Chapter-16

Harnessing Under-utilized Crop Species- A Promising Way towards Sustainability

Madhumita[1], S. Sheraz Mahdi[2], Suborna Roy Coudhary[2] and Aziz Mujtaba Aezum[3]

Abstract Agriculture is reeling under intense pressure to constantly produce increased quantities of food, feed and biofuel out of limited land resources. Present over-reliance on a handful of major staple crops has inherent agronomic, ecological, nutritional and economic risks and is probably unsustainable in the long run. Modern agricultural systems that promote cultivation of a very limited number of crop species have downgraded indigenous crops to the status of neglected and under-utilized crop species (NUCS). NUCS are indispensable in reducing food and nutrition insecurity, owing to their wider resilience to climate variability and inherent nutritional composition .Currently underutilized food sources ranging from minor grains and pulses, root and tuber crops and fruits and vegetables to non-timber forest products have the potential to make a substantial contribution to food and nutrition security, to protect against internal and external market disruptions and climate uncertainties, and lead to better ecosystem functions and services, thus enhancing sustainability. The integration of these species diversifies agricultural system and makes it much more resilient as well as strengthens its adaptation, mitigation and coping mechanisms. Most of the these crops do not require high inputs and can be successfully grown in marginal, degraded and wastelands with minimal inputs and at the same time can contribute to increased agricultural production, enhanced crop diversification and improved environment and have the potential to contribute useful genes to breed better varieties capable of withstanding and sustain the climate change scenario. However, what is required to promote NUCS is scientific research including agronomy, breeding, post-harvest handling and value addition, and linking farmers to markets. The paper largely emphasizes on –the potential of neglected and under-utilized crops in the present context owing to global menace of climate change and raised concerns of food and nutritional security for growing population, viable solutions and recommendations to promote its conservation as well as effective use in mainstream agriculture.

Key Words: Neglected and under-utilized crops (NUCS), agro-diversity, sustainability, resilience, food and nutritional security.

Madhumita[1], S. Sheraz Mahdi[2]and Suborna Roy Coudhary[2]
[2]Department of Extension Education, Bihar Agricultural University, Sabour, Bhagalpur, Bihar-813210,
[1]Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar-813210, Bihar India
Email: madhumita.300191@gmail.com
[3]Aziz Mujtaba Aezum,Department of Soil Science, SKUAST-K, Shalimar, Srinagar (J&K), India

16.1 The Growing Need

The unprecedented rise in population has engendered various challenges, most pertinent among them being food security and climate change. Agriculture is reeling under intense pressure to produce greater quantities of food, feed and biofuel on limited land resources for the projected nine billion people on the planet by 2050. It is envisioned that agricultural production has to increase by 70% by 2050 to cope with an estimated 40% increase in world population (Ebert, 2014).

While about 7,000 plant species are found useful in agriculture, only about 150 species among them are largely used and less than 30 plant species meet about 90 per cent of world's food requirement. 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 a few of them belonging to cereal and other crop groups, while many species are left out of priority. Such shrinking species content in the food basket is a matter of major concern (Ravi et al. 2010). Staple crops have to face the pressing need of producing sufficient food for the increasing population. It is thus strongly demanded that the diverse agricultural resources are tapped of their potential and so the burden on major crops is released off. This diversification away from over-dependency on staple crops will be significant as part of the progress towards the goal of achieving security of food production (Thakur, 2014). Dependence on a handful of major crops has inherent agronomic, ecological, nutritional and economic risks and is probably unsustainable in the long run, especially in view of global climate change. It is now generally accepted that climate change will have a major impact on both biotic and abiotic stresses in agricultural production systems and threaten yield and crop sustainability. Greater diversity, which builds spatial and temporal heterogeneity into the cropping system, will enhance resilience to abiotic and biotic stresses (Ebert, 2014). The underutilized plant species of economic importance are the key to sustainable agriculture in most of the developing countries facing resource constraints as well as rapid depletion of natural resources due to ever-increasing population pressure. From past UUC's have continuously contributed for 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 (Thakur, 2014)

16.2 Underutilized Crops/ Neglected and Underutilized Crop Species

Underutilized species, refers to lesser known species in terms of marketing and research but do have ability to survive in marginal or stress conditions. They can be defined as crops that have not been previously classified as major crops, have previously been under-researched, currently occupy low levels of utilization and are mainly confined to smallholder farming areas (Chivenge et al. 2015). These crops belonging to categories such as cereals and pseudo cereals, legumes,

vegetables, oilseeds, roots and tubers, aromatic and medicinal plants, fruits and nuts, have earned collective names such as 'neglected and underutilized' or 'forgotten', 'orphan', 'minor' crops (Padulosi et al. 2004, 2008).These species hold the potential to improve people's livelihoods, as well as food security, but their potential remains largely unrealized or unrecognized due to their limited competitiveness with commodity crops in mainstream agriculture. While they face under realization of potential on a national level, but are of significant importance locally, being highly adapted to marginal, complex, and difficult environments and contributing significantly to diversification and resilience of agro ecosystems. This manifests their significance in future adaptation of agriculture to climate change (Padulosi et al. 2011). Also they have the potential to contribute further to the mix of food sources than they currently do (Mayes et al. 2011).

Underutilized species include not just food plants but also many other species—wild or cultivated—used as sources of oil, fuel, fiber, fodder, beverages, stimulants, narcotics, ornamental, aromatic compounds, and medicine. To be considered as an 'underutilized food crop', a plant must have the following features:

- Crop must have a scientific or ethno botanical proof of food value.
- Crop must have been cultivated, either in the past, or only being cultivated in a specific geographical area,
- It must be currently cultivated less than other conventional crops,
- Crop must have weak or no formal seed supply system,
- Crops are recognized to have indigenous uses in localized areas,
- Received little attention from research, extension services, farmers, policy and decision makers and technology providers,
- May be highly nutritious and/or have therapeutic medicinal or therapeutic properties or other multiple uses (Thakur, 2014).

Neglected or underutilized crops have the potential to play a number of roles in the improvement of food security in India that include being:

- Part of a focused effort to help the poor for subsistence and income,
- A way to reduce the risk of over-dependency on very limited numbers of major staple food crops,
- A way to increase sustainability of agriculture through a reduction in inputs,
- Increase the food quality;
- A way to preserve and celebrate cultural and dietary diversity,
- A way to use marginal and wastelands for agricultural purposes to meet the ever increasing food demand (Mayes et al. 2011).

In addition, under- utilized crops are also seen as offering economic advantages due to their uniqueness, suitability to environments in which they are grown and low input requirements (Mabhaudi et al. 2016).

Most of the under- utilized crops have numerous potentialities within them which could be significantly useful to mankind. Uses of few of those have been done in Table No. 16.1.

Table 16.1 Some Under-utilized crops and their uses.

S.No	Name of the crop	Family	Common Names	Uses	References
1.	Bael	Rutaceae	Bel, Bael, belli, wood apple, golden apple	Pulp used in diarrhea, dysentery and other stomach ailments; marmelosin extracted from fruits have therapeutic properties, trifoliate leaves used in puja/prayer of Lord Shiva, treatment of digestive and gastrointestinal disorders, digestion, respiratory infections, scurvy, curing peptic ulcer, diabetes, chronic inflammation, snake bites.	Chadha &Pareek,1988;Ved 1991;Patnaik et.al., 1996; Mazumdar 2004;Bael fruit 2011; Kumari et al. 2011
2.	Artocarpus heterophyllus	Moraceae	Jackfruit, Kathal	Fruit contains isoflavones, antioxidants and phytonutrients all of which are credited for their cancer-fighting properties, anti-ulcer properties, and is also good for those suffering from indigestion; anti-ageing properties, treatment of a number of skin problems.	Chadha &Pareek,1988; Parimala, 2007; Patti, 2010
3.	Averrhoa carambola	Oxiladaceae	Carambola, Star fruit	Rich in anti-oxidants, potassium and vitamin C; low in sugar, sodium and acid.It is a potent source of both primary and secondary polyphenolic antioxidants.	Kapoor, 1990 ; Ved, 1991
4.	Carissa spp.	Apocynaceae	Karonda, Karmada, Karvanda	Curing anemia and as astringent, anti-scorbutic and as a remedy for biliousness; anticonvulsant; cardiotonic; antioxidant, hepatoprotective; antiviral and antibacterial	Vohra and De,1963; Jigna et al. 2005; Devmurari et al. 2009; Kumari et al. 2011.
5.	Grewia subequinalis	Tiliaceae	Phalsa	Unripe fruits are said to remove vata, kapha and biliousness; astringent properties and used for several stomach ailments	Chadha and pareek,1988; Ali and Rab, 2000
6.	Millets (Pennisetum, Eleusine, Setaria, Panicum, Paspalum)	Poaceae	Pearl, Thinai, Varagu, Finger, Sorghum and Jowar etc.	These tiny grain is gluten- free and packed with vitamins and minerals; act as prebiotic, rich in Ca, P, Mg, Mn, tryptophan, fibre, vitamin B group; antioxidant, antidiabetic	Ravi, 2004; Gruere et al. 2007; Upadhyay, 2009; Ravi, 2010

7.	Simmondsia chinensis schneider	Simmondsiaceae	Jojoba	Cosmetics purposes, treat sores, cure stomach problems and restore hair	Bhatnagar et al. 1991
8.	Zizyphus mauritiana	Rhamnaceae	Ber, Indian jujube, Indian plum, desert apple	Rich source of calcium, phosphorus, protein, minerals, vitamin C and A. Seeds and bark cure for dysentery and boils and fruit as laxative and aphrodisiac; fruits are applied on cuts and ulcers; are employed in pulmonary ailments and fevers; and, mixed with salt and peppers, are given in indigestion and biliousness.	Jawanda and Bal, 1978; Chadha &Pareek,1988; FACT,1998;Ved 1991; Kumari et al. 2011.
9.	Syzium cumini	Myrtaceae	Jamun, jambula, black plum	Antioxidant activity, stomachic, carminative, antiscorbutic and diuretic, antimicrobial properties.	Khurdia and Roy, 1958; Chadha &Pareek,1988;Ved 1991;Luximon- Rammaet al. 2003; Koley et al. 2011
10.	Tamarindus indica	Fabaceae	Tamarind	Culinary use, antimicrobial, antidiabetic	Chadha &Pareek,1988;Ved 1991; Ali and Rab, 2000Maiti, 2004; Doughari, 2006
11.	Zizyphus mauritiana	Rhamnaceae	Ber, Indian jujube, Indian plum, desert apple	Rich source of calcium, phosphorus, protein, minerals, vitamin C and A. Seeds and bark cure for dysentery and boils and fruit as laxative and aphrodisiac; fruits are applied on cuts and ulcers; are employed in pulmonary ailments and fevers; and, mixed with salt and peppers, are given in indigestion and biliousness.	Jawanda and Bal, 1978; Chadha &Pareek,1988; FACT,1998;Ved 1991;

Source- (Thakur, 2014)

16.3 Processed products from under- utilized crops

Various processed products such as canned jackfruit bulbs in syrup, squash, raw jack pickle, roasted jack seeds, jack seed flour and candied jackfruit have been prepared from jack fruit (Berry and Kalra,1998; Chadha and Pareek,1988; Chandra and Prakash, 2009). Various processed products such as nectar, suash, slab, toffee powder, etc. can be made with Bael pulp. Ber can be processed to prepare murabba, candy, dehydrated ber, pulp, jam and ready to serve beverage (Khurdiya, 1980; Pareek, 2001). Jamun fruits can be processed to prepare excellent quality fermented and non- fermented beverages.Besides that good qualityjelly, jam, leather can be prepared. The seeds can be processed into powder which is very useful to cure diabetes (Khurdia, 2001a and b).

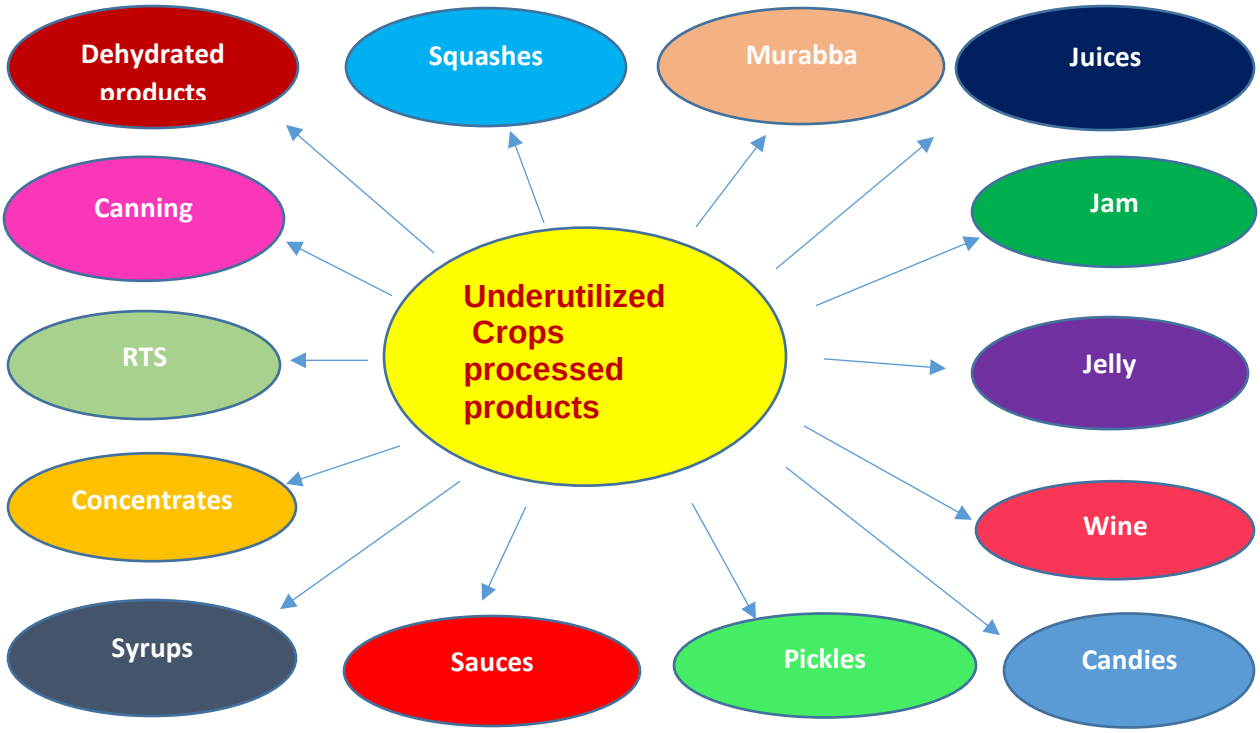

Fig: 16.1 Various processed food products from underutilized fruits

Source- (Thakur, 2014)

16.4 Their inherent potentialowing to the Global menace –Climate change

There is a large number of plant resources which holds promise to humanity in terms of nutrition or agricultural yield even in harsh or adverse conditions to which main or commercial crops succumb. Amaranth, cucurbits, and water spinach (Ipomoea aquatica) are some of the few crop choices under such extreme conditions (Kuo et al. 1992, Wang et al. 2012). Water spinach proved to be heat tolerant and amaranth moderately heat tolerant, whereas majority of vegetable crops are either heat sensitive or only slightly heat tolerant (Kuo et al. 1992). As a C4-cycle plant, amaranth can sustain high photosynthetic activity and water use efficiency under high temperatures and high radiation intensity, making it an ideal crop for abiotic stress conditions under changing climates (Wang et al. 2012). Amaranth is a very nutritious leafy vegetable, both in raw and cooked form. The nutritional value of this crop is comparable to spinach, but much higher than cabbage and Chinese cabbage (Ebert, 2011). Amaranth is increasingly gaining

importance both for household consumption and commercial production in Africa and Asia. There is a good market potential for this crop, both in the high-price and low-price segments.

16.5 NUCS "Wonder Plants": Indian perspective

Southern part of Rajasthan is predominantly a tribal dominated area having harsh climate, hence, only indigenous vegetables (IVs) which are hardy, drought resistant and have short duration grow well. Some of them namely kachari (Cucumis melo var. agrestis), snap melon (Cucumis melo var. momordica Duthie and Fuller), spine gourd (Momordica dioica Roxb. Ex Wild.), bitter melon (M. balsamina L.) and hill colocynth [Cucumis hardwickii (Royle) Gabaev, grow naturally during rainy season and generate good source of income for the tribals. These vegetables possess very good nutritive and medicinal value with resistance to biotic and abiotic stresses but till now no systematic efforts have been made to improve the existing land races of these IVs (Maurya et al. 2016).

India is endowed with a number of excellent crops. First crop in this list is a hardy tree- moringa (*Moringa oleifera*), the "wonder tree," which as well as its drought-resistance trait also has leaves of high nutritional content. Likewise, species from India including custard apple (*Annona squamosa*), Indian gooseberry (*Emblica officinalis*), ber (*Zizyphus mauritania*), tamarind (*Tamarindus indica*), and neem (*Azadirachta indica*) are also well recognized for their drought tolerance and ability to thrive in poor soils and marginal lands (Hegde 2009). A globally renowned hardy and multipurpose tree species known for its drought resistance is prosopis (Prosopis spp.), a reliable crop for both human consumption and animal feed in difficult areas (Pasiecznik et al. 2001). A good example is that of bambara groundnut (*Vigna subterranea*), a nutritious legume originating from west Africa and cultivated throughout sub-Saharan Africa (Heller et al. 1997). This legume, known for its drought tolerance (Andika et al. 2008), is found growing in harsh climates and marginal soils (Padulosi 1988; Heller et al. 1997); but in spite of these traits the crop still suffers from a status of neglect because of its unpredictability in yields, long cooking time, and negative social image (Mayes et al. 2009). Other underutilized crops known for their drought tolerance are the minor millets, a category of several "coarse" cereals used particularly in South Asia whose drought-resistant traits coupled with an excellent nutritious profile offer major opportunities for the development of areas increasingly affected by water shortages such as those in the marginal hills of Tamil Nadu or Karnataka States of India (Bala Ravi 2004; Padulosi et al. 2009).

Among perennial species, a good example is that of the sea buckthorn (*Hippophae rhamnoides*), a species naturally distributed from Europe to Central Asia and China, which has been found to be more tolerant to abiotic stresses than apple and pear—tolerance which seems associated with its high levels in ascorbic acid and myo-inositol (Kamayama et al. 2009).

Also, there area number of improved varieties released in underutilized crops like amaranth, buckwheat, winged bean, rice bean, faba bean, jojoba and guayule which have been described in the Table No. 16.2.

Table 16.2. List of improved varieties released in different underutilized plants in India.

Crop/Variety	Year	Economic product	Yield	Recommended areas/regions
Amaranth				
Annapurna	1986	Grain	2.25	Northwest hills
GA-1	1991	Grain	2.50	Gujarat, Maharashtra
Suvarna	1994	Grain	1.95	Karnataka
Buckwheat				
Himpriya	1991	Grain	1.50	High-altitude region
VL-7	1992	Grain	1.00	Mid-hills of UP
PRB-1	1997	Grain	2.00	Hills
Winged Bean				
AKWB-1	1991	Green pods	10.50	All winged bean areas
Rice-bean				
RBL-1	1987	Grain	1.50	Punjab State
RBL-6	1991	Grain	1.80	NW and NE regions
PRR-2	1997	Grain	1.50	North- west hills
Faba- bean				
VH 82-1	1994	Grain	4.20	Northern plains
Jojoba				
EC 33198	1986	Oil	4.20	Arid regions and coastal areas
Guayule				
Arizona-2	1986	Rubber	1.35	Arid and semi-arid regions
HG-8	1991	Rubber	1.50	Arid and semi-arid regions

Source- (Joshi et al. 2002)

16.6 Advantages of Crop diversity

Pest suppression

It is a persistent challenge with the farmers which consumes a voluminous amount of cost of cultivation. This very challenge will further aggravate due to impacts of climate change. The raised temperatures, higher humidity due to heat and other phonological changes have conducive effect on pest proliferation. This abundance will be accompanied by higher rates of population development, growth, migration, and overwintering. Diversity in crops helps break the pest cycle or pest –crop association that becomes integral in monocropping type situations. Also, with greater plant species richness and diversity in spatial and temporal distribution of crops, diversified agro ecosystems mimic more natural systems and are therefore able to maintain a greater diversity of animal species, many of which are natural enemies of crop pests (Lin, 2011).

Disease suppression-

Increasing diversification of cereal cropping systems by alternating crops, such as oilseed, pulse, and forage crops, is another option for managing plant disease risk. Disease cycles get interrupted through crop rotation by interchanging cereal crops with broadleaf crops that are not susceptible to the same diseases. Variety in plants as well as greater temporal and spatial diversity in agricultural systems hinders the disease infestation Reduced tillage could enhance soil biodiversity, leading to greater disease suppression, and stand densities could be adjusted to allow for better microclimatic adjustments to disease growth.

Climate variability buffering and mitigation

Agricultural vulnerabilities have been found in a number of important crop species. Temperature maximums and minimums, as well as seasonal shifts, can have large effects on crop growth and production. Research has shown that crop yields are quite susceptible to changes in temperature and precipitation, especially during flower and fruit development stages. Here, the importance of diversified agro ecosystems comes into picture, as complex systems help mitigate the effects of such fluctuations on crop production.

16.7 Their relevance in the present context-

Under the overarching goals of food security, poverty elimination and environmental sustainability, underutilized species should be selected on the basis of their capacity to best address such challenges:

Food security: Attention should be paid to both quantity and quality of food.

Underutilized species offer untapped potentials to contribute to fight malnutrition. Theirenhanced use can bring about better nutrition (vitamin C in the fruit of the Barbadoscherry -Malpighia glabra- is more than ten times higher than in the kiwi fruit –notablyvery rich in this micro nutrient; nutritional value of the Himalayan chenopod grains,Chenopodium spp., is superior to that of most major cereals). Emphasis should thus begiven to those species having comparative advantages in providing better food, beingaffordable by the poor and more available both in time and space (www.fao.org/docs/eims/upload/207051/gfar0089.pdf).

Nutrient security- Food and Agriculture Organization (FAO) statistics reveal (Swaminathan, 1999) that while about 800 million children, women and men are currently suffering from protein-calorie under nutrition over 2 billion suffer from hidden hunger and there is a high frequency of low birth-weight children caused by the deficiency of micronutrients in the diet, particularly iron. Such micronutrients are in plenty in Panicum miliaceum (proso millet), Paspalum scrobiculatum (kodo millet), Chenopodium (chenopod), Amaranthus (amaranth), Fagopyrum (buckwheat) and so on. These underutilized plants can help to make diets more balanced and hence can play an important role in combating silent hunger (Joshi et al. 2002). Many vegetables – indigenous vegetables in particular – have high levels of micronutrients and could significantly contribute to nutritional security if eaten as part of the daily diet.

Poverty elimination: Multiple uses offer greater opportunities to raise income of local people by diversifying valuable plant products. The greater the number of uses, the greater the chances to strengthen

local markets and contribute to improve well- being of people. In terms of numbers, the recorded 3,000 vascular species of economic importance are part of a much larger diversity basket, largely unexplored by R&D. As for figures on income generation, it is estimated that the use of minor forest products in India employs as a whole more than 10 million people per year.

Environmental sustainability: Underutilized species have recognized ability to grow in marginal areas. Selection criteria should thus take into consideration their comparative advantages in halting soil erosion, contribute to land rehabilitation, ability to withstand difficult soils (excess of salt, lack of water, etc..), contribute to maintain balanced ecosystems and ability to tolerate heat, cold and other abiotic stresses (www.fao.org/docs/eims/upload/207051/gfar0089.pdf).

Acting as Crop Wild Relatives (CWR) - Crop Wild relatives (CWR) as gene donors for plant breeding have been a major contributor to economic development and food security. With the accelerated rate of change predicted for future climate and recognition of the need to find quick solutions to expect increases in abiotic and biotic stresses, it is expected that the demand for such genetic traits will also rise significantly.

Resilience to Climatic Variability's- Resilience has been defined as the capacity of a system to absorb shock while maintaining function (Resilience Alliance 2008). Thus, a resilient agro ecosystem will continue to provide a vital service such as food production if challenged by severe drought or by a large reduction in rainfall. In agricultural systems, crop biodiversity may provide the link between stress and resilience because a diversity of organisms is required for ecosystems to function and provide services (Heal 2000).

The other way in which underutilized species help agriculture to adapt to climate change is through their contribution in enhancing the diversification and resilience of agro ecosystems in order to withstand the impacts of climate change scenarios (e.g., drought and increased frequency and intensity of extreme weather events such as cyclones and hurricanes). (Padulosi, 2011)

16.8 Advantages of UUC's:

The benefits of these underutilized plant species are manifold:

- They have potential to contribute to poverty elimination through employment opportunities and income generation and also through improved efficiency and profitability of farm household labour use in both rural and urban environments.
- With the use of underutilized crops, there is a way to reduce the risk of over-reliance on very limited number of major crops.
- They can contribute to sustainable livelihoods through household food security as they can widen the food edibility options.
- They add nutrients to the diet and are sometimes convenience food for low income urban people. They are adapted to fragile environments and can contribute to the stability of agro ecosystems, particularly in the arid, semi-arid lands, mountains, steppes and tropical forests.

- They provide a broad spectrum of crops to improve productivity and global food security and to meet new market demands.
- They assist development of rural community through small-scale investment.
- They have a strong cultural and sacred identify and are associated with traditional customs and beliefs. Therefore, a best way to preserve and celebrate cultural and dietary diversity. (Thakur, 2014)

16.9 Constraints in utilization and marketing of UUC's:

Overall, the slow progress and poor popularity in the effective development and utilization of underutilized crops results from a number of constraints which are summarized below:

- Lack of information on production, nutritional quality, consumption and utilization of many of the underutilized plant products which are unpopular compared to major fruits.
- Lack of awareness on economic benefits and market opportunities.
- Lack of technology for value addition through village level food processing.
- Lack of improved quality planting material.
- Lack of technology to reduce the gestation period and enhance the fruit production.
- Lack of interest by researchers, agriculturists and extension workers.
- Lack of producer interest.
- Low yield.
- Post-harvest and transport losses.
- Non-existence of marketing network and infrastructure facility for underutilized fruits.
- Lack of national policy.
- Lack of credit and investment.
- Non-availability of scientific resources for testing, valuation and post- harvest management of different underutilized fruits.
- Disorganized communities.

16.10 Global Initiatives/Organizations towards their conservation

AVRDC (Asian Vegetable Research and Development Center (AVRDC)

The World Vegetable Center, previously called Asian Vegetable Research and Development Center (AVRDC): Its genebank is a major source of germplasm for breeding abiotic stress tolerant vegetable crops. Heat-tolerant tomato, pepper, Chinese cabbage, and mungbean varieties developed by AVRDC have enabled increased production of these crops in tropical lowlands. Indigenous vegetables tolerant to degraded, drought-prone, or saline areas provide great potential to combat malnutrition and mitigate the risks that climate change poses to farmers in developing countries.

International Centrefor underutilized crops (ICUC)

This is a research, development and training organization. It provides expertise and acts as a knowledge hub and supported research on national priorities for germplasm collections, agronomy and post- harvest methodology of underutilized species and associated scientific conferences and training events.

Global facilitation unit (GFU)

The GFU is a multi-institutional initiative that acts globally to promote a wider use of underutilized plant species through supporting and facilitating the work of other stakeholders.

Crops for the future (CFF): has been an independent, international organization that works with its partners and has a mandate to promote and facilitate the greater use of neglected and underutilized crops to advocate research, policies, and capacity building on underutilized crops for the diversification of agricultural systems and diets (Thakur, 2014).

16.11 Conclusion

Owing to the present as well as the future food and other agricultural demands combined with the alarming menace of climate change to global agriculture, it is high time that we realize the importance of under-utilized crops. There is an urgent need to promote/revive indigenous crop varieties and reverse the loss of agro-biodiversity caused due to market drivers. The benefits or uses they offer is no less than wonder or treasure for nations. Many of these wonder plants were once 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. So, the factors or reasons that limit their full use must be identified as well as addressed adequately. This will actualize when there will be optimum research as well as promotion of these "jewel" crops as they truly hold greater promise for entire humanity and are awaiting to be explored.

References

- Ali, R. &Rab, F. (2000) Research needs and new products development from under-utilized tropical crops. Acta Hort. (ISHS) 518:241-248. Retrieved from http;//www.actahort.org/books/518/518_33.htm. Accessed on 10th April, 2014.
- Andika D. O., Onyango, M. O. A.&Onyango, J.C.(2008). Role of Bambara groundnut (*Vigna subterranea*) in cropping systems in Western Kenya. In: J Smartt and N Haq (eds) New Crops and Uses: Their Role in a Rapidly Changing World. Centre for Underutilized Crops, University of Southampton, Southampton, UK.

- Bael Fruit. (2011) Bael Fruit –Medicinal properties and health benefits. Retrieved from blog.onlineherbs.com/bael-fruit-medicinal- properties-an…-United States. Accessed on 11th March 2014.
- Berry, S. K., & Kalra, C. L. (1987). Cultivation and Processing of Jackfruit. *Indian Ed Pack*, *42*(5), 62-67.
- Bhatnagar, N., Bhandari, D. C., Dwivedi, N. K., & Rana, R. S. (1991). Performance and potential of jojoba in the Indian arid regions. *Indian Journal of Plant Genetic Resources*, *4*(2), 57-66.
- Chadha, K. L., & Pareek, O. P. (1988). Genetic Resources of Fruit Crops: Achievements and Gaps. *Indian Journal of Plant Genetic Resources*, *1*(1and2), 43-48.
- Chandra, D.S. & Prakash, J. (2009). Minor fruits: a livelihood opportunity for the tribal peoples of Tripura. *IInd International Symposium on pomegranate and minor including Mediterranean fruits*, ISPMMF 2009.
- Chivenge, P., Mabhaudhi, T., Modi, A. T., & Mafongoya, P. (2015). The potential role of neglected and underutilized crop species as future crops under water scarce conditions in Sub-Saharan Africa. International journal of environmental research and public health, 12(6), 5685-5711.
- Devmurari, V., Shivanand, P., Goyani, M. B., Vaghani, S., & Jivani, N. P. (2009). A review: Carissa congesta: phytochemical constituents, traditional use and pharmacological properties. *Pharmacognosy Reviews*, *3*(6), 375.
- Doughari, J.H. (2006). Antimicrobial activity of Tamarindus indica Linn. *Tropical J. Pharmaceutical Res., 5* (2) : 597-603
- Ebert, A. W. (2014). Potential of underutilized traditional vegetables and legume crops to contribute to food and nutritional security, income and more sustainable production systems. *Sustainability*, *6(*1), 319-335.
- Ebert, A. W., Wu T. H. and Wang S. T.(20110. Vegetable amaranth (Amaranthus L.). AVRDC Publication, (11-754).
- Ebert, A. W., Wu T. H. &Wang, S. T. (2011). International Cooperators' Guide—Vegetable Amaranth (Amaranthus L.); AVRDC - The World Vegetable Center: Tainan, Taiwan, p. 8.

- FACT (1998). Ziziphus mauritiana - a valuable tree for arid and semi-arid lands. Retrieved from: http://www.winrock.org/fnrm/ factnet/factpub/FACTSH/ziziphus.htm. Accessed on 29th June,2012.
- Gruere, G.P., Nagarajan, L., King, E.D.I. & Oliver (2007).Collective action and marketing of underutilized plant species. International Food Policy Research Institute (IFPRI). Series No. 69. Retrieved from: *http://www.ifpri.org/publication/ collective-action-and-marketing-underutilized-plant-species.* Accessed on 11th April, 2014.
- Heal G. 2000. Nature and the Marketplace: Capturing the Value of Ecosystem Services. Island
- Heller, J., Begemann, F. L. &Mushonga, J. (1997). Promotion, conservation and use of underutilized neglected crops. Bambara groundnut. *Proceedings of the workshop on conservation and improvement of Bambara groundnut*, November 14–16, 1995
- Hughes, J. D. A. & Ebert, A. W. (2011). Research and development of underutilized plant species: the role of vegetables in assuring food and nutritional security. *In II International Symposium on Underutilized Plant Species: Crops for the Future-Beyond Food Security 979* (pp. 79-92).
- Jawanda, J. S., & Bal, J. S. (1978). Ber-highly paying and rich in food value. *Indian Horti.***23** : 19-21.
- Jigna,P., Rathish, N. & Sumitra, C. (2005). Preliminary screening of some folklore medicinal plants from Preliminary screening of some folklore medicinal plants from Western India for potential antimicrobial activity eastern India for potential antimicrobial activity. *Indian J Pharmacol*, *37(*6), 408-409.
- Joshi, V., Gautam, P. L., Mal, B., Sharma, G.D., &Kochhar, S. (2002). 33 Conservation and Use of Underutilized Crops: an Indian Perspective.
- Kanayama, Y., Ohkawa, W., Chiba, E., Sato, K., Kanahama, K., & Ofosu-Anim, J. (2008, March). Nutritional components and nitrogen fixation in seabuckthorn (Hippophae rhamnoides L.). In *International Symposium on Underutilized Plants for Food Security, Nutrition, Income and Sustainable Development 806* (pp. 309-314).
- Kapoor, L. D. (2000). *Handbook of Ayurvedic medicinal plants: Herbal reference library* (Vol. 2). CRC press.

- Khurdiya, D. S., & Roy, S. K. (1985). Processing of jamun (Syzygium cumini Linn) fruit into a ready to serve beverage. *Journal of food science and technology*, *22*(1), 27-30.
- Khurdiya, D. S. (1980). new beverage from dried ber (Zizyphus mauritiana Lam). *Journal of food science and technology*.
- Khurdiya, D.S. (2001a). Post harvest management of underutilized for fresh marketing. *Winter school on exploitation of underutilized fruits*, pp. 266–274.
- Khurdiya, D.S. (2001b). Post harvest management of underutilized fruits for processed products. *Winter school on exploitation of underutilized fruits*, pp. 291–298.
- Koley, T. K., Barman, K., & Asrey, R. (2011). Nutraceutical properties of jamun (Syzygium cumini L.) and its processed products. *Indian Food Ind*, *30*(4), 34-37.
- Kumari, P., Joshi, G. C., & Tewari, L. M. (2011). Diversity and status of ethno-medicinal plants of Almora district in Uttarakhand, India. *International Journal of Biodiversity and Conservation*, *3*(7), 298-326.
- Kuo, C. G., Chen, H. M., & Sun, H. C. (1992). Membrane thermostability and heat tolerance of vegetable leaves. *Adaptation of food crops to temperature and water stress*, 160-168.
- Lin, B. B. (2011). Resilience in agriculture through crop diversification: adaptive management for environmental change. *BioScience*, *61*(3), 183-193.
- Mabhaudhi, T., O'Reilly, P., Walker, S., & Mwale, S. (2016). Opportunities for underutilized crops in southern Africa's post–2015 development agenda. *Sustainability*, *8*(4), 302.
- Maiti, R., Jana, D., Das, U. K., & Ghosh, D. (2004). Antidiabetic effect of aqueous extract of seed of Tamarindus indica in streptozotocin-induced diabetic rats. *Journal of ethnopharmacology*, *92*(1), 85-91.
- Maurya, I. B., Arvindakshan, K., Sharma, S. K., & Jalwania, R. (2006, December). Status of indigenous vegetables in southern part of Rajasthan. In *I International Conference on Indigenous Vegetables and Legumes. Prospectus for Fighting Poverty, Hunger and Malnutrition 752* (pp. 193-196).
- Mayes, S., Basu, S., Murchie, E. et al. (2009).BAMLINK. Across disciplinary programme to enhance the role of Bambara groundnut (Vigna subterranea L. Verdc.) for food security in Africa and India. *Acta Horticulturae 806*: 39–47.ISHS.

- Maurya, I. B., Arvindakshan, K., Sharma, S. K., & Jalwania, R. (2006, December). Status of indigenous vegetables in southern part of Rajasthan. In *I International Conference on Indigenous Vegetables and Legumes. Prospectus for Fighting Poverty, Hunger and Malnutrition 752* (pp. 193-196).
- Mazumdar, B. C. (2004). *Minor Fruit Crops of India: Tropical and Subtropical*. Daya Books.
- Padulosi, S. & I Hoeschle-Zeledon (2008). Crops for the Future: Paths out of Poverty. Strategic Plan 2009-2013, Bioversity International Regional Office for Asia, the Pacific and Oceania, Selangor, Malaysia. 16 p.
- Padulosi, S., Heywood, V., Hunter, D. &Jarvis, A. (2011) . Underutilized species and climate change: current status and outlook. *Crop adaptation to climate change, 1st edn*. Wiley, New York, 507-521.
- Padulosi, S., Mal, B., Bala Ravi, S., Gowda, J., Gowda, K. T. K., Shanthakumar, G., ... & Dutta, M. (2009). Food security and climate change: role of plant genetic resources of minor millets. *Indian Journal of Plant Genetic Resources*, *22*(1), 1.
- Pareek, O.P. (2001). Ber. International Centre for Crops. Southampton (U.K.).
- Parimala (2007). Medicianal uses of jack fruit. Retrieved from ww.jaspari.info/2007/03/medicial-uses-of-jackfruit.html. Accessed on 26th July 2013.
- Pasiecznik, N. M., Felker, P., Harris, P. J., Harsh, L., Cruz, G., Tewari, J. C., ... & Maldonado, L. J. (2001). *The'Prosopis Juliflora'-'Prosopis Pallida'Complex: A Monograph* (Vol. 172). Coventry: HDRA.
- Patti,A.K. (2010). Jackfruit (Artocarpus heterophylla). By Abhay Kumar Patti, Odisha, India, Retrieved from: http://prlog.org/books/518_31htm. Acta Hort., (ISHS) 518:233-236.
- Pattnaik, S., Subramanyam, V. R., Bapaji, M., & Kole, C. R. (1996). Antibacterial and antifungal activity of aromatic constituents of essential oils. *Microbios*, *89*(358), 39-46.
- Press. Hegde NG 2009. Promotion of underutilized crops for income generation and environmental sustainability. Acta Horticulturae 806: 563–577. ISHS.
- Pattnaik, S., Subramanyam, V. R., Bapaji, M., & Kole, C. R. (1996). Antibacterial and antifungal activity of aromatic constituents of essential oils. *Microbios*, *89*(358), 39-46.
- Rai, N., Asati, B. S., Patel, R. K., Patel, K. K., & Yadav, D. S. (2004). Underutilized horticultural crops in north eastern region. *ENVIS Bulletin Himalayan Ecology*, *13*, 46-52.

- Ravi, S. B., Hrideek, T. K., Kumar, A. K., Prabhakaran, T. R., Mal, B., & Padulosi, S. (2010). Mobilizing neglected and underutilized crops to strengthen food security and alleviate poverty in India.
- Ravi, B. S. (2004). Neglected millets that save the poor from starvation. *LEISA India*, *6*(1), 1-8.
- Ravi, S. B., Hrideek, T. K., Kumar, A. K., Prabhakaran, T. R., Mal, B., & Padulosi, S. (2010). Mobilizing neglected and underutilized crops to strengthen food security and alleviate poverty in India.
- Resilience Alliance. 2008. Website: http://www.resalliance.org
- Swaminathan MS 1999. Enlarging the basis of food security: role of underutilized species. In: *Proceedings of the International Consultation organized by the Genetic Resources Policy Committee (GRPC) of the CGIAR, M.S. Swaminathan Research Foundation, Chennai, India*, 17–19 February 1999, p. 22.
- Thakur, M. (2014). Underutilized food crops: treasure for the future India. *Food Science Research Journal*, *5*(2), 174-183.
- Upadhyay, H.D.(2009).Sustainable conservation and utilization of genetic resources of two underutilized crops-finger millet and foxtail millet- to enhance productivity, nutrition and income in Africa and Asia. Monograph. Retrieved from://oar.icrisat.org/id/eprint/5199.Accesssed on 12th May, 2014.
- Ved, P. (1991). Indian Medicinal Plant: Current Status in Himalayan Medicinal Plants: Potential and Prospects (Edited by Samant SS, Dhar U, Palni LMS). Gramodaya Prakashan, Nainital, 45-63.
- Vohra, M. M., & De, N. N. (1963). Comparative cardiotonic activity of Carissa carandas L. and Carissa spinarum A. DC. *The Indian journal of medical research*, *51*, 937-940.
- Wang, S.T.; Ebert, A.W. Breeding of Leafy Amaranth for Adaptation to Climate Change. In *High Value Vegetables in Southeast Asia: Production, Supply and Demand; Proceedings of the SEAVEG 2012 Regional Symposium*; Holmer R, Linwattana G, Nath P, Keatinge, JDH, Eds.; AVRDC - The World Vegetable Center: Tainan, Taiwan, 2013; pp. 36–43.
- www.fao.org/docs/eims/upload/207051/gfar0089.pdf