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Conservation and Use of Underutilized Crops: Challenges and Way Forward

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This paper reinforces the importance of underutilized crops and the need for organized research efforts for their improvement. These include species also classified as underexploited crops, under-developed crops, underused crops, abandoned crops, lost crops, orphan crops, minor crops, traditional crops, forgotten crops, vanishing crops, local crops, indigenous crops, niche crops, life support species, poor people's crops, subsistence crops, crops for future, nutri-rich crops, and new potential crops, which have great potential to be used in mainsteam agriculture. The domestication of new crops would promote agricultural diversity and could provide a solution to many of the problems associated with intensive agriculture. Being nutritionally very rich, they have proved good potential for food and nutritional security, health and income generation especially for local communities. The use of modern science to improve their productivity, value addition and use by agro-industries are new opportunities that need to be harnessed.

Introduction

The dependence of mankind on plant resources is inevitable. The paradox of agriculture is that there are 300,000 known plant species in the world out of which 100,000 are used by humankind in various ways. About 30,000 species are edible and 7,000 species are used as food at the local level and only 150 species have been commercially cultivated. Only about 30 species provide 90 per cent of plant calories, while only three species – rice, wheat and maize meet 60 per cent demand. These include cereals, legumes, root and other food crops (Paroda, 1988). Notwithstanding the food shortages becoming more acute particularly in the developing countries, an increased dependence on plants rather than animals for the protein in their diet is felt necessary. On the other hand, the ever increasing human population particularly in the developing world is a never diminishing challenge to growers. It has, therefore, become necessary to explore the possibilities of exploiting newer plant resources in order to meet the growing food requirements. There are large number of species known by various names as underutilized crops, underexploited crops, under-developed crops, underused crops, abandoned crops, lost crops, orphan crops, minor crops, traditional crops, forgotten crops, vanishing crops, local crops, indigenous crops, niche crops, life support species, poor people's crops, subsistence crops, crops for future, nutri-rich crops, and new potential crops which have great potential to be exploited.

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The concerns focussing attention on new or underexploited crops include resource management, agricultural diversification, self sufficiency, economic gains, germplasm augmentation, conservation, and nutrition. Interests in the underutilized plants are spurred by quite different reasons in developed and developing countries, which need strategic planning. These form a continuum related to crop diversification, production of value added products, rural development and increased income for growers and processors (Williams, 1993). The new crops/underutilized crops continue to be neglected and have to struggle hard in the competition for support and mostly underdeveloped markets.

Sustainable agriculture requires enhancement of the world's productive capacity as well as the conservation of resource base (Walsh, 1991). The traditional crops including lesser known pulses and pseudocereals have been grown for generations on marginal soils under low input management. This situation does not exist today in the same magnitude as even the small farmers are expected to contribute towards increased agricultural production for which new innovations in production technology including the use of alternative or new crops need greater emphasis.

The focus of scientific attention on a particular underutilized crop depends on availability of landraces which can adapt relatively quickly, possess an ability to fit well into cropping systems and capability of giving high yield of acceptable products. These factors need

strategic planning for identification of real promising underutilized crops out of a large number available. The importance of underutilized crops and the need for organized research efforts, for their improvement have been amply emphasized (Arora and Bhag Mal, 1991; Bhag Mal, 1990, 1993; Bhag Mal and Joshi, 1991; Bhag Mal *et al*., 1992; Bhag Mal and Paroda, 1988; Paroda and Bhag Mal, 1992; Paroda *et al*., 2022; Williams, 1993).

Asia-Pacific region possesses a rich genetic diversity of several plant species which are presently underutilized but have a great potential to be exploited for food production only in different countries within the region but also elsewhere in the world. The potential underutilized crops which merit urgent attention for improvement include a few pseudocereals, viz., amaranth, buckwheat, chenopods and grain legumes, viz. rice bean, adzuki bean, faba bean, winged bean, moth bean, horse gram, hyacinth bean, grasspea, French bean, lima bean, sword bean, jack bean and zombi pea.

In view of the need for diversification of future agriculture to meet various human needs, it is very timely to seriously consider paying enhanced attention on using the underutilized crops especially grain legumes and pseudocereals. One such approach is to explore non-conventional pathways such as wider adoption of UUCs, as possible future crops due to the fact they are adapted to a range of agro-ecologies, are nutrient-dense and offer better prospects in marginal production areas with low input agriculture. In fact, this approach is an affirmation of sustainable farming systems and human wellbeing known to indigenous local communities for generations. The domestication of new crops would promote agricultural diversity and could provide a solution to many of the problems associated with intensive agriculture. Being nutritionally very rich, they have proved good potential for food and nutritional security, health and income generation especially for local communities. The use of modern science to improve their productivity, value addition and use by agro-industries are new opportunities that need to be harnessed.

Challenges and Opportunities

There are several challenges and constraints which hamper the growth and development of neglected and underutililzed crops and need to be addressed. These include: relatively low yield, limited germplasm and lack of improved varieties, lack of improved agronomic practices, lack of scientific and technical information – production, consumption, utilization; problems associated with taste, cooking and antinutritional traits; lack of interest by researchers, agriculturists and extension workers; lack of awareness on economic benefits and market opportunities; lack of technology for processing, value addition and product development; lack of promotion of specific potential crops; lack of coordination between diverse stakeholders; lack of enabling policies, initiatives and incentives; and lack of credit and investment. Also these crops suffer with several problems relating to development of improved varieties such as asynchronous maturity, small seed size, lodging, seed shattering, difficulty in threshing, weed control, outcrossing, lack of systematic breeding, lack of well-defined seed production system, and lack of resistance to biotic and abiotic stresses.

These species are extremely important for diversification of agriculture as they are immensely helpful in enlarging narrow food base, sustainability of high-input agriculture at risk, rehabilitation of ecosystem, providing protection against climatic changes/unforeseen circumstances, extending cultivation to marginal/ degraded lands, balanced nutrition- micronutrient deficiency, meeting the changing human needs, promoting export potential and posterity for futue use. There are tremendous opportunities for exploiting the potential of these species due to their manifold benefits such as contributing to poverty alleviation, income generation, widening the food basket, adding nutrients to diet, providing food for low income group people, adapted to fragile environments, contributing to the stability of agroecosystems, meeting new market demands, and value addition and product development.

The underutilized species also play an important role in the subsistence farming and economy of poor people; have high potential for dietary diversification and nutritional enrichment – micronutrients such as vitamins and minerals; provide important environmental service - adapted to marginal soils and diverse climatic conditions; contribute towards food and nutrition security; possess high local importance in consumption and production systems; highly adapted to agro-ecological niches/marginal areas; represented by ecotypes/landraces contributing useful genes; and are cultivated and utilized relying on indigenous knowledge and hence provide enormous opportunities for wider utilization. These crops provide better water foot print, better carbon

foot print and also security in terms of food, feed, fodder and biofuel (green energy). They contribute towards Sustainable Development Goals 2, 3, 12 and 13 which address zero hunger, healthy lives, sustainable consumption and climate change.

Some of these species such as amaranth, buckwheat and chenopods possessing exceptionally high nutritional value attributed to high proteins and minerals (Fig.1) and higher amount of essential amino acids (Table 1) as compared to cereals definitely have the potential to become important components of agriculture. Amaranth, of course, has a great potential to offer for commercial cultivation in the plains as well.

National Program on Underutilized Crops

Amongst the developing countries, India is the only country having well organized national program on underutilized crops. The All India Coordinated Research Project (AICRP) on Underutilized and Underexploited Plants was initiated in 1982 with its headquarters at NBPGR involving 29 crops. Realizing the need for prioritization, the number of crops was reduced to 18. In 2002, the project was converted to network mode as All India Coordinated Research Network (AICRN) on Underutilized Crops with 18 crops. Subsequently, based on the recommendations of the Quinquinnial Review Team (QRT), the name of Network was changed

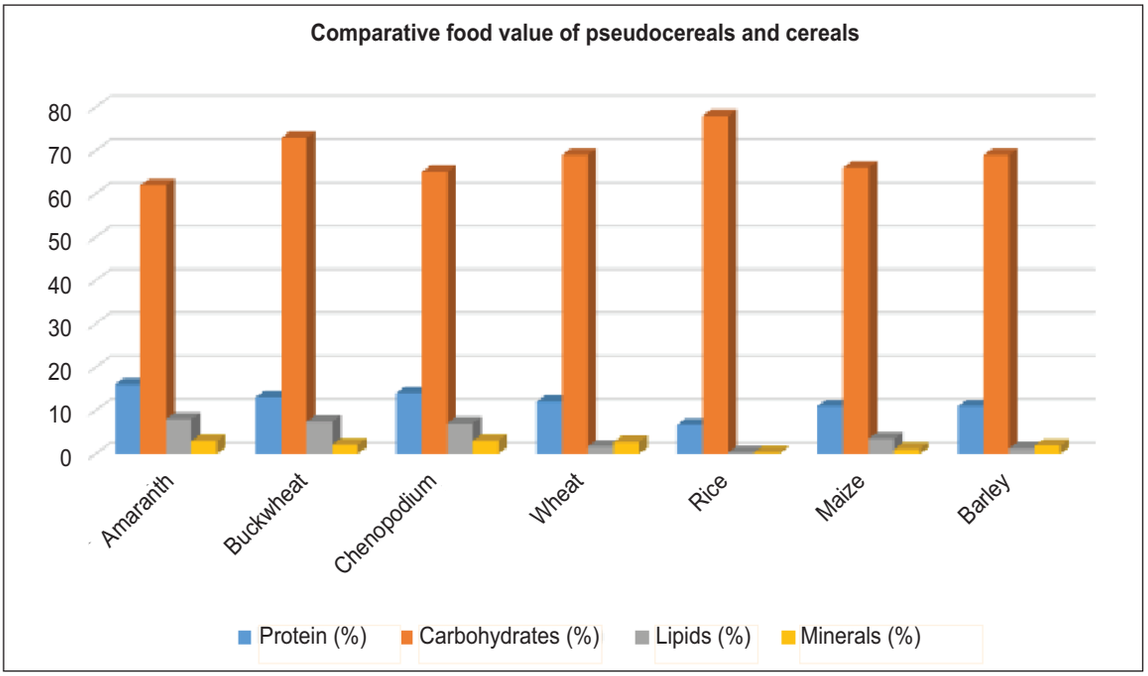

Fig. 1. Comparative food value of pseudocereals and cereals (Bhag Mal, 1994)

Table 1. Amino acid composition of pseudocereals and cereals

Amino acids	Content (g/100g protein)						
	Amaranth	Buckwheat	Chenopod	Wheat	Rice	Maize	Barley
Leucine	4.7	6.2	5.7	5.8	8.5	13.0	7.5
Isoleucine	3.0	3.7	3.3	3.3	4.5	4.1	4.0
Lysine	5.0	6.2	6.0	2.2	3.8	2.9	3.0
Arginine	6.6	10.1	6.9	3.6	3.7	2.9	3.8
Histidine	2.5	2.2	1.8	1.7	1.9	1.8	1.9
Methionine	4.0	1.6	2.2	2.1	3.0	3.4	3.2
Phenylalanine	6.4	4.2	4.1	4.2	8.4	6.4	8.2
Thereonine	2.9	3.7	4.0	2.8	3.9	2.7	3.2
Valine	3.6	5.1	4.0	3.6	6.7	5.6	4.7
Tyrosine	6.4	3.2	3.2	8.6	9.1	4.6	8.2
Cysteine	4.0	1.6	1.2	3.7	3.0	3.4	3.7

Bhag Mal (1994)

as AICRN on Potential Crops in 2014 embracing the important priority crops, namely, grain amaranth (*Amaranthus* Spp.), buckwheat (*Fagopyrum* spp.), chenopod (*Chenopodium* spp.), quinova (*Chenopodium quinova*), Job's tear (*Coix lacryma Jobi*); adzuki bean (*Vigna angularis*), faba bean (*Vicia faba*), rice bean (*Vigna umbellata*), winged bean (*Psophocarpus tetragonolobus;* perilla (*Perilla frutescens*), paradise tree (*Simarouba glauca*), *Moringa olefera;* kalingada (*Citrullus lanatus*), kankoda (*Momordica dioica*); *Vigna trilobata*, *Vigna glabrescens;* tumba (*Citrullus colocynthus*), *Vigna marina*. These species were prioritized for intensive research and development.

Significant progress has been made under the AICRN Project for collecting conservation, characterization, evaluation, conservation and utilization over the years. Also, International Workshop on Life Support Species in Asia and the Pacific Region was organized in collaboration with Commonwealth Science Council (CSC), UK at NBPGR, New Delhi, 1987 and the Proceedings were brought out.

Germplasm Conservation

As a result of concerted efforts, a total of 9,348 germplasm accessions of different underutilized crops, namely, pseudocerals, food legumes, oilseeds, vegetables, fodder crops, and crops for problem soils have been presently conserved in the National Genebank at the National Bureau of Plant Genetic Resources (NBPGR) and the field genebanks at different centres. The details of crop groups, crops and number of accessions conserved are given in Table 2.

Table 2. Germplasm of underutilized crops conserved in national genebank/field genebanks

S. No.	Crop Group	Crops	No. of Accessions
1	Pseudoce reals	Amaranth (*Amaranthus* spp.)	5,815
		Buckwheat (*Fagopyrum* spp.)	1,095
		Chenopodium (*Chenopodium* spp.)	204
2	Minor cereal	Job`s tears (*Coix lacryma jobi*)	150
3	Food Legumes	Adzuki bean (*Vigna angularis*)	200
		Faba bean (*Vicia faba*)	882
		Winged bean (*Psophocarpus tetragolobus*)	219
4	Oilseeds	Perilla (*Perilla frutescens*)	321
		Paradise tree (*Simarouba glauca*)	1
		Moringa (*Moringa* sp.)	13
5	Vegetables	Kalingada (*Citrullus lanatus*)	250
		Kankoda (*Momordica dioica*)	54
6	Fodder	*Vigna trilobata*	144
7	Crops of problem soils	Tumba (*Citrullus colocynthis*)	138
Total			9,348

Varieties Developed and Released

Under the All India Coordinated Program on Underutilized Crops at different centres, intensive selection/breeding programs are underway since its inception in 1982.Till date, a total of 60 varieties in different crops have been released and notified by the Central Variety Release Committee (CVRC) and the State Variety Released Committees. These varieties have been recommended for cultivation in different agro-ecoregions in the country. The details of crops and varieties released are given in Table 3.

The Way Forward

Germplasm Acquisition, Characterization and Conservation

- Ecogeographic surveys need to be conducted to develop the database on origin, distribution, habitat, agro-climatic requirements, benefits and scientific use of potential underutilized crops. There is also need for intensive studies on basic aspects of research especially on crop biology, nature and extent of pollination, ploidy level and crop husbandry.
- Well organised exploration programmes need to be undertaken to collect the existing diversity for which there is an urgent need to fix priorities for different crops and areas to be explored. The areas having rich diversity of landraces, primitive cultivars and wild relatives of specific crops need to be identified.
- Greater thrust needs to be given for collecting germplasm including locally adapted unique types as well as wild species from hitherto unexplored areas and the niche areas having rich genetic diversity and resistance against diseases, insect-pests, nematodes, lodging, seed shattering, drought, frost, salinity, etc. Germplasm with specific desirable traits also need to be introduced from exotic sources.
- Explorations should also be aimed at collecting material for filling the gaps in existing collections particularly the gene sources for photo-insensitivity, indeterminate growth habit and resistance against

Table 3. Varieties of underutilized crops released

Crop	No.	Name of varieties
Amaranth	19	Annapurna, PRA-2, GA1, GA-2, GA3, GA4, GA5, GA6, Durga, BGA-2, VL Chua 44, VLChua110, RMA-4, RMA-7, KBGA-1, KBGA-4, Phue Kartiki, Chhattisgarh Rajgira-1, Suvadra
Buckwheat	6	Himpriya, VL Ugal 7, PRB 1, Himgiri, Sangla B-1, Him Phaphra
Chenopod (*Bathua*)	2	Him Bathua, Pusa Green
Qinova	1	Him Shakti
Winged bean	4	AKWB-1, Indira Winged Bean-2, Chhattisgarh Chaudhari Sem-2, Phule Chardhari Wall (PB 11-2)
Faba bean	5	WH 82-1, HFB-1, HFB-2,Suvarna Gaurav, Suvarna Suraksha
Rice bean	11	RBL-1, PRR-2, RBL-6, VRB-3, KBR-1, Bidhan Rice bean-3, Bidhan -1, JRBJ05-2, Shyamla, Surabhi, Jawahar Rice Bean-2
Adzuki bean	1	HPU 51
Kalingada	3	Gujarat Kalingada-1, GK-2, CAZRI Kalingada-1
Kankoda	3	Indira Kankoda-1, Indira Kankoda-2, Chhatisgarh Kankoda-2
Perrila	2	RC Manithoiding 1, RC Manithoiding 2
Tumba	1	RMT 59 (Mansha Marudhara)
Jatropha	1	Chatrapat (SDAUJ 1)
Job's Tear	1	Bidhan Coix 1
Guayule	1	HG-8

Source: Haiger, 2022

diseases, insect-pests, nematodes, lodging, seed shattering, drought, frost, salinity etc. Germplasm with specific desirable traits also need to be introduced from exotic sources.

- The available germplasm needs to be characterized for diverse agro-morphological traits and be conserved on top priority through *ex situ* and *in situ* methods. Germplsm possessing specific desirable traits especially for biotic and abiotic stresses, wider adaptability, climate resilience and nutritional quality traits needs to be identified for use in breeding better varieties.
- Crop descriptor lists which are not available for many of these crops need to be prepared on priority basis. Crop catalogues on the available germplasm should be brought out soonest possible so as to make the information available to the interested researchers. Evaluation efforts should be concentrated on traits of vital importance for evaluation.

Crop Improvement

- Greater emphasis is needed to develop suitable plant-types possessing earliness, photo-insensitivity, high harvest-index, shattering resistance and determinate, bushy growth habit in underutilized grain legumes. Early, bold grained, photo-insensitive and lodging and shattering resistant varieties need to be developed in pseudocereals. The short duration varieties need to be developed to fit well in the existing cropping systems and to be grown successfully in non-conventional seasons and areas
- Intensive selection and breeding efforts on eco-regional basis need to be made to develop varieties possessing resistance to drought, frost, water logging, diseases, pests and nematodes. Sources of resistance genes should be identified and the resistance be incorporated in high yielding adapted cultivars. Use of related wild and weedy species which possess resistance genes could be important for such purposes.
- The possibilities of exploitation of specific crops for alternate uses need to be explored, for example, winged bean for oil or tubers; chenopods and faba bean for vegetable and for animal feed; amaranth, chenopod, rice bean and hyacinth bean for fodder and buckwheat for vegetables and also many of these crops for use in medicine. Suitable varieties should be developed for such specific purposes in order to have their economic cultivation.
- Basic studies which hitherto remained largely ignored in underutilized grain legumes and pseudocereals require urgent attention. The genetics of plant, fruit and seed characters need to be studied. The causes

of flower and fruit drop also need to be investigated so as to take up remedial measures.

- Timely availability of good quality seed to the farmers at reasonably low price deserves special attention. Sincere research efforts are required to study all aspects of seed production in specific crops. Seed production network involving central and state government agencies and the Research Institutes and State Agricultural Universities needs to be established for production of breeder, foundation and certified seeds.

Production Technology

- In order to integrate the underutilized grain legumes and pseudocereals into the existing agricultural systems, efficient agronomic management is required. Well planned experimentation is needed to determine the package of cultivation practices relating to time and method of sowing, seed rate, plant density and arrangement, irrigation, fertilization and harvesting in different crops.
- Post-harvest technology for each of these crops also needs to be standardised for proper storage of ripe seeds, tubers and immature pods. Systematic research should be carried out on aspects such as chemical treatment of seeds, temperature and humidity control for dry storage, determining optimum moisture content for stored seed and conditioning of stored seed before planting and food purposes.
- Appropriate plant protection measures are required to be developed crop-wise for controlling the diseases, insect-pests and nematodes and also the bird damage. Chemical protectants along with recommended doses need to be specifically determined. Introduction of predators and parasites feeding on harmful insects deserve consideration.

Product Development and Marketing

- In-depth studies on nutritional quality, nutraceutical properties and antinutritional factors need to be given greater thrust. Greater focus needs to be given to processing, value addition, product development and marketing.
- Urgent attention is required for intensive research on the processing and testing of various plant parts for different uses such as ripe seeds for use as food, edible oil and animal feed; plant and leaves for vegetable and fodder purposes; tubers for food and feed; leaves for protein extraction; ripe seed hull and seed in combination with other on grains to make different food products with improved nutritional value, devising methods of protein extraction from leaves, removing undesirable smell and flavours and easy cooking also require specific consideration.
- Appropriate methods of marketing the products of these crops need to be developed as to ensure adequate production for commercial processing through contract farming among small farmers. In-depth studies are required to estimate the resources required for intensive and extensive production at different locations and the amount of raw product required for efficient manufacture of various products. Any plan designed to increase cultivation of a given crop must be developed concurrently with a program to develop the market for it.

Technology Transfer

- In order to popularise the underutilized grain legumes and pseudocereals, demonstrations and tests are to be organised at no risk to the farmers. Front-line demonstrations should be organised by the Research Institutes/Centres and the State Agricultural Universities (SAUs) at farmers' fields. Adaptive and minikit trials should be conducted by the respective Departments of Agriculture in different States.
- Public awareness of the nutritional and other benefits as well as the profits from cultivation of these crops need to be created through exhibitions and farmers' fairs organised by the Research Institutions and the Departments of Agriculture in the States.
- Suitable publications such as books, brochures, research journals and newsletters on these crops may be brought out for faster dissemination and exchange of information. Preparation of production guides and recipes booklets and educational films with sound tracks in different languages deserve consideration for generating public awareness about the utility and cultivation methods of these crops among the masses.
- Training programmes need to be organised at regular intervals at the level of scientists, extension workers and the farmers in order to appraise them with the latest technology developments relating to particular crops.

Collaboration and Linkages

- Close linkage needs to be established among producers, traders, processors, consumers and other formal and informal sectors in order to develop effective value chain to promote the use of these potential underutilized crops.
- For quality analysis work and for processing, value addition and product development, strong collaboration needs to be developed with the Department of Food Processing/Home Science Department of State Agricultural Universities (SAUs) and concerned institutes and well established laboratories in the country.
- Earlier, there was a strong collaboration of the Indian Program on Underutilized Crops with International Centre of Underutilized Cops (ICUC) at Southampton (UK). Similarly, a close collaboration with the International Centre on Crops for Future (CFF) based in Kuala Lumpur, Malaysia needs to be established.

Policies

- Enabling policies for mainstreaming of use of underutilized crops in food systems needs be given priority attention. Their increased use in mid-day meals of school children needs to be promoted in view of their high nutritional value.
- Appropriate subsidies may be given to the farmers to encourage them for growing the underutilized crops. The cost of quality seed needs to be subsidised and procurement of their produce needs to be assured in the initial stages.
- Local political and administrative support should be developed to encourage cultivation of new crops or expansion of a known but neglected crop. Administrative authorities need to be convinced through proper dialogue about the cultivation of these crops. Farmers should be encouraged for growing the underutilized crops by providing them incentives and subsidies.
- Non-Government organisations (NGO's) may be involved at appropriate levels with a view to give required thrusts to the research and development programmes on underutilized crops.
- Adequate financial and human resource needs to be provided to strengthen the research and development programs on underutilized crops.

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