Journal of the Andaman Science Association Vol. 27 (Special issue):12-21 (2022)
ISSN 0970-4183, Printed in India

Genetic Resources and Crop Improvement in Underutilized Vegetables of Andaman and Nicobar Islands

Shrawan Singh*

ICAR-Indian Agricultural Research Institute, New Delhi-110012, India
***Corresponding author's E-mail:** singhshrawan@rediffmail.com*

Abstract

The indigenous vegetables (IVs) constitute important sources of dietary micronutrients and livelihood support for poor and marginal communities in rural and tribal regions. Their role has been well accepted in food-based approaches to fight against micronutrient and vitamin deficiencies which are of main concern for attaining Millennium Development Goals. Although, worldwide conservation efforts resulted in huge germplasm conservation at AVRDC-the World Vegetable Centre, Taiwan and National or Regional Gene Banks, but, received little or negligible attention for breeding of superior genotypes. These vegetables are vital for survival and health of marginal forest dwelling communities and remote rural areas, particularly in underdeveloped and developing countries. In the present paper, the efforts done at ICAR- CIARI, Port Blair for exploring the local diversity of indigenous vegetables of Andaman and Nicobar Islands, India are presented. During 2008-14, around 200 local germplasm of indigenous vegetables were collected and improved varieties were developed which showed remarkable gain in yield, uniformity and quality traits during selection process. Similar efforts to develop promising genotypes in locally adapted indigenous vegetables would help to tap their potential in achieving nutritional and livelihood security of island population.

Key words: *Breeding, Indigenous vegetables, nutrition, tribes, tropical islands*

Introduction

About 3 billion people in the world are malnourished and more than 70% of malnourished children live in Asia alone. Nearly half of the world's micronutrient-deficient population is in India (Stein and Qaim, 2007). It has been estimated that around 6.7 million deaths worldwide were attributed to inadequate intake of fruits and vegetables annually (Lim et al., 2010). The Food and Agriculture Organization (FAO) prescribes for intake of 500 g fruits and vegetables per capita per day. On similar line, the Indian Council of Medical Research (ICMR) has recommended 300 g vegetables and 100 g fruits for Indian population. However, vegetables are perishable foods with variable growing conditions, preferences amongst the consumers and are bulky. In specific ecologies, local or underutilized vegetables are key to food and nutritional security due to their regular access and affordable prices. Developing commercially acceptable cultivars in IVs is essential for tapping their potential in ensuring nutritional and financial security.

Although government schemes in the form of food supply, food fortification and supplementation programs helped significant population to cross the 'line of undernourishment', these programmes need additional activities to substantiate the on-going efforts. Therefore, there is need to have differential and customized approaches including both commercial and local vegetables to ensure regular access to quality vegetables at affordable prices.

Vegetable crops represent a diverse group of culinary plants. A large number of these crops or culinary plant species remain underutilized mainly due to limited area of cultivation, specific consumer base, limited preferences, recent identification or domestication and low commercial prospects in terms of global and national vegetable scenario. These underutilized native vegetable species are described as indigenous vegetables. Their major characteristics are (i) indispensable part of traditional food culture, (ii) lack of standardized agro-techniques for commercial cultivation, (iii) absence of seed production or marketing systems, (iv) insufficient attempts for genetic improvement and (v) cultivation in wild, home gardens, or small-scale farms. These criteria have been used to describe the terms 'indigenous leafy vegetables' (van Rensburg et al., 2007), 'traditional food crops' (FAO,1997) and 'indigenous traditional vegetables' (Keatinge et al., 2011).

Indigenous vegetables (IVs) are common food for vulnerable communities as these are easily accessible, acceptable and cheapest food source, easy to adopt livelihood option for tribal and rural youth and possess adaptive tolerance to biotic and abiotic stresses. These qualities make them a good choice for climate smart agriculture and organic farming. Development of improved varieties in IVs can significantly contribute in enhancing the nutritional security of island population.

Underutilized vegetables: diversity and local communities

Globally, around 400 plant species are being cultivated as vegetable crops. Of these, 218 vegetable species are distributed across 11 recognized centers of origin. In India, about 50 vegetable species are grown commercially but only a few contribute significantly to the total vegetable production. Besides, 521 wild plant species from 377 genera are used as leafy vegetables by tribes. India has about 550 communities and 227 ethnic groups living in more than 5000 villages and forest areas. This highlights the significance of underutilized vegetables in contributing to the nutritional security of these communities.

Food and nutritional significance of indigenous vegetables

The indigenous vegetables significantly contribute to food and nutritional needs of the tribes and rural communities (Singh et al., 2010) and many of them are nutritionally richer than their exotic counterparts. They are abundant, easily accessible, locally adaptable and acceptable (FAO, 1988). The indigenous vegetables are popular amongst tribes and ethnic communities and occupy major share in vegetable market during rainy or dry seasons (Prioni et al. 2001; Singh and Singh, 2012). Their rich profile in phytochemicals adds the value to their potential in countering the risk associated with non-contagious diseases related to cardiovascular, digestive, respiratory and nervous systems. The regular intake of these vegetables contributes to lowering the incidence of micronutrient (Fe, Ca) and vitamin (A, B, C, K) associated health problems. These are also helpful in global fight against anemia, blindness and other immunity associated diseases.

As per an estimate, the tropical regions will house around 55% of the world's population by 2050 but these are more vulnerable to climate change impacts (https://tropicaldatahub.org). Resource shrinkage due to rise in human population and climatic vagaries in these regions invite attention for measures to ensure food and nutritional security. In this context, the indigenous foods including vegetables could serve better and easy source for dietary microelements (Baruah and Borah, 2009) as they have been playing vital role in fight against micronutrient deficiencies in vulnerable communities due to their easy accessibility and better acceptance in traditional diets (FAO, 1988). Anti-nutritional factors in indigenous vegetables limit the bioavailability of dietary micronutrients and hence, efficient cooking processes are necessary to be devised to minimize the effects of unfavourable dements while retaining the beneficial ascorbic acid, anthocyanins and carotenoids (Udousoro et al., 2013; Singh et al., 2015).

Lack of systematic information on nutritive profiles, inconsistency and inadequacy in supply of nutrient rich vegetables and lack of efficient cooking practices hinder the integration of vegetables in nutritional security schemes. In natural habitats, indiscriminate exploitation lead to situation of 'more efforts less harvest' while poor market and technological support are major constraints in commercial farming of these vegetables. Proper rationing of harvest through community participation is essential to retain the regenerative capacity of the natural habitats and ensuring sustainability of traditional food system. This could be reverted by breeding of nutrient-rich varieties in prioritized indigenous vegetables and development of suitable production technologies (Singh et al., 2015). The IVs are important for food and nutritional security at the micro level or regional levels in vulnerable communities as shown in Fig. 1.

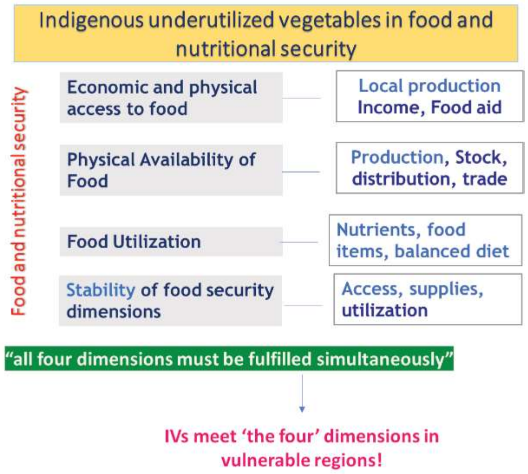

Fig. 1. The IVs in local food and nutritional security

Indigenous vegetables to strengthen regional economy

As in case of Andaman and Nicobar Islands, the Gross State Domestic product (GSDP) was estimated at US$ 810 million with per capita income of US$ 2,132 in 2010 (Basic Statistics, 2010). The contribution of the services sector (49%) was maximum followed by primary sector (17%) and secondary sector (34%). A significant share of income returns back to mainland India as charge of goods and services including vegetable crops. This 'drain of economy' can be reduced by producing vegetables locally to meet the demands of local population and tourists particularly in rainy season when the islands have off-season for commercial vegetable crops. For this, breeding of biotic and abiotic stress tolerant varieties adaptable to heavy rains in open condition and tolerant to partial shade and humid conditions inside the protected structures is a prerequisite. In Andaman Islands, the diversity of indigenous vegetables has potential to substitute the commercial vegetable crops and reduce the demand for import. Few examples include *Hibiscus sabdariffa* for sourness in place of tomato; *Eryngium foetidum* in place of leafy coriander; local tuber crops in place of potato; exotic chilli by local materials for pungency; local legume vegetables to replace import of exotic legumes; multiplier onion for common onion; indigenous pickle items; *Limnophila chinensis* for composite flavours etc.

Indigenous vegetables to mitigate climate change impact

The productivity of vegetables generally remains low in tropical islands (Olasantan, 2007) which could be due to genotypic and environmental factors or their interactions. Bray et al. (2006) reported yield losses of around 50% in vegetable crops primarily due to environmental stresses. In future, the climate associated stress events like high temperature, limited soil moisture and salinity stress will get magnified by climate change impacts (de la Pena and Hughes, 2007). Frequency of extreme events is likely to affect the response of technologies including high yielding genotypes against soil health degradation or changes in disease and pest equilibriums and reproductive biology with modified microclimate. The Andaman and Nicobar Islands are geographically isolated from continental India and form an archipelago of 572 islands fragmented by sea water. The islands have high vulnerability to extreme impact of natural disasters like tsunami and cyclonic storms (Krishnan et al., 2011). Singh and Bainsla (2014) also presented an analysis of breeding for climate resilient traits in vegetable crops with main emphasis on indigenous vegetable crops of the islands. Although, a systematic review was made by de la Peña and Hughes (2007) for improving vegetable productivity in a variable and changing climate with specific attention to tropical continental regions, there is little progress on exploitation of the real potential of these crops to harness their strength in climate change mitigation strategies.

Indigenous vegetables to utilize degraded land and water resources

The Tsunami (26th December 2004) damaged around 8,068.71 ha of precious agricultural land (out of total 50,000 ha agricultural land) of the Andaman and Nicobar Islands and directly affected the livelihood of more than 6,000 farmers. It caused total losses to island agriculture to the turn of INR 321 crores. It caused losses to plantation crops by 28% in Katchal Island, 17% in Car Nicobar (home of Nicobarese tribes) and 13% in Campbell bay (also commercial plantations of settlers). Small islands like Teressa (744.0 ha), Kamorta (637.0 ha) and Trinket (329.0 ha) Islands were mostly washed out by sea water. These lands were submerged by sea water which created saline soils and lowland areas got flooded during rainy season. Although, the raised bed technique is quite effective but the challenge is to breed varieties which can tolerate high salinity stress. Local germplasm of wild *Ipomea* sp., *Alternanthera* sp., *Portulaca* sp., *Amaranthus* sp. were seen in the Tsunami affected lands indicating the potential to identify varieties suitable for salt stress situations. Under occasional submergence conditions, *Ipomea aquatica* and *Alternanthera* sp. were found to grow well. On the other hand, water is an important limiting factor for vegetable cultivation during later phase of dry season in the islands i.e. March to April months which necessitates breeding of drought tolerant varieties to attain economic yield of quality produce in the islands.

Indigenous vegetables for enriching home gardens

Settlements in tropical islands have home gardens as integral component to meet the day to day requirements of food items. Vegetables, mainly cucurbits, leafy vegetables, chilli, brinjal, okra and cowpea, are the important constituents of these tropical home gardens (Pandey et al., 2007). Perennial tree vegetables such as drumstick, jackfruit and bread fruit are also common on boundaries while low-growing herbs such as *Centella asiatica*, *Eryngium foetidum* and *Bacopa monnieri* are grown in earthen pots. Tsunami also damaged the traditional home gardens of the islands but new home gardens having better crops and varieties were established to meet the daily needs of horticulture-based food items. Intensity of home gardens in rural areas of islands is higher (65%) as compared to peri-urban (40%) areas where manpower is oriented towards commercial farming. The research and development efforts were directed towards modernizing the home gardens with more crops and improved varieties, scientific production technologies, rain shelters, soil mount technique, use of multistorey cropping system, assuring irrigation water for dry phase and providing improved farm implements. Suggested future research efforts would include development of suitable varieties and devising modules for maximum edible product from components of home gardens to meet the maximum share of household needs for food items. Scientific evidence of increase in nutritional status of household members by adoption of home gardens is needed to promote this concept.

Indigenous vegetables for livelihood and entrepreneurship

The IVs are potential options as source of livelihood and entrepreneurship. These crops are more prevalent in areas which are geographically isolated, economically marginal with poor skills of growers to adopt the new and medium to high end economic activities. Though they have ready market in local communities and local markets, their promotion in other regional markets could facilitate the integration of the local farmer communities in economic activities. Also, the women and poor people find it comfortable to deal with economic activities in vegetables since they feel attached with their traditional practices. Other areas which can be seen as potential options are described as (i) production of quality planting material for local and national needs, (ii) growing and marketing of traditional crops having novel traits in 'zero land cultivation' concept for supplementing local income, (iii) tapping the potential of local crops for high end food industry – nutraceuticals and functional foods, (iv) sensitise and market local rare crops having strong traditional value in different forms, (v) local food outlets for tourists and urbanites with reliable and healthy cooking practices, (vii) processing and packaging local unique IVs for national markets, and (viii) integration of vegetables (particularly IVs) in integrated farming systems.

Research Programme on Indigenous vegetables

The research studies on indigenous vegetables are very less across the world including India. Various reasons for it include limited scope/impact of research outcomes, huge diversity of species, different growing requirements, poor acceptance among the non-traditional consumers, region and season specific preference among the growers, breeding beahaviour and lack of improved varieties etc. However, these crops are important in certain geographical regions particularly in islands, hill regions, tribal regions, desert areas, forest regions etc. These crop plants have evolved in the regional climatic situations over the years and hence, have attained adaptive changes which could be useful for breeding climate resilient crops/ varieties. Therefore, careful planning and implementation of research programme is essential to harness the potential of these neglected vegetable crops.

Since the impact of individual indigenous vegetable crop is limited due to small size of consumer base, simple and rapid breeding methods such as pure line selection and mass selection are to be practiced for developing trait specific varieties. However, need for prioritizing the crops and traits for systematic breeding programme has been given little attention. Efforts in this direction would prove to be effective against climatic and livelihood uncertainties in the geographically isolated islands.

Survey and documentation of IVs and their traditional uses

The target region and dwelling communities should be surveyed using proper surveying techniques for documentation of diverse indigenous vegetables and their consumption pattern. For this, food parameters (preference, food value, perceptions, frequency of use), nutritional perceptions, botanical descriptions (annual, biennial, perennial, edible part, mode of multiplication), habitat and growing situations (season, specific features), cooking parameters, market parameters etc. should be recorded for 2-3 years. In case of perennial IVs, the target plant should be marked with proper GPS location.

Germplasm collection, crop prioritization and conservation

After surveying, the germplasm of target indigenous vegetables should be collected with all the necessary descriptions. The collected germplasm should be grown in germplasm conservation houses located in almost similar geographical conditions for multiplication. The non-propagated germplasm should be collected again for enriching the germplasm and ensuring the representation of different locations in the field gene bank. Further, the edible parts of the target germplasm of different indigenous vegetables should be collected along with the propagating materials for evaluation of food and nutritive values through laboratory analysis. In this process, the major dietary elements, minerals and anti- nutrients should be assessed and they should be given adequate weightage in crop prioritization. In Andaman Islands, scientists of ICAR-CIARI surveyed different inhabited islands, and identified 42 IVs. Thirty species were evaluated for dietary elements and 10 were selected for breeding programme. While prioritizing the crops, food value, market potential and nutritional values were considered adequately.

Abraham et al. (2008) collected germplasm of vegetables and their wild relatives (185 nos.) and tuber crops and their wild relatives (44 nos.) along with other crop germplasm. Singh et al. (2015) also reported existence of diverse germplasm of different vegetables in the islands. The list included 150 species of vegetables, of which perennial vegetables constituted 18% followed by lesser-used-leafy vegetables (15%), local legume vegetables (10%), tuber crops (9%), lesser known cucurbits (7%) and wild related vegetables (5%). Commercial vegetables (18%) and new exotics (11%) were also recorded. Pandey and Diwakar (2008) reported 2,574 floral species including 1,752 dicots, 672 monocots, 8 Gymnosperms and 142 Pteridophytes. Sharma et al. (2010) reported 44 horticultural species including *Colocasia, Momordica, Dioscorea* and *Canavalia* species. Sharma et al. (2018) documented 36 endemic wild relatives including four rare species. They could enlist 308 species from the islands, some of which have potential in pre-breeding for climate change resilience, rare nutrients and biotic and abiotic stresses. They suggested for conservation of this germplasm, systematic screening for biotic and abiotic stresses, and attempting inter-specific hybridization for use in crop improvement programmes.

Germplasm diversity and characterization

Characterization of the unique germplasm in indigenous vegetable crops is particularly important to minimize the biopiracy, trait prioritization and benefit the custodian farmers in 'biodiversity hotspots' (Gautam et al., 2014). Investigations for search of unique traits or genotypes have been made by means of nutritive profiling of few indigenous vegetables (Singh et al., 2011). Characterization should be done for unique and prospective traits such as climate resilience, disease resistance, development of functional foods etc. In Andamans, extent of diversity was analysed using agro-morphological traits and molecular markers in indigenous vegetables namely *Colocasia*, spp. (Singh et al., 2011), *Capsicum* spp. (Singh, 2013), *Momordica* spp., *Amaranthus* spp., *Alternenthera* sp., *Basella* spp., *Centella asiatica, Ipomea* spp. and *Moringa oleifera* (Singh et al. 2011; 2013; 2018). Although, conservation in field gene garden and in seed form were attempted, there is wide gap in available and conserved species. Farmers and home gardeners are playing crucial role in conservation of agri-horticultural crops but systematic efforts are necessary. Notably, protocols for *in-vitro* conservation of germplasm for tropical regions have been developed which may be further fine-tuned for these underutilized but potential vegetable crop species.

Germplasm improvement methods for yield and related traits

Breeding for nutrient-rich genotypes in indigenous vegetable crops was attempted at ICAR-CIARI. For this, a concept was devised and attempted for improvement of indigenous leafy vegetable crops for nutrient contents which could result into promising genotypes. In self-pollinated crops, pure line selection, hybridization, pedigree method, bulk method, single seed descent (SSD) method and backcross methods are in common use. Pure line selection is the progeny of single self-fertilized homozygous individuals and preferably applied to improve local landrace of indigenous vegetables. From locally popular collection, a large number of plants were selected based on phenotypic basis and their individual progenies were evaluated till homozygosity was attained. It helps in maintenance breeding and attaining the uniformity in appearance and also in nutrient contents. The varieties thus developed and popularized not only increase productivity but also facilitate on farm conservation of local superior genetic resources.

The hybridization method is mainly used to generate variability in segregating progenies from promising parents having better phenotype and high general combining ability. The selected parents are crossed, and selection for desirable characters is made by pedigree and bulk methods. In pedigree method, single plant selection is followed up to F_{5} or F_{6} generations and in advance generation, families are selected on the basis of their records of phenotypic performance. It has been adopted to improve germplasm and develop variety for nutritional quality. The bulk method is one of the most economical methods of handling segregating population based on natural selection wherein poorly adapted types are eliminated and superior types prevail. Although, this method was employed to develop genetic stocks for tolerance to heavy, drought and waterlogging situation, it did not result in getting superior plants.

The single seed descent method was employed in *Hibiscus sabdariffa*, *Basella alba* and *Capsicum annum* to advance the selected individuals. Backcross method allows transfer of characters controlled by single or oligo-genes but lack of established varieties limits its scope in indigenous vegetable crops. For cross-pollinated vegetable crops, mass selection, line breeding, family breeding and recurrent selection; hybridization and heterosis breeding are suggested to improve the base material. Development of F_{1} hybrid is very suitable for enhancing nutraceuticals and edible colours but lack of suitable genetic mechanisms for affordable hybrid seed production is a big challenge. The mass selection is still the practical method applied so far for development of varieties in cross-pollinated indigenous vegetable crops. Based on the extent of available germplasm, floral behaviour and ease breeding programme, the mass selection, pure line selection and clonal selection methods have been generally recommended.

Breeding new varieties in indigenous vegetables

In indigenous leafy vegetable crops, breeding progamme was started in 2008 in the islands, which resulted in development of one variety each of *Eryngium foetidum* (CARI Broad Dhaniya), *Basella alba* (CARI Poi Selection), *B. rubra* (CIARI-Shan), *Amaranthus viridis* (CIARI-Harita) and *A. tricolor* (CIARI-Lal Marsha) for tropical island conditions. The detailed characteristics of these verities are well documented (Gautam et al., 2016). CARI Broad Dhaniya is the first variety of this crop in India and it was developed through mass selection using local germplasm from Andaman Islands. It produces 30-35% higher yield than the base material. Its leaves are rich in micronutrients and phytochemicals. The variety fits well in 'zero land cultivation' concept. The average yield is around 8-10t/ha/year. CARI Poi Selection is a new and first variety of Indian spinach (green type). It has attractive green and broad leaves, short internodal length and better shelf-life. It is rich in Fe and Ca, ascorbic acid and carotenoids. It is highly suitable to tropical climatic condition of Islands and yields around 18 t/ha (with single harvest) and 54 - 60 t/ha with multi-harvests i.e. 42 - 57 % higher than the local base materials. It was released by the Institute Variety Release Committee of ICAR-CIARI, Port Blair in 2013. CIARI-Shan (*Basella rubra*) was developed using local germplasm through mass selection method. It has dark attractive purple/magenta colour stems and green leaves with coloured veins and short intermodal length. It is rich in anthocyanin (leaf- 280 mg/100g; stem- 410 mg/100g FW) and micronutrients (Fe- 8.4mg/100g; Ca- 202.8mg/100g DW). It is ready to harvest at 35-40 days stage when it attains a height of 25-30 cm. It has yield potential of 48-52 t/ha with multi-harvest and 15-18 t/ha in single harvest. It grows well in partial shade (50%) with organic inputs.

A local germplasm was used in breeding of CIARI-Harita, which is a promising selection of amaranthus (*Amaranthus viridis*) from Andaman and Nicobar Islands. It has attractive green and broad leaves, fast growth habit, high preference among the farmers and consumers and high biomass yield. It is rich in antioxidants like chlorophyll (707.8±7.3 mg/100g) and carotenoids (509.5±2.5 mg/100g). It is well suited to tropical climatic conditions of Andaman and Nicobar Islands and has fast-growing habit. It has green leaf yield potential of 13-15 t/ha in island conditions.

Similarly, another local germplasm of red amaranth (*Amaranthus tricolor* L.) was utilized in development of CIARI Lal Marsha. It is a promising selection for higher yield, attractive leaf colour and better adaptability to tropical warm humid climate of Islands. It has attractive broad and purple/ magenta leaves, fast growth habit and high acceptance by farmers and consumers. It is preferred in home gardens for its attractive colour which also adds ornamental value. It is rich in anthocyanin (288.7±1.8 mg/100g), a strong antioxident for better health. It has green leaf yield potential of 14-16 t/ha in the tropical islands (CIARI, 2014).

The brinjal variety 'CARI Brinjal-1' has high level of resistant to bacterial wilt. It bears light green oblong shaped fruits. Plants have medium height, semi-spreading type with profuse branching habit. It is especially suitable for growing in rain-fed conditions during dry season in the tropical islands. Four types of wild relatives of brinjal, namely *Solanum torvum* (10 collections), *S. indicum*, *S. surratence* and *S. vairum*, were also collected and characterized. All the 10 accessions of *S. torvum* were observed to be free from all kinds of wilts (bacterial wilt, *Fusarium* wilt and *Verticillium* wilt). Immature berries of *S. torvum* are consumed as spiced dish in the islands. Three accessions of *S. virum* syn. *S. khasianum* from the vicinity of mangroves were also collected, which contain high amounts of secondary metabolites like solasodine with insecticidal and antibacterial properties. *Solanum indicum* is the second most abundant wild relative of brinjal in the islands after *S. torvum*. It is non-edible and acts as carrier of resistance to fruit-and-shoot-borer and wilt pathogen. *Solanum surratence* species contains alkaloids.

In case of chilli, around 60 local genotypes were evaluated for yield and to prevalent biotic stresses (bacterial wilt and leaf curl virus) which resulted in identification of five promising genotypes which were named as CIARI Chilli-1, CIARI Chilli-2, CIARI Chilli-3, CIARI Chilli-4 and CIARI Chilli-5. These genotypes have high yield potential than national and local checks besides better-quality attributes and resistance to leaf curl and bacterial wilt.

Locally collected germplasm of *Momordica cochinchinensis* and *M. subangulata* ssp. *subangulata* were evaluated for quality and horticultural traits (Singh et al., 2013; 2017). Among root and tuber vegetables, sweet potato (*Ipomea batatas*) has good extent of diversity and local germplasm was used for breeding of two new varieties (C1AR1-SP1 and CIAR1-SP2) through selection method. CIARI- SP-1 is non- twining spreading plant with slow growth rate and short internodal length (Gautam et al., 2016). It has medium sized mature green leaves and purplish-green immature leaves. The individual tuber weight is 81 g and yields 20.87 t/ha. CIARI- SP 2 is another variety, which has twining spreading plant with intermediate growth rate and intermediate internode length. It has medium sized mature green leaves and purplish-green immature leaves. Individual tuber weight is 93 g and yields 22 t/ha.

The elite lines from local germplasm were also developed in indigenous vegetables such as *Momordica subangulata* subsp. *renigera* (CARI Kakrol-1; uniform attractive green fruits with high yield potential (80-90 q/ha) in island condition), *Hibiscus sabdariffa* (CIARI HS-1; attractive green leaves, uniform growth, high yield (130 q/ha), early (35-40 days) and tolerance to foliar diseases); *Centella asiatica* (L.) Urban (CIARI CA-5; broad leaves, rich in micronutrients and yield 30-35 q/ha); *Ipomea aquatica* L. (CIARI NB-4; attractive green leaves and green stem, fast growing habit and yield potential of 80-90 q/ha); *Portulaca oleracea* (CIARI DB-8; rich in polyphenol, Ca, Fe and suitable for problem soils); *Alternanthera* spp. (CIARI MD-1: green leaves, tolerant to heavy rains and waterlogged situation and high yielding and CIARI MD-2: purple green leaves and high yield of 11-14t/ha) (CIARI, 2013; Singh and Bainsla, 2015).

Perennial indigenous vegetables in the islands

The islands have rich diversity of tree vegetable species such as *Moringa oleifera*, *Artocarpus heterophyllus*, *A. incisa*, *Murraya koenigii* and *Tamarindus indica*, which are prevalent in home gardens in the ANI (Abraham et al., 2008; Pandey et al., 2006). *Cycus rumphi* and *Calamus andamanicus* are eaten in the form of stew, soup, pickle, chutney or curry (Singh and Singh, 2012). Perennial vegetables as wild relatives of cultivated species viz. *S. melongena* and *C. annuum* (Abraham et al., 2008) have not been exploited so far. Fruit crops for use as vegetables such as vegetable banana, green papaya, carambola, immature green mango etc. are the dependable sources even during climatic aberrations. Besides, the islands have about 34 mangrove species, which cover 12% of geographical area, few of them being edible (Goutham-Bharathi et al., 2014). Over all, more systematic efforts are required to document and conserve germplasm resources of perennial vegetable species in the islands.

Strengthening 'On-site' production system with indigenous vegetables

Vegetables are perishable food items and their regular supply in adequate quantity remains a big challenge. Hence, measures to enhance production of vegetables 'in locale' through home gardens, kitchen gardens, container gardening, roof gardening etc. are essentially required not only for remote rural areas but also for urbanites. Establishment of new home gardens or enriching the existing traditional home gardens with nutrient rich locally adaptable crops and their superior varieties could contribute much better to the productivity and nutritional security in an environmentally sustainable manner. But, this requires identification of region specific vegetable crops and breeding of varieties for dietary nutrients, prolonged harvest period, adaptation to growing situation and high acceptance among the ultimate beneficiaries. The breeding objectives could include improvement for dietary nutrients and antioxidants, organoleptic scores, tolerance to partial shade, high portion of edible fruits/ parts, low gestation period, resistance to diseases and pests, tolerance to excess rainfall and salinity and response to organic sources etc. So far, research efforts remained targeted towards development of technologies and varieties for commercial scale but some varieties are quite fit for small scale growing in gardens. But, efforts are utmost required to develop plant types ideal for home gardens or other micro-scale production systems.

Way forward

'Indigenous People are the best guardians of the world's forests and biodiversity' as stated by UN Special Rapporteur Victoria Tauli-Corpuz in 2019, should be kept in mind while devising the strategy for development of agriculture in biodiversity hotspots. Andaman and Nicobar Islands have six primitive tribes and diverse settler communities. However, production-cum-consumer base, low investment in vegetable breeding, climatic constraints in continuation in breeding, narrow germplasm base and poor base of genetic stocks of ready to use genotypes for use in rapid breeding programme and production and marketing preferences are some of the constraints. Seasonal distinctiveness of the islands indicates that a number of indigenous vegetable crops can be grown in islands but it requires proper analysis with reference to crops, growing periods and suitable technological options. Although the indigenous vegetables have better adaptability, these are less popular among the economically better off populace who can afford to use exotic vegetable species due to impact of advertisement and popularization by private players on nutritional and quality grounds, while the local vegetables despite being highly nutritive and more useful are hardly popularized. These crops add to alternative sources for taste, flavor and product mix. Some of the indigenous species are much better sources of important nutraceuticals, flavours, minerals and vitamins. The current research and extension methodology is not enough towards making the islands self-sufficient in vegetable production. It largely helps the farmers to grow scientifically but hardly has any impact on broadening consumer base. The specific awareness programmes like debates, advertisements matching the private sector, comparison with commercial products available in market through more popular media like non-government TV and radio channels, newspapers etc. have to be launched. The vegetables produce harvested from organically certified sites and proper branding in the Islands can fetch more price not only locally but also from mainland states in India. This will create a driving force for island products which are unique, superior and matching in some case with imported items so that stigma of poor man's vegetable species can be eliminated and overruled by its nutritional worth. The breeding effort must be in tandem with the market as well as conservation of natural and biodiversity resources. The efforts must be accelerated for harnessing the power of marker assisted breeding and modern genomic tools this will not only reduce the time cycle but will also result in the development of and genetically tailored vegetable varieties with more precision.

References

Abraham, Z., Senthilkumar, R., Joseph, K.J., Sharma, T.V.R.S., Nair, N.V., Unnikrishnan, M., Kumaran, P.M., George, J.K., Uma, S., Latha, M., Malik, S.S., Mishra, S.K., Bhandari, D.C. & Pareek, S.K. (2008). Collection of plant genetic resources from Andaman and Nicobar Islands. Genet. Resour. Crop Evol. 55:1279–1289.

Afari-Sefa, V., Tenkouano, A., Ojiewo, C.O., Keatinge, J.D.H. & Hughes, J.D.A. (2012). Vegetable breeding in Africa: constraints, complexity and contributions toward achieving food and nutritional security. Food Secur. 4(1):115-127.

Bray, E.A., Bailey-Serres, J. & Weretilnyk, E. (2000). Responses to abiotic stresses. In: *Biochemistry and Molecular Biology of Plants*, Gruissem, W., Buchannan, B. and Jones, R., Eds., ASPP, Rockville, MD, pp. 1158-1249.

Chand, S., Srivastava, R.C., Singh, S., Birah, A. & Singh, A. (2010). Analysis of price trend behavior of vegetables in Andaman & Nicobar Islands. In: Abstract Book, *National Conference on Horticultural Bio-diversity for Livelihood, Economic Development and Health Care* held at UHS, Bangalore from 29-31 May, 2010, p. 114.

Chweya, J.A. (1997). Genetic enhancement of indigenous vegetables in Kenya. *Traditional African Vegetables. International Plant Genetic Resources Institute (IPGRI), Rome, Italy*, pp. 86-95.

CIARI (2013). Annual Report, ICAR- Central Island Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands.

CIARI (2014). Annual Report, ICAR- Central Island Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands.

de la Peña, R. & Hughes, J. (2007). Improving vegetable productivity in a variable and changing climate. International Crops Research Institute for the Semi-Arid Tropics, 4, 1-22.

Ebert, A.W. (2020). The Role of Vegetable Genetic Resources in Nutrition Security and Vegetable Breeding. Plants 9(6):736.

Gautam, R.K., Dam Roy, S., Singh, P.K., Singh, S., Singh, A.K., Ahmed, S.K.Z., Jaisankar, I. & Sakthivel, K. (2016). Improved varieties of field and horticultural crops for Andaman and Nicobar Islands, India, ICAR-CIARI, Port Blair, Technical bulletin, pp.36.

Keller, G.B., Mndiga, H. & Maass, B.L. (2005). Diversity and genetic erosion of traditional vegetables in Tanzania from the farmer's point of view. Plant Genet. Resour. 3(3):400-413.

Krishnan, P., Dam-Roy, S., George, G., Srivastava, R.C., Anand A., Murugesan, S., Kaliyamoorthy, M., Vikas, N. & Soundararajan, R. (2011). Elevated sea surface temperature during May 2010 induces mass bleaching of corals in the Andaman. Curr. Sci. 100:111–117.

Nyaruwata, C. (2019). Contribution of Selected Indigenous Vegetables to Household Income and Food Availability in Wedza District of Zimbabwe. Acta Sci. Agric. 3(3):170-188.

Olasantan, F.O. (2007). Vegetable Production in Tropical Africa: Status and Strategies for Sustainable Management. J. Sustain. Agr. 30:41-70.

Olujobi, O.J. (2015). Evaluation of the Nutritive Composition of Five Indigenous Tree Leaves Used as Vegetable in Ekiti State. J. Agric. Environ. Sci. 4(1):185-197.

Pandey, A., Pradheep, K., Gupta, R., Nayar, E.R. & Bhandari, D.C. (2011). Drumstick tree (*Moringa oleifera* Lam.): a multipurpose potential species in India. Genet. Resour. Crop Evol. 58:453-460.

Pandey, C.B., Rai, R.B., Singh, L. & Singh, A.K. (2007). Homegardens of Andaman and Nicobar, India. Agric. Sys. 92(1-3):1-22.

Pandey, R.P. & Diwakar, P.G. (2008). An integrated check-list Flora of Andaman & Nicobar Islands, India. J. Econ. Taxon. Bot. 33:403–500.

Seck, A. (1998). Breeding procedures and results on indigenous vegetalbles: Examples of African eggplant (*Solanum aethiopicum*) and okra (*Abelmoschus* spp.). In: XXV International Horticultural Congress, Part 12: Application of Biotechnology and Molecular Biology and Breeding-General, 522, Aug 2, 1998, pp. 195-208.

Sharma, T.V.R.S, Singh, S. & Singh, P.K. (2018). Wild relatives of agri-horticultural plants in Andaman and Nicobar Islands, India. Genet. Resour. Crop Evol. 65(8):2303–2317.

Singh, D.R., Singh, S., Sankaran, M., Damodaran, V., Sudha, R. & Dam Roy, S. (2012). Horticultural Technologies for Andaman and Nicobar Island, Technical Bulletin, CARI, Port Blair, pp. 25.

Singh S. & Bainsla, N.K. (2014). Breeding strategies for climate resilient vegetable production in tropical islands conditions. Curr. Opin. Agric. 3(1):14–21.

Singh, S., Singh, D.R., Singh L.B., Chand, S. & Dam Roy, S. (2013). Indigenous vegetables for food and nutritional security in Andaman and Nicobar Isalnds, India. Int. J. Agric. Food Sci. Technol. 4(5):503-512.

Singh, S. & Bainsla, N.K. (2015). Analysis of climate change impacts and their mitigation strategies on vegetable sector in tropical islands of Andaman and Nicobar Islands, India. J. Hortic. 2:1-5.

Singh, S., Singh, D.R., Sharma, T.V.R.S., Jaisankar, I., Damodaran, V. & Birah, A. (2017). Surveying potential genetic resources of *Momordica cochinsinensis* (Lour.) Sperng. from Bay Islands. J. Andaman Sci. Assoc. 22(2):115-121.

Singh, S., Singh, D.R., Chand, S., Birah, A & Roy, S.D. (2013). Analysis of perspectives of self-sufficiency in vegetable production under tropical conditions. Int. J. Veg. Sci. DOI: 10.1080/19315260.2013.823585.

Singh, S., Singh, L.B., Singh, D.R., Zamir Ahmed, S.K., Chand, S., Singh, V.N. & Dam Roy, S. (2018). Indigenous under-utilized vegetables for food and nutritional security in an island ecosystem. Food Sec. 10(5):1173–1189.

Sogbohossou, E.D., Achigan-Dako, E.G., Maundu, P., Solberg, S., Deguenon, E.M., Mumm, R.H., Hale, I., Van Deynze, A. & Schranz, M.E. (2018). A roadmap for breeding orphan leafy vegetable species: a case study of *Gynandropsis gynandra* (Cleomaceae). Hortic. Res. 5(1):1-5.

Received: 31st October, 2022 **Accepted: 18th December, 2022**