The Pharma Innovation Journal 2022; SP-11(2): 503-512

www.ThePharmaJournal.com

The Pharma Innovation

**ISSN (E): 2277- 7695**
**ISSN (P): 2349-8242**
**NAAS Rating: 5.23**
TPI 2022; SP-11(2): 503-512

www.thepharmajournal.com
Received: 19-12-2021
Accepted: 23-01-2022

**Ummaisa Rehman**
Division of Agronomy, Faculty of Agriculture, SKUAST-K, Wadura, Sopore, Jammu and Kashmir, India

**FA Bahar**
Division of Agronomy, Faculty of Agriculture, SKUAST-K, Wadura, Sopore, Jammu and Kashmir, India

**AA Saad**
Division of Agronomy, Faculty of Agriculture, SKUAST-K, Wadura, Sopore, Jammu and Kashmir, India

**MA Bhat**
Division of Agronomy, Faculty of Agriculture, SKUAST-K, Wadura, Sopore, Jammu and Kashmir, India

**Lal Singh**
Division of Agronomy, Faculty of Agriculture, SKUAST-K, Wadura, Sopore, Jammu and Kashmir, India

**SS Mahdi**
Division of Agronomy, Faculty of Agriculture, SKUAST-K, Wadura, Sopore, Jammu and Kashmir, India

**Mohd Saleem Mir**
Division of Agronomy, Faculty of Agriculture, SKUAST-K, Wadura, Sopore, Jammu and Kashmir, India

**Moneesa Bashir**
Division of Agronomy, Faculty of Agriculture, SKUAST-K, Wadura, Sopore, Jammu and Kashmir, India

**Tauseef A Bhat**
Division of Agronomy, Faculty of Agriculture, SKUAST-K, Wadura, Sopore, Jammu and Kashmir, India

**Tsultim Palmo**
Division of Agronomy, Faculty of Agriculture, SKUAST-K, Wadura, Sopore, Jammu and Kashmir, India

**Corresponding Author**
**Ummaisa Rehman**
Division of Agronomy, Faculty of Agriculture, SKUAST-K, Wadura, Sopore, Jammu and Kashmir, India

# Trends, challenges and prospects of underutilized food crops under temperate ecologies: A review

**Ummaisa Rehman, FA Bahar, AA Saad, MA Bhat, Lal Singh, SS Mahdi, Mohd Saleem Mir, Moneesa Bashir, Tauseef A Bhat and Tsultim Palmo**

## Abstract
By 2050, the world's population is predicted to exceed 9 billion people, necessitating a 50 percent increase in food production to feed the world's growing population while also improving nutrition. Despite possessing a large variety of food plants, the world's food and nutritional needs are met by a small number of key crops (rice, wheat, and maize). Because of the multiple socioeconomic and ecological constraints that crop production faces, global reliance on only a few basic crops for food is problematic. Climate change, according to new findings, will cause shifts in crop production areas and yield loss due to more unpredictable weather patterns. Alternative food crops with the potential to become one of the primary crops should be incorporated in people's diets in order to combat hunger and malnutrition and make the world more sustainable in terms of food security. Underutilized crops are a term used to describe these alternative crops. It will also give countries the ability to improve resilience and better adapt agricultural production systems to changing climates, where biodiversity plays a vital role in food security, climatic resilience, nutrition, income, genetic resources pool, and cultural identity.

**Keywords:** Biodiversity, climate change, food security, nutrition, sustainability, underutilized crops

## Introduction
To satisfy the expected 50 percent increase in demand for healthy food between 2012 and 2050, agricultural output must be enhanced in a sustainable way, as pledged in the 2030 Agenda for Sustainable Development (SDGs). More than 800 million people in the world, who are chronically hungry, with another two billion suffering from micronutrient deficiencies, highlighting to take action. There were 149 million stunted children below the age of five, 45 million wasting children, and 38.9 million fat children (WHO, 2021) [58]. India is one of the countries with a 15.3 percent (189.2 million) undernourished population, 51.4 percent anaemic women, 34.7 percent stunted children below the age of five, and 17.3 percent wasting (GHI, 2021) [19]. Heat and moisture stress, nutritional stress, pollution/heavy metal stress, salt stress, mechanical stress, and other abiotic stresses affect over 90% of worldwide agricultural land, restricting crop yield by up to 70%. These climate-related concerns are becoming more severe, resulting in socioeconomic insecurity, as well as hunger and health issues, especially in vulnerable groups. Furthermore, the effects of climate change have added to the already stressed natural resource base, diminishing the resilience of agro-ecosystems that provide security of food and nutrition to rural populations. On the world, there are 400,000 plant species identified, of which 30,000 are known to be edible and only 6000 are used as food. Furthermore, only 150 crops are farmed on a large scale around the world, with maize, wheat, and rice accounting for roughly 60% of our daily protein and carbohydrate needs (FAO Commission on Genetic Resources for Food and Agriculture, 2019) [17]. Over the previous century, a stunning 75 percent of crop diversity have been lost (an estimated 300,000 varieties). Every year, these trends deteriorate. Our agricultural systems are fragile due to the lack of genetic diversity in the gene pools of these few crops. Furthermore, reliance on such a limited food source renders our food supply particularly susceptible in terms of long-term food security. Clearly, the world requires a foremost green revolution to address the formidable challenges of hunger and malnutrition, which will fail if agro-biodiversity is not preserved. Food output is expected to increase, according to estimates by a factor of at least 70% by 2050 to support global population growth (Godfray *et al*., 2010a) [20]. Unexpected global heating has caused constant stress, such as droughts, high salinity and extreme temperatures, making it a challenge for farmers. In addition to these abiotic pressures, plants also face challenges arising from biotic stress, such as bacteria, fungi, viruses, nematodes, etc. As a result, all of these

biotic and abiotic stresses lead to significant yield losses (Godfray *et al*., 2010b) [21]. Therefore, there is a great need to concentrate on a variety of plants that can tolerate improved stress, yield and nutrition to ensure food security for future generations. Another alternative is to intensify agriculture, which can lead to an increase in yields per unit of land. The Green Revolution was the outcome of agricultural intensification, which included the widespread application of fertilizers and pesticides, besides the employment of agricultural machinery and genetically altered high-yielding cultivars (Pingali, 2012) [44]. Cereal crop production increased dramatically, with yields nearly tripling without a major increase in the amount of land under cultivation (Martin *et al*., 2019) [35]. Agricultural intensification, however, comes at a price in terms of the environment. Excessive fertilizer and pesticide use has thrown off the natural nitrogen and phosphorus cycles, contributing to pollution, sickness, and bio-magnification (Foley *et al*., 2011) [16]. Monocultures have increased the likelihood of disease outbreaks (Zhu *et al*., 2000) [60]. As a result, there is a pressing need for the creation of high-yielding, stress-tolerant cultivars that can be cultivated sustainably without putting an undue strain on scarce agricultural resources. Appropriate alternative crops that can replace and/or substitute for traditional food crops should have certain desirable properties, such as being nutritious, non-toxic, and long-lasting. Domesticated plants that were domesticated early in human evolution can be used as alternatives since they produce reasonable yields without the use of contemporary agricultural inputs like fertilizers and pesticides (Miller *et al*., 2016) [39]. Agricultural production worldwide is dominated by three major crops, namely maize, wheat and rice, which make up about 50% of calories and protein consumption. Furthermore, only 30 plant species are responsible for roughly 95% of world's food (Shelef *et al*., 2017) [52]. Agriculture is the primary source of income for more over 80% of the population in J&K. The main food crops are wheat, paddy, and maize. Climate change has had a disproportional impact on the production of J&K's top crops. According to the Annual publication 2013-2014 of the Directorate of Economics and Statistics of the Government of Jammu and Kashmir, rice, maize, and wheat output has already begun to decline by half, posing a significant risk to the people of J&K's food security. Furthermore, over 29 lakh women are anaemic, and over 15 lakh children below the age of five are malnourished (NITI Aayog report, 2021) [42]. As a result, biodiversity has severely decreased over the last few decades, as evidenced by the number of crops farmed and the diversity among the primary crops (Cardinale *et al.*, 2012) [9]. Diversifying production systems with alternative crops will protect food systems from socioeconomic shocks and climate threats while also strengthening agro-ecosystems, supporting smallholder agriculture, and preserving food cultures and economies based on local products and traditions. Alternative crops, also known as orphan, abandoned, neglected, lost, underutilized, local, minor, traditional, niche, or underdeveloped crops, are a diverse group of valuable species that are marginalized, if not completely ignored, by researchers, breeders, and policymakers. They are non-commodity crops that are part of a broad, bio-diverse family with the potential to serve as food crops and address future food security concerns. Cereals, fruits, vegetables, and root crops are examples of orphan crops. Drought and salinity are two of the most important abiotic factors affecting world food production. These crops are highly nutritious and are being promoted solely as healthy foods, in addition to being better suited to tough environmental conditions. "Those plant species having under-tapped potential for contributing to food security, health (nutritional/medicinal), income production, and environmental services," according to the Global Facilitation Unit (GFU) for Underutilized Species.

## 1. Features of Underutilized crops

a. A scientific or ethno-botanical verification of food value is required for each crop.
b. Crop has to have been farmed, either in the past or just in a specified geographical location.
c. It must be farmed less than other traditional crops at the moment.
d. The crop must have a shaky or non-existent seed supply system.
e. Crops have been identified as having indigenous applications in specific places. Research, extension services, farmers, policy and decision makers, and technology vendors have received little attention to it.
f. It could be highly nutritious and/or have medical or therapeutic capabilities, among other things

## 2. Significance of Underutilized crops

Orphan crops have the potential to solve many of current agriculture's problems while also assisting in the practice's sustainability. Even when main crops fail to deliver, these crops can provide reliable yields. Because most of these crops are adapted to growing in poor and marginal lands, just a little bit amount of fertilizer is required to improve output, and they require very little irrigation. These crops, when combined with other sustainable agricultural strategies such as intercropping and crop rotation, have the potential to maintain industrial agriculture's high yields while having a minimal environmental impact (Garibaldi *et al*., 2017) [18]. The majority of Underutilized crop species are resistant of extreme agro-climatic conditions, and they have great potential for establishing themselves on marginal and wasteland across the tropics (Hegde, 2002) [27]. As a result, due to their untapped potential, these Underutilized crop species will be investigated immediately to alleviate food insecurity. As a result, there seemed a push to diversify agriculture and investigate newer plant resources, as well as promote the use of underutilized nutritious food crops. These crops have evolved with a highly important genetic pool for biotic and abiotic stress resilience, in addition to being a storehouse of nutrients.

## 3. Diversity of underutilized crops

Millets, such as pearl millet (*Pennisetum glaucum*) and foxtail millet (*Setaria italica*), are prime significant cereal crops. They are mostly farmed as a primary food crop in African and Asian countries (Habiyaremye *et al*., 2017) [25]. These plants are recognized for their drought resistance, but are also resistant to salt pressure and have excellent water and nitrogen efficiency (Goron and Raizada, 2015) [22]. However, low yields and a lack of regional plant species have prevented widespread adoption Pseudocereals such grain amaranth (*Amaranthus hypochondriacus*), quinoa (*Chenopodium quinoa*) and buckwheat (*Fagopyrum esculentum* and *Fagopyrum tataricum*) have been reported to thrive in low-nutrient soils. They have several potential health benefits in addition to being resilient to various pressures (Zhang *et al*., 2017) [59]. Orphan legume crops are important protein sources that may be grown in nutrient-depleted soils. Cowpea (*Vigna unguiculata*), Chickpea (*Cicer arietinum*), Grass pea (*Lathyrus sativus*), and Bambara groundnut (*Vigna subterranean*) are some of the utmost commonly farmed legumes in Asia and Africa. With great drought tolerance and other pressures, these plants are planted as insurance against the failures of other crops (Sanginga *et al*., 2000) [50]. Sesame (*Sesamum indicum*), linseed (*Linum usitatissimum*), and castor bean (*Ricinus communis*) are all niche crops. Many developing countries produce root crops like cassava (*Manihot esculentum*) and sweet potato (*Ipomoea batata*) as a food source, owing to their drought tolerance and ability to thrive in impoverished soils (Tadale, 2019) [53].

## 4. Trends of underutilized crops

Pseudo-cereals, millets, and legumes have a diminishing area and output. Buckwheat production in the globe in 2018 was 2.9 million tons, down from 3.3 million tons in the previous three years (FAOSTAT, 2020) [15]. In India, millet area is declining, for example, Proso-millet area has decreased from 0.5 ha (2010) to 0.41 ha (2015-2016). In the last four decades, grass-pea area and output have decreased from 1.67 to 0.58 m ha and 0.84 to 0.43 million tons, respectively. Other underdeveloped crops followed a same pattern.

## 5. Current research status of Underutilized crops (UUC’s)

Over the last three decades, a diverse spectrum of research interests on under-tapped crops has emerged. A number of substantial programmes have been implemented in both poor and developed countries to promote underused species for agricultural systems, as alternative crops, or as sources of new goods. Furthermore, there has been a widespread understanding that underutilized crops should constantly be promoted in order to increase food security. A number of international research groups have been formed to focus on the UUCs that have been enlisted:

International centre for underutilized crops (ICUC), Global facilitation unit (GFU), Convention on biological diversity (CBD), Crops for the future (CFF).

## 6. Challenges to underutilized crops

The challenges to underutilized crops are enlisted below:

A. **Social:**

a. Farmers' decisions to switch from traditional, local crops to new types and improved crops
b. Loss of indigenous knowledge of traditional and local crops

B. Inadequate awareness of local species nutrition

C. Perceived low status of some local and traditional cuisines

**B. Economic:**

d. Land use changes
e. Low market value of neglected and underutilized crop species (NUS)
f. Lack of competition for NUS and other crops
g. Lack of market infrastructure
h. Farmers lacking incentives to keep NUS in their fields and gardens

**C. Environment**

i. Droughts, fires, pests, illnesses, overexploitation, overgrazing, land clearing, and deforestation all contribute to the genetic loss of NUS gene-pools.
j. Climate change impacts, policies, and initiatives
k. Degradation of ecosystems

**D. Agronomic**

l. Inadequate propagation materials and seeds
m. Inadequate seed supply systems
n. Pesticides, fertilizers, and other agrochemicals are used excessively

**E. Political**:

o. Governments at both the National and local levels have failed to prioritize NUS conservation and use
p. There are insufficient savings for ex situ conservation and there are insufficient equipments to maintain ex situ collections.
q. Governments' failure to encourage scientific study on NUS
r. A lack of knowledge on characterization, breeding, and evaluation
s. A lack of legal frameworks, national programmes, and strategies

## 8. Important Challenges to UUC’s

### a. Effects of climate change

Climate change has already begun to modify agro-ecologies in many places of the world, and this will have an impact on agro-biodiversity, including NUS. NUS, however, are predicted to provide farmers with more options to cope with abiotic pressures due to their greater resilience when compared to large crops (Padulosi *et al*., 2011) [43].

### b. Loss of genetic diversity and knowledge

Farmers are concentrating on fewer and fewer crops because of increased mechanisation and the demands and expectations of modern supply networks. As a result, biodiversity is steadily declining. Droughts, bushfires, pests and diseases, overexploitation, overgrazing, land clearing, deforestation, mining, overuse of pesticides, fertilizers, and other agrochemicals, increasing urbanization, and an insufficiency for farmers to maintain this diversity are all contributing to NUS extinction and genetic erosion in many places of the world. Along with the extinction of animals, there is a broad erosion of local traditions and knowledge, which is as worrying.

### c. Undervaluation through lack of knowledge and research

When the nutritional or economic values of local varieties are not recognized due to a lack of information or research, farm households and agricultural programmes tend to ignore them. Many of the agronomic approaches used in these crops have not been documented or even evaluated by academics, therefore their potential impact has gone unnoticed.

### d. Poor competitiveness and lack of infrastructure

Several NUS have been ignored in recent years. Consistent investments in research and development, as well as direct support for production and markets, have benefited major crops (e.g. subsidies and other incentives). Major crops have a stronghold on national and worldwide markets, as well as government policy, to the cost of hundreds of other vital life-saving crops.

**e. Policies and investment**

Inappropriate rural development policies and programmes that focus on a small number of commodities thwart the conservation and prudent, long-term use of NUS.

## 9. Specific neglected and underutilized temperate food crops

A. **Pseudo-cereals:**

**a. Buck Wheat**

Buckwheat is a pseudo-cereal and small cereal that is grown in India's mountainous regions every year. Buckwheat is a member of the Polygonaceae family and genus (*Fagopyrum* spp.) Buckwheat has the capacity to meet the increasing food demands in these places in the current atmosphere of global warming and ever-increasing population in mountainous areas. It is the best growing crop in such regions since it grows at higher elevations for a short period of time (3-4 months) (Babu, S. *et al*., 2018) [3]. Buckwheat can withstand extreme cold, a lack of water, low soil fertility, and a broad spectrum of climatic circumstances (Rodrguez, Juan Pablo, *et al*., 2020) [47]. It is regarded a sustainable pseudocereal because of its adaptation to marginal and barren lands in hilly locations, and it supports the livelihood of millions of people living in mountainous areas by increasing production due to improved yield in a short period of time (Babu, S. *et al*., 2018). Due to changing land use patterns in India, buckwheat cultivation and output are declining (Rana, Jai C., *et al*., 2012) [45]. Buckwheat is high in nutrients and a good source of macronutrients, micronutrients, and bioactive substances when compared to other grains (Rauf, Muhammad, *et al*., 2020) [46]. Table.1 shows the nutritional value of Buckwheat in relation to the most regularly consumed crops in India. ( Longvah, T. *et al*., 2017) [32]. Buckwheat has a unique nutrient profile, including lysine-rich protein, dietary fibre, mineral and trace elements, antioxidant-rich vitamins, and bioactive substances like rutin, quercetin, and other flavonoids (Babu, S. *et al*., 2018). Rutin has powerful anti-oxidant, anti-inflammatory, and anti-hypertensive qualities that are advantageous in cardiovascular illnesses, thus its demand in the pharmaceutical and cosmetic industries is growing. The tender leaves of the buckwheat plant are used to make accompaniments such as green chutneys and veggie curries. Buckwheat plant nectar yields a significant amount of honey, especially around daybreak.

**Table 1:** Comparison of nutritive composition (%) of buckwheat with other cereals and millets in India

| Source | Common Buckwheat | Tartary Buckwheat | Wheat, Whole | Rice, milled | Barley | Maize, Dry | Jowar | Ragi | Varagu | Bajra |
|---|---|---|---|---|---|---|---|---|---|---|
| Energy | 343 | 328 | 322 | 356 | 316 | 334 | 334 | 321 | 332 | 348 |
| Carbohydrate | 71.5 | 74.3 | 64.7 | 78.2 | 61 | 65 | 67.7 | 66.8 | 66.2 | 61.8 |
| Protein | 13.3 | 10.3 | 10.6 | 7.9 | 10.9 | 8.8 | 10 | 7.2 | 8.9 | 11 |
| Lipid | 3.4 | 2.5 | 1.5 | 0.5 | 1.3 | 3.8 | 1.7 | 1.9 | 2.5 | 5.4 |
| Dietary fiber | 10 | 6.3 | 11.2 | 2.8 | 15.6 | 12.2 | 10.2 | 11.2 | 6.4 | 11.5 |
| Ash | 2.1 | 1.8 | 1.4 | 0.6 | 1 | 1.2 | 1.4 | 2 | 1.7 | 1.4 |
| Moisture | 9.8 | 10.2 | 10.6 | 9.9 | 9.7 | 9.3 | 9 | 10.9 | 14.2 | 9 |

**b. Quinoa (*Chenopodium quinoa*)**

Quinoa production has continuously expanded in recent decades, and attempts are underway to sequence the various ecotypes and generate high-yielding variants (Zou *et al*., 2017) [61], and by 2013, when it was designated as the International Year of Quinoa, quinoa production and consumption had increased tremendously (Bazile, D and Baudon, F. 2015) [5]. It has gotten a lot of interest around the world, not only because of its nutritional and functional benefits, but also because of its capacity to grow in harsh climates. Quinoa plants are frost, salinity, and drought tolerant, as well as able to grow in marginal soils. It contains anti-oxidants and antibacterial qualities and is gluten-free energy booster and natural laxative. As a result, these features are especially important in locations where food insecurity is a problem. Due to its exceptional plasticity in adapting to various climatic conditions, there has been a surge in interest in this crop in recent decades.

**Table 2:** Essential amino acid profile of quinoa and other grains, compared to the FAO (FAO, 2013) [14]

| Amino acid | FAO | Quinoa | Maize | Rice |
|---|---|---|---|---|
| Isoleucine | 3 | 4.9 | 4.0 | 4.1 |
| Leucine | 6.1 | 6.6 | 12.5 | 8.2 |
| Lysine | 4.8 | 6.0 | 2.9 | 3.8 |
| Methionine | 2.3 | 5.3 | 4.0 | 3.6 |
| Phenyl alanine | 4.1 | 6.9 | 8.6 | 10.5 |
| Threonine | 2.5 | 3.7 | 3.8 | 3.8 |

**Table 3:** Mineral composition of quinoa and other grains (FAO, 2013)

| Mineral (mg per 100 g Seeds DM) | Quinoa | Maize | Rice | Wheat |
|---|---|---|---|---|
| Calcium | 148.7 | 17.1 | 6.9 | 50.3 |
| Iron | 13.2 | 2.1 | 0.7 | 3.8 |
| Magnesium | 249.6 | 137.1 | 73.5 | 169.4 |
| Phosphorus | 383.7 | 292.6 | 137.8 | 467.7 |
| Potassium | 926.7 | 377.1 | 118.3 | 578.3 |
| Zinc | 4.4 | 2.9 | 0.6 | 4.7 |

**B. Millets**

**a. Finger-millet (*Eleusine corocana* (L.) Gaertn.)**

In India, finger millet is the primary of the minor millets. It can be stored for years without becoming infested with storage pests, making it an ideal food grain for famine-prone areas (NRC, 1996) [41]. Finger millet is higher in fibre, minerals, and vitamins, all of which are typically lacking in Indian diets. Carbohydrates make up approximately 80% of the grain of finger millet. In comparison to other cereals, it has a lower fat and protein level. The energy content of 100 g of finger millet is around 336 Kcal. Valine (413 mg/g protein), Isoleucine (275 mg/g protein), Threonine (263 mg/g protein), Methionine (194 mg/g protein), and Tryptophan (191 mg/g protein) are among the necessary amino acids.

Grains with a high calcium content, soluble fibre content, low fat content, and a low glycemic index could be beneficial in patients with patients (Seetharam and Rao, 2007) [51]. In the production of idlis and dosas, finger millet can be substituted for rice (steamed and baked preparations). The malting capabilities of finger millet malt are exceptional, and it has a pleasant taste, a pleasant scent, and a long shelf life (Malleshi, 1989) [34]. Crop residues, which contain up to 61 percent total digestible nutrients, are a good supply of dry matter for livestock, especially during the dry season (National Research Council 1996). Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora (Saha, 2011) [49] has devised a technology for making finger millet biscuits that uses 70 percent finger millet flour instead of wheat flour. Diabetic individuals can eat these high-fiber biscuits.

**b. Foxtail millet (*Setaria italic* (L.) Beauv)**

Foxtail millet is the world's second-largest producer of millets. Foxtail millet is drought resilient, and because of its early maturity, it can avoid some droughts. It can be planted as a short-term catch crop due to its rapid growth. It may grow in a diversity of heights, soils, and temperatures. Water logging, however, is not an option. Its grain is utilized as human food as well as poultry and cage bird feed.

**c. Proso millet (*Panicum miliaceum* L.)**

Common millet, hog millet, and white millet are all names for proso-millet (*Panicum miliaceum*). Grains are nutritionally equivalent to or even superior to cereals, and grain protein is high in important amino acids. It is a short-season crop that develops 60-90 days after sowing and is hot and drought tolerant. It is favoured for harsh soil and climatic circumstances since it produces reasonable yields even in deteriorated soils and in the face of adverse weather (Baltensperger, 2002) [4]. It's a great crop for no-till and dry-land farming. It is a simple crop to raise, and seems to fit better than most crops in traditional agricultural practices. Proso-millet is prepared and eaten like rice in India. Antioxidants and vitamin E are abundant in proso millet. Proso-millet has a protein concentration that is equivalent to wheat and higher than rice. Waxy forms are favoured because to their sticky nature and improved sticking capabilities after cooking (Graybosch and Baltensperger, 2009) [23].

**C. Legumes**

**a. Grass pea**

Grass pea (*Lathyrus sativus*) is a drought-resistant legume that is grown on an area of 1 million hectares in some of Asia's drier regions, and also in Ethiopia (Tesgaye *et al*., 2005) [54]. The ability of the grass pea to grow in waterlogged soils makes it a good crop to cover on paddy rice in Bangladesh and India. Because of its hardiness, grass pea can provide a source of protein when other crops have been devastated by drought or other natural catastrophes like flooding (Campbell *et al*., 1993) [8]. The toxin -b-N-ozalyl-L-a-diaminopropanoic acid is found in modest concentrations in the plant (ODAP). Although this toxin can induce irreversible paralysis, known as 'lathyrism,' the condition only occurs in humans when massive amounts of grass pea are ingested without any other foods (Lambein, 2009) [31]. Modern breeding techniques like marker-assisted selection (MAS) provide up new possibilities for crop development (Ibitoye and Akin-Idowu, 2010) [29]. MAS could be used to develop high-yielding, locally adapted grass pea lines with low toxin content and high disease resistance. With low fat and high carbohydrate content, grass pea has a nutritional profile similar to field pea (*Pisum sativum*) and faba bean (*Vicia faba*). The 25–27 percent protein level is higher than that of field pea or faba bean, but lower than that of soybean (Hanbury *et al.*, 2000) [26]. The profile of amino-acids is comparable to that of other legumes, rich in lysine content and free of sulphur amino acids. Because of the 58 percent of unsaturated fatty acids in grass pea, it is highly acceptable for human consumption (Grela *et al*., 2010) [24]. It also has decorative and medicinal benefits (treatment of cardiovascular disease, hypoxia). Grass pea is a cover crop that is planted near the end of the rice harvest to provide green manure and weed control. This technique takes advantage of the grass pea's ability to thrive in marshy environments as well as its drought resistance, exploiting residual rainwater in paddy fields and maturing throughout the dry season (Das, 2000) [11].

**b. Lentil**

Lentil is a drought-tolerant crop that can withstand low annual rainfall distributions in the wide range of 280-300 mm (Brennan, J. *et al*., 2011) [7]. Lentil can thrive in a wide range of climates, from cool temperate steppes to subtropical arid zones (McVicar, R. *et al*., 2010) [38]. Lentil production thrives in soils with a pH of 6-8, although it can even tolerate moderate alkalinity (Mulugeta, F. 2009) [40]. Matus *et al*. 1997 found that when lentils were grown in zero tillage, nitrogen fixing was 10% higher than when they were grown in conventional tillage. Furthermore, it provides an indispensible extra benefit from its unique ability to restore and sustain soil fertility [36].

**Table 4:** Nutritional profile of grass-pea (Arslan, 2017) [2]

| Retinol | 25.6-44.1 microgram/kg |
|---|---|
| Beta- carotene | 240.8-410.1mg/kg |
| Thiamine | 3.74-5.44 mg/kg |
| Riboflavin | 1.86-2.76 mg/kg |
| Niacin | 12.37-20.25 mg/kg |
| Pantothene | 14.43-22.41 mg/kg |
| Pyridoxine | 4.92-6.62 mg/kg |
| Folic acid | 4.04-6.77 mg/kg |
| Ascorbic acid | 33.4-58.2 mg/kg |
| Phosphorus | 380.4-511.6 mg/100g |
| Calcium | 131.6-200.1 mg /100g |

**c. Bambara groundnut (*Vigna subterranean*)**

Following the well-known groundnut, cowpea, and soybean, Bambara groundnut is the fourth grain legume crop. It is drought resistant, stress resistant, contains more nutrients than other legumes, and is known to generate good yields even in poor soils (Chibarabada, T. P. *et al*., 2017) [10]. The protein composition contains 6-43% globulin, 14-71% albumin, 1.6-2.2% prolamins and 3.3-5.2% glutelin (Hillocks, R. J. *et al.*, 2012) [28]. It gets 51-67 percent of its nitrogen from symbiotic fixation, therefore it might be used as a high-protein feed crop for animals. (Hillocks, R. J. *et al.*, 2012).

**Table 5:** Nutritive value (per 100g) of legumes

| Legumes | Botanical names | Protein (g) | Fat (g) | Carbohydrate (g) | Fibre (g) |
|---|---|---|---|---|---|
| Lathyrus pea | *Lathyrus sativus* | 28 | 1 | 47 | 2 |
| Bambara groundnut | *Vigna subterranean* | 20 | 6-8 | 60 | 3-6 |
| Cowpea | *Vigna unguiculata* | 8.0 | 0.5 | 21.0 | 7.0 |
| Chickpea | *Cicer arietinum* | 19.0 | 6.0 | 61.0 | 17.0 |
| Faba-bean | *Vicia faba* | 26.12 | 1.53 | 58.59 | 25.0 |

**D. Oilseed**

**a. Safflower (*Carthamus tinctorius* L.)**

Safflower is a temperate zone plant that thrives in arid and semi-arid climates (Mc Pherson *et al*., 2004) [37]. Safflower is planted as a multipurpose crop such as vegetable crop, cut flower, fodder crop, medicinal plant, textile dye crop, and safflower oil is used in the production of high-quality paints (Emongor *et al*., 2015) [13]. Drought, heat, cold, and salinity tolerance are all traits of safflower (Emongor *et al*., 2015). It is the profuse drought-tolerant oil-seed crop and can generate a high seed production in semi-arid places, while its tolerance to salt is a crucial advantage as the amount of land affected by salinity increases around the world (Weiss, 2000) [57]. Increased demand for vegetable oil for biodiesel and edible oil (Mailer *et al*., 2008) [33], a huge shortfall in oilseed production in countries with a large area with little rainfall, to which safflower is best suited, consumer preference for healthy oil with less saturated fats, for which safflower is well known, and medicinal uses of flowers in China and extraction of edible dyes have all boosted interest in safflower cultivation ( Emongor, 2010) [12]. According to Arslan *et al*. (2003) [1], safflower oil with a higher linoleic acid concentration contains tocopherols, which are antioxidants with a high vitamin E content. As a result, safflower oil is commonly utilised in the diets of patients with cardiovascular disorders, and its anti-cholesterol properties are highly valued (Arslan *et al*., 2003). Safflower leaves are used to improve blood circulation, reduce phlegm, and treat fractures, contusions, and strains (Wang and Li, 1985)[56]. Several chronic disorders, including high blood pressure, heart disease, rheumatism, and male and female fertility issues, have been linked to safflower petals.

**9. Prospects of underutilized crops.**

**A. Food security and resilience of food systems**

Hunger eradication is a necessity for international peace and security in a world that is becoming increasingly globalised and interdependent society. More diverse agricultural and food systems are required to feed 9,000 million people by 2050 in a sustainable manner while also conserving the environment, delivering food that is healthy and nutritious food for everyone, and boosting farmer livelihoods. Known as 'famine food,' farmers have turned to and relied on NUS whenever major staple crops have failed throughout history. NUS can also provide as a safety net during stressful times or in the aftermath of tragedies. NUS provide lower yields than other main staple crops, but they compensate by being more resistant to biotic issues and generating reliable harvests in a wide range of climatic situations and on challenging soils. One of the most crucial feature of many NUS is their ability to adapt to harsh environmental conditions. They are frequently grown in poor locations with challenging agro-ecological circumstances and when smallholder farmers lack the financial resources to pursue high-input farming systems aimed toward major staple crops. Diversifying agro-ecosystems by producing alternative food and forage crops will improve their tolerance to extreme climatic circumstances and tolerant to biotic and abiotic pressures, as well as providing resistance to biotic and abiotic stresses.

**B. NUS and Nutrition:**

The Green Revolution and the following decades, agricultural research focused on increasing yields to ensure adequate calories for the hungry. Nutritional quality, however, received less emphasis, with the provision of an adequate quantity of food taking precedence over the supply of healthy meals. Because of that, many sections of the world still have diets low in important vitamins and micronutrients. Globally, 811 million people are malnourished. Low-yielding plants provide essential micronutrients and thus replenish basic nutrients. Many NUSs are high in carotenoids and minerals and can therefore play a role in helping to improve the micro-nutrient content in the diet of millions of people worldwide. Wild foods and other non-traditional foods, particularly those that are locally available and culturally acceptable, appear to be well positioned to play a larger role in enhancing nutrition and health (Kahane *et al*., 2013) [30].

**C. NUS, income and livelihoods**

The high incomes of smallholder farmers and entrepreneurs are often cited as one of the benefits of improving neglected and underutilised production and quality, especially high value crops, such as local fruits and vegetables. Neglected and underutilized crops has consistently contributed to income generation in both domestic and foreign markets, according to several research and projects (Rojas *et al*., 2010) [48]. In India, for example, increasing the value of tiny millet tripled farmers' incomes and created jobs in villages – especially for women. Women's social position and self-esteem were also increased as a result of NUS (Vijayalakshmi *et al*., 2010) [55]. Strategic placement of NUS in large commercial locations, such as supermarkets serving to urban populations and the developing middle class, can help establish higher-value niche markets. Processing, packaging, bookkeeping, economies of scale, getting market information (e.g. such as text messaging on mobile phones), bargaining with multiple actors, and learning how to respond to market changes will all require extensive training (Kahane *et al*., 2013).

**D. Cultural identity**

Traditional food systems are increasingly being acknowledged as being linked to indigenous peoples' cultural identities. Over generations, their understanding of local ecosystems and food sources has grown. Traditional food systems are increasingly being recognised as a significant means to contribute to the preservation of local ecosystems and food sources, and indigenous tribes are actively seeking strategies to counteract the loss of their food heritage and sense of "connection to the land."

## 10. Research gaps found in mainstreaming alternative crops

### A. Land use classification
There is a need for a paradigm shift in present land use classification systems, which continue to ignore alternative crops. As a result, crop suitability mapping and fitting these crops into specific agro-ecologies are required.

### B. Agronomy
Although there have been steps in defining agronomy for other unique plants, there are still huge gaps in matters such as proper planting, pest and disease control and fertilizer control, among other things. Alternative crops are difficult to market since there are typically no production guidelines detailing the optimum management strategies for them.

### C. Eco-physiology
Several alternative crops have been reported to be resistant to abiotic conditions such as drought and heat stress. However, much of this data is anecdotal and incomplete. As a result, additional empirical research on the eco-physiology of alternative crops is required. To facilitate crop suitability mapping/land use classification, this should be linked to agro-ecologies.

### D. Post-harvest handling and storage
In many different plants, there is a complete written record of management and storage. This means that even if farmers are able to grow these crops, severe post-harvest losses are possible. Developing proper post-harvest handling and storage procedures for these crops would also help to build best management practices.

### E. Nutritional value
Similar to the agronomic characteristics of alternative crops, similar information on the nutrient content of these crops is lacking. Addressing this information gap would help to raise awareness of the nutritional benefits generally linked with the usage of alternative crops, and their promotion as healthy alternatives.

### F. Product development
Alternative crops are currently used in the development of few items. Product development research would also open up new markets and uses for these crops, contributing to the new paradigm of their enhanced worth and inclusion.

### G. Marketing
Existing markets have been created to sustain the big crops, based on the current paradigm, which only supports a few large food crops. There is a need for research into market analysis in order to identify opportunities to integrate or disrupt existing markets to allow for the inclusion of other crops. Such study should also look into the possibility of creating new niche markets expressly for these crops.

## 11. Strategies for promoting and mainstreaming alternative crops

### A. Documentation and dissemination
- Development of eco-geographic databases on target species
- Development of use-oriented and nutritional databases to assess social impact of these species across the territory;
- Dissemination of information on improved varieties and agronomic requirements for enhancing productivity to users;
- Development of tools (newsletters, internet web pages, training programmes, workshops) for disseminating relevant information to stakeholders.

### B. Raise public awareness
- Provide evidence to legistators and establish global on-farm alternative crop species conservation programme
- Target area delineation and crop matching with agro-ecologies for less rivalry among farmers but significant advantages for alternative crops in participatory research

### C. Participatory research
- Participatory plant breeding and selection activities Study on adaptable features in alternative crops landraces
- Strengthen technique in alternative crops research
- Link scientific and indigenous knowledge

### E. Marketing
- Develop market-oriented tactics,
- Improve value chains, and
- Establish direct ties between producer and customer to lower marketing and demand-driven production costs.

### F. Capacity building
- Building capacity in value chains, fostering synergism at the national, regional, and international levels,
- Boosting infrastructure and institutions,

### G. Partnerships
- Partnerships Encourage collaboration in alternative crop research, promotion, conservation, and long-term usage
- Collaborate with local communities
- Engage farmer and women's organizations and encourage local seed production and distribution and create multi-stakeholder platforms.

### H. Policy
- Streamlining best practices, processing, and value addition
- Providing incentives under crop diversification for sustainable agriculture, subsidising marketing
- Extending crop insurance schemes to alternative crops

**12. Future action needed** needs to be done?

### A. Raising the profile of neglected and underutilized crop species means
- Developing better varieties and Improving farming practices
- Improving value-added technology and helping producers gain better market access
- Evidence and promoting the benefits of neglected and underutilized nutrition
- Successfully maintaining genetic diversity on the farm
- Stakeholder capacity building skills and develop national and international policies that will be supported.

### B. Change perceptions
It is critical to raise awareness of the benefits of saving and utilising NUS among smallholder farmers and consumers in both urban and rural areas of poor countries, as well as among scientists and politicians.

**C. Enhance research**

It is very important to invest in NUS research and development. Data on NUS use, propagation and growth characteristics, resistance qualities, and intra-specific variation must be routinely gathered, disseminated, and shared, and methodology must be reinforced.

**D. Improve conservation**

Species that are not suitable for gene-bank conservation must be conserved on the farm. In addition, when possible, enhanced ex situ storage of neglected and underutilized species in gene-banks is required. Traditional rights, cultural identities, environmental integrity, and the ideals of sustainability must all be considered when increasing the use of NUS. Increased use of NUS must be consistent with traditional rights, cultural identities, ecosystem integrity, and gender equity principles, and must benefit both rural and urban customers. It is required to build a global on-farm conservation programme for NUS.

**E. Involve stakeholders**

Small-scale farmers (both men and women), communities, and organisations must be recognised and supported by international and national research networks and genebanks in order to preserve diversified and resilient agricultural systems.

**F. Add value and upgrade market chains**

At the local, national, and international levels, sustainable markets for NUS must be built and strengthened while ensuring that benefits are shared fairly. A priority is to conduct research to create new ways to minimise harvest and postharvest constraints, as well as to develop lucrative local NUS firms. Farmers and other people, particularly the poor, must have access to technological advancements along value chains.

**G. Create a supportive policy environment**

To preserve NUS, legal mechanisms are required (wild or cultivated). National governments must also implement policies that will effectively conserve and utilise NUS. On-farm management of NUS requires incentives. Policies based on equality and justice must protect germ-plasm for agricultural improvement and sharing, as well as improve access to worldwide markets.

**H. Cooperation**

Furthermore, cooperation among all stakeholders must be encouraged along the entire value chain, from farm to fork.

## 13. Conclusion

NUS can be excellent tools for reducing food insecurity because of their increased adaptation to adverse climatic conditions and resistant to biotic and abiotic stressors. NUS will generate harvestable yields in areas where major crops may fail, despite its lower yields. They're also excellent for combating hidden hunger, and they're especially good for diets that are overly high in refined carbohydrates and fats. Furthermore, agricultural production based on agro-biodiversity can help to preserve and harness centuries-old traditions, and is a valuable tool for farmers and indigenous groups to maintain their cultural identities. Neglected and underutilized crops offer enormous untapped potential to help farmers and rural communities on a small scale to improve their incomes, food security, and genetic resources while also addressing current and future environmental concerns. However, utilizing these crops fully will require improved 'modern' cultivars that are more commercially viable. Part of the reason for this low competitive value is that poor rural communities typically lack the capacity to negotiate with the private companies, preventing access to new technology and markets that could help these locally grown products grow more. Neglected and underutilized crop species crops, which have been perfected over millennia of agricultural research and cultural transmission of knowledge, are a wealth that need to be carefully conserved because of the various benefits they provide to populations around the world. This resource can be passed down to coming generations and used to promote humanity's well-being through coordinated international, local, and national action.

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