* **2018**, *6*, 370–385. [CrossRef]
83. Kuruvilla, K.M.; Singh, A. Karyotypic and electrophoretic studies on taro and its origin. *Euphytica* **1981**, *30*, 405–413. [CrossRef]
84. Purseglove, J.W. Eleusine coracana (L.) Gaertn. In *Tropical Crops. Monocotyledons*; Longman Group Limited: London, UK, 1972; pp. 147–156.
85. Singh, D.; Mace, E.S.; Godwin, I.D.; Mathur, P.N.; Okpul, T.; Taylor, M.; Hunter, D.; Kambuou, R.; Rao, V.R.; Jackson, G. Assessment and rationalization of genetic diversity of Papua New Guinea taro (*Colocasia esculenta*) using SSR DNA fingerprinting. *Genet. Resour. Crop. Evol.* **2008**, *55*, 811–822. [CrossRef]
86. Lebot, V.; Hartati, S.; Hue, N.T.; Viet, N.V.; Nghia, N.H.; Okpul, T.; Pardales, J.; Prana, M.S.; Prana, T.K.; Thongjiem, M.; et al. Characterizing taro using isozymes and morpho-agronomic descriptors. In *The Global Diversity of Taro: Ethnobotany and Conservation*; Ramanatha, R.V., Matthews, P.J., Eyzaguirre, P.B., Hunter, D., Eds.; Bioversity International: Rome, Italy, 2010; p. 39.
87. Bhattacharjee, M.; Tarafdar, J.; Sadhukhan, R. Assessment of genetic diversity of some indigenous collections of upland taro *Colocassia esculenta* var. antiquorium (L.) Schott for selection of genotypes aiming at improvement in breeding programme. *J. Agric. Vet. Sci.* **2014**, *7*, 31–43. [CrossRef]
88. Lebot, V.; Prana, M.S.; Kreike, N.; Van Heck, H.; Pardales, J.; Okpul, T.; Gendua, T.; Thongjiem, M.; Hue, H.; Viet, N.; et al. Characterisation of taro (*Colocasia esculenta* (L.) Schott) genetic resources in Southeast Asia and Oceania. *Genet. Resour. Crop. Evol.* **2004**, *51*, 381–392. [CrossRef]
89. Mulualem, T.; WeldeMichael, G.; Belachew, K. Genetic diversity of Taro (*Colocasia esculenta* (L.) Schott) genotypes in Ethiopia based on agronomic traits. *Time J. Agric. Vet. Sci.* **2013**, *1*, 23–30.
90. Orji, K.O.; Ogbonna, P.E. Morphological correlation analysis on some agronomic traits of taro (*Colocasia esculenta*) in the plains of Nsukka, Nigeria. *J. Glo. Biosci.* **2015**, *4*, 1120–1126.
91. Hu, K.; Huang, X.F.; Ke, W.D.; Ding, Y. Characterization of 11 new microsatellite loci in taro (*Colocasia esculenta*). *Mol. Ecol Resour.* **2008**, *9*, 582–584. [CrossRef]
92. FAOSTAT. FAO Statistical Database. 2015. Available online: https://www.fao.org/faostat/en/#compare (accessed on 10 February 2022).
93. Mbi, T.K.; Ntsomboh-Ntsefong, G.; Tonfack, L.B.; Youmbi, E. Field management of Taro (*Colocasia esculenta* (L.) Schott) leaf blight via fungicidal spray of foliage. *JCAS* **2021**, *16*, 197–208.
94. Dansi, A.; Adjatin, A.; Adoukonou-Sagbadja, H.; Faladé, V.; Adomou, A.C.; Yedomonhan, H.; Akpagana, K.; de Foucault, B. Traditional leafy vegetables in Benin: Folk nomenclature, species under threat and domestication. *Acta Bot. Gall.* **2009**, *156*, 183–199. [CrossRef]
95. Dansi, A. *Chapter 21: Collecting Vegetatively Propagated Crops (Especially Roots and Tubers)*; Guarino, L., Ramanatha, R.V., Goldberg, E., Eds.; Bioversity International: Rome, Italy, 2011; p. 8.
96. Akplogan, R.M.; Cacaï, G.H.T.; Ahanhanzo, C.; Houédjissin, S.S.; Traoré, E.R. Endogenous Perception of the Diversity of Taro (*Colocasia esculenta*) Cultivars Produced in Benin. *J. Plant. Sci.* **2018**, *6*, 144–148.
97. Bammite, D.; Matthews, P.J.; Dagnon, D.Y.; Agbogan, A.; Odah, K.; Dansi, A.; Tozo, K. Agro morphological characterization of taro (*Colocasia esculenta*) and yautia (*Xanthosoma mafaffa*) in Togo, West Africa. *Afr. J. Agric. Res.* **2018**, *13*, 934–945.
98. Boampong, R.; Boateng, S.K.; Adu Amoah, R.; Adu Gyamfi, B.; Aboagye, L.M.; Ansah, E.O. Growth and Yield of Taro (*Colocasia esculenta* (L) Schott.) as Affected by Planting Distance. *Int. J. Agron.* **2020**, *2020*, 1–8. [CrossRef]

99. Mgbedike, N.; Celestine, U.; Josephine, O.; Cletus, A. Strategies for Improving Cocoyam Production among Farmers in Anambra State, Nigeria. 2017. Available online: https://www.semanticscholar.org/paper/Strategies-for-Improving-Cocoyam-Production-among-%2C-Mgbedike-Celestine/78d939e5d33a183b2a31326c9070b856ee0ad289 (accessed on 9 September 2021).
100. Jackson, G.V.H.; Pelomo, P.M. Breeding for Resistance to Diseases of Taro, *Colocasia esculenta*, in Solomon Islands. In *International Symposium on Taro and Cocoyam in Baybay Philippines*; International Foundation for Science: Stockholm, Sweden, 1980; Volume 5, pp. 287–289.
101. Brown, V.M.; Asemota, H. PCR-Based Characterization of Dasheen (*Colocasia* sp.) and Cocoyam (*Xanthosoma* sp.). *J. Biotech. Res.* **2009**, *1*, 28–40.
102. Ivancic, A.; Garcia, J.Q.; Lebot, V. Development of visual tools for selecting qualitative corm characteristics of taro (*Colocasia esculenta* (L.) Schott). *Aust. J. Agric. Res.* **2003**, *54*, 581–587. [CrossRef]
103. Cho, J.J. Breeding Hawaiian taros for the future. In Proceedings of the Third International Taro Symposium, Nadi, Fiji Islands, 21–23 May 2003.
104. Quero-García, J.; Letourmy, P.; Ivancic, A.; Feldmann, P.; Courtois, B.; Noyer, J.L.; Lebot, V. Hybrid performance in taro (*Colocasia esculenta*) in relation to genetic dissimilarity of parents. *Theor. Appl. Genet.* **2009**, *119*, 213–221. [CrossRef]
105. Singh, D.; Hunter, D.; Iosefa, T.; Okpul, T.; Fonoti, P.; Delp, C. Improving taro production in the South Pacific through breeding and selection. In *The Global Diversity of Taro: Ethnobotany and Conservation*; Ramanatha, R.V., Matthews, P.J., Eyzaguirre, P.B., Hunter, D., Eds.; Bioversity International: Rome, Italy, 2010; p. 168.
106. TaroGen. *AusAID/SPC Taro Genetic Resources: Conservation and Utilisation Project*; Annual Report 1998/1990; Secretariat of the Pacific Community: Noumea, New Caledonia, 1999.
107. Singh, D.; Hunter, D.; Okpul, T.; Iosefa, T. Introduction to techniques and methods of taro breeding. In Proceedings of the AusAID/SPC Taro Genetic Resources: Conservation and Utilization, Taro Pathology and Breeding Workshop Taro Pathology and Breeding Workshop, Alafua Campus, Samoa, 5–7 November 2001; pp. 38–41.
108. Wilson, J.E. *Taro Breeding. AgroFacts Crop, No. 3/89*; IRETA Publications: Pittsburgh, PA, USA, 1990.
109. Tuia, V.S. In Vitro Multiplication of Taro (*Colocasia esculenta* var. esculenta L. Schott). Ph.D. Thesis, University of the South Pacific, Suva, Fiji, 1997.
110. Thinh, N.T. Cryopreservation of Germplasm of Vegetatively Propagated Tropical Monocots by Vitrification. Ph.D. Thesis, Kobe University, Kobe, Hyogo, Japan, 1997.
111. Verma, V.M.; Cho, J.J.; Aikne, J.; David, J. High frequency plant production of taro (*Colocasia esculenta* (L.) Schott) by tissue culture. In Proceedings of the 4th International Crop Science Congress, Brisbane, Australia, 26 September 2004.
112. Deo, P.C.; Harding, R.M.; Taylor, M.; Tyagi, A.P.; Becker, D.K. Somatic embryogenesis, organogenesis and plant regeneration in taro (*Colocasia esculenta* var. esculenta). *PCTOC* **2009**, *99*, 61–71. [CrossRef]
113. Fukino, I.T.O.N.; Hanada, K.; Ajisaka, H.; Sakai, J.; Hirochika, H.; Hirai, M.; Hagio, T.; Enomoto, S. Transformation of Taro (*Colocasia esculenta* Schott) using particle bombardment. *Jpn. Agric. Res. Q.* **2000**, *34*, 159–165.
114. He, X.; Miyasaka, S.; Fitch, M.M.; Zhu, Y.J.; Moore, P.H. Transformation of taro (*Colocasia esculenta*) with a rice chitinase gene (Abstract). *Vitr. Cell Dev. Biol. Plant* **2004**, *40*, 2104.
115. He, X.; Miyasaka, S.C.; Fitch, M.M.; Moore, P.H.; Zhu, Y.J. Agrobacterium tumefaciens-mediated transformation of taro (*Colocasia esculenta* (L.) Schott) with a rice chitinase gene for improved tolerance to a fungal pathogen *Sclerotium rolfsii*. *Plant Cell Rep.* **2008**, *27*, 903–909. [CrossRef]
116. Deo, P.C. Somatic Embryogenesis and Transformation in Taro (*Colocasia esculenta* var. esculenta). Ph.D. Thesis, The University of the South Pacific, Suva, Fiji, 2008.
117. Coates, D.J.; Yen, D.E.; Gaffey, P.M. Chromosome Variation in Taro, *Colocasia esculenta*: Implications for origin in the Pacific. *Cytologia* **1988**, *53*, 551–560. [CrossRef]
118. Sreekumari, M.T. Cytological studies in taro—A review. *J. Root Crops* **1997**, *23*, 1–7.
119. Parvin, S.; Kabir, G.; Ud-Deen, M.M.; Sarker, K. Karyotype analysis of seven varieties of taro, *Colocasia esculenta* (L.) Schott, from Bangladesh. *J. Biosci.* **2008**, *16*, 15–18. [CrossRef]
120. Lakhanpaul, S.; Velayudhan, K.C.; Bhat, K.V. Analysis of genetic diversity in Indian taro [*Colocasia esculenta* (L.) Schott] using random amplified polymorphic DNA (RAPD) markers. *Gen. Reso. Crop. Evolu.* **2003**, *50*, 603–609. [CrossRef]
121. Ivancic, A. Abnormal and unusual inflorescences of taro *Colocasia esculenta* (Araceae). *Aust. J. Bot.* **1995**, *43*, 475–489. [CrossRef]
122. Deo, P.C.; Taylor, M.; Harding, R.M.; Tyagi, A.P.; Becker, D.K. Initiation of embryogenic cell suspensions of taro (*Colocasia esculenta* var. esculenta) and plant regeneration. *PCTOC* **2009**, *100*, 283–291. [CrossRef]
123. He, L.; Lu, L.; Zong, M.; Zhou, H.; Wang, L.; Chen, N.Z.; Yuan, J.Y.; Jiang, E.P.; Zheng, L.; Li, Q.; et al. The Significance of KL-6 as Prognosis Monitoring Biomarker in Patients with Severe COVID-19 from Stabilized Stage toward Convalescence. *EuropePMC* **2021**.
124. You, Y.; Liu, D.; Liu, H.; Zheng, X.; Diao, Y.; Huang, X.; Hu, Z. Development and characterisation of EST-SSR markers by transcriptome sequencing in taro (*Colocasia esculenta* (L.) Schoot). *Mol. Breed.* **2015**, *35*, 134. [CrossRef]
125. Wang, L.; Yin, J.; Zhang, P.; Han, X.; Guo, W.; Li, C. De novo assembly and characterization of transcriptome and microsatellite marker development for Taro (*Colocasia esculenta* (L.) Schott.). *Int. J. Genet. Mol. Biol.* **2017**, *9*, 26–36. [CrossRef]
126. Liu, H.; You, Y.; Zheng, X.; Diao, Y.; Huang, X.; Hu, Z. Deep sequencing of the *Colocasia esculenta* transcriptome revealed candidate genes for major metabolic pathways of starch synthesis. *S. Afr. J. Bot.* **2015**, *97*, 101–106. [CrossRef]

127. Dong, X.; Fang, L.; Ye, Z.; Zhu, G.; Lai, Q.; Liu, S. Screening of biocontrol bacteria against soft rot disease of *Colocasia esculenta* (L.) schott and its field application. *PLoS ONE* **2021**, *16*, e0254070. [CrossRef] [PubMed]
128. Lebot, V. Taro *(Colocasia esculenta)* Genetic Improvement: A Need for International Collaboration. *Aroideana* **2005**, *28*, 166–173.
129. Okogbenin, E.; Porto, M.C.M.; Egesi, C.; Espinosa, E.; Santos, L.G.; Ospina, C.; Marín, J.; Barrera, E.; Gutiérrez, J.; Ekanayake, I. Marker-assisted introgression of resistance to cassava mosaic disease into Latin American germplasm for the genetic improvement of cassava in Africa. *Crop. Sci.* **2007**, *47*, 1895–1904. [CrossRef]
130. The African Orphan Crops Consortium (AOCC). 2020. Available online: http://africanorphancrops.org/ (accessed on 26 March 2022).