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Pulses, Importance and Constraints

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Abstract

Pulses are a crucial component of global and Indian agriculture, contributing significantly to food security, nutrition, and sustainable farming practices. India is the largest producer of pulses, cultivating over 28 million hectares and contributing 31% of the world's pulse production. Major pulses include gram (45% of total production), tur (17%), urd (11%), and mung (10%). As legumes, they enhance soil fertility by fixing 20–25 kg of atmospheric nitrogen per hectare, reducing dependence on synthetic fertilizers and promoting sustainable agriculture. Pulses are also a rich source of plant-based protein (20-25%), dietary fiber, essential amino acids, vitamins, and minerals such as iron and calcium, making them vital for balanced diet. Despite their importance, pulse production in India faces several constraints, including fluctuating climatic conditions, marginal land cultivation, lack of irrigation, and limited access to improved seed varieties. Socio-economic and agronomic challenges further hinder productivity. Addressing these constraints through improved agricultural practices, better post-harvest management, and policy interventions can enhance pulse production and ensure a more resilient and sustainable food system.

1. Introduction

The term "pulses" is limited to crops harvested solely as dry grains, which differentiates them from other vegetable crops, that are harvested while they are still green. Pulses, including lentils, beans, chickpeas, pigeon pea, moth bean, green gram, black gram, peas, etc. are basically edible seeds which belongs to the legume family. Dried beans, lentils and peas are the most commonly known and consumed types of pulses. The first evidence of pulses comes from 11,000 years ago from region in the Middle East which was home to some of the earliest human civilizations. As a staple in diets of larger population, pulses continue to play a crucial role in ensuring food security and promoting a balanced, healthful lifestyle. Pulses are grown all throughout the world, with Asia, especially India, accounting for over half of global production.

Pulses and pulse crop residues are also major sources of high-quality livestock feed in India. Mostly pulses are grown as rainfed or with limited irrigation, but due to the availability of improved

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high-yielding varieties farmers are growing pulses as an irrigated crop. Commonly cultivated pulses are chickpea (*Cicer arietinum*), pigeon pea (*Cajanus cajan*), lentil (*Lens culinaris*), black gram (*Vigna mungo*), green gram or mung bean (*Vignar adiata*), lablab bean (*Lablab purpureus*), moth bean (*Vigna aconitifolia*), horse gram (*Macrotylo mauniflorum*), pea (*Pisum sativum* var. *arvense*), grass pea or khesari (*Lathyrus sativus*), cowpea (*Vigna unguiculata*) and broad bean (*Vicia faba*). Pulses are grown in all three seasons in India viz., *kharif* (Arhar, black gram, green gram, cowpea), *rabi* (Gram, lentil, pea, lathyrus and rajmah), Zaid (green gram, black gram and cowpea).

2. Importance of Pulses

Pulses, the edible seeds of leguminous plants, play a crucial role in human nutrition, agriculture, and environmental sustainability. Pulses stand out as nutritional powerhouses, particularly due to their high protein content, which typically ranges from 20-25%, significantly surpassing that of most cereals (FAO, 2016). This makes them a crucial protein source, especially in regions where meat consumption is limited. Furthermore, pulses are rich in essential amino acids, critical for human growth and development. They also provide a valuable source of vitamins, including vitamin A, and minerals like calcium and iron. The provided data highlights that pulses offer a substantially higher concentration of vitamin A compared to wheat, illustrating their superior nutritional density. Geil and Anderson (1994) also emphasize the nutritive value of dry beans, a type of pulse, highlighting their role in providing essential nutrients. As global diets shift towards healthier and more sustainable options, pulses continue to gain recognition as a powerhouse of nutrition. As per Indian Council of Medical Research (ICMR) recommendation, the per capita per day availability of pulses should be 69.0 g but at present only 41.9 g per capita per day pulses are available.

A key ecological benefit of pulses lies in their ability to fix atmospheric nitrogen through a symbiotic relationship with rhizobia bacteria in their root nodules. This process enriches the soil with nitrogen, a vital nutrient for plant growth, thereby reducing the need for synthetic nitrogen fertilizers (Ouma et al., 2016). The text indicates that pulses can fix approximately 20-25 kg of nitrogen per hectare, making them invaluable for sustainable agriculture. Additionally, pulse crops contribute significant organic matter to the soil through their root systems and fallen leaves, improving soil structure and fertility. Foyer et al. (2016) further emphasize the importance of legumes, including pulses, in sustainable food production and human health, highlighting the negative impact of neglecting these crops. Pulses play a vital role in soil conservation due to their deep root systems, which effectively bind the soil and prevent erosion (Lal, 1997). Their dense vegetative growth provides a protective ground cover, shielding the soil from the erosive forces of wind and water. This is particularly important in regions prone to soil degradation. By improving soil structure and reducing erosion, pulses contribute to long-term soil health and agricultural productivity.

The residues of pulse crops, such as stems and leaves, serve as valuable fodder for livestock. This is particularly important in regions where forage resources are limited. The high protein content of pulse residues contributes to animal nutrition, supporting livestock health and productivity. The dense growth of pulse crops creates a "smothering effect," effectively suppressing weed growth. This natural weed control mechanism reduces the need for herbicides, promoting more sustainable agricultural practices. Pulses are essential components of crop rotation systems. Their nitrogen-fixing ability improves soil fertility for subsequent crops, reducing the reliance on synthetic fertilizers. Mixed cropping with pulses enhances biodiversity and reduces the risk of crop failure.

3. Constraints of Pulses Production in India

3.1. Cultivation on marginal and sub-marginal lands

A significant proportion of pulse cultivation occurs on marginal and sub-marginal lands, which are characterized by low soil fertility, poor water retention, and limited access to irrigation. Studies indicate that a considerable percentage of pulse-growing areas in states like Rajasthan, Maharashtra, and Madhya Pradesh fall under these categories. Consequently, yields are significantly lower compared to areas with better soil and water resources. The lack of proper soil management practices, such as tillage, nutrient application, and water conservation, further exacerbates the problem.

3.2. Rarely grown as pure crops

Pulse crops in India are frequently grown as mixed or intercrops, often as a secondary component in farming systems. This practice, while offering some diversification benefits, results in less focused management and lower yields. Data shows that a substantial percentage of pulse cultivation involves mixed cropping, where pulses are grown alongside cereals or oilseeds. This diminishes the amount of attention given to the pulse crop, limiting the yield potential.

3.3. *Vulnerability to rainfed conditions*

A large proportion of pulse cultivation in India relies on rainfed agriculture, making it highly susceptible to weather fluctuations. Data indicates that a significant percentage of pulse-growing areas lack access to assured irrigation, rendering them vulnerable to rainfall variability. Delayed or insufficient monsoons, as well as prolonged dry spells, severely impact pulse yields.

3.4. *Neglect of manures and fertilizers*

Despite their role as soil builders, pulses are often cultivated with minimal application of manures and fertilizers. Farmers frequently rely on the inherent nitrogen-fixing ability of pulses, neglecting the need for supplementary nutrients. Data from soil testing laboratories reveals widespread nutrient deficiencies in pulse-growing areas. This lack of proper nutrient management leads to soil degradation and limits yield potential.

3.5. *Predominance of low-yielding local varieties*

The widespread cultivation of traditional, low-yielding pulse varieties is a significant constraint. Data from agricultural research institutions indicates that the adoption of improved, high-yielding varieties is limited, particularly among smallholder farmers. Local varieties often lack the genetic potential for high yields and are susceptible to diseases and pests. This limits the overall pulse production in India.

3.6. *Photosynthetic inefficiency (C_3 Plants)*

Pulses are C_3 plants, which have lower photosynthetic efficiency compared to C_4 plants. This limits their ability to convert sunlight into biomass, resulting in lower yields. Additionally, pulses often exhibit weak source-sink relationships, which further restricts yield potential. Scientific studies on plant physiology highlight the limitations of C_3 photosynthesis in pulse crops.

3.7. *Biotic and abiotic factors*

Major pulse production is limited by biotic and abiotic factors. For example, the main biotic barriers to raising chickpea yield include Ascochyta blight, Fusarium wilt, root rots, pod borers (*Helicoverpa armigera*), and botrytis Gray mold. Pod borer, pod fly, Fusarium wilt, and sterility mosaic disease are among the biotic stressors that significantly reduce pigeon pea output. Comparably, the main pests and diseases influencing lentil production in India include pod borer, aphids, cutworm, powdery mildew, rust, and wilt. Because legumes are rich in phosphorus (P) and nitrogen (N), diseases and insect pests find them appealing. In India, the majority of pulses are cultivated in unreliable environmental circumstances, poor soil fertility, and troublesome soils. Rain feeding makes up about 87% of the area planted to pulses. Seed yields can be cut in half by heat stress and drought, particularly in dry and semi-arid areas. Another significant issue is the salinity and alkalinity in soils, which are found in both the Indo-Gangetic plains and the semi-arid tropics (Pal et al., 2017). Drought years witness a decline in pulse sowing, while years with favorable monsoons may see a temporary increase. The unpredictability of the monsoon, with its delayed onset or erratic distribution, leads farmers to shift towards more stable cereal crops.

3.8. *Socio-economic factors*

Pulses are considered secondary crops by Indian farmers. In addition, until recently, the government placed less value on pulses than on staple grains. Farmers typically have restricted access to inputs due to a lack of outlets to sell their excess pulse yield as well as insufficient purchasing power. Due to this circumstance, farmers prioritize cash crops and basic cereals when allocating inputs, with pulses coming in second. As a result, pulses continue to be grown on poor soils with low inputs. A significant obstacle to expanding grain legume production is the availability of high-quality seed of improved varieties and other inputs (Pal et al., 2017).

3.9. *Ecological factors*

Pulse production is highly vulnerable to ecological factors, particularly in India where a significant portion is rainfed. The reliance on residual soil moisture, with only a small percentage (approximately 8%) under irrigation, exposes crops to water stress during critical growth stages. Moreover, pulses are sensitive to excess soil moisture, leading to waterlogging and root damage. Soil salinity, alkalinity, and acidity further compound these issues, hindering nutrient uptake and reducing yields. These factors are exacerbated by climate change, causing more erratic rainfall, and increasing soil degradation (FAO, 2016)

3.10. *Agronomic factors*

Poor management practices significantly contribute to low pulse yields. Improper sowing time and methods, inadequate seed rate, and imbalanced nutrition deprive crops of optimal growing conditions. The lack of seed treatment, defective sowing methods, and inadequate interculture further compound these issues. Poor weed, water, and pest management lead to yield losses. Additionally, the practice of "utera" sowing (sowing seeds into a standing rice crop before harvest), while conserving moisture, often results in poor crop establishment.

3.11. Basic research factors

The lack of high-yielding varieties (HYVs) and hybrids tailored to Indian conditions is a major constraint. There's a need for varieties with synchronous flowering, multiple resistance to pests and diseases, and improved responsiveness to inputs. Limited basic research in these areas results in the cultivation of older, less productive varieties. This situation creates stagnation in improving the yields of pulses.

4. Constraints in Post-harvest Technology

Post-harvest losses in pulses are significantly exacerbated by several critical constraints. A major issue is the lack of modern storage facilities, such as silos and warehouses, which leads to substantial spoilage from moisture, pests, and mold, causing both quantity and quality reductions. Traditional storage methods often fail to prevent these losses. Additionally, pulses are highly susceptible to damage from various insects during storage, and the absence of effective pest control amplifies losses due to consumption and contamination. Inefficient processing and milling, particularly with traditional techniques, contributes to reduced yields and lower nutritional value, a problem compounded by limited access to modern processing technologies. Improper drying and rough handling during transportation and storage result in mold growth, physical damage, and increased vulnerability to pests and diseases, compromising quality and nutritional content. Furthermore, poor transportation infrastructure and limited market and processing facility access increase post-harvest losses and reduce farmer market access. Finally, the slow adoption of improved post-harvest practices is due to farmers and processors having limited access to modern technology information, and insufficient extension services and training, which perpetuates the use of inefficient traditional methods.

5. Conclusion

Pulses are a cornerstone of food security and sustainable agriculture, offering significant nutritional, environmental, and economic benefits. As leguminous crops, they naturally improve soil fertility, reduce the need for synthetic fertilizers, and contribute to biodiversity and climate resilience. Their high protein, fiber, and micronutrient content makes them an essential dietary component, particularly in vegetarian diets. However, challenges such as climatic variability, low productivity (885 kg ha^{-1}), limited irrigation (87% rainfed cultivation), and post-harvest losses hinder their full potential. The green revolution era majorly focused on staple food like rice and wheat. Pulses were mostly grown on marginal land with low inputs, which resulted in reducing per capita availability of pulses to the masses. In order to meet the required demand, there is a need to increase the pulses production

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