African Yam Bean: a Crop with Food Security Potentials for Africa

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Abstract

The references to African yam bean (AYB) in the African culture is proof that it had sustained livelihoods in the past. The wide diversity within the crop's germplasm, its striking nutritional capacity as described in scientific reports, and its genetic stability across a wide range of environments with appreciable yields are reliable evidence of the need to foster the crop for its economic importance in Africa's food security. Like every other crop with low or no research attention, awareness of African yam bean is poor. It is mostly appreciated by the elderly farmers and rural women. The continual availability of the genetic resources of the crop is threatened. Moreover, the cultivation of the crop may further decline due to neglect and underutilization. Wide exploration of AYB's genetic resources in Africa will provide assurance of its future genetic improvement.

Key words: African yam bean, genetic resources, food security, underutilized, diversity

Introduction

Sastrapradja [1] asserted that biodiversity is obviously not equally distributed on the earth; the tropical belt holds more diversity than other regions of the world. Africa has huge underexploited plant genetic resources with potentials for meeting some of her micronutrient needs; however, many food components are available but yet undiscovered in the wilds of Africa [2]. Africa is richly endowed with a very high diversity of plants in wild and cultivated forms. Thousands of them, though not commercialized, somehow adequately sustained rural livelihood for ages.

The Green Revolution has been implicated in overturning the traditional African food culture and entrenching a few crops for full commercial production, lately coupled with nutrient fortification. The global dependence on these few crops has largely affected the utilization of others which have become neglected. Their production has lessened and the diversity of their germplasm is at serious risk of genetic erosion. The depletion of crop genetic resources in Africa may have drastic consequences on hunger and malnutrition.

Underutilized crops are indigenous, relatively common in specific areas, available, accessible, well-adapted, easy and cheap to produce, and culturally linked to the people who use them traditionally [2, 3, 4, 5]. Their cultivation and utilization usually draw on indigenous knowledge. The ecotypes and landraces of these species are cultivated less than in the past. They are rarely found in urban markets. They cannot compete with crops which now dominate the world's food. They are hardly represented in *ex situ* genebanks, so efforts to characterize them depend on the limited available and loosely-representative diversity [6]. They are therefore usually ignored by policy makers probably because their economic value is not apparent [7] and hence are excluded from the development agenda by research institutions. However, underutilized crops are important as household food and their contribution to food security is unquestionably significant [2, 8].

African yam bean (AYB)

African yam bean (*Sphenostylis stenocarpa*), is the most economically important among the seven species of *Sphenostylis* [9] and it is one of the most important tuberous legumes. The domestication, cultivation, and distribution of the crop are very evident in the tropics of Africa [3, 9, 10, 11] where it had been reported to exhibit very high diversity. There is no record of any other center of diversity for the crop beyond tropical Africa. It should not be confused with the *Pachyrhizus* spp. which in many places in the literature are referred to as "yam bean", Mexican yam bean, Jicama, etc. *Pachyrhizus* spp. is a more popular tuberous legume that is common in the tropics of Asia and Southern America.

The botanical profile and morphology of African yam bean

AYB belongs to the family Fabaceae, sub-family Papilionoideae, tribe Phaseoleae, sub-tribe Phaseolinae, and genus *Sphenostylis* [3, 12]. The crop has twining vigorous vines, which could be green or pigmented red. The vines twine clockwise around the stakes or climb other supports to a height of about 3 meters or more. The leaves are compound trifoliate. The large pink and purple flowers are admirable and attractive ornamentals. Pods are usually linear, housing about 20 seeds. These vary in size, shape, colour pattern, etc.

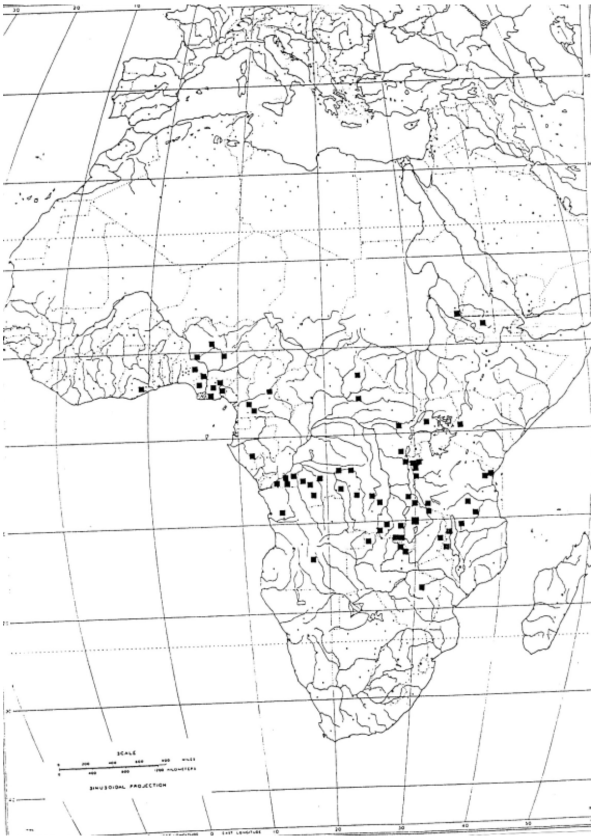
Eco-geographical distribution of AYB

The origins of AYB as indicated by GRIN [13] includes the following countries within the tropical regions of Africa: Chad and Ethiopia (Northeast tropical Africa); Kenya, Tanzania and Uganda (East tropical Africa); Burundi, Central African Republic and Democratic Republic of Congo (West-Central tropical Africa); Côte d'Ivoire, Ghana, Guinea, Mali, Niger, Nigeria, and Togo (West tropical Africa); Angola, Malawi, Zambia, and Zimbabwe (South tropical Africa). The centre of diversity of AYB is only within Africa (See **Figure 1**). Nigeria is very significant for AYB production [9] where extensive cultivation had been reported in the eastern [14] western, and southern [15] areas of Nigeria.

Domestication, cultivation, and the cultural place of AYB

AYB is rarely planted as a sole crop in Ghana and Nigeria; it is mostly interplanted with yam [3, 16]. The seeds and tubers (**Plates 1** and **2**) are the two organs of economic importance, providing food for humans and livestock. How-

Figure 1. The Distribution of African yam bean in Africa



(Source: Potter, D. & Doyle, J. J. 1992 [44]).

ever, there is a cultural and regional preference for each: West Africans prefer the seeds to the tubers while the tubers are highly relished as food among East and Central Africans, especially among the Bandudus, the Shabas, and the tribe at Kinshasha in Democratic Republic of Congo [9, 17]. This exceptionally nutritious pulse [18] has a very significant link with African sociocultural life. For instance, the Avatimes in Ghana prepare a special meal from it during the celebration of the puberty rites of adolescent girls [16]. Likewise a special meal from it features during the marriage ceremony among the Ekitis in Nigeria [9]. Different forms of local recipes are prepared from the crop to meet the dietary needs of the people.

Potentials of African yam bean

1. Food and nutrition

The economic potentials of AYB are immense. Apart from the production of two major food substances, the value of the protein in both tubers and seeds is comparatively higher than what could be obtained from most tuberous

Plate 1. Diversity in colour, colour pattern, structure, texture, brilliance etc. of African yam bean seeds

Plate 2. Tuberous root of an accession of African yam bean

and leguminous crops [3, 17]. The protein in the tuber of AYB is more than twice the protein in sweetpotato (*Ipomea batatas*) or Irish potato (S*olanum tuberosum*) [19] and higher than those in yam and cassava [20]. Moreover, the amino acid values in AYB seeds are higher than those in pigeon pea, cowpea, and bambara groundnut [21]. Protein content is up to 19% in the tuber and 29% in seed grain The content of crude protein in AYB seeds is lower than that in soybean, but the amino acid spectrum indicated that the level of most of the essential amino acids especially lysine, methionine, histidine, and iso-leucine in AYB is higher than those in other legumes including soybean [14, 19, 22, 23, 24]. Generally, the amino acid profile of AYB (**Table 1**) compares favorably with whole hens' eggs and most of them meet the daily requirement of the Food and Agriculture Organization (FAO) and World Health Organization (WHO) [25]. AYB is rich in minerals such as K, P, Mg, Ca, Fe, and Zn but low in Na and Cu [26, 27].

2. Insecticidal and medicinal usefulness

AYB as a crop is less susceptible to pests and diseases [28] compared with most legumes; this quality may undoubtedly be due to the inherent lectin in the seed of the crop. Omitogu *et al.* [29] advanced the prospect that the lectin in the seed of the crop is a promising source of a biologically potent insecticide against field and storage pests of legumes. Therefore, the inclusion of the lectin extract from AYB in the meal for three cowpea insect pests, namely, *Maruca vitrata, Callosobruchus maculatus,* and *Clavigralla tomentosicollis* gave a mortality rate greater than 80% after 10 days. The physiological system of *C. tomentosicollis* was found to be very vulnerable to the lectin in AYB [30]. In Togo, Ghana, and Nigeria, paste made from the seeds of AYB is used as a cure for stomach aches, and when the paste is mixed with water it is traditionally used for the treatment of acute drunkenness [31, 32]. Asuzu [32] reported that there might be pharmacological evidence for the use of AYB in treating such conditions.

3. Stable yield across wide environments

The seed yield of AYB can be as high as 3000kg/ha [3, 28]. The average seed/plant is between 100 and 200g and the tuber yield per plant is 0.5 kg [10, 19]. In different yield trials in Nigeria (IITA, Ibadan and Nsukka), the most productive accession in each case gave 1860 kg and 2000 kg of seeds/ha [19]. Coupled with high yield is vast adaptability to diverse edaphic conditions [33, 34]. AYB produces an appreciable yield (See **Plate 3**) more than most other pulses on poor soil and in a hot climate [26]. AYB has very high ability to fix nitrogen [35]; it is therefore an important crop which merits significant consideration for land reclamation.

Limitations in AYB

Over time, some conditions have negatively influenced the productivity and acceptability of the crop among cultivators, consumers, and research scientists. Notable among the list are, i) the characteristic hardness of the seed coat [36, 37] which makes a high demand on the cost and time of cooking, ii) the agronomic demand for stakes, the long maturation period [11, 19], and iii) the presence of antinutritional factors (ANF) or secondary metabolites [38]. The photoperiodic sensitivity of AYB [10] seems to compound the above disadvantages as it confines the cultivation and production of the crop to one season in the year. However, a concerted crop breeding research programme may overcome these problems.

The way forward

Diversification in the production and utilization of crops is an essentially important strategy to alleviate food insecurity [39]. This will entail producing different foods and producing enough of each food crop to reduce its price and increase its supply, availability, and consumption. Climate change is already having a strong impact on human societies and the natural world; this is expected to continue for decades to come [40]. Africa has been identified as one of the continent most vulnerable to climate change and variability [41]. An adequate strategy needs to be in place for food security in Africa. Food security, quality of life, and livelihood for billions of people in the present and future generations are guaranteed only by the availability of diversity in crop genetic resources. Diverse genetic crop resources provide the foundation on which crop improvement depends; moreover, they provide diversity and are sources of traits to improve yield and quality, resistance to diseases/pests, and adaptability to climatic changes. For instance, Klu *et al.* [16] had speculated that AYB was nearing extinction. The quantity and availability of AYB's germplasm may have been declining over time. However, the ability of the crop to adapt to diverse environments [33, 34] may have been responsible for its continual existence and survival. Intensive exploration and conservation of large amounts of germplasm are an utmost necessity for AYB and other indigenous African crops. The amino acid requirements can be met by the consumption of mixtures of legumes in large amounts [17, 42]. Apart from the use of soybean as an animal-alternative protein source, the exploitation of protein from other legumes is rare [43]. With the acknowledgment of the nutritional potentials of AYB, the crop may well contribute to solving food security problems in Africa if its genetic diversity is saved for future genetic improvement.

Plate 3. An African yam bean plant with mature pods ready for harvest

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Table 1. Essential Amino acid content of some tropical food and feeding stuffs (Mg/N). Source: [24].

Common names	Botanical names	Argi-nine	Histi-dine	Iso-leucine	Leu-cine	Lysine	Phenyl-lanine	Tyro-sine	Cystine	Me-thio-ninie	Threo-nine	Trip-to-phan	Valine
Cowpea	*Vigna ungui-culata*	444	194	256	456	394	325	190	106	119	238	60	325
Groundnut (whole)	*Arachis hypo-gaea*	775	150	250	438	319	325	220	81	88	244	70	313
Gnut protein (Arachin)	*Arachis hypo-agea*	763	119	413	425	250	344	300	81	38	144	56	244
Gnut protein (Conarachin)	*Arachis hypo-gaea*	744	119	219	363	375	106	156	163	106	113	31	200
Soybean meal	*Glycine max*	519	175	306	488	406	306	200	94	94	244	81	319
Lima bean	*Phaseolus lunatus*	388	206	350	556	431	400	160	61	119	300	56	363
Bambara nut	*Vigna subter-ranea*	394	118	275	494	400	350	219	180	113	219	-	331
Field bean	*Dolichus lablab*	456	163	228	525	388	325	220	69	50	225	-	244
Common pea	*Pisum sati-vum*	-	-	350	520	460	320	250	80	80	240	70	350
Green gram seed	*Phaseolus aureus*	-	188	350	560	430	300	100	40	70	200	50	370
Pigeon pea	*Cajanus ca-jan*	419	213	238	475	438	544	210	75	94	213	30	313
Sunflower seed	*Helianthus annuus*	513	137	356	419	238	313	163	88	213	250	81	331
Geocarpa seed	*Kerstingiella geocarpa*	425	181	275	494	388	369	220	63	94	244	-	406
Stenocarpa seed	*Sphenostylis stenocarpa*	388	231	275	481	425	331	270	94	119	256	-	350

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