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AGROBIODIVERSITY IN AGRARIAN REFORM TERRITORIES: EXPERIENCES WITH GIZZARD YAM (*Dioscorea bulbifera*)

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Abstract: This work proposes a look at Dioscorea bulbifera from historical-cultural and agronomic perspectives. The article reflects on the centers of origin and geographic distribution of the species, as well as its medicinal and functional properties, according to world literature. It then presents a report and analysis of experiences with gizzard yam in Agrarian Reform territories in the Federal District, Brazil. To this end, a literary search was carried out on Dioscorea bulbifera, through which the most recurrent themes in scientific approaches to the species were categorized and an analysis of studies on the species was prepared from the locus of knowledge production. Based on productive characteristics, four agronomic experiments were also evaluated to focus on agrotechnical recommendations aimed at the traditional planting of Dioscorea bulbifera, conducted on live posts. Finally, future perspectives are discussed in order to think about different ways of managing the plant and the valorization of gizzard yam in family farming in agrarian reform territories.
Keywords: Ethnobotany, peasantry, plant management, family farming.

INTRODUCTION

The diversity of cultivated plants is the result of a process of coevolution between humanity and nature (Posey 1987; Balée 1994). Along this path, human beings were able to select the species of greatest interest, establishing the process of domestication of plants and animals, crucial to the establishment of anthropic landscapes. Human selection of individual plant phenotypes produces a response in the future population, which is also subject to natural selection (Clement, 2019, p.18).

Thus, the use and management of many species is the result of knowledge accumulated by different populations and expresses the biocultural diversity associated with the territories. This knowledge is expressed in the practices and links established by populations with locally available natural resources (Gargoloff et al., 2011). For this non-linear co-evolutionary process, important factors are: the genetic variability available for human selection, the needs and preferences of humans and the environmental variability where the new population will be managed or cultivated (Clement et al, 2015).

In this co-evolutionary dynamic, the factors of time and space are articulated in a way that assumes varying degrees, from incipient domestication, to semi-domestication, to domestication. In addition to these factors, it is also important to consider those that determine the occurrence of species, such as different natural abundances in the landscape, genetic variability and cultural diversity, which guides human needs and preferences. In general, human groups have more species in incipient domestication than species with domesticated populations (Clement, 2019).

This process results in biocultural heritage. Cultures are thought of here as ways of life: knowledge and practices, conventions and norms, rights, social networks, artifacts and other manifestations associated with biodiversity. The connections between cultures and agrobiodiversity converge in agri-food systems (Edti and Udry, 2019).

Managed diversity is reflected in the populations' food base, that is, there is a direct relationship between biodiversity, culture, food and health. Food, in addition to nutritional aspects, expresses cultural meanings and symbols. Among these, we can say that life stories and ancestry influence cropping, management and food choices. This fact is expressed in the spread of plant species across different locations, which allowed, in the history of agriculture, for many species to be cultivated on different continents

(Ferreira et al, 2020). Thus, the origin of species is associated with the history of arrival of different populations in territories, their knowledge and what they bring with them.

A widely cultivated genus throughout the world is yam (Family Dioscoreaceae and genus Dioscorea), with around 600 species (Kouam et al, 2018). According to Ferreira et al (2020), yam cultivation is important in several aspects, it is widely distributed throughout the world, in tropical and subtropical zones, which demonstrates its relevant adaptation capacity. The most important species of this genus are known to produce edible tubercles, such as D. cayennensis, D. rotundata, D. alata, D. trifida and D. esculenta (Santos et al, 2006).

Among the species of this genus, Dioscorea bulbifera stands out for food and medicinal use and was widely disseminated in Brazil. The plant is an herbaceous vine that can reach 20 meters in length, with abundant branching that occurs from the lengthening of the main stem. Its leaves are cordiform in shape, alternate, bright green in color, with palmate veins and rounded basal lobes originating from a bud. The inflorescences are axillary spikes that appear approximately four months after the plant sprouts, emerging from the leaf axil. The flowers are unisexual and have tepals. The tubers are aerial and form in the axils of the leaves two months after the plant sprouts (Kundu et al, 2020; Jiménez-Montero and Martínez, 2016).

In Brazil, Dioscorea bulbifera is popularly known as gizzard yam, butterfly yam, air yam and cord yam (Rodrigues et al, 2020). This species is widely used for food and medicinal use. Among its characteristics are: high nutritional value and ability to adapt to different agroecosystems. However, the species is still little recognized and used for commercial plantings, being restricted to direct marketing strategies, such as fairs and baskets.

Knowing more about the species, its potential uses and forms of management contributes to its recognition and expansion of cultivation areas. To do this, it is necessary to know the main places of occurrence, forms of use and cultivation strategies. As it is a species associated with migratory flows, it is also important to gather knowledge from local populations, as well as develop participatory research strategies for field experimentation.

This study proposes an analysis of the species considering historical-cultural and agronomic perspectives. The centers of origin and geographic distribution of the species are presented, highlighting the medicinal and nutritional properties of the cultivated plant. Some experiences associated with an action research process on the use and management of gizzard yam in Agrarian Reform territories in the Federal District, Brazil, are also reported and analyzed.

MATERIAL AND METHODS

ACTION RESEARCH CONTEXT

This study is the result of an action research process on the use of agrobiodiversity management carried out collaboratively with families from two agrarian reform territories that were constituted from the struggle for land of rural workers who are part of the Workers' Movement Landless Rural Workers (MST). The settlements are located in the municipality of Planaltina, Federal District, Brazil, and are inserted in the Savannah biome.

The Pequeno Willian settlement was created by the Institute of Colonization and Agrarian Reform (INCRA) on 12/26/2011, in an area of 144.17 hectares (latitude: -15.68505; longitude: -47.70130), with 22 families seated. The Oziel Alves III pre-settlement was created on 12/20/2012, with an area of 2,317.80 hectares and 168 settled families (latitude: -15.56856; longitude: -47.49465). At Oziel

Alves III, families adopt different management strategies for production systems, from organic and agroecological to conventional. In the Pequeno Willian settlement, families established a collective agreement to adopt agroecological principles for the management of their production systems.

The beginning of the action research occurred with the first agrobiodiversity survey carried out with ten families from the Pequeno Willian Settlement, in 2018. In 2019, the floristic survey continued with four families and in the Savannah remnant areas in the pre-settlement Oziel Alves III.

DIALOGUE OF KNOWLEDGE AND PARTICIPATORY EXPERIMENTATION

As part of the participatory experimentation process, agronomic experiments were implemented with gizzard yam, together with four families from the Pequeno Willian Settlement and the Pre-settlement Oziel Alves III, both in Planaltina, Federal District, Brazil.

Planting in the settlements took place between November 2021 and June 2022. Based on the characteristics previously analyzed in each plot, a planting method was planned that included the areas, practices and technologies already used by the families. Thus, four different gizzard yam implementation systems were carried out: planting with staking of the aerial part of the plant using an espalier and the tubers grown in a bed; planting with espalier staking and tubers planted in cradles; planting in the middle of the typical savannah with staking made by native trees and tubers planted in cribs; and planting within an Agrocerratense System (SACE) with staking carried out in native trees and tubers planted in cribs (Table 1).

In each production system, four different accessions of D. bulbifera were implemented, which are part of the germplasm collection of the Brazilian Agricultural Research Corporation – National Center for Vegetable Research (Embrapa Hortaliças), namely, gizzard yam white SC, gizzard white yam ES, the gizzard yam purple, the gizzard yam black. At Embrapa Hortaliças, the planting of gizzard yam is done in lines with an espalier staking system (1.60 cm high), similar to the planting of passion fruit, with soil from the bed fertilized in the cribs with organic fertilizer and thermophosphate, in addition to the use of manure, green manure with millet or mowed forage sorghum periodically interspersed with the planting lines. Planting is carried out more densely (space between 1.5 m and 2.0 m between rows x 1 to 1.5 m and 2.0 m between plants in the rows) aiming to obtain greater productivity (production per area).

One of the families involved in the experiment had the structure and vocation for agronomic work very close to that developed at Embrapa Hortaliças. Therefore, it was decided to use the method described above (Figures 1 and 2), modifying only the fertilization to that already used by the farmer, which is made with the use of poultry manure only.

When planting in the middle of the typical savanna (Figure 3), tree species were chosen for the climbing plant, in accordance with observations from previous experiments by the farming family. Among the four accessions of gizzard yam, eleven seedlings were planted, the trees of Pau-terra-roxo (*Qualea parviflora*). The remaining seedlings were implemented alongside the following trees: Pau-terra-grande (*Qualea grandiflora*), Laranjinha do savannah (*Styrax ferrugineus)*, Pau Doce (*Vochysia elliptica*), Carvoeiro (*Tachigali vulgaris),* Seca-ligeiro (*Pera glabrata),* Curriola (*Pouteria ramiflora*), Pau de sobre (*Emmotum nitens*). A total of 40 cm cradles was opened near the base of the tree, which were filled with soil composted by the

Territory	Sector	Typification
Pequeno Willian	Sector 1	Treating with espalier, planting in beds
Pequeno Willian	Sector 2	Tutoring with native trees, planting in a crib
Oziel Alves III	Sector 3	Treating with espalier, planting in a crib
Oziel Alves III	Sector 4	Tutoring with native trees, planting in a crib

Table 1: Gizzard yam (D. bulbifera) planting systems implemented with four families in the Pequeno Wililam and Oziel Alves settlements, Planaltina, Distrito Federal, Brazil. (Elaborated by the authors).

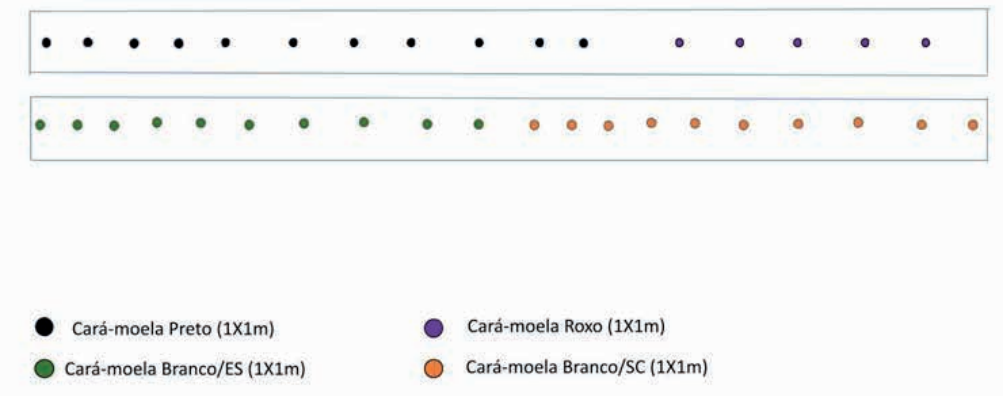

Figure 1 - Sketch of planting in bed with espalier (Elaborated by the authors)

Figure 2: Planting with espalier inside a flowerbed in one of the families. (Photograph by the authors).

farmer himself, the only fertilization carried out in this experiment. The gizzard yams were planted buried in the ground, but without sinking the tuber too much.

SACE is a biodiverse plantation inspired by typical savannah vegetation, with the intention of meeting the demand for productive restoration systems for the biome's savanna landscapes, which are those where there are trees scattered among small plants (grasses, herbs and shrubs). At SACE, we seek to reconcile agricultural production and the ecological restoration of degraded environments. Agricultural plants coexist with trees, herbs, shrubs and grasses native to the Savannah, promoting benefits for the environment, increased productivity and restoration effectiveness. In the restoration area of one of the families there were already remaining native trees, at the foot of these individuals 20 cm deep cribs were opened for planting the four accessions of gizzard yam, using only cattle manure as fertilizer (Figure 4).

When planting with espalier staking, without a bed, the farmer opened beds 20 cm deep to plant the four accessions of gizzard yam and fertilization was done with cattle manure and thermophosphate. The gizzard yams were planted at a smaller spacing (50 cm), as the farmer wanted to test the use of a greater number of plants in a reduced area.

In the experimental areas, in addition to Dioscorea bulbifera, eighteen species were implanted, which are also part of the germplasm collection of the Brazilian Agricultural Research Corporation – National Vegetable Research Center (Embrapa Hortaliças) (Table 2).

SYSTEMATIC REVIEW

Interviews were carried out about the use and planting of gizzard yam with farming families from two agrarian settlements in the Federal District, Brazil. At the same time, a bibliographic review was carried out on the species in the database of the Periodicals Portal of the Coordination for the Improvement of Higher Education Personnel (CAPES) with the entry "Dioscorea bulbifera". This portal brings together and makes available content produced in Brazil and others signed with international publishers, with more than 49 thousand full-text periodicals and 455 databases of diverse content.

In this search, all articles published in peer-reviewed journals were collected from 1965 to 2022, which resulted in 361 articles, among which those that provided information about centers of origin and geographic distribution of the species were analyzed. To understand the main themes of studies associated with Dioscorea bulbifera in contemporary times, the literary search was refined in the 2012-2022-time frame, obtaining 53 articles. Recent articles were grouped around the most recurring themes, with the following categorization: 1. Medicinal properties; 2. Biodiversity, genetics and conservation; 3. Functional properties; 4. D. bulbifera as an invasive plant.

RESULTS AND DISCUSSION

TRENDS IN STUDIES ON DIOSCOREA BULBIFERA

The majority of studies on Dioscorea bulbifera (2012-2022) involved medicinal properties (69.9%), while 16.9% researched biodiversity, genetics and conservation. 9.4% of the articles address data on functional properties and only 3.8% deal with the species and its invasive potential (Figure 5).

The proportion of topics studied on Dioscorea bulbifera depends on the locus of knowledge production. The largest number of articles is concentrated among researchers from China (18 articles), followed by India

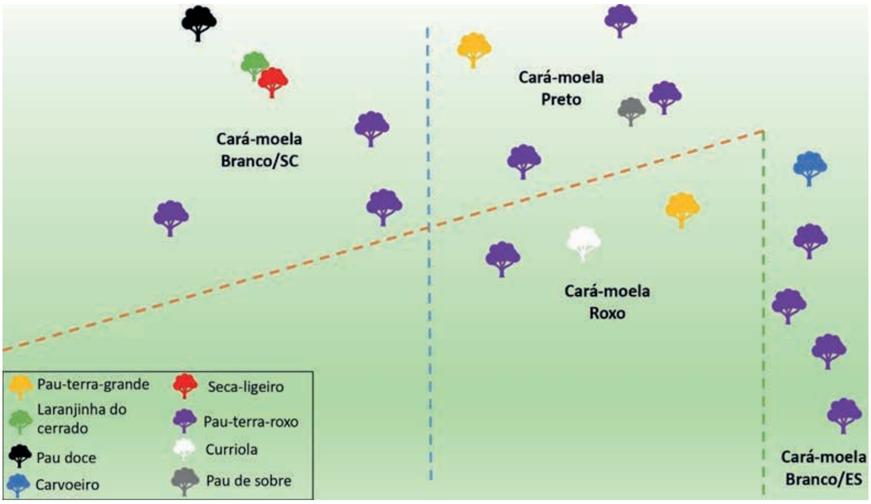

Figure 3: Sketch of the planting in the middle of the typical savanna, with the implementation of gizzard yam with staking in native tree species. (Elaborated by the authors).

Figure 4: Development of the purple gizzard yam within the Agrocerratense System. Photograph of the authors.

Scientific name	Popular name
Dioscorea bulbifera	Cará-moela (Cará-do-ar)
Dioscorea cayennensis	Cará branco, variedade pezão
Dioscorea alata	Cará roxo
Dioscorea altissima	Cará-de-espinho (Cará-japecanga)
Xanthosoma riedelianum	Mangarito
Maranta arundinacea	Araruta, variedade seta-MG e redonda-BA
Pereskia aculeata	Ora-pro-nóbis
Cnidoscolus aconitifolius	Chaya (Espinafre de árvore), variedades mansa e estrela
Talinum triangulare	Cariru (Língua-de-vaca)
Talinum paniculatum	João-gomes (Beldroegão)
Amaranthus cruetuns	Caruru (Bedro), variedades roxo e verde
Celosia argentea	Celósia (Espinafre africano)
Brassica juncea	Mostarda
Hibiscus sabdariffa	Vinagreira (Cuxá)
Lagenaria ciceraria	Caxi (Abóbora d'água)
Cyclanthera pedata	Maxixe-do-reino (Chuchu-de-vento)
Dolichos lablab	Feijão-mangalô
Basella alba	Bertalha

Table 2: Traditional vegetables implemented in the Pequeno Willia and Oziel Alves III settlements, Planaltina, Federal District, Brazil. (Elaborated by the authors)

(11 articles), Nigeria (8 articles), Southeast Asia - Indonesia, Thailand, Vietnam and Malaysia - (7 articles), USA (4 articles), Brazil (2 articles), Uganda, Cameroon and Japan (2 articles each).

Among the studies on medicinal properties (35 in total), 48.5% are by Chinese researchers, 25.7% were published by Indians, 14.2% by Africans (Nigeria and Cameroon), 8.5% from Southeast Asia (Thailand, Vietnam and Malaysia), 2.8% from the USA and 2.8% from Brazil.

Nigerian researchers have published in significant quantities on various topics, namely, functional properties; biodiversity, genetics and conservation; and medicinal properties. The topic of functional properties is mostly studied in Nigeria, only one article on the subject was published by Japan. In the case of China, the vast majority of articles (16) deal with the medicinal properties of D. bulbifera, only two articles address biodiversity, genetics and conservation. The invasive potential of Dioscorea bulbifera has only been studied by North American researchers.

Regarding the temporality of publications, it is observed that, between 2017 and 2020, there was a growing trend of topics such as biodiversity, genetics and conservation. Between 2019 and 2022, the theme of functional properties was highlighted. The medicinal properties of D. bulbifera were researched in greater quantities in 2014 and 2021. While the invasive potential of the plant was the subject of research in 2015 and 2022.

Next, we discuss some data found in the bibliographic review based on the categorization proposed. Initially, issues linked to biodiversity, genetics and conservation are addressed, also considering the invasive potential of the species. Next, the focus will be on the medicinal and functional properties of D. bulbifera.

CENTERS OF ORIGIN AND GEOGRAPHIC DISTRIBUTION OF THE SPECIES

The centers of origin of the main species of food interest of Dioscorea spp. are diverse. Dioscorea rotundata and Dioscorea cayenensis appear to originate from Africa, as do oil palm (Elaeis guineensis), African rice (Oryza glaberrima), millet (Pennisetum glaucum), among other species. The tallest Dioscorea, the thorny yam, possibly has the Americas as its center of origin, especially the Amazon regions (Schiefenhövel, 2013).

Dioscorea bulbifera may have Southeast Asia, Papua New Guinea and/or Africa as its center of origin (Schiefenhövel, 2013; Horrocks et al, 2008) (Figure 7). There is a hypothesis that its center of origin is Southeast Asia, with New Guinea being a secondary center of dispersion. Another hypothesis considers New Guinea to be the place of origin of the species as it is the center of greatest genetic diversity (Horrocks et al, 2008).

Africa, in turn, also has a relevant genetic diversity of Dioscorea bulbifera (Croston et al, 2011). Although studies on the genetic diversity of D. bulbifera cover more of China, morphological analyzes of intraspecific diversity in continental Africa indicated more than 11 varieties, based on bulbil and leaf morphology, against nine Asian varieties (Croston et al, 2011).

In a study on the gizzard yam found in Florida (USA), researchers characterized the genetic diversity of the African gizzard yam, sampling six haplotypes on that continent. Three of the most prevalent African haplotypes were geographically widespread in West and East Africa. These three are also the most genetically distant from the Florida and Chinese haplotypes, relative to other African haplotypes, as determined by parsimonious network analysis (Croston et al, 2011).

Given the morphological differences

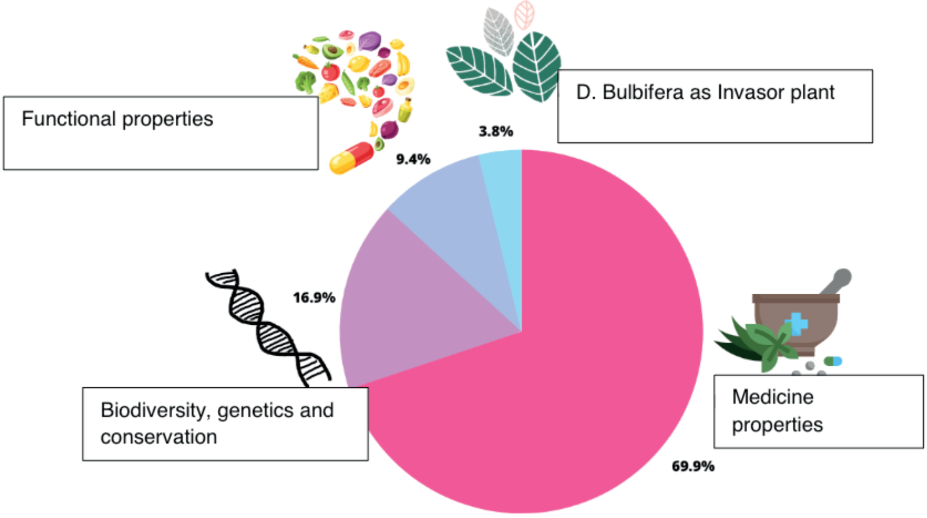

Figure 5 - Categorization of scientific approaches to D. bulbifera between 2012 and 2022 (Elaborated by the authors. Source: articles searched on the CAPES journal portal)

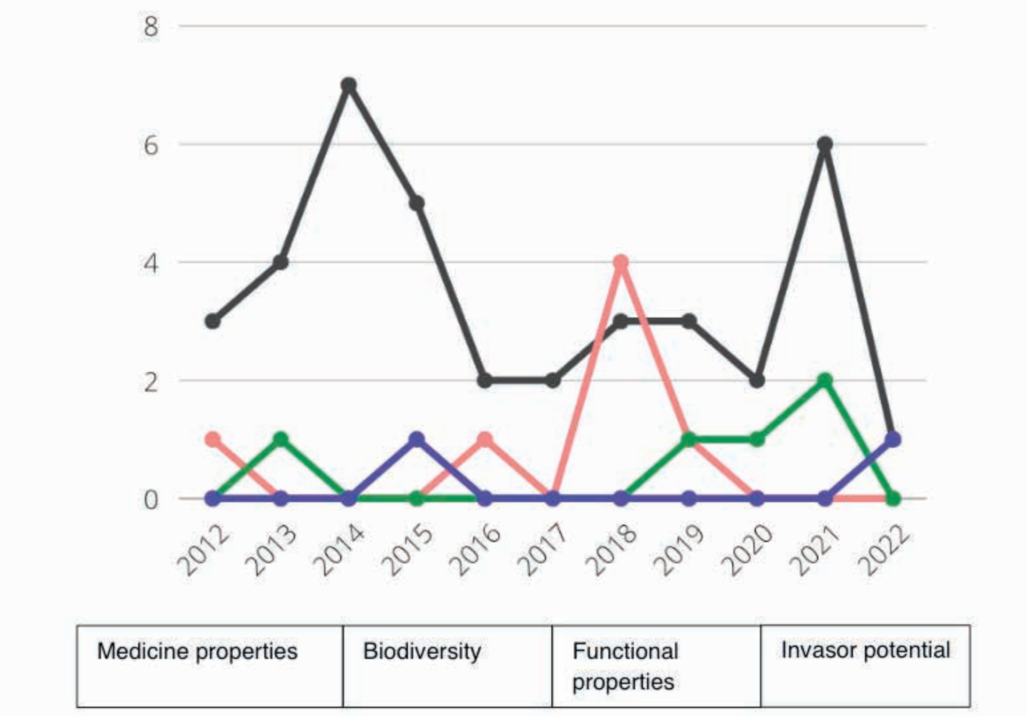

Figure 6 - Temporality of scientific approaches to D. bulbifera according to the proposed categorization (Elaborated by the authors. Source: articles searched on the CAPES journal portal).

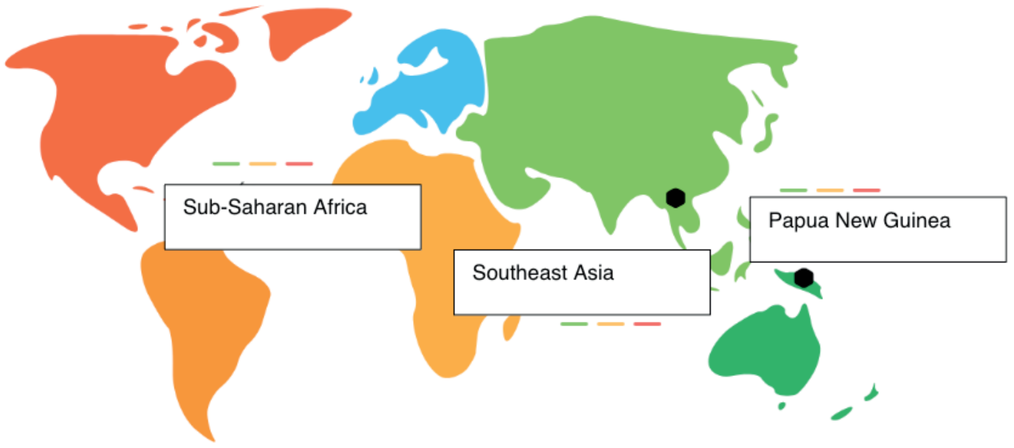

Figure 7 - Possible centers of origin of D. bulbifera

(Elaborated by the authors. Source: articles searched on the CAPES journal portal).

Figure 8: Geographic distribution of D. bulbifera.

Adapted from Kundu et al, 2020, p.2.

between the African and Asian varieties of D. bulbifera, hypotheses were launched that they were distinct species. African D. bulbifera has angular tubercles. Cultivated African varieties have hairs on the leaf epidermis, which are absent in cultivated Asian and African varieties (Croston et al, 2011). Genetic studies based on chloroplast restriction patterns confirm morphological analyses, pointing to a clear separation between African and Asian plants (Croston et al, 2011).

In addition to the morphological and genetic dimensions, studies on the species allow for an analysis related to its uses. As seen in the previous topic, while in China D. bulbifera is closely associated with traditional medicine, in West Africa, especially in Nigeria, the cultivation of gizzard yam is also associated with food.

Horrocks and other researchers from the University of Auckland, New Zealand, carried out studies with plant fossils found in archaeological sites located in New Caledonia (Me´ Aure´ Cave), which dates back to an occupation 3,240 years before the present, and in Papua New -Guinea (Yuku rock shelter), whose human occupation dates back to 14,200 years before the present. In both, traces of the species Dioscorea bulbifera were found, along with other species of the genus Dioscorea, namely Dioscorea alata, Dioscorea nummularia and Dioscorea pentaphylla (Horrocks et al, 2008).

To identify plant fossils, morphological analyzes were carried out using starch grains. Based on size and shape, four species were grouped: Dioscorea alata, Dioscorea bulbifera, Dioscorea nummularia and Dioscorea pentaphylla. All have average grain sizes greater than 35 mm with widely overlapping standard deviations and a distinctive oval to triangular, often elongated, shape. Due to the corrosion of fossil grains and given the wide overlap in the morphology of starch grains in this group, researchers were unable to differentiate between the four species within the group (Horrocks et al, 2008, p.294).

Archaeological findings suggest the manipulation of these species since the first use of the site, possibly before 14,200 calibrated years before the present. Although the plant has the ability to reproduce spontaneously, in an environment where it does not form a native population, it is rarely found in nature. Panamanian peasant communities insist that D. bulbifera is a cultivated plant (Jiménez-Montero and Martínez, 2016). Horrocks et al (2008) identify D. alata as a pan-tropical domesticated species, while the others, including D. bulbifera, would be non-domesticated cultivated species. However, based on other studies, one could think of the gizzard yam as a species with incipient domestication.

It is known that species of the genus Dioscorea were the main starchy staple foods in the Highlands of New Guinea. However, the yam produces little or no phytoliths of taxonomic importance (Horrocks et al, 2008) and the pollen grains of many species are small, apparently delicate and without distinct ornamentation, so that it was not possible to identify the yam by means of pollen and phytoliths. Nevertheless, according to researchers, starch analysis is highly suitable for identifying yams in archaeological deposits, especially because many species have relatively large and distinctly shaped starch grains (Horrocks et al, 2008, p.300).

Studies point to New Guinea, especially its Highlands, as an important center of agricultural origin, with emphasis on horticulture and arboriculture (Schiefenhövel, 2013). The Yuku site, as it is estimated to date before the beginning of agriculture, is interpreted as a seasonal camp of hunting-gathering societies. The presence of different yam species suggests evidence of ancestral

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plant cultivation in the New Guinea Highlands (Horrocks et al, 2008; Schiefenhövel, 2013). Genetic sequencing and molecular analysis would make it possible to confirm the identification of the fossils and collect data on the genetic diversity of Dioscorea bulbifera, as well as D. alata, D. nummularia and D. pentaphylla.

Finally, studies point to both Africa, Oceania and Asia as possible centers of origin for gizzard yam. At the same time, Dioscorea bulbifera occurs abundantly in regions of Asia, northern Australia, America and sub-Saharan Africa. Due to its geographic distribution, D. bulbifera is a plant from the Global South (Lees, 2020) (Figure 8).

In a scenario of "ecological imperialism" (Crosby, 1993), the characterization of the species D. bulbifera as a plant from the global South draws attention. The biological invasion carried out by European populations in different regions of the planet constitutes what Crosby called "portable biota", responsible for expelling or even eliminating the flora, fauna and native inhabitants of different regions of the world (Crosby, 1993). Thus, the circulation and permanence of this species on three different continents, all located in the Global South, is a great feat of resistance. One could think of gizzard yam as a counter-colonial plant, in the sense proposed by Mestre Bispo (Santos, 2015).

The presence of gizzard yam in the United States of America reinforces its characterization as a plant from the global south. D. bulbifera was introduced to North America and the West Indies as a result of the West African slave trade (Croston et al, 2011). Later, at the beginning of the 20th century, between 1902 and 1925, historical records indicate that the United States Department of Agriculture (USDA) brought the species to Florida from West Africa, Asia, Polynesia and the West Indies.

Only in the American literature, D. bulbifera is treated as an invasive plant, present in a variety of ecosystems, especially in disturbed areas (Croston et al, 2011; Rayamajhi et al, 2016; Rayamajhi et al, 2020). It grows rapidly to the top of tree canopies and forms a mat that weighs down and shades native vegetation, leading to declines in canopy height diversity and changes in plant community function (Croston et al, 2011).

While in Oceania, Asia and Africa the bibliography reports traditional uses of gizzard yam associated with medicine and food, in the USA, the plant is apparently not used by the local population. However, in Latin America, the plant is a traditional food (Jiménez-Montero and Martínez, 2016; Souza, 2021). It is present in Brazil and Panama, as well as Mexico (Yucatán, Chiapas, Tabasco and Campeche), where it is known as bauyak, makal or flying potato; Cuba, called flying yam; Nicaragua, where it is known as the "Caribbean potato"; and Colombia, where it is called tabena or yam by indigenous and Afro-descendant communities (Jiménez-Montero and Martínez, 2016).

When thinking about the migratory flows of the species, it is observed that, in Latin American countries, D. bulbifera is a traditional vegetable. In the United States, studies point to the development of biological control strategies for the species, due to its inhibitory action on native species. This way, partnership relationships between the gizzard yam and human groups are present in countries in the Global South. When developing in northern countries, gizzard yam appears as a disturbing element in local landscapes, which reinforces its counter-colonial character.

MEDICINAL AND FUNCTIONAL PROPERTIES OF D. BULBIFERA

The graph presented in the previous topic, on the characterization of scientific approaches to D. bulbifera, shows that almost 70% of the articles published in the last ten years focus on the medicinal properties of the species (Figure 5). The medicinal properties of D. bulbifera cover a wide range of action: anticancer, antibacterial, anti-inflammatory, antiobesity, antidiabetic, antiviral (D. bulbifera has anti-HIV-1 integrase compounds), neuroprotective (protection against neurological disorders), among others (Kundu et al, 2020, Ikiriza et al, 2019).

Studies on the medicinal properties of the species highlight, however, its toxicity, especially its hepatotoxicity. Most articles that address the medicinal properties of D. bulbifera propose technologies to isolate chemical compounds and inhibit the toxic effects of the plant (Guan, Zhu, Xiao, et al, 2017; Tapondjou et al, 2013; Shi, Zhang, Zhao, et al 2018; Tan et al, 2022; Qu et al, 2017; Trivedi et al, 2021; Sun et al, 2021; Ma el al, 2014; Ma et al, 2012; Lin et al, 2014; Yang et al, 2014; Li et al, 2016; Ma et al, 2018).

The others deal with different topics, including anti-cancer action, antioxidant action, anti-diabetic action, anti-inflammatory action, anti-malarial action, treatment for dysentery and diarrhea, treatment of myocardial ischemic reperfusion injury and others.

D. bulbifera a plant very present in traditional Indian, African and Chinese medicine for different purposes and with very varied ways of use (Ikiriza et al, 2019). "D. bulbifera has been widely used to treat various diseases such as hemoptysis, goiter, skin infections, orchitis, pharyngitis and cancer in traditional Chinese medicine" (Kundu et al, 2020, p.1).

As an infusion it is applied to cuts and wounds due to its high tannin composition which is used to accelerate wound healing in an inflamed membrane (Ikiriza et al, 2019). Thus, it is used for blood clotting and poison detoxification (Kundu et al, 2020).

It is also used for improving memory, anti-aging, constipation and fever (Ikiriza et al, 2019). In Cameroon and Madagascar, crushed bulbils are applied to abscesses, boils and wound infections (Ikiriza et al, 2019). Regarding sexual and reproductive health, D. bulbifera has medicinal uses as contraceptives and as a remedy for sexual vigor (Ikiriza et al, 2019). The bulb of D. bulbifera has also been identified to contain steroid saponin, a phytochemical called diosgenin, which has anti-fertility activity (Shajeela et al, 2011). It is also used to combat hemorrhoids, dysentery, syphilis, ulcers, tuberculosis, leprosy, cough and diabetes.

Some studies reveal the nutraceutical properties of the species, emphasizing its broad nutritional value. Olatoye and Kazeem (2019) carried out a study with fifteen cultivars of gizzard yam, processing them into flour and evaluating them for nutrient and phytochemical content, using standard methods. The cultivars' flour had low lipid and moisture content, but high carbohydrate and energy values. Potassium was the most abundant mineral. The cultivars were also rich in calcium, magnesium, phosphorus and iron. Antinutritional factors Tannins, Phytates and Oxalates were also evident (Olatoye and Kazeem, 2019). The researchers concluded that the species has potential for the development of food and functional products.

Ikiriza et al (2019) corroborate the study by Olatoye and Kazeem (2019), highlighting a superior nutritional value in D. bulbifera compared to other species of Dioscorea, with the highest levels of calcium, magnesium, sodium and zinc, greater values of vitamins B1, B3 and C and higher protein content. As it is more nutritious and less sweet, it is recommended for treating diabetes and obesity (Ikiriza et al 2019).

Although some articles address the

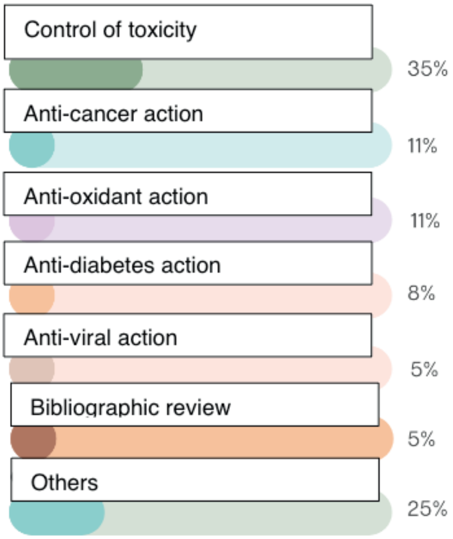

Figure 9 - medicinal properties of D. bulbifera in articles from 2012-2022.
(Elaborated by the authors. Source: articles searched on the CAPES journal portal).

Figure 10. Gizzard yam from one of the families **Figure 11.**: Purple gizzard yam from Embrapa Hortaliças
(Photographs by authors)

cultivation and consumption of gizzard yam in different peasant contexts around the world, such as in western Nigeria (Kayode et al, 2017) and Panama (Jiménez-Montero and Martínez, 2016), few studies systematize the cultivation methods of the species. The next sections of the article are dedicated to this topic.

GIZZARD YAM IN AGRARIAN REFORM TERRITORIES IN THE FEDERAL DISTRICT, BRAZIL

The farming families involved in this action research have an ancestral relationship with D. bulbifera. During an interview, one of the farmers says that, when she lived in Bico do Papagaio, an area in the state of Tocantins, northern Brazil, gizzard yam was used in her family for medicinal purposes. The children had curubas (a type of skin irritation) caused by the rice harvest; his grandmother would then grate or macerate the tuber, make a poultice and place it on the skin, a procedure similar to what is done in India (Tiwari and Pande, 2006), Cameroon and Madagascar (Ikiriza et al, 2019). Gizzard yam was also the food that nourished the family when there was nothing to eat at home. His grandmother then asked the children to go look for gizzard yam in the woods. She says that it was not a plant cultivated by the family, but it was always available locally, which is no longer a reality today. This is a memory that dates back to the 1970s approximately.

In the southern region of Brazil, in the state of Paraná, another farmer reports that the gizzard yam accompanied his family on migratory processes. When moving to a new residence, the family built an espalier over the washing tank and planted gizzard yam there, which benefited from the water and, at the same time, offered shade for domestic activities. When migrating to the states of Goiás and Distrito Federal, in the Central-West region, the farmer reconnected with the gizzard yam in a mnemonic search guided by food culture, based on the "foods of the past".

In another family, relations with the species go back one hundred (100) years, passing through four different generations. The gizzard yam travels between the states of Minas Gerais and the Federal District, respectively the southeast and central-west regions of Brazil. In the three families, food is consumed mainly cooked, alone or accompanied by some animal protein, such as chicken, for example.

In Panama, it is also observed that D. bulbifera is a species with a very old presence in communities, its main use being human food. Just like Brazilian settled families, Panamanian peasants highlight the importance of the species as a highly nutritious food with some medicinal uses (Jiménez-Montero and Martínez, 2016). While in Panama it is a food intended exclusively for self-consumption, farming families in the Federal District, Brazil, experience the sale of gizzard yam at fairs and peasant baskets.

In the experiment carried out with farming families, in parallel with the ancestral experiences with the plant, four different accessions of the species were included: the white gizzard yam ES, coming from the region of São Bento de Urania - Espírito Santo; the white gizzard yam SC, from Joinville / São Francisco do Sul - Santa Catarina; the purple gizzard yam, collected in the community of Bonfim, Três Marias - Minas Gerais; and black yam from a family farming fair - Rio Grande do Sul. All are part of the yam germplasm collection at Embrapa Hortaliças and are cultivated annually during the rainy season (September-October to April-May) aiming at the conservation and promotion of the species.

The accessions cultivated locally by the farming families of Planaltina-DF, as well as some of the accessions cultivated by Embrapa Hortaliças and introduced into the plots of the farming families, morphologically resemble the African form of the gizzard yam, due to the angular shape of the bulbils.

Regarding forms of use, the Brazilian experience is also close to the African one, as gizzard yam in Brazil is mainly a food. Its medicinal uses are in the background, a fact confirmed by field and bibliographical research. This may be an indication that the gizzard yam introduced in Brazil comes from Africa and possibly arrived in Brazilian territory through transatlantic trafficking, as in the case of the USA (Croston et al, 2011). The same may have happened in Panama, where there is a perception of the plant as revitalizing, "levanta muertos", with a high nutritional power (Jiménez-Montero and Martínez, 2016, p.63).

PARTICIPATORY EXPERIMENTATION

In surveys carried out in both territories, we verified the presence of traditional vegetables, referred to as important plants by the families involved. Traditional vegetables are regional foods, made from local agri-food crops (Madeira, 2013). The cultivation of traditional vegetables in Brazil is carried out mainly by family farmers, peasants, traditional people and communities. The knowledge of these plants is passed from generation to generation. Among traditional vegetables are the so-called Non-Conventional Food Plants (PANC's) (Jesus et al, 2020).

Participatory experimentation has been presented as a proposal to strengthen environments for interaction and agroecological innovation, contributing to the recognition of the use and management of traditional vegetables and their experimental planting, with emphasis on yam. This strategy leads to the design and implementation of a process of learning, building and managing agroecological knowledge. This type of approach can also help in the domestication and popularization of Dioscorea bulbifera, a plant with high adaptive capacity to local soil and climate conditions and which has high nutritional value.

In the process of installing the experimental areas, different knowledge about the ways of planting gizzard yam was verified. At this stage it was possible to promote the exchange between the scientific technical knowledge developed by Embrapa Hortaliças and the socio-ecological knowledge developed by the settled families. Among families, there are different forms of coexistence with the plant, mediated by the socio-ecological environments where the plant was located, and also by the academic environment. Thus, four ways of planting and managing gizzard yam were identified and are in the process of experimentation: the scientific technician; the replacement of inputs for fertilization, using resources available to the family; planting associated with native Savannah vegetation in agrocerratense systems (SACE); and more dense planting.

When we compare the experiences in focus with the strategies of Panamanian peasants, we see that the planting proposals are similar. They plant by burying the entire tuber in the ground, close to a living plant or a trunk or branch that serves as support. Machete and hoe are used in sowing work. Restful soils with good drainage and shallow slopes are preferred, as gizzard yam does not develop in floodable soils. It is usually associated with any other plant that provides support (Jiménez-Montero and Martínez, 2016).

Regarding productivity, it was possible to observe that, in plot 1, in systematized planting with espalier staking and in beds, there was greater production of gizzard yam, compared to the other plots. The purple gizzard yam produced 1.53 kg plant-1, followed by the white gizzard yam SC with 1.30 kg plant-1. Regarding tuber size, the four accessions weighed between 110 and 200 g, which converges with the values found by Botrel et al. (2017), from 50g to 600g as the weight of each tuber. It is understood that the interaction between some factors may lead to a decrease in productivity and that it is necessary to observe factors such as: drought (the 2021 rainfall index was below the 2017 to 2020 time series); the production window (gizzard yams were planted late, at the end of November); the condition of the seedlings (they had damaged sprouts and withered tubers); the size of the seedling tuber is not standardized.

In plot 2, cultivation using native trees from the typical savannah as tutors, better development of the aerial part of the plant was observed, as well as the production of tubers, using the species Pouteria ramiflora (curriola) as a natural tutor for the gizzard yam. Even so, productivity was not significant, with some plants not establishing fruiting. From the experience of the farmer involved in this experiment, productivity is better in the second year of planting.

In plot 3, there was a severe attack by ants, and in plot 4, the entry of uncontrolled fire from a neighboring area compromised production, highlighting the fragility of properties surrounded by areas with conventional agriculture with a high degree of imbalance. As observed in Panama, the main pest is drovers or leaf-cutter ants (Atta spp.), but stink bugs (Trigona spp.) and crickets (Gryllus spp.) are also mentioned. In any case, pests are of greater importance in the initial stages of farming, as they can completely inhibit its growth, as occurs with attacks by crickets and drovers (Jiménez-Montero and Martínez, 2016, p.62).

Gizzard yam cultivation is easy to manage and presents good yields. One of its characteristics is resilience. The plant has a basal tuber that enters a dormant state at the end of the vegetative cycle and resprouts with the first rains of the following season, probably stimulated by the increase in humidity, generating a new plant (Jiménez-Montero and Martínez, 2016). It is observed that the traditional management of gizzard yam among Brazilian and Panamanian peasants involves staking the plant on living posts. The native tree species provides the soil with nutrients necessary for the gizzard yam that is associated with it. Furthermore, it is a rustic and economical form of management, which does not require investment in structuring beds and espaliers.

Some agrotechnical recommendations can be highlighted from the experiment, with a view to improving the traditional management of yam with staking on live posts (Table 3).

FINAL CONSIDERATIONS

Agri-food systems encompass a complexity of temporalities and spatialities that range from the domestication of wild species, through different production processes to the arrival of food on the table. Food cultures permeate this system, signaling the paths through which production systems and food preferences are designed.

Considering the possible centers of origin of Dioscorea bulbifera and its historical trajectories, it is imagined that the gizzard yam crossed the Atlantic Ocean together with enslaved peoples from Africa to the Americas. If in the Eastern Hemisphere the plant is used mainly for medicinal purposes, with broad powers in traditional African, Chinese and Indian medicinal systems, in the diaspora to the Western Hemisphere of the globe, the gizzard yam takes on an eminently nutritional character. It has adapted very well to the American tropics, growing in partnership

Aspects	Answers obtained	Agrotechnical recommendation
Plant seedling quality	Direct influence on plant development	Use larger tubers, with good nutritional reserves, resistance to droughts and other adversities
Susceptibility to pests	Pests transition from the guardian species to the gizzard yam	Choose a guardian species in good phytosanitary condition. Avoid species with high susceptibility to diseases. Use organic solutions for pests.
	Nutrients are made available to the soil.	Select guardian species in association with mycorrhizal fungi with a view to improving the nutritional quality of the soil for the cultivation of gizzard yam
Characteristics of the guardian species	Diameter of the base and characteristics of the stem favor the initial conduction of gizzard yam	Choose a species with a reduced diameter at the height of the base, rough stem and branches 50 centimeters above the base to facilitate the climb of the gizzard yam on the trunk of the guardian
	Deciduousness directly influences the Development of the gizzard yam	Select deciduous or short-deciduous species. The loss of leaves allows sunlight to enter and generates organic matter for the soil.

Table 3: Agrotechnical recommendations for management using parent species to support gizzard yam. (Elaborated by the authors).

with plants native to the continent, including arboreal components. It possibly fed Africans and quilombola Africans, for whom the opening of extensions of land for larger-scale cultivation was unfeasible.

Even today, gizzard yam is a food present in Afro-descendant contexts in Brazil, Colombia and among the Latin American peasantry in general. Due to its nutritional properties, it is a food that quenches the hunger of rural people and "levanta muertos", as the Panamanian peasants say. It is a plant of resistance, a counter-colonial plant. Thus, the gizzard yam constitutes a biocultural heritage of the diaspora, a species guarded over time by families and communities.

Due to its powerful medicinal and nutraceutical properties, gizzard yam is a species that deserves attention. The threat of extinction of the species in African countries amplifies the importance of studies on the gizzard yam. As a biocultural plant, its preservation is directly linked to knowledge about it, which, in Panama, is in the process of erosion, which is reflected in the decrease in its cultivation and the level of knowledge about its management.

The present study was dedicated to the cultivation of different accessions of Dioscorea bulbifera as on-farm conservation. Thus, it contributes to the construction of backup germplasm for the collection and to the systematization of cultivation practices for the species. Experimentation continues, in order to test agrotechnical recommendations and improve traditional ways of growing the plant. Regarding food, the researchers develop culinary tests and plan to carry out organoleptic tests, with a view to understanding the potential and food preferences related to each accession of the plant. To publicize the gizzard yam, a Web series is being created about the species, containing interviews with farming families, information about the history and culture of the plant, as well as recipes made with *D. bulbifera*.

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