State of Nature Conservation in Malaysia 2025, 173–182
doi: 10.62613/sonc2025.v1flc15

CHAPTER 15

Conservation and sustainable utilisation of root crop genetic resources: The case of sweet potato, cassava and underutilised tuber species in Malaysia

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Abstract: Root and tuber crops play an important role in Malaysia's agricultural landscape by contributing to food security, rural livelihoods, and agrobiodiversity conservation. Among these crops, sweet potato (*Ipomoea batatas*) and cassava (*Manihot esculenta*) are widely cultivated due to their adaptability to diverse environments, low input requirements, and multiple food and industrial uses. In addition, several underutilised tuber species possess unique genetic traits and nutritional values that remain largely untapped. The increasing challenges posed by climate change, agricultural intensification, urbanisation, and the replacement of traditional varieties with commercial cultivars have heightened the risk of genetic erosion, threatening valuable plant genetic resources. This chapter reviews the current status of root crop genetic resources in Malaysia, with particular emphasis on sweet potato, cassava, and selected underutilised tuber species. It examines their diversity, cultural and economic significance, and the contribution of local landraces and farmer-managed varieties to agricultural resilience. The chapter further discusses major threats to genetic resources and highlights conservation strategies implemented through *ex situ* and *in situ* approaches, including the role of national germplasm collections and community-based conservation efforts. Recent advances in breeding and genetic improvement programmes aimed at enhancing yield, nutritional quality, and tolerance to biotic and abiotic stresses are also presented. Finally, the chapter outlines key challenges and opportunities for sustainable utilisation and proposes policy recommendations to strengthen the conservation, management, and future use of root crop genetic resources in Malaysia.

INTRODUCTION

Root and tuber crops have been part of Malaysia's agricultural heritage for generations. While rice remains the country's main staple food crop, sweet potato (*Ipomoea batatas*) and cassava (*Manihot esculenta*) continue to play significant roles in complementing household diets, supporting rural livelihoods, and contributing to local food cultures (Bradshaw 2010). These crops are often grown in smallholdings, village backyards, mixed farms, and semi-commercial estates, reflecting their versatility and adaptability (Best *et al.* 2006; Ngongo *et al.* 2022). Sweet potato, or locally known as *keledek*, is favoured for its quick growth cycle and wide culinary uses, from traditional *kuih* (pastries) to savory dishes. Cassava (*ubi kayu*), once seen as a survival crop, has risen in importance due to its economic value. It is used in *keropok* (crackers), starch processing, animal feed, and even emerging food industries targeting gluten-free ingredients and functional foods.

Their resilience makes these crops strategic assets for Malaysia's food security. Sweet potato and cassava tolerate poor soils, require minimal inputs, and have a natural ability to withstand short droughts, making them well-suited for climate-uncertain periods. These strengths highlight why genetic conservation and sustainable utilisation of these crops are vital for Malaysia's long-term agricultural development (Sapakhova *et al.* 2023; Abraham *et al.* 2025).

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This paper provides an overview of the current status of sweet potato and cassava genetic resources in Malaysia. It examines their diversity, highlights threats to their survival, and discusses conservation efforts led by researchers and local communities. The chapter also presents real-world insights from farmers and proposes policy recommendations to guide future work in conservation and sustainable use.



Figure 1. Left: Sweet potato (*Ipomoea batatas*); **Right:** Cassava (*Manihot esculenta*).

AGRO-BIODIVERSITY OF SWEET POTATO AND CASSAVA IN MALAYSIA

Historical roots and cultural significance

Sweet potatoes and cassava have been cultivated in Malaysia for centuries. Sweet potato is believed to have arrived during early trade routes, while cassava was introduced during colonial times. Over decades, both crops blended into local food cultures. Sweet potato is widely used in *Bubur Cha Cha*, *kuih keria*, and numerous village snacks.

Cassava, on the other hand, is central to dishes such as *tapai* (fermented cassava), *bingka ubi*, and a range of traditional cakes. In Sabah and Sarawak, cassava carries deep cultural significance. Indigenous communities cook cassava leaves as a vegetable, pound them into greens, or use them in traditional stews. These uses demonstrate how these crops are embedded in local identities and food sovereignty.

A Landscape of Rich Diversity

Malaysia's smallholders maintain an impressive range of sweet potato and cassava varieties. These "landrace" varieties are maintained by farmers over many generations and each have different colours, shapes, flavours, and cooking characteristics. In Kelantan, farmers identify sweet potato varieties by their tuber colour: purple, orange, deep yellow, or creamy white. Each colour is associated with a specific taste or culinary use—purple flesh for desserts, orange flesh for its sweetness and nutritional value, and yellow flesh for frying or steaming. Cassava varieties also differ in tuber shape, skin thickness, fiber content, and starch quality. Some varieties are preferred for 'keropok' processing due to their starch levels, while others are chosen for home cooking because of their soft texture.

Scientific evaluations conducted by MARDI have confirmed that this diversity goes beyond outward appearance. Morphological assessments and molecular studies reveal substantial differences in growth habits, disease tolerance, nutrient content, and adaptation to soil types. Such diversity forms the foundation for future crop improvement, especially in responding to climate change.

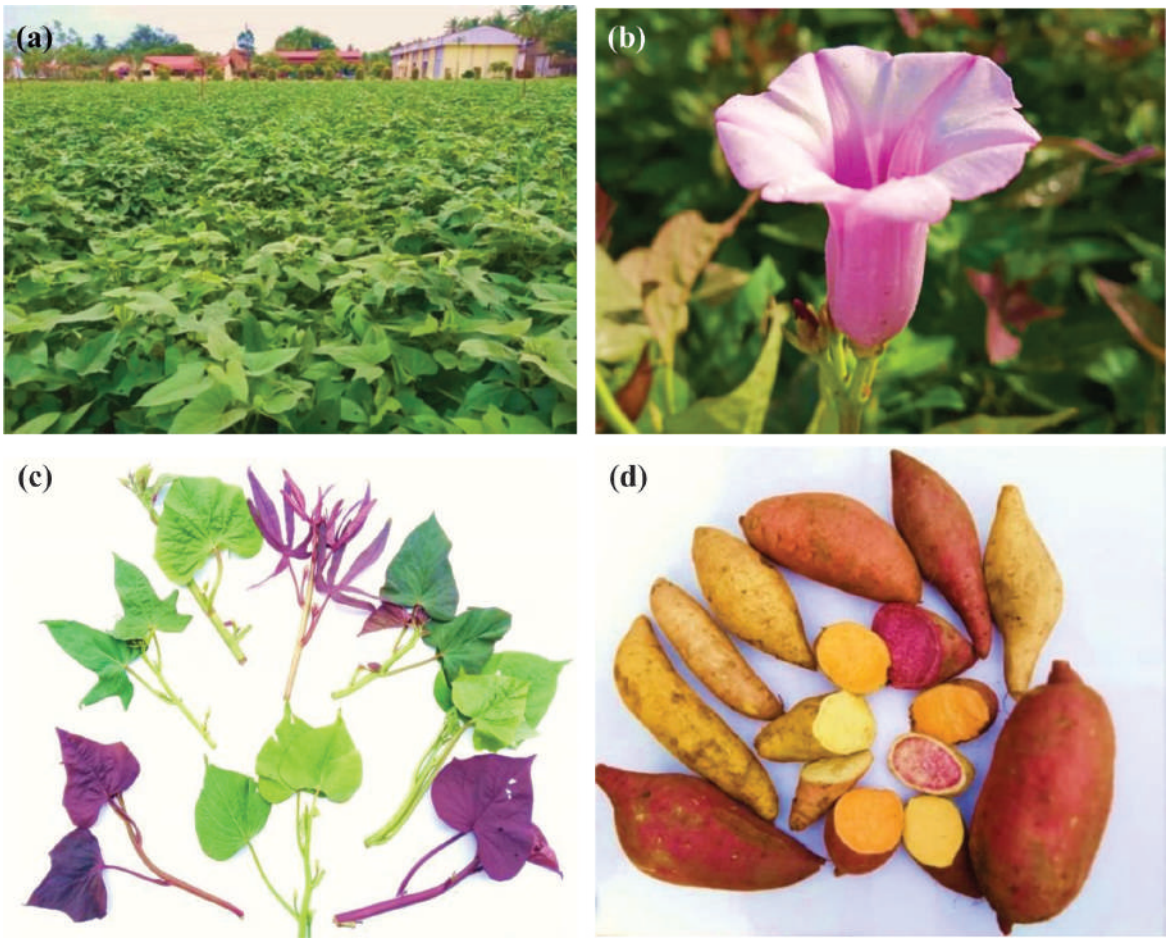

Figure 2. Morphology of the sweet potato **(a)** plant, **(b)** flower, and the variations of **(c)** leaves and **(d)** tubers cultivated at MARDI Bachok, Kelantan

THE IMPORTANCE OF CROP WILD RELATIVES OF UNDERUTILISED TUBER SPECIES OF MALAYSIA

Crop Wild Relatives (CWRs)—that is wild species which are related to modern crops—are a critical repository of traits such as drought tolerance, natural pest resistance, or enhanced nutrient content. While many farmers are unfamiliar with CWRs, researchers view them as vital sources for breeding new varieties. Protecting these wild species requires preserving forests, landscapes, and mixed farming areas where they naturally occur.

Among these, wild yams (*Dioscorea*), comprising more than 600 species within the Dioscoreaceae (Amanze *et al.* 2011; Kumar *et al.* 2017)), represent one of the most taxonomically diverse groups of monocotyledonous tuber crops worldwide. Globally, yam ranks as the fourth most important root and tuber crop after potato, cassava, and sweet potato, contributing approximately 10% of total root and tuber production (Viruel *et al.* 2016). Beyond its economic value, yam serves as a critical subsistence and famine food, particularly for smallholder farmers and forest-dependent communities during periods of food scarcity (Anuar *et al.* 2023). Nevertheless, compared with other major staple crops, yam remains relatively under-researched and under-utilised.



(a) *Ubi badak* (*Dioscorea alata*)



(b) *Ubi nasi* (*Dioscorea esculenta*)



(c) *Ubi angin* (*Dioscorea bulbifera*)



(d) *Ubi sarek* (*Amorphophallus paeniifolius*)



(e) *Ubi kemili* (*Plectranthus rotundufolius*)



(f) *Keladi seratah* (*Xanthosoma sagittifolium*)

Figure 3. Minor root crops, occasionally known as neglected root crops, include yams (*Dioscorea* and *Amorphophallus*) and edible aroids (*Plectranthus*, *Colocasia*, and *Xanthosoma*), which can be found across Malaysia.

Despite their recognised nutritional advantages—including appreciable protein content, balanced essential amino acids, and essential minerals (Shajeela *et al*. 2011; Baah *et al.* 2009)—wider utilisation of Dioscorea species is constrained by anti-nutritional` compounds and inconsistent tuber quality traits across taxa. Importantly, the extensive diversity present in wild yam species remains insufficiently characterised at the phenotypic, biochemical, and molecular levels. Many wild taxa continue to function as traditional food resources among indigenous and rural communities; systematic evaluation of their nutritional composition, phytochemical profiles, and agronomic performance however is still lacking.

Similar knowledge gaps are evident in other wild tuberous genera found in Malaysia, including *Amorphophallus*, *Xanthosoma* (Araceae) and *Plectranthus* (Lamiaceae). Several species of *Amorphophallus* (*ubi gajah*, *ubi sarek*) possess high starch content and industrial potential, yet remain under-utilised. Likewise, tuber-forming *Plectranthus* (*ubi kemili*) species, some of which are traditionally consumed or used medicinally, have received limited scientific attention regarding their nutritional quality, anti-nutritional factors, and genetic diversity. The absence of integrated morphological, biochemical, and molecular studies across these wild tuber taxa restricts their incorporation into breeding programmes, domestication strategies, and value-chain development.

More critically, inadequate understanding of population structure and genetic diversity across wild yam and other tuber species has contributed to genetic erosion, particularly under pressures from land-use change and habitat fragmentation. The limited deployment of molecular markers, genomic tools, and pre-breeding frameworks further constrains the identification and utilisation of superior genotypes carrying traits for nutritional enhancement, abiotic stress tolerance, and climate resilience (Arnau *et al.* 2017).

A concerted evaluation effort of wild tuber species in Malaysia including *Dioscorea*, *Amorphophallus*, *Xanthosoma* and *Plectranthus* is therefore urgently required. Integrating ethnobotanical knowledge with nutritional, anti-nutritional, phytochemical, and molecular characterisation would unlock their bio-prospecting potential for food and pharmaceutical industries while strengthening conservation and pre-breeding strategies. Addressing these gaps is essential to safeguard genetic resources and to reposition wild tubers as strategic components of future food and nutritional security frameworks under changing climatic and socio-economic conditions.

THREATS TO GENETIC RESOURCES

Land use change and habitat loss

Malaysia's rapid development has reshaped landscapes nationwide. Agricultural land is being converted into housing, industrial zones, highways, and large-scale plantations. As a result, areas traditionally cultivated with diverse root crops are shrinking. When small farms close or shift to new crops, unique varieties may be lost forever.

Urbanisation and decline of home gardens

Home gardens historically served as living collections of crop diversity. Many families maintained several varieties of sweet potato or cassava for household consumption. Today, however, younger generations tend to migrate to urban centers, leaving fewer people to maintain these gardens. Without new caretakers, many traditional landraces face extinction.

Erosion of traditional knowledge

Local farmers, especially the elderly, possess rich knowledge about planting materials, soil preferences, pest management, and seasonal planting cycles. This information is rarely documented. As older farmers retire, this knowledge may disappear unless captured through community documentation or collaborative projects.



Figure 4. Traditional cassava varieties cultivated for generations by a small group of farmers in Kampung Siburan, Sarawak.

Climate variability and its impacts

Increasingly unpredictable weather patterns pose new challenges. Farmers in Kelantan and Sabah report more frequent dry spells, sudden heavy rains, and pest outbreaks. Some landraces that once thrived under stable climates now struggle to produce consistent yields.

Cassava, known for drought tolerance, has shown signs of stress under prolonged heat waves, while sweet potato varieties that prefer moist soils may not survive extended drought periods. Emerging diseases—especially viral infections—can rapidly spread and wipe out susceptible varieties.

Case study 1: *Local Voices from Kelantan*

During a field visit in Bachok, farmers shared stories of how their preferred *keledek* varieties have changed over time.

Pak Hassan, a 62-year-old farmer, recalled:

"*Dulu, keledek oren ni senang hidup. Sekarang, cuaca lain, serangan serangga pun banyak. Kena tanam beberapa jenis, mana tahu yang mana boleh tahan*."

("In the past, orange sweet potato grew easily. Now the climate is different, and pest attacks are more frequent. We must plant several varieties because we don't know which ones will survive.")

His statement reflects a broader trend observed across Malaysia: maintaining diversity is a must-do conservation strategy.

CONSERVATION STRATEGIES

***Ex situ* conservation: Safeguarding diversity off-site**

Ex situ conservation involves preserving plant genetic materials outside their natural environment. MARDI plays a central role through:

- Field gene banks where living plants are grown and maintained.
- Tissue culture collections holding clean, disease-free plantlets.

These collections ensure survival of genetic resources even when field conditions change or disasters occur. *Ex situ* collections also support research such as variety testing, pest resistance screening, and breeding.



Figure 5. Sweet potato conservation at MARDI Bachok, Kelantan. Germplasm collections are planted in microplots, with vine cuttings transferred every two weeks.



Figure 6. Tissue culture of traditional and commercial varieties of sweet potato and cassava carried out at the Tissue Culture Laboratory, Agrobiodiversity and Environment Research Centre, MARDI Serdang, Selangor.

In situ and on-farm conservation: Protecting diversity where it grows

In situ conservation keeps plants in their original or traditional environments. This method helps preserve not only the plants but also the ecosystem interactions and farming knowledge that sustain them. On-farm conservation, where farmers actively grow multiple varieties, has proven especially effective. In Sabah, smallholders maintain diverse cassava types for food, feed, and cultural practices. In Sarawak, community seed exchange remains common, ensuring planting materials circulate widely among villages.

Community participation and traditional knowledge

Successful conservation efforts rely on valuing farmers' contributions. Traditional knowledge about which landraces are drought-tolerant, which resist pests, or which varieties are best for certain recipes is crucial for selecting varieties worth conserving.Programs involving community workshops, farmer field schools, and shared trials strengthen these connections. Recognising and documenting farmer knowledge through video interviews, community booklets, or digital archives helps preserve local wisdom.

CHALLENGES TO EFFECTIVE CONSERVATION

Key challenges include:

- Limited funding for genebank maintenance
- Threats from pests, diseases, and extreme weather
- Labor needed for regenerating planting materials
- Limited incentives for farmers to maintain traditional varieties
- Gaps in policies governing genetic resources and benefit sharing
- Addressing these challenges requires coordinated, long-term commitments.

Genetic improvement and breeding programs

Developing improved and mutant lines

Malaysia continues to develop improved varieties of sweet potato and cassava to support farmers and industries. Breeding programmes use conventional selection, controlled crossing, and mutation breeding, where genetic variation is induced using gamma radiation. These approaches have produced high-yielding, pest-resilient, and nutritionally enhanced lines. For instance, orange-fleshed sweet potato varieties rich in vitamin A have gained popularity due to their health benefits.

Traits Targeted for National Priorities

Sweet potatoes rich in natural antioxidants (e.g., purple-fleshed varieties) and cassava with improved starch quality offer promising commercial opportunities. Therefore, breeding focuses on traits that address Malaysia's needs:

- High and stable yields
- Resistance to major pests and diseases
- Drought and soil tolerance
- Enhanced starch content for industry

Using local germplasm to strengthen breeding

Local landraces are crucial resources because they possess traits adapted to Malaysian conditions. Integrating these varieties into breeding broadens the genetic base and ensures future crops can withstand new challenges.

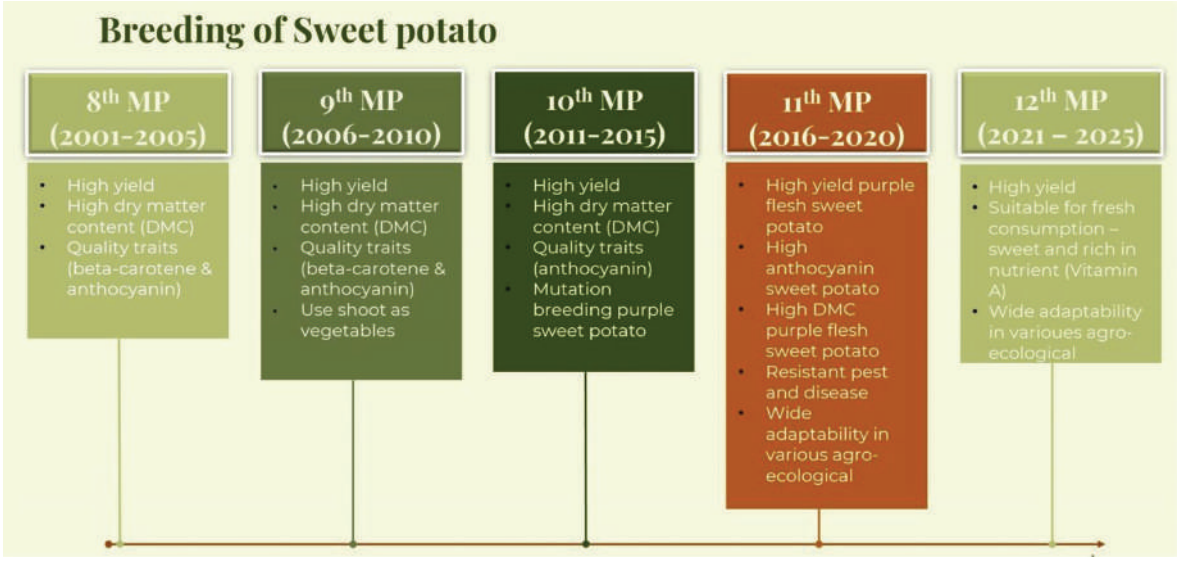

Figure 7. The diagram shows the objective of sweet potato breeding at MARDI which focuses on developing high-yield, nutrient-rich varieties that are adaptable to various agroecological conditions.

Case study 2: ***Farmer–Researcher Partnership in Sabah***

In Kota Belud, a collaborative trial between researchers and local farmers evaluated new cassava lines. While researchers emphasized yield and disease tolerance, farmers prioritised taste, cooking quality, and storage ability.

One farmer, Puan Mary, explained:

"*Ubi yang tahan simpan dan sedap rebus penting bagi kami. Bukan setakat hasil banyak.*"

("Cassava that stores well and tastes good when boiled is important to us. It's not just about high yield.")

This experience underscores the need to include farmer preferences early in breeding programmes.

CONCLUSION AND POLICY RECOMMENDATIONS

Sweet potato and cassava genetic resources hold immense potential for Malaysia's future. They support food security, rural livelihoods, and climate resilience while offering opportunities for new industries. To strengthen conservation and sustainable utilisation, the following policy actions are recommended:

- Develop a national strategy for root crop genetic resources, integrating research, extension, and community participation.
- Support on-farm conservation through incentives, community seed networks, and farmer -led documentation.

- vStrengthen *ex situ* collections with secure funding, upgraded facilities, and advanced technologies like cryopreservation.
- Promote participatory breeding so that new varieties meet farmers' real needs and preferences.
- Encourage local processing industries to utilise diverse varieties, creating market demand that supports conservation.
- Integrate root crops into national food security planning, especially as climate-resilient alternatives to water-demanding crops.
- Recognise and reward traditional knowledge holders, ensuring their skills continue across generations.

By combining scientific innovation, farmer expertise, and strong policies, Malaysia can safeguard its rich root crop heritage while unlocking new opportunities for sustainable agriculture.

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