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DESCRIPTION OF SOME MORPHOLOGICAL ATTRIBUTES OF POLYNESIAN ARROWROOT FROM BENUE STATE, NIGERIA

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ABSTRACT

Polynesian arrowroot is popularly known as ″Amora″ or ″Gbache″ by some ethnic nationalities in the Middle Belt region of Nigeria amongst whom its starch is used in preparing several local delicacies. The plant is found growing wild in the tropical rainforest and guinea savannah agro-ecologies of Nigeria and is yet to be domesticated. In recent years, its population has dwindled possibly due to human encroachment on its natural habitat, increasing use of herbicides and climate change. There is also an increasing recognition of the industrial quality of its starch thus bringing to the fore the need to domesticate the plant. As part of the effort to domesticate Polynesian Arrowroot, there is the need to describe in detail the morphological attributes of the plant which will aid its domestication. This forms the objectives of this paper. Based on visual observations of plants grown from tubers collected from the wild in Zaki-Biam Local Government Area (L.G.A.) of Benue State, Polynesian arrowroot is acaulescent; 2-7 leaves extend from the apex of the underground tuber. Peduncles subtend at their apex an umbellate inflorescence bearing many flowers (10-50). Fruits are many (1-20), ovoid, ribbed, with persistent tepals at the apex. Each fruit is a berry and contains numerous striated brownish seeds that are dormant at harvest. Tubers, mostly one per plant, are spherical and somewhat flattened at the apex and are subtended by stolons which grow down vertically from the base of the apex of the mother tuber. Tubers weighed mostly between 200-600 g each, but a few weighed up to 900 g. The main roots are adventitious ranging from 20-50 and grow to lengths ranging from 10-25 cm. There are roots on the surface of developing tubers. The implications of these observation on domestications of the plant were discussed.

Keywords: Polynesian arrowroot, ‘amora’; domestication; morphology; *Tacca leontopetaloides*
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INTRODUCTION

Polynesian arrowroot (*Tacca leontopetaloides* (L.) Kuntze) is popularly known as ″Amora,″ or ″Gbache″ by some ethnic nationalities in Nigeria. It is native to tropical Africa, South Asia, Southeast Asia, northern Australia, New Guinea, Samoa, Micronesia, and Fiji. It belongs to the genus *Tacca* and family Taccaceae (IPNI, 2005). However, some taxonomists group it with the yam family Dioscoreaceae (Caddick *et al*., 2002). It is a perennial monocot, found as a plant only in the rainy season, because from September through the dry season the shoot dies off and the tubers become dormant; new shoots sprout and emerge at the onset of rains the following year. It can be propagated both by seed and by tuber. In Nigeria, as in other parts of Africa, these plants grow in the wild as solitary plants in open fields, under the shade of trees or on hilltops (Satdom and Ajala, 2020). Polynesian arrowroot is found naturally growing in the tropical rainforest and guinea savannah agro-ecologies of Nigeria. The plant is wide-spread in the middle belt of Nigeria (Manek *et al.*, 2005) and in the south-western states (Borokini *et al*., 2014). Specifically, Pate *et al.* (2014) reported that it is found widely in Plateau and Nasarawa states. They have also been collected from the wild in Anyamelu L.G.A. of Anambra State and Bende LGA of Imo State. In Plateau State, the tubers are a delicacy to the people of Shendam, Langtang and other

inhabitants of lower Plateau and are eaten especially when other staple foods are scarce (Ogbonna *et al*., 2017). The tubers are rich in starch which varies according to growing conditions and soil substrate. It ranges from 10% to 25% of tuber weight (Spennemann, 1994). Although the tubers are poisonous, the poison is removed by soaking or washing them in water and rinsing repeatedly. Thereafter, they can be boiled or roasted (Borokini *et al*., 2014). The indigenous people of Middle Belt region of Nigeria who consume the starch from the tubers of Polynesian arrowroot see this plant as a gift from God as it is always there in the wild for them to gather. They have, therefore, seen no need to domesticate it. However, in recent years, the population of the plant in the wild has dwindled probably due to increasing use of herbicides and urbanisation. This coupled with the increasing recognition of the industrial quality of its starch used for pharmaceutical purposes (Kunle *et al*., 2003; Vu *et al*, 2017); food and drug systems (Ukpabi *et al*., 2009; Ogbonna *et al*., 2017); bioplastics (Nurul Shuhada *et al*., 2013); have brought to the fore the need to domesticate the plant. National Root Crops Research Institute (NRCRI) Umudike and Raw Material Research and Development Council (RMRDC) Abuja are collaborating in the pilot effort to cultivate Polynesian arrowroot. This paper describes the morphological variation in Polynesian arrowroot with a view to highlighting its features. The knowledge of this is necessary in order to harness its potentials for successful domestication.

MATERIALS AND METHODS

Tubers of Polynesian arrowroot of various sizes collected from Zaki-Biam L.G.A. of Benue State in October 2017 were used to plant a hectare at Umudike in a collaborative project between National Root Crops Research Institute (NRCRI) Umudike and Raw Materials Research and Development Council (RMRDC) Abuja. The very large tubers were cut into 2-3 pieces, each piece containing part of the apical portion. The cut pieces were cured for 3 days by covering them with leaves under tree shade for the cut surfaces to heal before planting. The tubers were planted one per stand on ridges spaced one metre apart in November, 2017. The top of the ridges was mulched with matured leaves of *Panicum maximum*. The tubers started sprouting in March, 2018 and were fertilised at 9 weeks after sprouting with NPK 15:15:15 at the rate of 600 kg/ha. Primextra was applied as pre-emergence herbicide on February 27th, 2018 with the first rain at the rate of 4 L/ha to control weeds. The farm was subsequently weeded manually twice before harvest. At harvest in September/October of 2018, the plants were gently lifted and sprayed with water to wash off the soil particles for easy observation of the tubers and other underground parts. The morphological attributes of the Polynesian arrowroot plants grown on this one-hectare plot based on visual observation were monitored and described. These attributes include plant height (from soil level to the tip of the umbellate inflorescence), number and length of leaves, number and length of peduncles, number of flowers, number of filiform bracteoles, number of fruits, number and length of stolon, number and weight of tubers per plant, tuber shape and skin colour and number and length of main adventitious roots.

RESULTS AND DISCUSSION

The range in attributes of Polynesian arrowroot grown at Umudike in the rainforest agro-ecological zone is presented in Table 1.

Tale 1: Range of attributes of Polynesian Arrowroot grown at Umudike

Attributes	Range
Plant Height (cm) (3 MAS)	30 – 63 cm
Number of leaves/plant (3 MAS)	2 - 7
Length of leaves (cm) (3 MAS)	17 – 30 cm
Number of peduncles/plant (3 MAS)	0 - 2
Length of Peduncles (3MAS)	30 – 63 cm
Number of flowers/plant (3 MAS)	10 - 50
Number of bracteoles/plant	9 - 48
Length of bracteoles	10 – 14 cm
Number of fruits/plant (4 MAS)	2 - 21
Number of stolons/plant (at Harvest)	1 - 8
Length of stolon (at Harvest)	5 – 15 cm
Number of tubers/plant (at Harvest)	1 - 8
Weight of Tubers/plant (at Harvest)	200 – 900 g
Number of Adventitious roots plant (at Harvest)	20 – 50
Length of Adventitious roots (at Harvest)	10 – 25 cm

MAS=Months after sowing

Above ground parts

The seed tubers sprouted well giving good plant establishment (Figure 1). Polynesian arrowroot is acaulescent (with no visible aerial stem). The stem is an underground tuber with apical and auxiliary buds. Generally, the plants were upright growing to a medium size ranging from 30 -63 cm in height (Table 1).

Figure 1: Polynesian arrowroot showing good field establishment at Umudike

Leaves

Two to seven leaves per plant were observed with each leaf extending from the apex of the underground tuber (Fig 2). Meena and Yadav (2010) reported 1-3 leaves per plant for *T. leontopetaloides* landrace they found in Rajasthan, India. The leaves have longitudinally ribbed long hollow petioles which extend from the underground apex of the tuber and bear large trifid and pinnately lobed leaflets with reticulate veined lamina at their apex. The base of the petiole is sheathed.

Figure 2. Leaves of Polynesian arrowroot

Floral structures

The plants flowered profusely. The floral structures became established before the foliage, suggesting that the plant places a higher premium on the production of seeds over the production of tubers. Hollow peduncles of varying length with sheathing base arise from the underground tubers. There is usually one peduncle per plant but plants having no peduncles and a few with two peduncles were observed. Hutchinson and Dalziel (1968) reported only one flowering stem per plant. Based on their length, three types of peduncles were observed.

(i) Short Type: Peduncles at or shorter than the foliage usually with drooping tip;
(ii) Medium type: Peduncles erect, slightly above the foliage;
(iii) Long type: Peduncles erect, very much longer than the foliage.

Peduncles subtend at their apex an umbellate inflorescence bearing as many as 10-50 flowers subtended by several green to purple whisker-like filiform bracteoles (almost as many as the flowers) about 10-14 cm long and greenish two whorled bracts. The bracts of the outer whorl are larger than the inner bracts (Fig 3). Anthers are attached to a hood-like structure which brings them very close to the stigma. This floral structure is in tandem with their autonomous self-pollinating habit (Zhang *et al*., 2007). The stigma is 3-lobed with each lobe divided into two.

Figure 3: Floral structure (umbellate inflorescence) of Polynesian arrowroot

Fruits

Fruits are many (2-21), ovoid, ribbed, with persistent tepals at the apex (Fig 4). They are subtended by short pedicels 3-5 cm in length. The fruit, a berry, develops from an inferior unilocular ovary with parietal placentation. They are green when immature but turn yellow when matured.

Figure 4: Developing fruits of Polynesian arrowroot

Seeds

Each fruit contains numerous striated brownish seeds with various shapes such as spherical, ovate, obovate and elliptical (Fig 5). Seeds are dormant at harvest.

Figure 5: Seeds of Polynesian arrowroot

Underground Parts

Stolon

Stolons develop from the base of the apex of the mother tuber and grow vertically downwards swelling at the tip to form the tuber (Figure 6). The stolon is cylindrical, stout, 5-15 cm in length and takes the tubers deeper into the soil below the mother tuber and probably away from pests.one to four stolons were mostly observed per plant but often only one ended up with fully formed tubers.

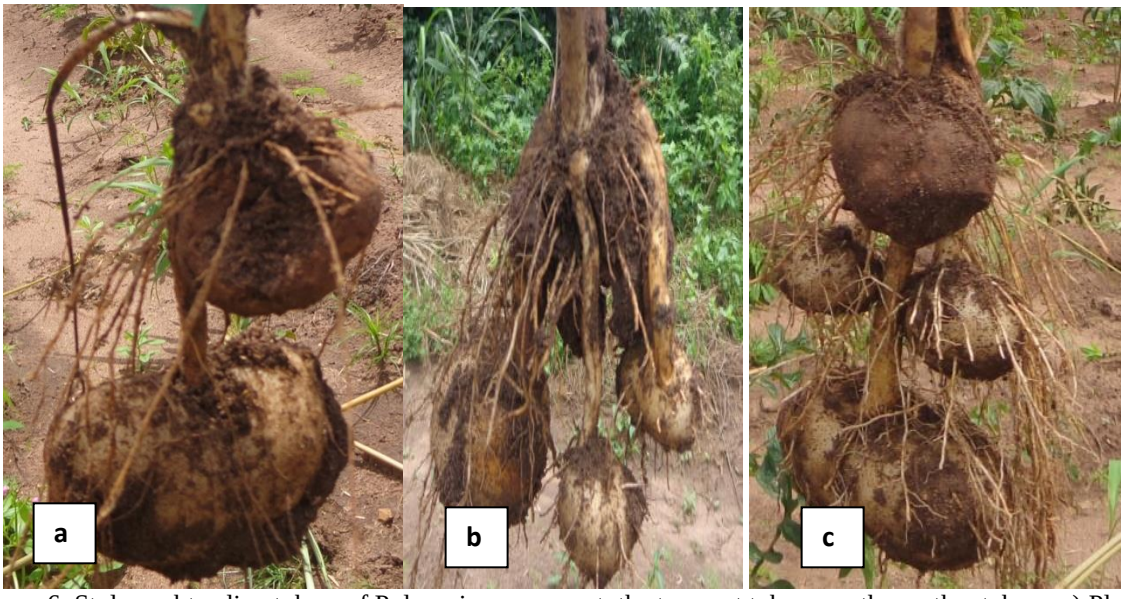

Figure 6: Stolon subtending tubers of Polynesian arrowroot, the topmost tubers are the mother tubers; a) Plants with single tubers; b & c) Plants with multiple tubers

Tubers

Most plants produced only one tuber but a few produced two to four tubers (Figure 6). A plant with 8 tubers (1 big, 2 small, and 5 tiny tubers) was observed (Fig 7). The tubers are globose and somewhat flattened at the apex (Figure 8). They have cream coloured skin and white flesh colour. Tubers weighed mostly between 200-600 g each but a few weighed up to 900 g. Tubers are dormant at harvest.

Figure 7: A rare plant with 8 tubers

Figure 8: Tubers of Polynesian Arrowroot

Roots

The main roots are adventitious ranging from 20-50 depending on the size of the mother tubers. They arise from the base of the apex of the tuber and grow to lengths ranging from 10-25 cm. There are roots on the surface of developing tubers (Fig 9).

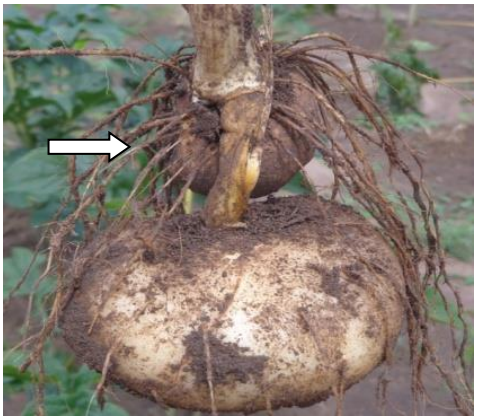

Figure 9: Roots from apex of the mother tuber and body of developing tubers

Implications of the Morphology of Polynesian Arrowroot on its Domestication

Generally, the plants were upright, growing to a medium size and as such will tolerate closer spacing than the 1m x 1m used in this project for increased productivity per unit area. The floral structures become established before the foliage, suggesting that the plant places a higher premium on the production of sexual seeds than the production of tubers. Since most of the early resources mobilised from the mother tuber goes to establish the floral structures at the detriment of the foliage, removing the floral structures as soon as they emerge above-ground may lead to more robust foliage that will result in the production of more assimilate which could be channeled to tubers for higher yield.

Most plants produced only one tuber per plant. Considering that tuber is the economic and consumable part of the plant and at the same time the main means of propagation, 1:1 multiplication ratio poses a major limitation to domestication. However, few plants were found to produce multiple tubers suggesting the existence of variability upon which selection can be made to improve the number of tubers. In addition, cut sets of large tubers that were used as planting materials sprouted suggesting that these tubers may be amenable to rapid multiplication using the miniset technique currently in use for its close relative, yam. Furthermore, multiple stolon produced by a good number of plants indicate that it has the potential to produce more than one tuber under favourable condition.

CONCLUSION

Some morphological characteristics of Polynesia arrowroot that are important for its domestication have been described and highlighted. Polynesian arrowroot was shown to have attributes which can be explored to ensure its successful domestication to save it from extinction and harness its food and industrial potentials.

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