

Alternate crops for sustainable food systems: A potential role in SDGs

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Ensuring food system is one of the most challenging tasks of the world. Despite the best efforts, millions of people around the globe are malnourished or live with hunger. Hence, we highlight the potential role of alternative crops (ACs) to achieve sustainable food systems to meet the sustainable development goals (SDGs). The introduction of ACs in new regions is more essential to fight against the global food crisis to enhance food safety. Nevertheless, the adoption of ACs would rely upon the implementation of food systems and consumer healthy food habit.

Keywords: Alternate crops, Sustainable food systems, Underutilized crops

TRADITIONAL crops have played a key role in ensuring global food system. However, common agricultural crops like cereals, pulses, oilseeds, fruits, vegetables and many others crops face problems of biotic/abiotic stresses, climate resilience, quality, nutritive value, yield plateau and limited cultivable land to meet food requirement for burgeoning population. Moreover, in 2022 Global Report on Food Crisis, the Secretary-General of the United Nations stated that “we are facing hunger on an unprecedented scale, food prices have never been so high, and millions of lives and livelihoods are hanging in the balance”. Of course, managing such a threat is a challenging task that requires integrated interdisciplinary approach. Therefore, there is need to introduce the Alternate Crops (ACs) to address these issues.

The ACs can be introduced into a new agro-ecosystem or new geographical area in lieu of traditional crops owing to their high nutritive value and/or other health benefits or agronomical importance. ACs are mostly mixed up with under-utilized or neglected or orphan or niche crops. These ACs or under-utilized crops were primarily grown in their centre of origin regions, at some point of time they lost their importance but now have regained importance and becoming popular. The FAO defines that food safety is the state when “all people have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs, and food preferences for an active, and healthy life”. It is based on four pillars, i.e. food availability, food access, food utilization and food stability. To increase

food availability, the introduction of ACs to a region such as low-productivity area would target to enhance food availability in terms of high quantity, quality and nutritive values in that particular region. Given the nutritional importance of ACs for health point of view, these crops have been well known as climate resilient to cope up with biotic and abiotic stress under climate change scenario. ACs are apt due to their acclimatization potential to marginal environments and/or their tolerance to biotic (pests and diseases) or abiotic stress (heat, drought, salt stress, frost etc.). A list of potential ACs with nutritive values is listed in Table 1.

Underutilized horticultural crops as alternate crops for nutritional security

Horticultural crops, particularly, fruits and vegetables are not only the source of vitamins, minerals, fat, proteins, carbohydrates and dietary fibers, but eating them reduces the risk of diseases. Low intake of fruits and vegetables has been recognized as a top risk factor for global mortality by the World Health Organization. It is important to consume a variety of fruits, vegetables, spices, and condiments to derive the required nutrition because no single fruit or vegetable can nourish the body with all the vital ingredients. In India, the per capita consumption of fruits and vegetables is only about 120 and 250 g per day per person, which is less than the minimum dietary requirement of 200 and 300 g per day per person. This warrants the need for scaling up the horticultural production in the country. Several fruits with high nutrient density are super-

Table 1. List of potential alternate crops (ACs) for sustainable food systems to meet the SDGs

Common name	Scientific name	Origin area	Nutritional value
Amaranthus	<i>Amaranthus retroflexus</i>	Americas	High seed protein content (13–19%), high oils content rich in squalene and high antioxidants
Buckwheat	<i>Fagopyrum esculentum</i>	Asia	Protein content similar wheat protein, ~3% fat content and high crude fiber
Camelina	<i>Camelina sativa</i>	Europe	Excellent source of essential unsaturated fatty acids, particularly Omega-3 fatty acids
Canihua	<i>Chenopodium pallidicaule</i>	Andes	Exceptional protein, fat, ash and carbohydrate content
Chia	<i>Salvia officinalis</i>	Central America	Seed rich in high protein content (>15%), lipids, minerals and 500 kcal per 100 g seeds
Cowpea	<i>Vigna unguiculata</i>	Southern Africa	Rich in protein (<20%) and minerals (calcium, potassium, sodium etc)
Einkorn	<i>Triticum monococcum</i>	Asia Minor	High antioxidants (ascarotenoids, tocols, conjugated polyphenols, alkylresorcinols and phytosterols)
Emmer wheat	<i>Triticum turgidum</i>	Eurasia	High resistant starch, minerals, fibre, carotenoids and antioxidants
Foxtail	<i>Setaria italica</i>	Southern Asia	High protein, fatty acids, minerals and amino acids
Guar	<i>Cyamopsis tetragonoloba</i>	Africa	High protein, ash and polyphenol contents
Indian mustard	<i>Brassica juncea</i>	West Asia	Seed rich in glucosinolates, sterols and phenols. Leaf rich in glucose, fructose and minerals
Khorosan wheat	<i>Triticum turgidum</i> ssp. <i>turanicum</i>	Mesopotamia	Higher protein, crude ash and vitamine E contents than in wheat
Lablab	<i>Lablab purpureus</i>	South-east Asia	Rich in proteins, carbohydrates, minerals and vitamins
Nigella	<i>Nigella sativa</i>	Eastern Europe	Rich in fatty acids, phytosterols, glycolipids, and phospholipids
Pearl millet	<i>Pennisetum glaucum</i>	West Africa	Seed rich in calories (360), carbohydrate (67 g), protein (12 g), fat (5 g), fibres (1 g) per 100 g seed
Pigeon pea	<i>Cajanus cajan</i>	South Asia	Rich in starch, protein, calcium, manganese, crude fibre, fat and minerals
Purslane	<i>Portulaca oleracea</i>	Eurasia	Rich in omega-3, amino acids and vitamins
Quinoa	<i>Chenopodium quinoa</i>	Andes	Gluten-free, with high protein concent, rich in unsaturated fatty acids, vitamins and minerals
Salicornia	<i>Salicornia bigelovii</i>	North America	Rich in bioactive compounds, vitamin A, minerals and fatty acids. Seedoil rich in linoleic acid
Sesbania	<i>Sesbania</i> sp.	North-East Africa	High protein content (>40%), vitamin C and calcium
Spelt	<i>Triticum aestivum</i> subsp. <i>spelta</i>	Europe	Higher protein content, more non-essential amino acids and less lysine
Sweet potato	<i>Ipomoea batatas</i>	Americas	High protein content (4–27%), beta-carotene and anthocyanin
Teff	<i>Eragrostis tef</i>	Somali Peninsula	Gluten-free, rich in protein, dietary fiber, polyphenols and minerals
Triticale	<i>xTriticosecale</i>	Europe	Higher protein content and nutritive values than in wheat
Tritordeum	<i>Tritordeum martinii</i>	Europe	High total phenol, antioxidants, dietary fibres, and total free amino acids
White lupin	<i>Lupinus albus</i>	Mediterranean basin	Fair protein, fatty acid, and fibre content, as well as oligosaccharides, antioxidants and non-starch carbohydrates



Pearl millet



Amaranth



Buckwheat



Foxtail millet



Quinoa

Grains of some alternate crops

foods, viz. coconut, banana, guava, papaya, etc. Fruits and vegetables contain several bioactive compounds or phytochemicals (ascorbic acid, carotenoids, tocopherols, and phenolic compounds) enabling them to act in our body as antioxidant, anti-allergenic, anti-carcinogenic, anti-inflammatory, etc. Under the instances of lower production of antioxidants, the human body becomes more dependent on food sources for antioxidants. For these conditions, nutraceutical rich vegetable crops like red and black carrot, beet root, pumpkin, tomato etc. are more beneficial for health. Green leafy vegetables are a rich source of calcium, iron, alpha-carotene, ascorbic acid, riboflavin, thiamin, niacin, and folic acid. The root and tuber vegetable crops like sweet potato, taro, elephant foot yam, yam bean, etc. are rich in carbohydrates and energy. Cooked yams have about 2% protein, cassava and sweet potato provide ascorbic

acid, whereas, cereal-based foods have none. Sweet potato also contains important amino acids while rice is deficient in lysine. Roots and green tops of sweet potato (orange and yellow-fleshed type) are rich in vitamin A. Besides, sweet potato is rich in anti-oxidant and nutrients (β -carotene, ascorbic acid, and tocopherol) which can prevent coronary disorder and cancer. Peas and beans are known for the richness of proteins. Chilli, brinjal, tomato, okra, cowpea, etc. not only add diversity to the diet but also provide a lot of vitamins, minerals, and fiber-rich food. The nutritional benefits of dietary fiber are well established for reducing the risk of cancer and for lowering blood cholesterol. Cruciferous vegetables are enriched with glucosinolate components which inactivate the carcinogens by reducing their reactivity with endogenous ligands and thereby facilitating their elimination from the body. Natural

Table 2. List of underutilized fruits which can be used as a potential source of food system

Scientific name	Family	Distribution	Economic utility
<i>Actinidia strigosa</i>	Actinidaceae	Sikkim	Eaten fresh
<i>A. callosa</i>	Actinidaceae	Arunachal Pradesh	Eaten fresh
<i>Baccaurea sapida</i>	Euphorbiaceae	Sikkim, Meghalaya, Assam, Arunachal Pradesh, Tripura	Eaten fresh
<i>Averrhoa carambola</i>	Oxalidaceae	Meghalaya, Assam	Eaten fresh
<i>Docynia indica</i>	Rosaceae	Khasi hill (Meghalaya), Sikkim	Eaten fresh, pickle, jelly
<i>Emblica officinalis</i>	Euphorbiaceae	Sikkim, Meghalaya, Assam, Arunachal Pradesh, Tripura	Pickle
<i>Phyllanthus acidus</i>	Euphorbiaceae	Mizoram	Eaten fresh
<i>Elaeagnus latifolia</i>	Elaeagnaceae	Arunachal Pradesh, lower Assam, Meghalaya	Fruit eaten fresh, chutney, jam
<i>E. pyrifolia</i>			
<i>Garcinia lanceaefolia</i>	Clusiaceae	Meghalaya, Mizoram, Nagaland, Assam	Eaten fresh
<i>Garcinia cowa</i>	Clusiaceae	Mizoram	Fruit eaten fresh and for juice
<i>Myrica fraquhariana</i>	Myricaceae	Sibsagar (Assam), Nagaland, Meghalaya	Pickle, eaten fresh, refresh drink
<i>Passiflora edulis</i>	Passifloraceae	Meghalaya, Mizoram, Manipur, Nagaland, Sikkim	Eaten fresh, juice
<i>P. edulis var. flavicarpa</i>			
<i>Pyrus pashia</i>	Rosaceae	Khasi and Jaintia hills (Meghalaya)	Eaten fresh in rootstock for pear
<i>Prunus nepalensis</i>	Rosaceae	Khasi and Jaintia hills (Meghalaya)	Eaten fresh, jam, jelly, refresh drink, wine
<i>Dillenia indica</i>	Dilleniaceae	Meghalaya, Assam	Chutney, pickle
<i>Machilus edulis</i>	Lauraceae	Sikkim, Arunachal Pradesh and other NE regions	Pulp of fruit skin eaten
<i>Diploknema butyracea</i>	Sapotaceae	Sikkim, Arunachal Pradesh	Used in soaps, candle and to treat gout and rheumatism
<i>Phoebe cooperiana</i>	Lauraceae	Arunachal Pradesh	Fruit is eaten raw or cooked
<i>Aegle marmelos</i>	Rutaceae	Sikkim, Arunachal Pradesh and other NE Regionss	Ripe fruits are eaten fresh
<i>Anthocephalus chinensis</i>	Rubiaceae	Lower Assam	Mild acidic fruit either eaten raw or cooked with fish or as vegetable
<i>Annona reticulata</i>	Annonaceae	Sikkim, and other NE Regions	Ripe fruits are eaten fresh
<i>Artocarpus lacucha</i>	Moraceae	Nagaland, Lower Assam, Arunachal Pradesh, Tripura	Raw fruits are used for the preparation of pickling and in vinegar while mature and ripe fruits are consumed fresh
<i>Averrhoa carambola</i>	Oxalidaceae	Tripura, Lower Assam, Arunachal Pradesh, Manipur	Ripe fruits are eaten fresh
<i>Baccaurea sapida</i>	Euphorbiaceae	Manipur, Tripura, Arunachal Pradesh, Lower Assam	Ripe fruits are eaten fresh
<i>Castanopsis megacarpa</i>	Fagaceae	Assam, Arunachal Pradesh, Manipur, Khasi hills (Meghalaya)	Edible nut
<i>Choerospondias axillaris</i>	Anacardiaceae	Manipur, Tripura, Arunachal Pradesh, Lower Assam	Fruit, which is eaten both fresh and made into a variety of sweetmeats and chutney

Table 3. Minor vegetables as source of food system in NE region of India

Species	Diversity rich area
<i>Cucurbita ficifolia</i> , <i>Coccinia indica</i> , <i>Cucumis callosus</i> , <i>Cucumis melo</i> var. <i>momordica</i> , <i>Luffa acutangula</i> , <i>Luffa cylindrical</i> , <i>Momordica cochinchinensis</i> , <i>Momordica dioca</i> , <i>Trichosanthes anguina</i> , <i>Trichosanthes dioca</i> , <i>Cylanthra pedata</i> , <i>Benincasa hispida</i> , <i>Sechium edule</i> , <i>Cucurbita maxima</i> , <i>Cucurbita moschata</i> , <i>Cucurbita pepo</i> , <i>Solanum macrocarpon</i> , <i>Solanum xanthocarpum</i> , <i>Solanum indicum</i> , <i>Solanum mammosum</i> , <i>Solanum khasianum</i> , <i>Solanum torvum</i> , <i>Solanum berbisetum</i> , <i>Capsicum annuum</i> var. <i>avicular</i> , <i>Capsicum frutescens</i>	Assam, Mizoram, Nagaland, Arunachal Pradesh, Meghalaya, Manipur, Tripura, Sikkim

pigments from vegetable crops, e.g. black carrots, beet root and coloured hybrids of radish have the potential to be used as the source of nutraceutical to address the number of ailments and chronic diseases and to restore the wellness of the body after diseases. Fruits and vegetable therapy is now a practice to have good health without medication and many crops are used as herbal medicine. The fruits (aonla, bael, jamun, papaya), vegetables (carrot, cauliflower, onion, garlic, leafy vegetables) protects against various kinds of diseases. Horticultural crops provide a viable option for ensuring the livelihood security of the farmers. The economic returns per unit area are high in horticultural crops when compared to field crops. Being labour intensive these high value low volume crops ensure year-round employment to the entire family. The food preference and the consumption pattern are shifting towards fruits and vegetables from a cereal-employment in agro-chemical industries, small scale processing, marketing of fresh fruits and vegetables and processed products are various alternatives for livelihood security. The list of potential underutilized horticultural crops as ACs are listed in Table 2 and 3.

The International Year of Millets 2023 and the G20 Presidency of India

The United Nations general assembly at its 75th session in March 2021 declared 2023 the International Year of Millets (IYM 2023). FAO is the lead agency for celebrating the Year in collaboration with other relevant stakeholders. Millets can grow on arid lands with minimal inputs and are resilient to changes in climate. They are therefore an ideal solution for countries to increase self-sufficiency and reduce reliance on imported cereal grains.

Under the G-20 Presidency of India, the Meeting of Agricultural Chief Scientists (MACS) was held during 17–19 April, 2023 at Varanasi, India. The G-20 Member States, Invited Countries and International Organizations participated in the MACS to discuss and identify the Research and Development (R&D) priorities in agriculture to foster transformation towards diverse, resilient and sustainable agriculture and food systems. Global food security concerns have been aggravated by the COVID-19 pandemic and climate change. This requires multi-layered solutions in the spirit of “One Earth, One Family, One Future”. MACS intend to safeguard the global food security and nutrition by strengthening our efforts towards sustainable agriculture and food systems by leveraging science, technology and innovations.

MACS highlight the importance of locally adapted crops for the transition towards resilient agriculture and food systems, enhancing agricultural diversity, and improving food security and nutrition. Recognizing the achievements of the Wheat Initiative, they intend to continue the R&D efforts to provide inclusive solutions for climate-resilient, nutritious, locally adapted, indigenous and underutilized grains. To strengthen the research collaboration and public awareness of these grain crops, we support the launch of the “Millets and Other Ancient Grains International Research Initiative (MAHARISHI)” with voluntary membership from G20 member countries, non-member countries, International Organizations and the private sector.

Sustainable development goals (SDGs) of the UNO

In the 2030 agenda, the United Nations has set 17 Sustainable Development Goals (SDGs), which were



The 17 SDGs of the UNO are

- No Poverty
- Zero Hunger
- Good Health and Well-being
- Quality Education
- Gender Equality
- Clean Water and Sanitation
- Affordable and Clean Energy
- Decent Work and Economic Growth
- Industry, Innovation and Infrastructure
- Reduced Inequality
- Sustainable Cities and Communities
- Responsible Consumption and Production
- Climate Action
- Life Below Water
- Life on Land
- Peace and Justice and Strong Institutions
- Partnerships to achieve the Goal

adopted by world leaders at a historic UN Summit officially came into force on 1 January, 2016. Though, the time is limited to achieve these SDGs, yet the ACs can play a very vital role in achieving many of these SDGs directly or indirectly. ACs are very promising to meet sustainable food system in future agriculture. The introduction of ACs also complies with the SDGs set by the UN. The sustainability food system has become a major challenge for policy makers worldwide. The adoption of ACs could also facilitate the implementation of the 2030 strategy of the Asian Development Bank that intends to tackle climate change while strengthening food safety in Asia by 2030.



Contributions of ACs in SDGs

The ACs contribute directly or indirectly to meet the SDGs, as:

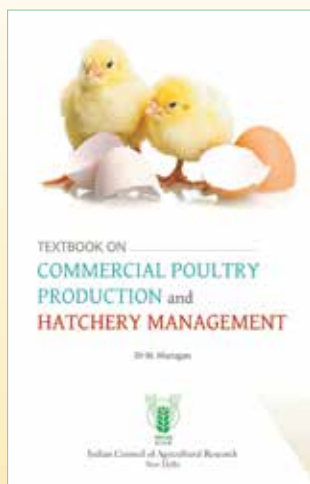
- ACs improve rural income (SDG # 1, 8, 10)
- ACs reduce malnutrition rates (SDG # 2)
- ACs reduce obesity rates (SDG # 3)
- ACs promote sustainability and consumer choice (SDG # 4, 12)
- ACs reduce chemical leaching (SDG # 6, 14)
- ACs promote green bio-fuel (SDG # 7)
- ACs enhance traditional knowledge as cultural heritage practices (SDG # 11)
- ACs reduce carbon dioxide emission and contribute to climate change mitigation (SDG # 13)
- ACs increase export and trade from their centre of origin (SDG # 17)

SUMMARY

Alternate crops can be used as a viable option for sustainable food systems owing to their high nutritive value and/or other health benefits or agronomical importance. These ACs or underutilised crops were farmed largely in traditional systems, but they somehow lost relevance. Now, they have regained it and are becoming more and more well-liked. The introduction of ACs to a region, such as a low-productivity area, would aim to promote food availability in that specific location in terms of high quantity, quality, and nutritional characteristics.

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TECHNICAL SPECIFICATIONS

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