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4. Underutilized/Pseudo-Cereals Production

Abstract:

This study explores underutilized or pseudo-cereals, including quinoa, amaranth, teff, fonio, and buckwheat, highlighting their unique qualities often overshadowed by mainstream crops. Despite historical cultivation, these grains are labeled "underutilized" due to limited recognition and investment. Positioned as solutions to contemporary challenges like food security, climate change, and biodiversity loss, these cereals showcase resilience in marginal environments, thriving in adverse conditions like drought and poor soil quality. Emphasizing their adaptability, this research invites readers to consider the pivotal role underutilized cereals play in global agricultural and nutritional challenges.

The study underscores their contribution to biodiversity preservation, essential for mitigating risks linked to monoculture. Moreover, it identifies these grains as an opportunity to develop resilient, climate-smart crop varieties, aligning with the growing demand for ecologically friendly agriculture due to their lower input requirements. Insights into the cultivation practices of amaranthus and buckwheat reveal nutritional richness and adaptability to diverse agro-climatic conditions. Despite their advantages, challenges such as limited infrastructure, research gaps, and market access barriers impede widespread adoption. The study concludes by stressing collaborative efforts from governments, NGOs, and the private sector to unlock the full potential of underutilized cereals. Establishing robust value chains and markets is crucial to incentivize farmers, ensuring consumer access to diverse and nutritious food options. This research marks underutilized cereals as a strategic approach for a more resilient, diverse, and environmentally sustainable agricultural future.

Keywords:

Underutilized, Pseudo-cereals, Buckwheat, Amaranthus and NGOs.

4.1 Introduction:

In the realm of agriculture and nutrition, the spotlight often falls on staple crops like wheat, rice, and corn, overshadowing a group of extraordinary grains known as underutilized or pseudo-cereals. These lesser-known grains have been cultivated for centuries by diverse cultures around the world but have only recently begun to garner attention for their potential to address various challenges facing global food systems. Underutilized cereals include quinoa, amaranth, teff, fonio, and buckwheat, among others, each possessing unique nutritional profiles and agro-ecological adaptability.

The term "underutilized" stems from the fact that, despite their remarkable qualities, these grains have not received the same level of recognition and investment as their mainstream counterparts. As we confront the complex issues of food security, climate change, and biodiversity loss, exploring the production and consumption of underutilized cereals emerges as a promising avenue. These grains often thrive in marginal environments, showcasing resilience to adverse conditions such as drought and poor soil quality, making them valuable assets in the face of a changing climate. One of the standout pseudo-cereals, quinoa, for instance, has gained popularity in recent years due to its exceptional protein content and adaptability to various climates.

Amaranth, another underutilized cereal, boasts a rich nutrient profile, including essential amino acids, making it a potential contributor to addressing malnutrition in vulnerable populations. Despite these qualities, challenges such as limited infrastructure, lack of research and development, and insufficient market access have impeded the widespread cultivation and consumption of these grains.

This introduction sets the stage for a deeper exploration into the world of underutilized cereals, inviting readers to delve into the untapped potential of these grains in addressing contemporary agricultural and nutritional challenges. As we embark on this exploration, we will uncover the myriad benefits and opportunities that lie within the cultivation and utilization of these underappreciated treasures of the plant kingdom.

Delving further into the realm of underutilized cereals, it becomes evident that these grains harbor not only nutritional benefits but also contribute to the preservation of biodiversity. Many underutilized cereals are indigenous to specific regions, embodying centuries of adaptation to local ecosystems.

The cultivation of these crops supports agricultural diversity, helping to safeguard against the homogenization of our food supply and mitigating the risks associated with the reliance on a limited number of major crops. This aspect is particularly crucial in the context of climate change, as the diverse genetic traits within underutilized cereals can be harnessed to develop more resilient and climate-smart crop varieties. Moreover, the promotion of underutilized cereals aligns with the growing demand for sustainable and ecologically friendly agricultural practices. These grains often require fewer inputs, such as pesticides and fertilizers, compared to conventional crops, making them environmentally friendly options. In addition, their ability to thrive in diverse agro-ecological zones can contribute to more sustainable land use practices, reducing pressure on ecosystems and promoting conservation. Despite their numerous advantages, the path to mainstream acceptance for underutilized cereals faces obstacles that span from cultivation to market access. Agricultural research and development efforts often prioritize major crops, leaving underutilized cereals with limited support. Governments, NGOs, and the private sector need to collaborate to invest in research, infrastructure, and education to unlock the full potential of these grains. Establishing robust value chains and markets for underutilized cereals is also crucial to incentivize farmers to cultivate these crops and ensure that consumers have access to diverse and nutritious food options.

In conclusion, the exploration of underutilized or pseudo-cereals represents an exciting frontier in the quest for sustainable and resilient food systems. As we navigate the complexities of a changing climate, a growing global population, and the need for more sustainable agriculture, the cultivation and promotion of underutilized cereals emerge as a strategic and holistic approach. By recognizing and harnessing the potential of these grains, we can contribute to a more resilient, diverse, and environmentally sustainable food future.

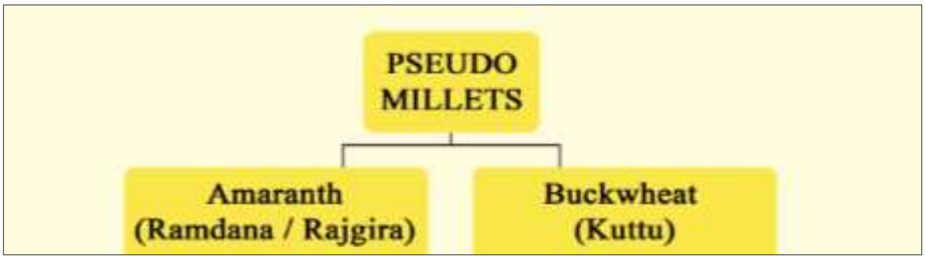

Figure 4.1: Classification of Pseudo Millets

A. Amaranthus (*Amaranthus viridis*):

Amaranthus is commonly known as *Ramdana, Rajgira, Chaulai, etc.*

Amaranthus is a

- Short duration crop, gives quick response to manures and fertilizers, high yielding, easiness in cultivation and availability of diverse types suited to specific agro-climatic situations which has made it a favorite crop of farmers to fit in any cropping systems.
- Amaranthus is available in both leaf and grain types and it play a vital role to combat malnutrition of the poor people.
- Amaranthus crop is best suited under changing climatic situations due to its climate resilient nature.

Table 4.1: Nutritional Value of Amaranthus Grain

Protein	14.5 %
Lysine	0.85 %
Carbohydrates	63 g
Calcium	162 mg
Iron	10.0 mg
Phosphorus	455 mg
Potassium	290 mg
magnesium	266 g
Zinc	3.7 mg
Copper	0.77 mg
Riboflavin	181

a. Land Selection:

- Amaranthus could be grown in poor to fertile soil.
- The selected land should be free from weeds.

- The land should be ploughed 2-3 times to get the land well prepared and properly levelled.

b. Seed Selection and Time of Sowing:

- The best season to take up sowing is the rainy/*kharif* season (June-July).
- Seeds used for seed production should be of good quality and certified from an authentic source.

c. Seed Rate and Spacing:

- Recommended seed rate for sowing of Amaranthus for seed production purpose is 150-200 g/kanal (1.5 kg/acre) with a spacing of 20 x 10 cm.

d. Nutrient Management:

- During final ploughing, apply compost or farm yard manure and incorporate it well into the soil @ 12-15 q/kanal (95-120 q/acre).
- Apply 3.5:3:1.75 kg Urea, DAP and MOP/kanal, respectively for proper seed production of Amaranthus.
- Apply 1 kg urea/kanal as top dressing before flowering. Foliar spray of 1% urea or diluted cow urine is also good for promoting crop growth and higher grain yield.

e. Varieties:

- Annapurna, PRA-2, GA-1, GA-2, GA-3, GA-6, Durga, Kartiki.

Intercultural:

- Amaranthus is a short duration and shallow rooted crop. Provide light hoeing to prevent soil crust formation and to keep soil loose. Field also should be kept weed-free, especially during initial stages.
- One hand weeding should be done at 20-25 days after sowing (DAS).

f. Irrigation:

- Grain Amaranthus is a drought tolerant crop and can withstand a dry period of 10-15 days falling in between the cropping season (rainy season).
- However, farmers can apply locally available crop residues as mulches to the seed production crop if the drought period extends more than 20 days.

B. Buck Wheat (*Fagopyrum* spp.)

Buck wheat is commonly known as *Kuttu, etc.*

Buck wheat is a

- Buckwheat is an important crop of the mountain regions grown in cool season up to an elevation of 1400 m amsl or above for grain and green leaves.
- It has a growing season of 80-90 days but the duration could be prolonged depending upon the elevation, area, weather and temperatures conditions.
- Buckwheat is also grown as a cover crop to smother weeds and improve the soil fertility. The crop seems to improve soil tilth, and is reported to make more available phosphorus, possibly through root-associated mycorrhizae.
- The protein is of high quality due to its high lysine content, which is normally deficient in cereal products. Buckwheat is a health food because it is rich in essential nutrients including protein and minerals. It is known to contain various antioxidative compounds such vitamins B1, B2, and E, and phenolic compounds.
- Buckwheat crop is best suited under changing climatic situations due to its climate resilient nature.

a. Climate:

Buckwheat is normally a plant of cool, moist and temperate region. It is sensitive to high temperatures and hot dry winds especially when moisture is scarce. Buckwheat is a hard plant and useful in short season climates and poor soils.

b. Soil:

It is best suited to light to medium textured, well-drained soils such as sandy loams, loams and silt loams. It produces a better crop than other grains on infertile, poorly drained soils if the climate is moist and cool. It is an efficient crop in extracting phosphorus of low availability from the soil. In addition, soils high in nitrogen, lodging may occur and cause a reduction in yield.

c. Field Preparation:

Field is prepared by one deep ploughing followed by two harrowing/tilling and planking resulting in good germination and uniform stand of the crop. It may also help the crop to achieve higher rate of establishment and early growth. Being a cover crop, it does not require extensive land preparation and can grow well on poorly tilled soil.

d. Recommended Varieties:

Local cultivars, Himpriya, Himphaphra, Sangla, B-1, PRB-1, Mithey, Tithey, PRB-1, VL-Ugal, Sangla, B-1.

e. Seed Rate and Sowing Time:

Healthy and disease-free quality seed should be selected for sowing purposes.

Generally, the seed are sown in the residual moisture after harvesting of *kharif* crops particularly in the month of October to November. The seed rate varies is 2 kg/kanal (16 kg/acre) for seed production/grain crop. Buckwheat should be placed at 3 to 5 cm deep in line and kept 30-45 cm row-to-row spacing and 10-15 cm from plant to plant spacing depending upon varieties. Seed treatment with *Azotobacter*, *Azophos* or Azospirillum @ 2-3 g/kg of seed should be done before sowing. Thinning should be done 15-20 days after sowing (DAS) to keep the proper spacing. The crop emerges usually within 4-5 days.

Table 4.2: Nutritional Value of Buckwheat Grain

Protein	13.3 g	**Selenium**	8.3 µg
Lysine	0.58 %	**Thiamin**	0.1 mg
Carbohydrates	72 g	**Riboflavin**	181 mg
Calcium	12 mg	**Niacin**	7 mg
Iron	2.8 mg	**Folate**	30 µg
Phosphorus	347 mg	**Vitamin B-6**	0.2 mg
Potassium	460 mg	**Calories**	343
Magnesium	1.3 g	**Sugar**	0 g
Zinc	2.4 g	**Dietary Fibre**	10 g
Copper	1.1 mg	**Fats**	3.4 g

f. Nutrient Management:

- During final ploughing, apply mixed compost or vermicomposting and incorporate it well into the soil @ 2-2.5 q/kanal (20 q/acre) along with the application of neem cake @ 25 kg/kanal (2 q/acre) for obtaining good crop yield.
- Apply 3.5:2.25:1.75 kg Urea, DAP and MOP/kanal, respectively for proper seed production of buckwheat crop.

g. Intercultural:

Buckwheat plants are very good competitor for weeds and generally fast growing capacity makes them a smother crop. Under such conditions, one weeding and hoeing at 20-25 days after sowing (DAS) is helpful for raising a good crop.

h. Irrigation:

Generally, buckwheat is grown as rain fed crop in the maximum areas. However, the most critical stages are pre-flowering and pod formation stage for buckwheat.

i. Harvesting for Seed Production:

Timely harvesting of buckwheat is essential to prevent shattering of grains. Careful handling of the crop is very important because grain shattering results in losses up to 25 per cent. Due to its gradual formation and maturity, harvesting is done periodically and finally the crop is cut and then threshed when the rest of the seeds are fully matured. After harvesting the seeds must be well-dried and kept at about 12-14 per cent moisture for the safe storage of buckwheat grains. Over-matured seeds when in contact with high moisture, germinate very quickly.

Figure 4.2: Image Of Major Staple Cereal Grains and Seven Selected Underutilized (Pseudo) Cereal Grains.

g. Differences Between Amaranth and Buckwheat:

Rajgira, or amaranth, is a gluten-free grain loaded with protein, fiber, and micronutrients. "It is an excellent source of calcium, making it ideal for those looking to boost bone health. Rajgira is also known for its anti-inflammatory properties, making it suitable for individuals with joint issues," Dr. Batra said. Popular rajgira dishes include Rajgira Paratha, Rajgira Ladoo, and Rajgira Sheera. Rajgira can be consumed in moderation, providing a nutritious alternative during fasting. Its versatility allows for the creation of both savory and sweet dishes. Amaranth provides gluten-free protein, which can be consumed even by people with health conditions such as gluten allergy or celiac disease. "Rajgira seeds are abundant in fiber, which not only supports the digestive system but also helps prevent constipation, contributing to overall gut health," said Dr. Hansaji. Rajgira is an excellent choice for those looking to maintain energy levels and boost overall nutrition during fasting, added Chawla.

Kuttu, or buckwheat, is rich in amino acids, fiber, and essential minerals. Calling it an excellent source of energy, Dr Batra said that it is known to regulate blood sugar levels, making it a smart choice for individuals with diabetes. "It's an excellent choice for most people during fasting because it provides sustained energy and a variety of essential nutrients. Kuttu is also gluten-free," said Chawla. Popular kuttu dishes include Kuttu Ki Puri, Kuttu Ka Dosa, and Kuttu Ki Khichdi. Due to its high nutritional value, moderate consumption of kuttu is recommended during Navratri. "Its versatility allows for a variety of dishes to be prepared, ensuring a well-rounded diet," Dr. Batra mentioned.

h. Pseudo Cereals as Super Foods of 21st Century:

The cultivation and utilization of pseudo cereal crops, recognized as crops of the 21st century, hold significant importance. These crops have garnered UNESCO's recognition as important crops due to their declining cultivation and exploitation in the wild. Pseudo cereals have gained global prominence in the nutraceutical industry, attributed to their robust nutritional profiles compared to traditional cereals. Rich in active principles such as polyphenols, flavonoids, amino acids, dietary fiber, lignans, vitamins, minerals, antioxidants, unsaturated fatty acids, and essential components like fagopyritols, these crops offer a diverse array of health benefits.Notably, pseudo cereals surpass cereals in both the quality and quantity of protein, qualifying them for integration into the functional food industry. Their amino acid composition, including arginine, tryptophan, lysine, and histidine, proves essential for infant and child health, positioning pseudo cereals as valuable food supplements for child nutrition. Parameters such as Net Protein Use (NPU), Protein Efficiency Ratio (PER), digestibility, bioavailability of protein, and available lysine highlight the superior nutritional quality of pseudo cereal proteins compared to cereals, approaching levels comparable to casein. The protein composition of pseudo cereals, encompassing 2S albumin, 11S and 7S globulin, aligns them with legume proteins. Additionally, pseudo cereal proteins prove beneficial for individuals with celiac disease due to their low prolamin content. Overall, the nutritional richness and diverse health-enhancing components make pseudo cereals pivotal players in the contemporary agricultural landscape and the evolving nutraceutical industry. Pseudo cereals, particularly rich in fatty acids, especially linoleic acid when compared to traditional cereals, demonstrate a mineral content approximately twice as high as other cereals.

This characteristic presents significant potential in addressing the hidden hunger problem. Given the limitation of agricultural land, cultivating these crops often necessitates the utilization of marginal lands, which are frequently affected by abiotic stresses such as drought, temperature fluctuations, salinity, and heavy metal stress. The ability of pseudo cereals to withstand such stresses makes them a viable option for cultivation. This becomes especially relevant as underdeveloped and developing countries grapple with the challenge of ensuring national food security, exacerbated by the potential impact of climate change on various dimensions of food security, including availability, accessibility, utilization, and stability. While adapting agricultural systems to climate change is imperative for maintaining food security, pseudo cereals emerge as resilient crops capable of thriving in conditions unsuitable for traditional cereals. As a result, they are considered crucial for addressing malnutrition and potential food crises in the future. Recognizing this, there is an urgent need to employ recent biotechnological interventions for crop improvement and the domestication of pseudo cereal crops.

4.2 Current Limitations for Developing Underutilized (Pseudo) Cereals:

The agronomic potential of underutilized grain crops, including quinoa, teff, chia, and amaranth, remains poorly characterized. Unlike major staple grains that benefit from high-input agriculture, these underutilized crops often grow in low-input systems, limiting our understanding of their yield and quality in comparison to major staple grains. For underutilized grains like broomcorn millet, buckwheat, and canary seed that can benefit from high-input agriculture, their use is usually constrained to secondary roles, replacing destroyed fields or serving as quick alternatives to summer fallow. The short and suboptimal growth season allocated to these grains hinders direct comparisons with staple grain counterparts, contributing to their low planting acreage compared to major cereal crops.

Genetic limitations pose challenges for certain underutilized (pseudo)cereal crops, such as buckwheat's natural cross-pollination and self-incompatibility, necessitating the development of self-compatible lines for breeding. Additionally, the lack of established pipelines for mutagenesis and transformation, along with limited intersections between genomics and breeding, constrains the full potential of these underutilized grains in high-input agricultural systems. While local communities possess cultivation and breeding knowledge for many underutilized grains, the dissemination of this knowledge faces barriers. Traditional knowledge and modern research often struggle to cross language barriers, particularly for teff, amaranth, chia, quinoa, and buckwheat, where relevant information is primarily available in languages like Amharic, impeding the global exchange of valuable insights. Efforts to bridge these knowledge gaps and enhance breeding initiatives are crucial to unlocking the full agronomic potential of underutilized grain crops in high-input agricultural systems.

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