

PROSPECTS OF UTILIZATION OF YAM BEAN GERMPLASM

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Global population is projected to reach approximately 10.9 billion by 2100 hence, food security is becoming a big challenge. Despite their numerous benefits in food, fibre, fodder, oil, and nutrition, as well as medicinal characteristics, many crop plant species are ignored and underutilised. These crops, on the other hand, serve a critical role in the sustenance and economic progress of underprivileged people throughout their lives, as well as enriching agro biodiversity. These crops are still neglected, and a lack of investment in research and development has resulted in a loss of agricultural biodiversity while also increasing the vulnerability of the global food supply. Yam bean [*Pachyrhizus erosus* (L.) Urban], is an underutilised legume tuber crop with numerous health benefits due to its nutrients and therapeutic characteristics. The cultivated yam bean yields a substantial root with a high starch and sugar content. However, availability of limited genetic information in yam bean hinders the genetic improvement of this crop.

Introduction

The yam bean [*Pachyrhizus erosus* (L.) Urban] is an underutilised vegetable crop that has recently gained popularity due to its excellent nutritional value. It is a member of the Fabaceae family, subfamily Faboideae, Tribus Phaseoleae, and Subtribe Diocleinae, which is related to the Glycininae and Phaseolinae subtribes (Sorenson 1996; Cassandria G. Tay et al., 2021). It is known as Shankalu (Bengali), Kasaur, Sankalu, Misrikand (Hindi), Tani Uttan Kai (Tamil) and Kandha (Telugu) in India (Lim, 2016). Yam beans are produced for their starchy root, however they are only propagated by seeds. To devise conservation strategies, researchers must first understand how these various methods affect the crop's genetic diversity dynamics. This necessitates the use of molecular tools that provide information on key parameters such as heterozygosity and allelic frequencies, which are required for the computation of most population genetic statistics. Efforts to document these mostly unexplored genetic riches have likely been hampered by a lack of molecular tools. *Pachyrhizus* species' phylogenetic relationships are still mostly unknown. Varietal identification is required in agriculture for breeding, registration, seed production, trading, and inspection. Characterization of genetic stocks is required for registration with the competent authority and the grant of plant breeder's rights under the Distinctness, Uniformity, and Stability (DUS) criteria, as well as farmer's rights under the Protection of Plant Varieties & Famer's Rights Authority of India (PPV&FR).

Origin and Distribution

Pachyrhizus erosus came from the semi-arid tropics of Central America, *P. tuberosus* came

from the tropical lowlands on both sides of the Andean mountain range, and *P. ahipa* came from Andean England (Sorenson et al., 1996). Yam bean is mostly grown in Central America, China, India, Southeast Asia and Bangladesh and also in the Caribbean, French Guyana, Brazil as well as Central and West Africa (Lauti'e et al., 2013; Sørensen, 1996). In India its grown in West Bengal, Assam, Bihar, Odisha, and Andhra Pradesh (Pati et al., 2021).

Cytogenetics of yam bean

Yam bean is a self-pollinating crop, having bisexual flowering. The chromosome number of the three cultivated species of yam bean are $2n=2x=22$ (Santayana et al., 2014). Due to easy sample preparation and a rapid, convenient, and accurate procedure, flow cytometry is commonly used for ploidy analysis, detection of mixoploidy and aneuploidy, genome size estimation, or 2C DNA content (Fig. 1). Pati et al., (2019) utilized six accessions of *P. erosus* and three accessions of *P. tuberosus*, using *O. sativa* cv Nipponbare ($2C = 0.91$ pg) as an internal reference standard for genome size estimation. The genome size ranged from 572- 597Mbp in *P. erosus* and 523-533Mbp in *P. tuberosus*.

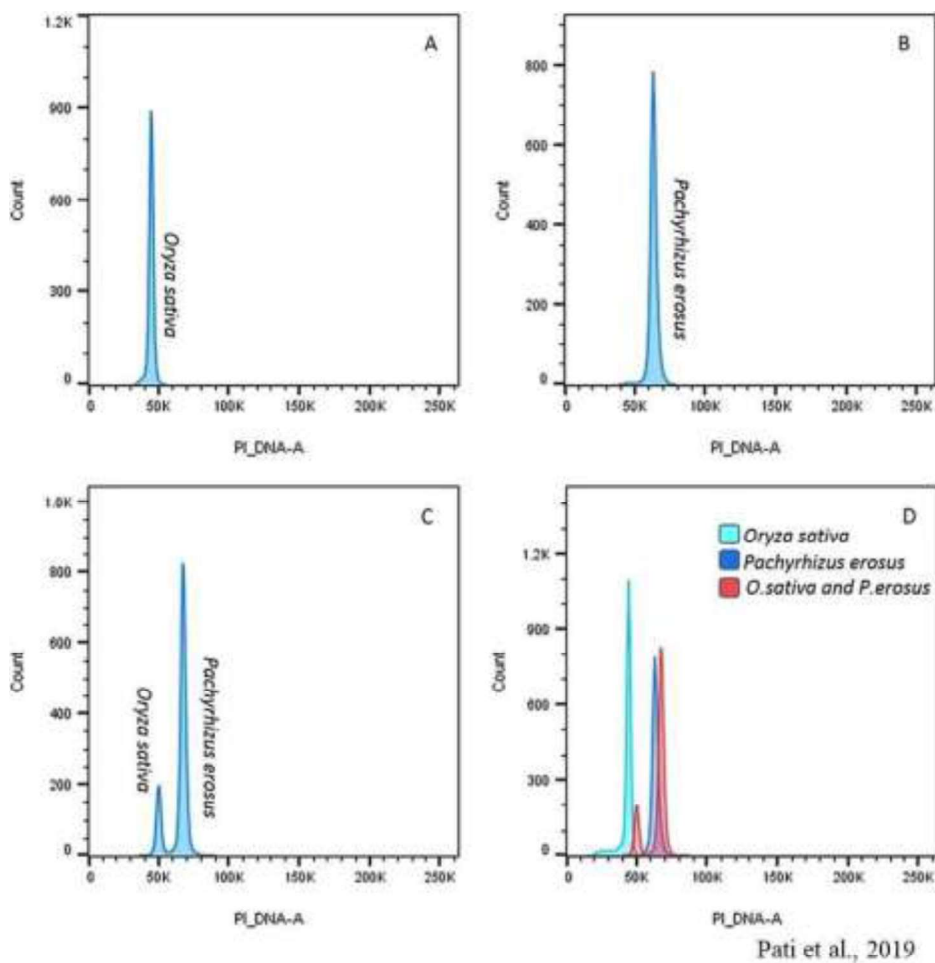


Fig. 1. Estimation of Ploidy and Nuclear DNA content in *Pachyrhizus erosus* using rice(*Oryza sativa*) cv Nipponbare as standard.

Agronomy

Yam bean grown in tropical and sub-tropical climatic conditions. The basic requirement is frost free condition during the growth period. It grows up to an altitude of 1000m. Though yam bean requires 14-15h of photoperiod for good vegetative growth, shorter days are required for better tuberization. Hot days and cooler nights are suited for good tuberization. Fertile, well drained Sandy loam soil is considered ideal for the cultivation of yam bean. This crop adapts well to loamy and clay loam soil. Water logging is not at all desirous for yam bean cultivation. Optimum soil pH requirement is 6.0-7.0. The time of sowing of seed varies from June- September according to the purpose of the crop. For seed purpose, June-July is the best time of sowing at a spacing of 30x 30 cm. For tuber, sow the seed in August –September at a spacing of 30x30cm. Normal seed rate is 20-60 kg/ha depending upon the time of sowing and spacing. Traditionally yam bean is sown during June- July with the onset of rain in North-Eastern India and is usually being harvested in December-January. The peak harvesting period is at the time of saraswati puja in Odisha, West Bengal and Bihar i.e. during the last of January to February. Flower and tuber formation occur almost simultaneously during plant development. Removal of flowers results in higher yield, biomass production, sugar content, protein content. Manual deflowering is time consuming and expensive. Chemical deflowering by one spraying with 2, 4-D (50ppm) at the bud initiation stage has equally effective and labour intensive. Yam bean is harvested 110- 120 days after planting. The average yield of RM-1 variety is 30-35 t/ha and local variety produce 18-20t/ha.

Characterization of yam bean germplasm

Yam bean is an underutilised tuberous legume crop which has great potential as a food crop. As a root crop, it produces high yields and as a legume, it can produce protein-rich food. BBCH (Biologische Bundesanstalt, Bundessortenamt and Chemische Industrie) scale was developed for the identification of different phenological growth stages of yam bean (Fig. 2) like, germination, leaf, formation of side shoots, stem elongation, tuber formation, inflorescence emergence, flowering, development of pods, ripening of pods, and senescence (Pati et al., 2020). This phenological study in yam bean will be helpful for better crop management, crop improvement and characterisation of germplasm. This scale will also be useful for the yield enhancement of this crop as an emerging underutilised tuber crop.

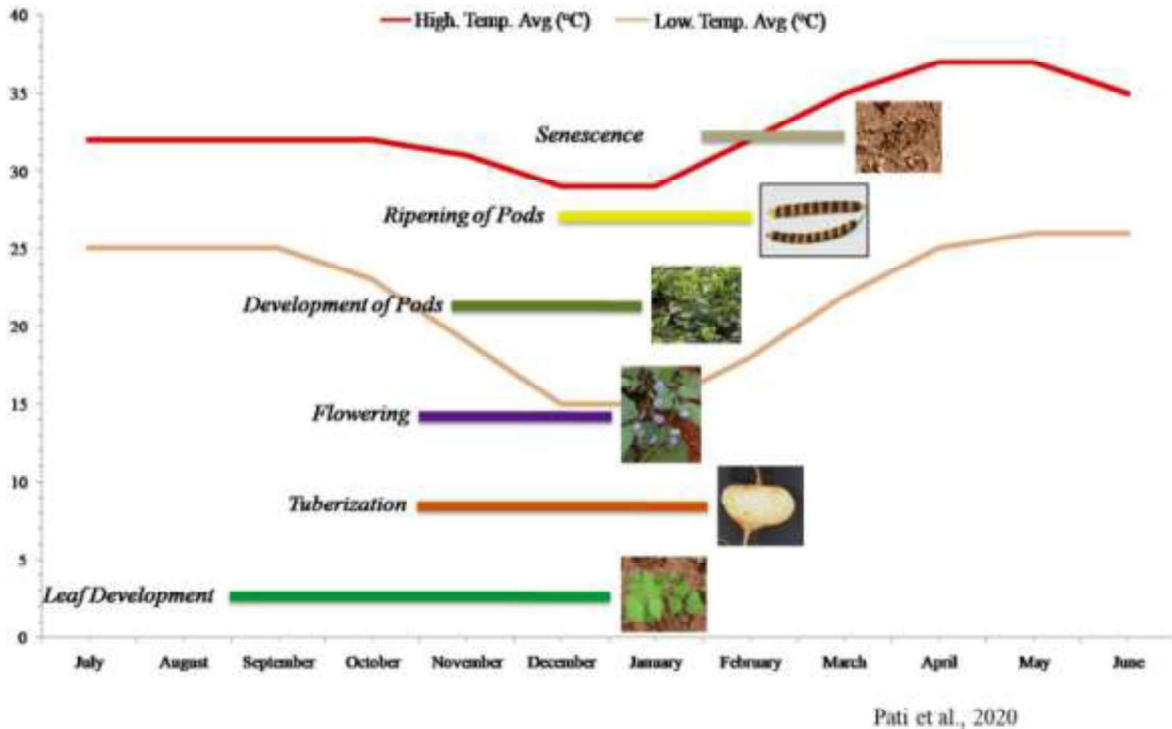


Fig. 2. The sequential progression of principal growth stages of yam bean.

The inheritance pattern of flower colour in underutilized tuberous legume crop yam bean was studied by utilizing a white flower colour line (YBWF- 1) and two purple flower colour lines (RM-1 and L No-3). The segregation of flower colour suggested monogenic dominant control of purple flower colour in yam bean using white flower colour genotype YBWF-1 (Pati et al., 2020).

Proton-induced X-ray emission (PIXE) technique helped in determining the amount of nutrients availability in thirty yam bean genotypes. Certain minor and trace element concentration were identified and quantified in yam bean genotypes as P, S, K, Ca, Ti, Mn, Fe, Ni, Cu, Zn, Rb and Sr by using the software package named GUPIX-2000. PIXE measurements were carried out with 3 Me V proton beams with 20 nA beam current on target for element analysis (Pati et al., 2021).

Molecular Characterization

High differences (polymorphisms) within a nucleic sequence between distinct individuals are used as molecular markers. Insertions, deletions, translocations, duplications, and point mutations are examples of these variations. Molecular analysis of germplasm has become a useful method for identifying and distinguishing different accessions with comparable morphological and agronomical features (Karuri et al., 2010; Goncalves et al., 2010). In yam bean only limited molecular resources available.

Deletre *et al.* (2013) reported 17 simple sequence repeat (SSR) markers with perfect di and tri-nucleotide repeats developed from 454 pyro sequencing of SSR-enriched genomic libraries in yam bean. Loci were characterized in *P. ahipa* and wild and cultivated populations of four closely related species. All loci successfully cross-amplified

and showed high levels of polymorphism, with number of alleles ranging from 3 to 12 and expected heterozygosity ranging from 0.095 to 0.831 across the genus.

Santayan *et al.* (2014) characterized 58 accessions of three cultivated *Pachyrhizus* species by Amplified Fragment Length Polymorphism (AFLP) molecular markers in order to estimate genetic diversity and interspecific relationships. Eight AFLP primer combinations detected 136 (68.7 %) polymorphic bands.

Tay Fernandez *et al.*, (2021) assembled a draft genome of *P. erosus* of 460 Mbp in size containing 37,886 gene models. Compare three cultivars each of *P. erosus* and the closely related *P. tuberosus* and identified 10,187,899 candidate single nucleotide polymorphisms (SNPs). The assembly revealed that *P. erosus* is more genetically distinct than *P. tuberosus*, and adds support to the *Glycine* family being the closest major crop relative to the *Pachyrhizus* species. The resulting assembly can be utilised as a starting point

for future research, and the findings can be used to describe the genetic composition of yam bean.

Breeding in Yam bean

The national research system in India has paid little attention to yam bean research due to lack of information and resources. As a result, traditional land races are still used by farmers in the country. Recently, it's gaining popularity due to nutritional status and ability to adaption in different agro climatic condition. ICAR- Central Tuber Crops Research Institute (CTCRI), and its Regional Centre, Bhubaneswar and ICAR-All India Co-ordinated Research Project on Tuber Crops (AICRPTC) are conducting yam bean research in India.

Hybridization and selection of best hybrids in yam bean programme is going on at ICAR-CTCRI, Regional Centre for selection of early maturity, high dry matter content, enhanced nutrition and pest and disease resistance (CTCRI Annual Report 2020).

Future Prospects

As a significant future crop for food and nutritional security for India and other parts of the world, yam bean production requires attention among the research community. This crop can be produces in non-traditional areas and improve the rural economy. More scientific investigation required for full utilization of the crop. Yam bean is described as minor crop or underutilized or neglected crop having great potential for income generation as well as combating 'hidden hunger' caused by micronutrient deficiencies.

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