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Underutilized Potential Crops for Food and Nutritional Security under Changing Climate

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ABSTRACT

In recent years, narrowing of agro-biodiversity, climate change and its variability are emerging as major challenges to Indian Agriculture. There are few crops which have potential for climate resilience but not exploited for cultivation. These crops are termed as underutilized crops (UUC) and categorized under five groups such as Pseudo Cereals (Grain Amaranth, Buck wheat and Grain Chenopods), Minor Cereal (Job's Tear), Food Legumes (Rice Bean, Faba Bean, Adzuki Bean and Winged Bean), Vegetables (Kankoda and Kalingada) and Oil Seed Crops (Perilla, Simarouba, Tumba, Jatropha and Ojoba). Of these crops, AICRN on Potential Crops, Bengaluru center is concentrating on Grain amaranth, Quinoa, Chia, Rice bean and Winged bean. The nutritional benefits and status of research on these crops in addition to challenges, researchable issues and strategies to promote underutilized crops in general are discussed in this paper. The review of work on these crops has indicated that these underutilized crops have potential to reduce food and nutrition insecurity and can help to combat effects of climate change.

Keywords : Under utilized crops, Biodiversity, Climate change, Food and Nutrition Security, Potential Crops

BIODIVERSITY is fundamental for ecosystem functioning, sustainable agricultural production and the attainment of food and nutritional security. Agricultural Biodiversity is critical for food security throughout the world, but only few crop species are utilized for food production (Thrupp, 2000). In addition to provisioning for food, maintaining biodiversity in agriculture is important for providing regulatory ecosystem services such as nutrient cycling, carbon sequestration, soil erosion control, reduction of greenhouse gas emissions and control of hydrological processes. Modern agricultural systems promote cultivation of high-input and high-yielding crop species with the intensification of a limited number of species. This has caused a decline in crop diversity in agricultural systems across the world, associated with diminishing regulatory services. As a consequence, the cultivation of traditional crops has declined and continues to decline globally, yet such crops offer a greater genetic biodiversity and have potential to improve food and nutritional security. This is particularly important to ensure food and nutritional security for the increasing population in the world. Currently, India is facing the challenge of producing adequate food to meet the demands of ever increasing population from shrinking natural resource base. Intensification of agriculture through enhanced productivity and resource use efficiency has to be the main focus as competition for land and water are increasing from non-farm sectors. Further, the climate change and its variability are emerging as major challenges to Indian agriculture in recent years. In view of these, immediate thrust is needed for enhancing production without reduction in natural resources under variable climate. On the other hand, over the past several decades, the productivity levels under rainfed condition has not increased substantially as these areas are constrained by various abiotic stresses and other issues (Srinivasa Rao *et al*., 2015).

Agriculture in India is predominantly rainfed with nearly 58 per cent of the total cultivated area and contributes about 40 per cent of the country's food production (Venkateswarlu and Prasad, 2012). In addition to the temporal variation of the environment, there is also a large spatial variation in the rainfed belt. Feeding the ever-increasing population remains an uphill task with the rapid increase in population along with climatic adversities. The biodiversity rich India is known for cultivation of few hundreds of species where in the process over historic period had evolved variable wealth of genetic diversity in all these species. Global food security has become increasingly dependent on only a handful of crops. Out of an estimated total of 80,000 plants of possible economic use about 30,000 plants have been found to be edible in nature and approximately 7,000 plants have been cultivated by mankind at one time or the other, of which only 158 plants are widely used for food (Collins and Hawtin, 1999). Among these food plants, 30 crops provide 90 per cent of the world's food and only 10 crops supply 75 per cent of the world's food budget. Of these, 10 crops, only three crops *viz.,* rice, wheat and maize provide 60 per cent of the world's total food requirement. This narrow level of food base may imperil the existence of mankind during the time of impending crisis. Therefore, there is a need for enlarging our food basket with alternative food crops to safeguard against any possible unforeseen in the future. The more recent intensification of agricultural research, production and associated policy support at the national and global levels had been narrowing the species base with emphasis only on few of them belonging to cereal and other crop groups, while many species are left out of priority. Such narrowing of agro-biodiversity and shrinking species content in the food basket is a matter of major concern (Swaminathan, 2005). The extra-ordinary hardiness of many of these species and their ability to cope with adverse growing and climatic conditions offers a great promise in the era of climate change (Bala Ravi *et al.,* 2006).

In view of these, there is an urgent need to address the climate change and variability issues holistically through improving the natural resource base, diversifying cropping systems, adapting farming systems approach and weather based management to enhance the agricultural productivity of the country and meet the future challenges of climate change in the dryland regions of the country. In India, there are large areas of marginal and wastelands which are not suitable for cultivation of staple crops, either due to poor quality of soil or lack of water resources. Most of Underutilized Crop (UUC) species are tolerant to harsh agro-climatic conditions and they have excellent potential for establishment on marginal and wasteland throughout the tropics (Hegde, 2002).

Climate change and its impact on crops

In the recent years, climate change and its variability are emerging as major challenges in the Indian Agriculture. The projections of global climate change include altered average temperature, rainfall, and increased extreme events (*e.g.,* heat and cold waves, drought flooding), enhanced atmospheric carbon dioxide, ground-level ozone concentrations and rise in sea level leading to inundation of coastal areas, etc. In the recent past, of is more evident as one or the other part in the country is affected by droughts, excessive rains, floods, cyclones, frost, heat wave and other climatic aberrations. The 4th and 5th IPCC reports clearly outlined the global and regional impacts of projected climate change on agriculture, water resources, natural ecosystems and food security. Although, climate change impacts are being witnessed world over, the countries in which larger population is dependent on agriculture, such as India, are more vulnerable. The risks are likely to be experienced more by small and marginal farmers of rainfed and other risk prone regions with poor coping mechanisms. Climate change will have negative effect on irrigated crops yield across regions in India both due to temperature rise and changes in water availability. While, rainfed agriculture primarily impacted due to rainfall variability and reduction in number of rainy days (Venkateswarulu and Shankar, 2012). Shifts in seasons, increase in temperature and change in rainfall pattern are already being observed. In view of these, the crops may encounter extreme weather events like drought, flood, heat and cold during its life cycle, resulting in substantial yield losses. The impact of these may vary with region, crop and cropping systems, soils and management practices. The yield reductions are likely to be caused by shortening of growing period, increased photo respiration, negative impact on reproduction, grain filling and decrease in water availability at critical growth stages. The negative impact due to terminal heat in the month of January and February, increased water stress and reduction in number of rainy days on yield of wheat and paddy are already being felt (Rao and Bapuji Rao, 2013). Climate change impacts the crop yields both directly and indirectly. The direct effects are mainly due to change in crop duration and impacts reproductive processes such as pollination and fertilization. While the indirect effect are largely due to changes in water availability, altered pest, disease and weed dynamics.

The impacts of climate change on all the crops is obviously not similar as the model outputs reveal that the yields of wheat, rice and maize will decrease while it could be neutral or positive with groundnut, soybean and chickpea (Aggarwal, 2008). Rainfed crops are more vulnerable to climate change because of the limited options for coping with variability of rainfall and temperature. This will result in shift in sowing time and shorter growing season which may necessitate effective adjustment in sowing and harvesting dates. Frequent and more intense extreme events may become the norm of the day for common farming community (Anon., 2013). Among various crops, cultivation of coarse cereals (91%), pulses (91%), oilseeds (80%) and cotton (65%) predominates rainfed regions in India. There are various factors that can be affected due to weather aberration, especially in rainfed areas where more than 80 per cent farmers are small and marginal (having less than 1 ha of land), thus having less capacity to cope with ill effects. Water stress at any stage of crop growth cycle will adversely impact the productivity, while terminal droughts are more critical as the reproductive stage is highly sensitive. Water stress, which is mostly, associated with an increase in ambient temperature results in forced maturity. Drought and heat stress at terminal stage of crop is high in the northern, western and central India, resulting in higher yield loss in case of major food crops such as, wheat and rice. This necessitates the real time implementation of contingency plans to overcome the adverse impacts of weather aberrations in agriculture.

To mitigate the climate change, effects on agricultural production and productivity, a range of adaptive strategies need to be considered. Changing cropping calendars and pattern will be the immediate best available option with the available crop varieties to mitigate the climate change impact (MOEF, 2004). The options like introducing new cropping sequences, early maturing crop varieties depending on the available growing season, conserving soil moisture through appropriate tillage practices and efficient water harvesting techniques are also important. Developing heat and drought tolerant crop varieties by utilizing genetic resources that may be better adapted to new climatic and atmospheric conditions should be the long-term strategy (Anon., 2003).

What is underutilized crops?

Underutilized Crops (UUC) means to enhance agro-biodiversity and climate resilience. The term 'underutilized species' has been defined in a number of ways. One definition is: those species either cultivated or wild that have a great potential for agricultural development and production diversification, thereby ensuring food security, the preservation of cultural diversity & traditions and the generation of income for people living in severe marginal environments. The Global Facilitation Unit (GFU) for Underutilized Species defined them as those crop species with a potential, not fully exploited, to contribute to food security and poverty alleviation and that tend to have the common features like a strong link to cultural heritage, poorly documented and researched, adapted to specific agro-ecological niches, weak or non-existent seed supply systems, traditional uses and produced with little or no external inputs. This variation in definitions tends to suggest that the perception of utility of underutilized species is not uniform. A species that is not fully exploited today may be fully exploited at some time in the future. Underutilized species are probably best understood when they are considered within a specific locality and over a specific period of time. Hence, it is difficult to define just what qualifies as an 'underutilized species'. The terms such as 'underutilized', 'neglected', 'orphan', 'minor', 'promising', 'niche' and 'traditional' are often used interchangeably to characterize the range of plant species those with under-exploited potential for contributing to food security, health (nutritional/medicinal), income generation and environmental services.

As quoted in other references, underutilized crops are plant species that are used traditionally for their food, fibre, fodder, oil or medicinal properties, but have yet to be adopted by large scale agriculturists. Underutilized plants, in general, constitute those plant species that occur as life support species in extreme environmental conditions and threatened habitats, having genetic tolerance to survive under harsh conditions and possess qualities of nutritional and/or industrial importance for a variety of purposes. Kunkel (1984) discussed that once underutilized food crops are properly adopted and utilized, they may help to contribute in food security, nutrition, health, income generation and environmental services when properly utilized. The underutilized foods can be defined as 'the foods which are less available, less utilized or rarely used or region specific' (Williams and Haq, 2002). There are many underutilized food crops in India and majority are not well known or well documented (Solomon, 1998). Singh *et al.* (2012) studied the diversity of underutilized vegetable crop species in North-East India.

Research network on underutilized crops in India

About 70 species of underutilized, neglected and minor crops have been identified to have promise in the Asia-Pacific region (Eyzaguirre *et al.,* 1999; Arora, 2002). Amongst this vast array of pants deserving attention, only a few have been prioritized for scientific exploitation in a phased manner in India. Realizing the significance of the underutilized and under explored plants in diversifying agriculture under different strategic situations, an All India Coordinated Research Project (AICRP) on Underutilized and Underexploited Plants, now rechristened as All India Coordinated Research Network on Underutilized Crops, was initiated in 1982 under ICAR umbrella with the main objective of generating improved technology in selected crops of the minor economic importance for food, fodder and industrial use. The Network Coordinating Unit is located at the National Bureau of Plant Genetic Resources, New Delhi. At present, the network is conducting research on 17 crops of food, fodder and industrial value through 13 main, six cooperating and three voluntary centers located in diverse agro-climatic zones of the country. The below listed crops have been categorized in six groups which are as follows.

1. *Pseudo-cereals*: Grain Amaranth (*Amaranthus* sp.), Buckwheat (*Fagopyrum* sp.), Grain Chenopods (*Chenopodium* sp.)
2. *Minor Cereal*: Job's Tear (*Coix lacryma*-jobi L.)
3. *Food Legumes*: Rice Bean [*Vigna umbellata* (Thunb.) Ohwi and Ohashi], Faba Bean (*Vicia faba* L.), Adzuki Bean (*Vigna angularis* (Wild.) Ohwi & Ohashi), Winged Bean (*Psophocarpus tetragonolobus* (L.) DC.
4. *Vegetables*: Kankoda (Momordica dioica (Roxb.) Ex. Wild), Kalingada [*Citrullus lanatus* (Thunb.)]
5. *Oil Seed Crops*: Perilla (*Perilla frutescens* L.), Simarouba (*Simarouba glauca* DC), Tumba [*Citruillus colocynthis* (L.) Schrad, Jatropha (*Jatropha curcas*), Ojoba (*Simmondsia chinensis*)
6. *Industrial Crop (Rubber)*: (*Partennium argentatum* Gray).

The available information with regard to few selected underutilized crop species are reviewed here.

Amaranth (*Amaranthus* spp.) is a multipurpose crop with good potential for exploitation as grain, vegetable and fodder. Considerable variation has been observed for different nutritional constituents. The seed protein content has been reported to vary from 8.86 to 19.6 per cent (Misra *et al.*, 1985). Analysis of foliage of 61 accessions of *Amaranthus* species revealed the best combination of high carotene, appreciable level of protein and low nitrate and oxalate contents among some vegetable types as well as among a few grain types (Prakash and Pal, 1991). Its grains have high protein with high lysine and a good balance of other essential amino acids. Being an excellent source of iron and carotene, it can help in reducing iron and vitamin A deficiency, especially among rural populations. The presence of a higher amount of folic acid can help in increasing the blood hemoglobin. Amaranth is used as an important ingredient in food by people from the entire Himalayan region and to some extent in the states of Gujarat, Maharashtra, Karnataka and eastern parts of Uttar Pradesh (UP). Amaranth can be utilized to manufacture products such as baby cereal foods, candies and snacks, protein drinks and particularly hypoallergenic foods (Williams and Brenner, 1995), thus value-addition can make this crop more attractive. Grain amaranths are broad leaved, C_4 plants with small seeds. The C_4 photosynthetic pathway is particularly efficient at high temperature, in bright sunlight and dry conditions. Once the growth of the plant is well under way it can even withstand acute drought conditions. There are three species of cultivated amaranth, namely, *Amaranthus hypochondriacus, Amaranthus caudatus* and *Amaranthus cruentus*, which are used as grain and leafy vegetables in the Himalayas. These species are sensitive to day length and are known to be short day species. The evaluation of germplasm collections of grain *Amaranthus* over several years led to the identification of accessions that offer opportunities for its utilization and improvement. IC 42258–1 (Annapurna) originating from Pauri Garhwal, UP, has been released for cultivation by the Central Varietal Release Committee (Joshi and Rana, 1991). Two varieties, GA-1 from Gujarat and Suvarna from Bangalore have also been released. A catalogue on 800 accessions evaluated for 29 descriptors has been published (Joshi, 1981). The highest content of protein (15.3%), sugar (6.4%) and iron (10.66 ppm) was observed in Suvarna variety.

Quinoa (*Chenopodium quinoa* willd.) is an annual herbaceous plant belongs to Amaranthaceae family, but formerly placed in Chenopodiaceae family that originated in the Pacific slopes of the Andes in South America. It was cultivated and used by the *Inca* (ruling class) people since 5,000 B.C. It is consumed in wide variety of forms *i.e.,* grains, flakes, pasta, bread, biscuits, beverages, meals etc. Quinoa is discovered as a health food by North Americans and Europeans in the 1970's and its popularity is dramatically increased in recent years because it is gluten-free (helpful for diabetic patients) and higher in protein content. In India, quinoa is cultivated in an area of 440 hectares with an average yield of 1053 tonnes (Srinivasa Rao *et al*., 2015). As per United Nations Organization for Agriculture and Food, the quinoa grain is the only vegetable food that provides all amino acids essential to the life of humans in optimum quantities and is comparable with milk. The protein content ranges from 7.47 to 22.08 per cent with higher concentration of lycine, isoleucine, methionine, histidine, cystine and glycine. The ash content is 3.4 per cent containing high amount of Ca, Fe, Zn, Cu and Mn. The oil content is 1.8 to 9.5 per cent and rich in essential fatty acids like linoleate and linolenate. In addition, quinoa seed is rich in thiamine (0.4 mg), folic acid (78.1 mg), vitamin C (16.4 mg), riboflavin (0.39 mg) and carotene (0.39 mg) in 100 g seed, respectively. The calorific value is 350 cal per 100 g grains and is greater than that of other cereal and legume foods. The digestability of quinoa protein is more than 80 per cent. In addition to above nutritional factors, the Quiona grain is soft, gluten free, gets cooked quickly and has a pleasant taste. Quinoa also contain natural anti-oxidants like α-tocopheral (5.3 mg), γ-tocopheral (2.6 mg) in 100 g seed and phytoestrogens that prevent chronic diseases such as osteoporosis, breast cancer, heart diseases and other feminine problems caused by lack of oestrogen during the menopause. Hence, FAO nominated 2013 as International year of Quinoa (Bhargava *et al*., 2006).

Chia (*Salvia hispanica* L.) is an edible seed that comes from an annual herbaceous plant, *Salvia hispanica* L. of mint family (Lamiaceae). The shape of seed is oval with 1 to 2 mm in size, which may be black, grey or black spotted to white in colour. Chia means strength and the tiny seeds have been used as energy booster its seeds can be used in the form of whole seeds, mucilage, flour and oil seed (Da Silva *et al*., 2014). Seeds are highly valued for their nutritional properties and medicinal value. It contains healthy omega-3 fatty acids, polyunsaturated fatty acids, dietary fiber, and protein-including all essential amino acids, vitamins, calcium and other important minerals (Ullah *et al*., 2016). In water, its seeds produce a gel, which have a great potential in the development of food products as thickener, emulsifier and stabilizer. The small seeds contain full of important nutrients. Besides, maize, amaranth and beans, chia seed was an important staple food of pre-Columbian Central America (Ali *et al*., 2012). Due to the superior nutritional quality of seeds, it is re-discovered as crop recently. It has now been cultivated in many countries, including Mexico, America, Canada, Chile, Australia, New Zealand and Southeast Asia for different purposes, and consumed worldwide as ingredients of various food products. It contains high amount of lipids (40%), of which 60 per cent is omega-3 fatty acids (Segura *et al.,* 2014). Omega-3 fatty acids help to raise high-density lipoprotein (HDL) in human, which protects from heart attack and stroke. Besides, Chia seed also contains protein of high biological value (15-25%), carbohydrates (26-41%), fiber (18-30%), ash (4-5%) along with high amount of vitamins, minerals, and antioxidants (Ali *et al*., 2012).

Job's tear or Adlay [*Coix lacryma - job;* (L)] is commonly known as Jargadi in Sanskrit, Sankru in Hindi, Gurgur in Bengali, Netpavalam in Tamil, Ranmakha in Marathi and Sohriu in Khasi Hills. It is a tall (3-6 ft in height), erect, diploid (2n=20) annual plant with broad leaves. This minor cereal belongs to family Gramineae / Poaceae. The plant is monocious with terminal loose spike which bears large, shining, pear shaped fruits showing fanciful resemblance to tears. The fruits contain a whitish or light brownish grain similar to rice. Job's tear is considered to be a good substitute for rice. It is rather considered to be more wholesome by virtue of its higher fat and protein content. It can be used in preparation of any food item that is usually made from rice with same degree of palatability. Milling and baking trials in Philippines showed that its flour is suitable for baking purposes when mixed with wheat. A light beer 'Dzu' is made from adlay by the Nagas. The fruits are used in medicine either as tincture or as decoction for catarrhal infection of the air passage and inflammation of the urinary passage. The fruits of wild varieties, var. *stenocarpa* and var. *mominfera* are used for making necklaces, rosaries, bead curtains etc. The foliage may be used as fodder for cattle, horses and elephants. It can also be turned into silage. The mature straw and leaves are used for thatches.

Buck wheat (*Fagopyrum* sp.) is the most important crop of the mountain regions above 1600 MSL both for grain and greens (Singh and Thomas, 1978). It occupies about 90 per cent of the cultivated land in the higher Himalayas with solid stands. It is a short duration crop (2-3 months) and fits well in the high Himalayas where the growing season is short. In the higher Himalayas, up to 4500 m, this is the only crop grown (Joshi and Paroda, 1991). The tender shoots are used as a leafy vegetable, the flowers and green leaves are used for extraction of rutin used in medicine (McGregor and McKilllican, 1952), the flower produces honey of good quality. A total of 577 accessions have been collected including *Fagopyrum esculentum* (284), *Fagopyrum emarginatum* (55), *Fagopyrum tataricum* (198), *Fagopyrum tataricum* var. *himalianum* (30), *Fagopyrum giganteum* (5) and *Fagopyrum cymosum* (5) in 27 multicrop explorations covering diverse agroecological regions of the Himalayas. A set of 408 accessions has been evaluated for 31 descriptors and a catalogue has been published (Joshi and Paroda, 1991). A wide range of variation was found for several traits, which can be used for improvement of this crop. On the basis of multi-location testing at Shimla, Almora and Ranichauri, the varieties Himpriya and VL-7 have been released for cultivation.

Rice Bean (*Vigna Umbellata*) is a promising multipurpose legume crop with good potential as food, fodder, green manure and a cover crop. The dried seeds are usually cooked and eaten with or without rice, young immature pods and leaves are used as a vegetable. The seeds contain a higher amount of protein (20.9%) and limiting amino acids, tryptophan (0.79–1.10%) and methionine (0.45–1.18%), which rank it as one of the best among pulses (NAS, 1979). Though it is suited for the low land humid tropics, some of the cultivars are also adapted to subtropical conditions in the plains. It does well in sandy loam to heavy soils. It is also reported to be moderately drought tolerant (Duke, 1981). In India, its distribution is mainly confined to the tribal regions of the hilly areas of north-eastern hills and the Western and Eastern Ghats (Arora *et al*., 1980; Chandel *et al*., 1984). Field evaluation of 530 accessions of rice bean for 36 descriptors at NBPGR, New Delhi, revealed a wide range of variation for a number of traits and considerable variation existed between collections from different geographical areas (Chandel *et al*., 1988). Analysis of the biochemical constituents of rice bean seeds (15–16) revealed variation for crude protein (17.8–25.2%), ash (3.8–4.1%), calcium (315–450 mg 100 g^{-1}), phosphorus (197–393 mg 100 g^{-1}), iron (1–5 mg 100 g^{-1}). RBL-1 has been released for cultivation.

Adzuki Bean (*Vigna angularis*) is a legume crop having wide variety of uses. The dried seeds are used for human food, either cooked whole or made into a meal used in soups, cakes or confections. In Japan, it is used largely as human food in the form of meal or paste. In India, it is used as a pulse, either whole or split (Thomas *et al*., 1974). Sprouted beans are used as a vegetable. The crop is also reported to be grown for forage and also as green manure in China and Japan. The seeds and leaves have medicinal properties (Sacks, 1977). The seeds contain 19.9 g protein per 100 g of seed (Duke, 1981). Adzuki bean is a short-day plant and requires almost the same climatic conditions as soybeans. It can be grown on all types of soil from light to heavy clay but does not grow well on extremely acidic soil. The crop is more tolerant to heavy rainfall than other grain legumes. It is also reported to be grown as a rainfed crop (Thomas *et al*., 1974). Thirty-one accessions were evaluated at NBPGR Regional Station, Shimla, and a wide range of variation was observed for several important traits. The observation row trial comprising 13 promising lines was conducted at three locations, Shimla, Palampur and Ranichauri, which revealed HPU-1 to be an early maturing (110 days) accession.

Faba Bean (*Vicia faba*) is one of the main sources of protein for people in the Middle East and North Africa since ancient times. In India, it is reported to be under cultivation as a minor crop in the Himalayan hills, Bihar, Eastern Uttar Pradesh, Punjab, Haryana, Jammu and Kashmir. Today, Faba bean is becoming important as a source of protein (26.2%). The nutritive value of the crop is quite higher and is regarded as a substitute for meat or skimmed milk. The green pods are used as a vegetable, and the seed is used dried, fresh or canned. It prefers a cooler climate and is grown as a winter annual in warm temperate and subtropical areas. It grows best on rich loamy soils and is tolerant to acidic soils. It is unable to withstand drought. It tolerates annual rainfall of 23–209 cm, annual mean temperature of 5.6–27.5°C and pH of 4.5-8.3 (Duke, 1981). Evaluation of germplasm at Haryana Agricultural University, Hisar (Chhabra, 1983), indicated a wide range of variation for a number of important traits. Considerable genetic variation has also been reported for seed protein (Akbar *et al.*, 1992). Haryana Agricultural University, Hisar Centre, provided the lead function for Faba bean breeding and VH 82-1 with seed yield of 420 kg ha^{-1} was released for cultivation in the Northern Plain Region.

Winged Bean (*Psophocarpus tetragonolobus*) is rich in protein (29.8–37.4% in seeds and 10.9% in tubers) and oil, and has potential as a multipurpose crop. Its grains and roots are edible and the plant is used as fodder, green manure and cover crop. The immature pods, leaves, young sprouts and flowers are consumed as a vegetable or in soups seed oil is used for cooking and the oil cake as animal feed. Protein in seeds is comparable with that of soybeans in digestibility. Seeds are rich in the antioxidant, tocopherol, which improves human utilization of vitamin A, often deficient in the tropics. Seeds are reported to contain trypsin and chymotrypsin inhibitors. It is largely cultivated as a backyard or a garden crop in most of Southeast Asia and is consumed locally. In India, its cultivation is confined to humid, subtropical parts of the north-eastern region, Bengal, Bihar, Western Ghats. The crop can be grown in a range of soil types and is found typically on well drained acid soils (pH 4.3–7.5). It is reported to tolerate annual precipitation of 70–410 cm and annual mean temperature of 15.4–27.5°C (Duke, 1981). Evaluation of 88 accessions for 25 descriptors revealed considerable variability for different yield attributes, and the information has been catalogued (Chandel *et al.*, 1984).

Kankoda (*Carissa carandas*) is a hardy, evergreen, spiny and indigenous shrub which thrives well as rainfed crop. The fruit belongs to the family Apocynaceae. Fruits are sour and astringent in taste and are very rich in iron contain a good amount of vitamin C. They also containing protein, carbohydrates, fat, fibre and calcium. The ripened fruits may be eaten as dessert or used for the preparation of jelly, sauce, carissa cream or jellied salad. Unripe fruits are used for making pickles, sauces and chutney. The dried fruits may act as a substitute for raisins. The wine prepared from ripe fruits contains about 14.5 to 15 per cent alcohol and is very much liked by wine fanciers. Fruits can also be used in dyeing and tanning industries. Its fruit is considered to be antiscorbutic and is also very useful in curing anaemia, stomach ache and is anthelmintic. Root extracts are used in lumbago, chest complaints and venereal diseases (Azam-Ali, 2010).

Kalingada [*Citrullus lanatus* (Thunb.) Mansfeld] commonly called local Matira or the wild watermelon, is a hispid drought hardy cucurbitaceous creeper. Stem is herbaceous and has a length of about 3 m. Kalingada and matira are the different forms available as local types / land races of watermelon which are less sweet and have small sized fruits. Generally, the fruits of these forms/local types are used as vegetables and for extracting seeds for magaz purpose, these forms have different seed characteristics. The plants are monoecious with male and hermaphrodite flowers. Some genotypes also have male and female flowers. Seeds are used either for 'magaz' or extracting oil. Its fruits are globose, sub globose and ellipsoid with 15-20 cm diameter weighing about 0.25 to 5.0 kg, smooth, green mottled with irregular bands of dark green or uniform in colour. Pericarp is hard but not woody, pulp solid white, pink or reddish pink. Seeds are numerous, 6-10 mm long, pyriform, compressed with dark brown, black, pink, white or mowed in colour. Distribution and Adaptation Though cultivated in the warmer parts of the world, it is a true native of sandy dry areas of Tropical Africa. The plant grows in hot and dry situations on any ordinary soil provided there is sufficient moisture. Generally, it is grown as rainfed crop and does not withstand water logging and frost.

Current research status of underutilized crops in India

The past three decades have seen a wide and varied range of research interests on underutilized crops. Whereas, most of these interests were focused on particular projects of individual researchers, there have been a number of significant programmes to promote underutilized species for agricultural systems, as alternative crops or as sources of new products and these programmes have been undertaken in both developing and developed countries. Additionally, there has been a broader recognition that underutilized crops should always be promoted to improve food security. A report on current research and research proposals for enhanced cooperation on UUC's was documented by Williams and Haq (2002).

In India, strategy development and appropriate policies are limited to a large extent by lack of authentic documentation on underutilized crops. The Indian government policies and strategies for food security should take into account the diversity of underutilized crops. For this ethno-botanical data available on indigenous, neglected Indian crops is more valuable. Indigenous knowledge must be tapped and combined from various localities and merged with scientific solutions to create new opportunities. Recognition of UUC's in India was initiated in 1960's at the Indian Agricultural Research Institute, New Delhi. This research was later extended by, All India Coordinated Research Project (AICRP) on Under-utilized plants (UUP) in 1982, with its headquarters at National Bureau of Plant Genetic Resources (NBPGR), New Delhi, towards collection, evaluation, utilization and conservation/ maintenance of underutilized crops. Later on, this work was also carried out in various parts of India (Bhag Mal, 1988; Joshi *et al*., 2002). So far, 115 leafy vegetables and 46 other vegetables have been documented as underutilized in India (Anon., 2003). Similarly, Ravi *et al*. (2010) discussed the mobilizing neglected and underutilized crops to strengthen food security and alleviate poverty in India. In India, also a national co-ordinated project by Ministry of Agriculture has been launched to conduct research on UUC's. Still the threat has been there for the crops as their underutilized potential is continued to be underutilized, ultimately may lead to disappearance of the same crop.

Crop improvement and salient achievements in AICRN on UU crops scheme

The project has helped to introduce under exploited nutritive crops to diversify the narrow based use of food crops. Lot of awareness has been created with farmers and consumers about the nutritional qualities of the crops. Germplasm evaluation was also carried out in Rice bean, Grain amaranth, Winged bean and Quinoa crops. Hybridization and mutation breeding was attempted in amaranth, rice bean and winged bean. Coordinated trials on rice bean, grain amaranth and winged bean were carried out and as a result, high yielding varieties have been developed and released in Grain Amaranth, Rice Bean and Winged Bean which are as follows:

Grain Amaranth: Three varieties have been developed in AICRN on potential crops, Bangalore center

1. *Suvarna*: Released in 1996 and recommended for cultivation in peninsular region (Karnataka, Orissa Maharashtra, Tamil Nadu and Gujarat states) of the country. In Southern Karnataka, the variety is recommended for the Agro climatic zones – Zone IV, Zone-V & Zone-VI. The variety was developed as pure line selection from the introduced material 'Rodale Plus'. It is photo insensitive it can be grown throughout the year. It is early in maturity (80-90 days) and attains 120-130 cm height. It has green leaves, strong stalk and open inflorescence which is green in colour. The variety is highly self-pollinated which helps in maintenance of its seed purity unlike other varieties. The yield potential goes up to 25 q/ha with protective irrigation and 15 q/ha under rainfed condition. The variety is used as national check in coordinated trials.

2. *KBGA-1*: This variety is released during 2012. This variety is shorter in duration by 5-10 days as compared to Suvarna and inflorescence is very attractive with purple colour. There is 10 per cent yield advantage over Suvarna variety.

3. *KBGA-4* : This variety is released during 2016. This variety is shorter in duration by 5-10 days as compared to KBGA-1 and inflorescence is very attractive with purple colour. There is 10 per cent yield advantage over KBGA-1 variety.

Rice Bean: Two varieties have been identified and they are due for release.

1. *KBR-1*: It is released during the year 2017. It is also a short duration variety with bold seeds and yield potential is 10-12 q/ha and suitable for marginal soil conditions and paddy fallows.

Winged Bean

1. *KBWB-1*: This variety is due for release which was developed as superior to Mysore Local for short duration, higher Green pod yield and seed yield. The Green pod yield potential is up to 20 tonnes/ha and seed yield up to 15 q/ha.

Research issues to be addressed on underutilized crops in future

The demand and expectations of modern supply chain lead farmers to concentrate on fewer crops, mostly handed in a top-down approach without consideration of IK and local communities (Sillitoe and Marzano, 2009), which has resulted in a steady loss of agro-biodiversity. This loss, if not corrected, will lead to irretrievable loss of strategic underutilized crop resources necessary for the wellbeing of millions of people, particularly those living in marginal areas. The rate of loss of UUC through extinction and genetic erosion is accelerating in many parts of the world as the result of drought, pest and diseases, over exploitation, over grazing, land clearance, deforestation and lack of incentives for farmers to maintain this agro biodiversity (Van de Wouw *et al*., 2010). Together with loss of species, there is an accompanying and equally alarming wide spread erosion of local traditions and knowledge. Thus, for UUC to play a significant role as future crops and there is a need to tap into IK, so as to incorporate local traditions and make production of UUC relevant to local peoples (Sillitoe and Marzano, 2009). Additionally, there is need for concerted efforts to promote on-farm genetic resource conservation of the UUC given that the farmers have IK passed on from generations and there has been co-evolution of social and ecological systems at local levels (Barbieri *et al*., 2010). This means that the sustainability of UUC lies in the integration of IK and involvement of the local communities through local genetic conservation. However, while conservation of genetic resources is important for the sustainability of UUC, breeding efforts are needed so at to improve the competitiveness of the different crop species and to make them adaptable to different climates (Sthapit *et al*., 2010). It is not surprising that UUC have been neglected in breeding programs, yet landraces have been widely utilized for genes that provide genetic resilience. Instead, breeding programs should focus on improving UUC and make them more adaptable to the changing climate. In addition, there is a need to develop value chains of different UUC from the input side and the marketing of the produce. so as to make them commercial products that can be traded not only on the local market, but also internationally. This means that there is a need to promote the utilization of UUC coupled with value addition of the harvested crops. Consequently, sustainability of UUC requires concerted efforts to improve utilization of the produce coupled with conservation of the genetic resource base, its genetic improvement and value chain development.

Prospects of underutilized crops (UUC) in future

The combination of water scarcity, climate change and variability and increasing population that India is facing has painted a gloomy picture of future food security for a region that already has scarce water resources. Decades of 'neglect' by researchers and farmers in favour of major crops have meant that UUC had to survive over the years, often under harsh conditions, without much assistance from man. As such, UUC may have evolved to become adapted to adverse environmental conditions such as drought stress (Mabhaudhi and Modi, 2015). If indeed UUC have evolved to become drought tolerant, they may have a role to play in guaranteeing future food security either directly as alternative crops in areas that are predicted to become drought-prone or indirectly as germplasm resources for crop improvement. In addition to their adaptation to diverse ecological niches, most UUC are said to be highly nutritious and in some cases to have medicinal properties. There is, however, limited quantitative information proving some of these claims. Some of the knowledge on the nutrition of UUC remains hidden in IK systems and this may explain why certain communities have continued to preserve and utilize certain UUC. Their unique adaptation and diverse uses speak to the role that they have historically played in rural communities.

Constraints and strategies to promote underutilized crops

There are many difficulties in popularizing UUC's at market and consumer level because of a variety of reasons. Hence, there has been at most need to give guidance and knowledge to the consumers about the use of UUC's. Major fruit and vegetable distributors, failed to market UUC's and their products in the most desired and tempting way by displaying the quality, price and information results in ignorance about the fruit texture, colour, flavour and optimum maturity before consumption by consumers. Basically most of the consumers are unaware about these plant products, their mode of usage, expectation of sensory qualities and mode of storage and ripening. Finally, there is a lack of sustained and informative research on the same field. The availability of information has been always a major constraint in the promotion of underutilized plant species. The possibility of accessing these data to guide workers at local level should also be addressed. Improving the availability of information on underutilized crops has been one of the most important areas demanding our immediate attention. At the formal level, individual studies on underutilized crops continue to need support to ensure their publication. At local level, there has been a need to gather and document information which has been maintained within farming communities. The recognition of the value of this by researchers and scientists can often act as a powerful stimulus to improve a community's own valuation of the knowledge (Singh *et al.,* 2008). A spectacular wide strategy has to be developed for underutilized crops for the benefit of mankind. But for the same protocol for increasing use of underutilized crops for food security involves overcoming many constraints and obstacles, from genetic through management, cultural acceptability and marketing to policy and decision making in the government (Padulosi *et al.,* 2002). There are very good examples for the development of an indigenous crop within its local community where it provides direct benefits to that community through food and often income security, providing the local community with purchasing power (Mayes *et al*., 2011). The major constraints in poor popularity of UUC's are associated with the following points.

a) Lack of information on production, nutritional quality, consumption and utilization of many of the underutilized plant products which are unpopular compared to major fruits

b) Lack of awareness on economic benefits and market opportunities

c) Lack of technology for value addition through village level food processing

d) Lack of improved quality planting material

e) Lack of technology to reduce the gestation period and enhance the fruit production

f) Lack of interest by researchers, agriculturists and extension workers

g) Lack of producer interest

h) Low yield

i) Post-harvest and transport losses

j) Non-existence of marketing network and infrastructure facility for underutilized fruits

k) Lack of national policy

l) Lack of credit and investment

m) Non-availability of scientific resources for testing, valuation and post harvest management of different underutilized fruits

n) Disorganized communities

With the increasing population pressure, India is facing serious challenges of food security, unemployment and environment degradation. About 65 per cent of the Indian population is presently living in rural areas and 85 per cent of these rural families are dependent on agro-based activities for their livelihood (Williams and Haq, 2002). Staple crops face major challenges in the near future and a diversification away from over-dependency on staple crops will be important as part of the progress towards the goal of achieving security of food production. Just three crops rice, maize and wheat account for about 40 per cent of the world's consumption of calories and protein. About 95 per cent of the world's food needs are provided by just 30 species of plants. In contrast, at least 12,650 plant species names have been compiled as edible (Kunkel, 1984). From the past, UUC's continue to play a persistent role in the subsistence and economy of poor people throughout the developing countries. Despite their potential for dietary diversification and the provision of micro-nutrients such as vitamins and minerals, they still continue to attract little research and development attention. Therefore, the developing countries like India are being encouraged to diversify their food exports by developing new resources. In India, there are large areas of marginal and wasteland, which are not suitable for cultivation of staple crops, either due to poor quality soil or lack of water resources. Most of UUC species are tolerant to harsh agro-climatic conditions; they have excellent potential for establishment on marginal and wastelands throughout the tropics (Hegde, 2002).

Many underutilized crops are more widely grown but are today falling into disuse for a variety of agronomic, genetic, economic and cultural factors. Farmers and consumers are using these crops less because they are in some way not competitive with other crop species in the same agricultural environment. The general decline of these crops may erode the genetic base and prevent the use of distinctive useful traits in crop adaptation and improvement. Production, post harvest handling and processing of underutilized crops practiced today perpetuate heavy losses. Inadequate infrastructure facilities cripple marketing prospects, low productions of UUC's are indispensable for food and nutritional security and will have a greater potential for income generation and environmental services. As Underutilized Crops have a great potential to alleviate hunger directly through increasing food production in the challenging environments where major food crops are severely limited day by day. It can be concluded that with the realization of importance and uses of the underutilized crops in India, the potential for agricultural, rural development and food and nutrition security can be unlocked.

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