

Review Paper

## India's Journey to Pulse Self-Reliance: achievements and path ahead

Ashok K Parihar, Shailesh Tripathi\*, Vaibhav Kumar and GP Dixit

ICAR-Indian Institute of Pulses Research,  
Kanpur-208 024, Uttar Pradesh, India

\*Corresponding author:  
shaitri@rediffmail.com

### ABSTRACT

During the last five decades, pulse production has increased 2.8 times, mainly due to expansion in cultivated area and improvement in productivity. Most notably, sustained and dedicated efforts over several decades in the pulses sector led to the so-called 'Pulse Revolution', resulting in near self-sufficiency with a production touching 27.30 million tonnes. Nevertheless, the growth achieved in pulses production is still far less than the growth registered in the cereals production. Since pulses are an essential component of the Indian diet, achieving the goal of a 'Viksit Bharat' requires self-sufficiency in pulse production to ensure food and nutritional security for an alarmingly growing population. Within the Indian pulse basket, chickpea contributes the largest share followed by mungbean and arhar. Pulse consumption is more diversified than cereal consumption and has increased in recent years. Of the total pulse consumption, arhar accounts for 30.9%, followed by gram (23.8%), masoor (13.9%), moong (12.9%), and urd (11.3%). India is the world's largest producer and consumer of pulses; however, it continues to face a persistent gap between domestic supply and demand. A dedicated pulses varietal development programme started in 1966 with the inception of All India Coordinated Pulses Improvement Project (AICPIP), and to date, nearly 570 high-yielding, short-duration varieties with major biotic and abiotic stress resistance have been developed, along with improvements in the availability of quality seed to the farmers. To increase pulses production government of India launched many programmes during the last five decades, which have contributed significantly in enhancing pulses production. Despite these efforts, the productivity of most of the pulse crops is still below the global average, mainly because they are cultivated on marginal land under rainfed conditions and are more vulnerable to various biotic and abiotic stresses. In addition, limited availability of quality seeds and inputs, poor market infrastructure, and lower economic returns compared to cereals further constrain pulse production. Therefore, to achieve self-sufficiency in pulses, India must adopt a multi-prong strategy with a major focus on developing climate-resilient varieties/hybrids using modern tools such as genomics, genome editing, speed breeding, genomic selection, and high-throughput phenotyping. There is huge untapped potential for unlocking the potential of rice-fallows keeping in mind water budgeting and risk-smart cropping sequence. Other key interventions include designing climate-smart production technologies, mechanization, intercropping with pulses, value addition, reduction of post-harvest loss, strengthening market infrastructure, development of site-specific technologies, and ensuring remunerative prices to pulse growers.

**Key words:** Constraints, Food, Nutrition, Self-sufficiency, Supply gap

### INTRODUCTION

Recently, India celebrated 75 years of its independence, which also marked the beginning of its *Amrit Kaal* or 'golden era' (2022-47) during which the country has committed to transforming itself into '*Viksit Bharat*', a developed nation. The agricultural sector contributes significantly to the

socio-economic growth and development of the country (Pathak *et al.* 2022). As the principal source of income and livelihood for more than half of the population, agriculture will play a pivotal role in achieving the '*Viksit Bharat*' mission. By the end of this decade, India's population is projected to surpass 1.5 billion, and this upward trend is expected to continue till early 2060s, when it will

peak at around 1.7 billion people (Anonymous 2024a). Therefore, a major challenge lies in ensuring food and nutritional security for every individual in this rapidly increasing population, irrespective of resource availability. The declining trend in land holding, soil fertility, and groundwater availability under changing climatic conditions represents a major bottleneck to achieving sustainable food and nutritional security for the growing population (Das *et al.* 2022, Gulati *et al.* 2023, Saleem *et al.* 2025). However, over the past five years, India has witnessed an increasing trend in the area and production of major food crops. Consequently, total food grain production reached a record production of 357.70 million tonnes in 2025 (DA and FW 2024). Since the Green Revolution, India has remained largely self-sufficient in cereal production owing to a noteworthy upsurge in rice and wheat production (Davis *et al.* 2018). In contrast, pulses- which play a crucial role in human's nutrition, and soil health as nutrient-dense leguminous crop-continue to face a supply deficit. Despite several research, development, and policy level interventions, India still depends on import to meet domestic pulse demand. Over the past decade, pulse production has increased at an appreciable annual growth rate of 4.43%, driven by area expansion at the rate 3.0% per year and productivity enhancement at the rate of 1.39% per year. The continued and dedicated efforts over several decades culminated in the 'Pulse Revolution' by providing near self-sufficiency in pulses with 27.30 Mt production (Yadav *et al.* 2019, Pathak *et al.* 2022, NAAS 2022). Nevertheless, pulse production has increased only 2.8 times over the past five decades, which is considerably lower than the growth achieved in cereals production. Therefore, to attain the 'Viksit Bharat' tag country must achieve self-sufficiency in pulses production to ensure food and nutritional security for its alarmingly increasing population. This article presents the current and historical status of pulse research and development in India along with future strategies to improve sustainable pulse production.

## PULSES FOR FOOD AND NUTRITION

Pulses are an essential ingredient of the Indian diet, especially among resource-deprived vegetarians. They are a rich source of proteins, carbohydrates, micronutrients, vitamins, and minerals like folate, iron, calcium, magnesium, zinc, and potassium. In comparison to cereals, pulses possess 1.67, 2.47, 3.54, and 5.31 times more iron, protein, vitamin A, and dietary folate, respectively

(NAAS 2022). Owing to their high nutritional value, pulses are considered one of the most preferred supplements for achieving a balanced diet. The nutritional benefits of pulses can be further enhanced when consumed with other foods; for instance, the combined consumption of pulses and cereals improves overall dietary quality (FAO 2016). Moreover, consumption of pulses with Vitamin-C-rich food enhances iron absorption and plays an instrumental role in preventing anemia (Rani *et al.* 2024, FAO 2021). Besides being an excellent source of dietary fibre with low glycemic index and fat, pulses are considered an ideal food for the management of cholesterol and diabetes, good digestive health, and regulating energy levels in humans. In addition, pulses are rich in phytochemicals and antioxidants, which offer anti-cancer properties (Parihar *et al.* 2016, 2021, 2022, Singh *et al.* 2017). Beyond their nutritional importance, Pulses have immense potential to improve soil fertility and resource-use efficiency, reduce greenhouse gas emissions, and augment system diversity. These crops fix the atmospheric nitrogen for their growth, thereby reducing dependence on external nitrogen inputs and increasing nitrogen availability for subsequent crops. The symbiotic relationship between pulses and soil improves soil structure and supports soil's microbial biodiversity, which in turn enhances soil health and crop yields (Lasisi and Liu 2023, Kumar *et al.* 2023). Consequently, pulses form an important component of diverse cropping systems across the country, with region-specific variations in preferences and suitability to respective agro-ecologies.

## CURRENT SCENARIO OF PULSES PRODUCTION AND AVAILABILITY

A dozen pulse crops, categorized as major (Chickpea, Pigeonpea, Mungbean, Urdbean, and Lentil) and minor pulses (Field pea, Moth bean, Cowpea, Horsegram, Rajma and Rice bean) are indispensable components of different cropping systems in India. These pulses collectively cover an area of 27.62 million hectares, producing 25.68 million tonnes with an average productivity of 926 kg/ha. After a long phase of stagnation, pulses production increased by 67% between 2015-16 (16.4 m tonnes) and 2021-22 (27.3 m tonnes), indicating that the country gradually headed toward self-sufficiency in pulses. Among pulses, the highest increase in production was recorded in chickpea with 53% increase. The growth rate of pulse production during this period was more than 2.6

times higher than that of cereal production. This increase in pulses production is mainly attributed to increases in area and productivity, coupled with favourable Government policies. As a result of the gradual march towards self-sufficiency in pulses production and the continuous increase in population, the per capita availability of pulses has shown only a modest improvement. The per capita availability of pulses increased from 15.8 kg per year (2013) to 19.6 kg per year in 2022 (NAAS 2022, Anonymous 2024).

However, in recent years, a decreasing trend in both area and production of pulses has been noticed (**Figure 1**), which has emerged as a serious concern for researchers and policymakers. In the Indian pulse basket, chickpea has the highest contribution of 43 %, followed by mungbean (17%), Arhar (14%), during 2020-21 to 2024-25 (Figure 2). Major pulses production comes from five states, viz., Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh, and Karnataka (DA & FW 2024).

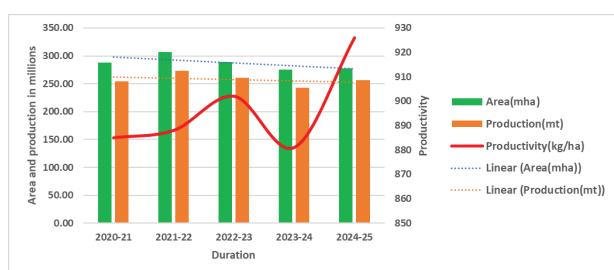


Figure 1. Area, production and productivity trend of pulses during 2020-21 to 2024-25

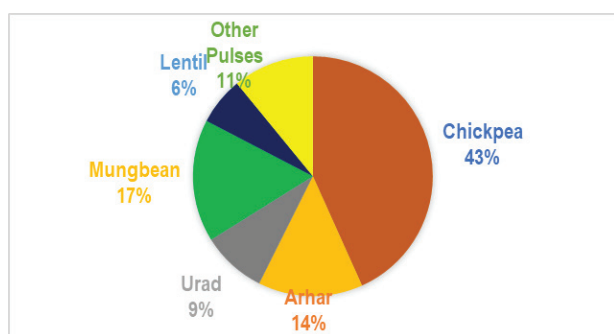


Figure 2. Composition of the Indian pulses basket during 2024-25

Despite the substantial increase in pulses production during recent years, India still depends on imports to meet its domestic requirement. The increased availability of pulses has come at the cost of foreign exchange; hence, dedicated efforts to replace imports with domestic production became necessary. In the fiscal year 2023-24, a total of 47.75 lakhs MT of pulses, valued at US\$ 3743.68 million,

were imported to fulfil domestic requirement. Pulse imports further surged in the 2024-25, reaching up to 7.34 million tonnes, a significant jump from the previous year. This rise was mainly driven by reduced domestic production, rising demand and cheaper import. Major supplying countries included Canada, Myanmar, and Russia, and yellow peas, pigeon peas (tur), and lentils (masur) dominated the import basket. Despite improvements in domestic production, India continue to remain a major importer (5-7 MT annually) to meet its huge consumption demand (25-28 MT) and control fluctuating market prices. This dependence is further influenced by frequent changes in import duties and fluctuations in global supply. Among the imported pulses, the maximum import was of yellow pea, followed by pigeon pea, lentil, and urdbean.

## CONSUMPTION PATTERN OF PULSES

In a large segment of the country's population, the intake of micronutrient-dense foods like whole grains, pulses, and fresh vegetables remains below the recommended level. ICMR-National Institute of Nutrition "My Plate for the Day" guidelines recommend that, to meet a daily requirement of 2000 calories, 17% of calories should be derived from pulses/flesh food, 10% from milk and milk products, and 45% from cereals/millets (Dietary Guidelines for Indians, 2024). However, cereals currently contribute >50% of total daily energy intake, pulses, meat, poultry, and fish together contribute only 6% to 9% of total energy intake per day, as against the recommended 14-15% of total energy intake from these food groups (Hemalatha *et al.* 2023). Therefore, educating the people about the nutritional magnitude of these foods is not only important from a health point of view but also important for the correct estimation of the future demand and setting realistic targets for pulses production. Notably, pulse consumption is more diversified than cereals and has increased in recent years. In total pulse consumption, Arhar contributed 30.9%, followed by gram (23.8%), masoor (13.9%), moong (12.9%), and urd (11.3%) (John *et al.* 2021). Among pulses, chickpea consumption has shown the largest increase, and overall pulse consumption has also increased, indicating a positive association with income level. According to the recommendation of India's National Institute of Nutrition (2011), the per capita daily pulse intake should be 80 g per person (National Institute of Nutrition, 2011). In correspondence with these recommendations and

increasing awareness among consumers about the health benefits of pulses, consumption of pulses and their demand is expected to accelerate at a faster rate than cereals in the coming years.

### DEMAND AND SUPPLY GAP IN PULSES

India is the world's largest producer and consumer of pulses; however, it continues to face a persistent deficit between domestic supply and demand. Pulse crops together are cultivated in more than 27 million ha in the country, with a production of 25.68 million tons in 2024-25 (DES, MoA&FW 2025). Chickpeas remain the vanguard with > 43% share in the total pulses production, followed by pigeon pea (14%), green gram (17%), black gram (9%), and lentils (6%). The states of Madhya Pradesh, Maharashtra, Rajasthan, Gujarat, and Uttar Pradesh contribute more than 70% of the total pulses production in the country. However, recent years (2022-23 and 2024-25) have been unfavorable for the pulses, resulting decline in production. Consequently, the import has increased substantially, reaching 7.34 million tonnes worth of US\$5.47 billion. The major pulses imported were yellow pea, followed by Pigeon pea, Lentil, and Urdbean (The Economic Times 2025). Pulse demand is projected to reach 35 million tonnes by 2030-31 and 49 million tonnes by 2047-48 under the business-as-usual (BAU) scenario. In the high-income growth (HIG) scenario, demand will further increase to 52 to 57 million tonnes by 2047-48. The daily required intake of pulses for an individual engaged in sedentary and moderate physical activities is 79 and 99 grams per person, respectively. Accordingly, the normative demand for pulses is estimated to be 43-54 million tonnes by 2030 and 47-59 million tonnes by 2047 under different income growth scenarios. To bridge the demand and supply gap, the average pulse productivity increase is projected to be 1258 kg/ha in the BAU scenario, while a higher productivity level of 1485 kg/ha would be necessary under the high-yield growth (HYG) scenario (Anonymous 2023).

In the past decade, both imports and production of pulses have shown considerable fluctuations. The production increased from 17.2 million tonnes in 2014-15 to 27.3 million tonnes in 2021-22. The imports peaked at 6.6 million tonnes in 2016-17, declined in subsequent years, and again attained a peak of 7.34 million tonnes during 2024-25. The inflation rate of pulses experienced high fluctuations over the years, with notable ups and downs. High inflation is primarily driven by a combination of lower domestic production and increased demand for pulses and pulse-based products. As per ICMR recommendations, an individual needs to consume approximately 70 grams of meat to derive the same quantity of nutrients which he/she gets from 30 grams of pulses. If pulse consumption has to be substituted by meat, then the country needs to produce 92-115 million tonnes of meat, which would exert far greater pressure on natural resources than required for pulse production. However, as the Indian population consumes both pulses and non-vegetarian products, the actual normative demand for non-vegetarian products would be substantially lower. Sincere efforts have been made to boost the pulses production in the country, including expansion of area, development of improved varieties and technologies, provision of incentives and subsidies to farmers, procurement of pulses at remunerative prices, and promotion of intercropping and mixed cropping systems (Mishra *et al.* 2023). Despite these efforts, a significant gap between pulse demand and supply persists, underscoring the need for further interventions to achieve self-sufficiency in pulses to realize a nutritionally secure 'Viksit Bharat' by 2047.

At present, pulse production remains insufficient to meet the growing demand, and this gap may persist in the future in the absence of yield improvements and adequate acreage allocation to them. Under the HYG scenario, pulse production will suffice to meet the growing demand. The area under pulses is expected to grow at annual rate of

Table 1: Minimum support prices (in Rs) of various pulses during 2015-16 to 2025-26

| Crops     | MSP 2015-16 | MSP 2020-21 | MSP 2021-22 | MSP 2022-23 | MSP 2023-24 | MSP 2024-25 | MSP 2025-26 | % increase in MSP over 2015-16 |
|-----------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------------------------|
| Pigeonpea | 4625        | 6000        | 6300        | 6600        | 7000        | 7550        | 8000        | 57.81                          |
| Chickpea  | 3500        | 4875        | 5100        | 5230        | 5335        | 5440        | 5650        | 61.95                          |
| Mungbean  | 4850        | 7196        | 7225        | 7755        | 8558        | 8682        | 8768        | 55.31                          |
| Urdbean   | 4625        | 6000        | 6300        | 6600        | 6950        | 7400        | 7800        | 59.30                          |
| Lentil    | 3400        | 4800        | 5100        | 5500        | 6000        | 6425        | 6700        | 50.75                          |

Source: Commission for Agricultural Costs and Prices (CACP)

1.10 %, compared to a higher growth rate of 1.69 % observed during 2011-12 to 2019-20 (Anonymous 2023). If the current trend in the pulse crops acreage continues, and yield growth accelerates, achieving self-sufficiency in pulses is feasible. Attaining self-sufficiency in pulse production would significantly reduce foreign exchange outflows and lower the country's import expenditures, thereby contributing to national economic stability. Therefore, dedicated and sustained efforts are required to increase pulse production in line with the projected demand.

### ACHIEVEMENTS IN PULSES BREEDING AFTER INDEPENDENCE

Dedicated efforts towards the improvement of pulses in India began in 1966 with the inception of the All India Coordinated Pulse Improvement Project (AICPIP). Sustained and concerted efforts over several decades led to the development of numerous varieties with improved plant architecture and resistance to multiple diseases. In chickpea wilt resistance varieties such as Radhey, Avarodhi, KWR 108, and the heat-tolerant variety JG 14 ruled the seed chain for several years (Ali and Gupta, 2012). In the past decade, the advancement in genomic research paved the way toward the deployment of marker-assisted breeding, thereby accelerating varietal development. Consequently, the wilt-resistant chickpea varieties, i.e., Pusa Chickpea 20211, Super Angier 1, and IPCMB 19-3, and drought-tolerant chickpea varieties like Pusa 10216, IPCL 4-14, Pusa Chickpea 4005 (BG 4005), Pusa JG 16, NC 7, and NC 9 were tailored for targeted agro-ecologies. Considering consumer preference for large seed size, sincere efforts were made to design extra-large-seeded kabuli chickpea varieties like KAK 2, JGK 6, MNK 1, RLBGK 1, and Kota Kabuli chana 2. In the recent past, the increased cost of cultivation and labour shortage warranted researchers to develop chickpea varieties suitable for machine harvesting. Consequently, varieties such as Phule Vikram, Pusa 3062, JG 2016-24, NBeG 47, RVG 204, Kundan, Pusa Chickpea Aswini, and GBM 2 were developed (Project Coordinator report 2025).

Systematic breeding efforts began in pigeonpea in the seventies, which delivered the most popular varieties UPAS 120 (early duration), Asha (Medium duration), and Bahar (late duration), and these varieties dominated the pigeonpea cultivation for decades. In the late 1980s, emphasis was on hybrid development in pigeonpea by engaging different male sterility systems (GMS and CGMS), which

resulted in the first GMS-derived hybrid ICPH 8 and the first CGMS-based hybrid GTH 1. Most recently, two CGMS-based hybrids, IPH 9-05 and IPH 15-03, have been developed to diversify the rice-wheat cropping system (Table 2). Likewise, the mungbean improvement programme started 1949; however, outstanding progress was made after 90s and several varieties with earliness, MYMV resistance, synchronous maturity and non-shattering were released, for example HUM 1, IPM 02-3, Samrat, SML 668 and Virat with a shorter duration and photo-thermo insensitivity which has increased mungbean cultivation in non-traditional niches i.e. spring and summer in the recent decade. Additionally, the release of kharif season suitable varieties like IPM 02-3, MH 421, and GM 4 helped in a three-fold increase in Rajasthan within six years, which made the state a vanguard in mungbean production in the country. Similarly, breeding efforts in the urd bean started in 1949 with the selections from land races for high yield and desirable plant types. Later on, varieties were developed for different growing situations with resistance to major diseases (MYMV and powdery mildew). The first powdery mildew-resistant variety, LBG 17, was released in 1983, which revolutionised urd bean cultivation in coastal areas. The first photo-thermo-insensitive variety, LBG 787, was released in 2016 and facilitated the expansion of urd bean cultivation in non-traditional niches (Pratap, 2025). Significant progress has been made in lentil breeding during the last seven decades. The first large-seeded lentil variety, K 75 released in 1986, and still developments of extra-large-seeded varieties for export purposes is still the priority of breeders. Several large-seed varieties with wilt resistance, i.e., DPL 62, JL-3, L4727, DPL 15, IPL 316, L4717, Kota Masoor-1, etc., were developed. Similarly, efforts were made for the development of varieties suited to the north eastern plains with small seed size and rust resistance, including WBL 77, HUL 57, and IPL 220, which were developed. Considering malnutrition, particularly for iron and zinc bio-fortified varieties, such as Pusa Vaibhav and IPL 220, were developed. In the case of field pea, several varieties have been developed with suitable plant types and multiple disease resistance for different growing conditions. The landmark varieties were Rachna, HFP-4, HUDP 15, Prakash, Vikas, Aman, IPFD 10-12 (green-seeded), and IPFD 12-2, which ruled the seed chain and contributed significantly to productivity enhancement, which is the highest among the pulses (Parihar *et al.* 2022a, 2025). The Lathyrus improvement program delivered low ODAP

varieties like Bio L 212, Mahateora, and Prateek, whose seeds were made available for large-scale cultivation (Parihar *et al.* 2022b). Collectively, these breeding achievements with matching production technologies and supportive policy contributed immensely to the pulses revolution in India, which can also be acknowledged as a “protein revolution” (Project Coordinator report, 2025). The development of nearly 570 high-yielding, short-duration varieties with major biotic and abiotic stresses, along with enhanced seed availability and quality, ensured increased production and productivity of pulses, despite a gradual shift of pulse cultivation from northern to central and southern India.

Table 2: Some CGMS-based hybrids in pigeonpea released in India.

| Year | Hybrid    | Maturity Group | Yield (q/ha) | Adaptation     |
|------|-----------|----------------|--------------|----------------|
| 2006 | GTH1      | Early          | 17-18        | Gujarat        |
| 2013 | ICPH 2671 | Medium         | 20-22        | Madhya Pradesh |
| 2015 | ICPH 2740 | Medium         | 20-22        | Telangana      |
| 2019 | IPH 15-03 | Early          | 15-16        | NWPZ           |
| 2020 | IPH 09-5  | Early          | 16-17        | NWPZ           |

## POLICY EFFORTS TO BOOST PULSES PRODUCTION

To increase pulses production, the Government of India has launched many programme over the last five decades, including the Pulses Development Scheme (1969-74), the Food Grain Production Programme on Pulses (1985-90); The Technology Mission on Pulses, Oilseeds and Maize (1990s); the Integrated Scheme on Oilseeds, Pulses and Maize (2004-10); the National Food Security Mission for Pulses which was later rechristened as the National Food Security and Nutrition Mission (2007-12) and the Accelerated Pulses Production programme (2010-14). Despite the implementation of many programmes, pulse production declined to 16.35 million tonnes (MT) during 2015-16, which necessitated the import of approximately 6.0 MT to meet domestic demand. In response, the Government of India (GoI) has introduced several farmer-centric schemes since 2015-16, including the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), Pradhan Mantri Fasal Bima Yojana (PMFBY), Paramparagat Krishi Vikas Yojana (PKVY), Soil Health Management (SHM), and Soil Health Card (SHC), and the National Agriculture Market scheme (e-NAM). Recognizing the need for price support and improved market access, the GoI launched the Pradhan Mantri Annadata Aay Sanrakshan Abhiyan (PM-AASHA) scheme to procure pulses

at Minimum Support Prices (MSP). Under this umbrella scheme, the Price Stabilization Fund (PSF) is now a key component for price stabilization interventions and daily price monitoring. Additionally, the e-Samridhi portal empowers pigeonpea, black gram, and lentil producers by facilitating procurement at better prices through the National Agricultural Cooperative Marketing Federation of India Limited (NAFED) and the National Cooperative Consumers Federation of India Limited (NCCF). To achieve self-reliance in pulses, the GOI revitalized NFSM, which is being implemented in 28 states and 2 UTs, with more than 60% funds allocated to pulses. Several notable initiatives have been undertaken to strengthen quality seed production (breeder seed production; certified seed production) by establishing 150 seed hubs; accelerated dissemination of recently released varieties through mini-kits distribution; and support for cluster development, improved farm machinery, efficient irrigation systems, plant protection, nutrient management, processing, and farmer training on improved cropping systems. Besides, the Targeting Rice Fallow Area (TRFA) initiative has played an instrumental role in promoting pulse cultivation in rice fallow areas (NITI Aayog, 2025).

Furthermore, to strengthen the pulse value chain, the GOI introduced several initiatives over the last decade. The Pradhan Mantri Rashtriya Krishi Vikas Yojana (PM-RKVY) focuses on state-specific agricultural projects, while the *Per Drop More Crop* (PDMC) scheme aims to enhance irrigation efficiency. The Sub-Mission on Agricultural Mechanization (SMAM) supports farm mechanization and the use of drones for timely agricultural operations. In addition, the Seed Authentication, Traceability & Holistic Inventory (SATHI) portal ensures quality assurance and traceability in seed production and distribution. Other initiatives, including the Agri Infrastructure Fund (AIF), Pradhan Mantri Formalisation of Micro Food Processing Enterprises (PMFME), Farmer-Producer Organizations (FPOs), and Pradhan Mantri Fasal Bima Yojana (PMFBY), facilitate integrated development, value addition, and risk management in the pulse sector (NITI Aayog, 2025). Furthermore, the GoI significantly increased the MSP for major pulse crops (Table 1), which led to a substantial increase in pulse production. To stabilize prices and enhance domestic availability, the Government approved the creation of a buffer stock of 2.0 MT. By implementing several pulses productions focused programs and monitoring mechanisms, the area,

production, and productivity of pulses in India have increased considerably. Between 2016-17 and 2021-22, pulse production increased from 23.13 MT to a record 27.30 MT, while productivity rose by nearly 38%, from 0.656 t/ha in 2015-16 to 0.902 t/ha in 2022-23. Import dependency has significantly decreased from 29% in 2015-16 to 10.4% in 2022-23. This remarkable achievement reflected a significant step towards self-sufficiency in the pulse sector. However, the fiscal year 2024-25 saw a sudden rise in imports to 7.34 MT, representing about 28.58% of domestic demand. This sudden surge underscores the need for continued efforts to enhance domestic pulse production and reduce reliance on imports, particularly amid rising food prices and their implications for inflation.

### MAJOR CONSTRAINTS IN ACHIEVING SELF-SUFFICIENCY IN PULSES

Most pulse crops are grown on marginal and problematic soils under rainfed conditions (87%) with minimum external inputs, which led to low productivity. The other major reasons for the low productivity of pulses are erratic rainfall, biotic and abiotic stress, non-availability of quality seeds, poor market infrastructure, and being less lucrative than cereals. Major biotic stresses affecting pulses include soil-borne disease (*Fusarium wilt*, root rots), air-borne disease (ascochyta blight, sterility mosaic disease, botrytis gray mold, yellow mosaic disease, powdery mildew, rust), and insect pests such as pod borer, pod fly, aphids, and cutworms (Parihar *et al.* 2022, Bohra *et al.* 2024, Naik *et al.* 2024, Revanappa *et al.* 2024). The abundance of nitrogen and phosphorus in plant tissue often increases susceptibility to insect pests and diseases (Sinclair and Vadez, 2012). Likewise, prevailing abiotic stress-drought, heat, cold, frost, water-logging, salinity, and alkalinity- substantially reduce pulses production (Bhaskar *et al.* 2025, Belliappa *et al.* 2024, Jain *et al.* 2023). Among these, drought and heat stress can reduce seed yields by up to 50%, especially in arid and semi-arid regions (Nam *et al.* 2001, Nayyar *et al.* 2006). The problematic soils are major problems in semi-arid tropics and in the Indo-Gangetic plains (Bhattacharyya *et al.* 2015). Poor drainage/water-logging during the rainy season causes heavy losses in pigeonpea due to reduced plant stand and increased incidence of phytophthora blight disease (Mishra *et al.* 2025). Although numerous high-yielding pulse varieties have been developed, the limited availability of their quality seed remains a serious bottleneck in harnessing the

full yield potential of these varieties. In addition, poor market infrastructure and low profitability of pulses compel farmers to cultivate cereals and other cash crops with available inputs; pulses shift to second place in their priority. Notably, the post-harvest losses are upto the tune of about 9.5 percent of total pulse production, with storage sharing 7.5 percent, processing, threshing, and transportation contributing 1.0, 0.5, and 0.5 percent, respectively (Deshpande and Singh, 2001).

### ROAD MAP FOR ACHIEVING SELF-SUFFICIENCY IN PULSES

Improved availability and adoption of high-yielding varieties of pulse crops, along with matching crop production technologies, have led to a pulse revolution in India. Expansion of the area under pulses in rice fallows, the summer season, and non-traditional areas, coupled with favourable government policies such as enhanced minimum support prices and public procurement of pulses, has also played a catalytic role. These efforts have helped bridge the demand-supply gap to some extent. However, to achieve self-sufficiency, India must adopt a multi-pronged strategy with a major focus on vertical expansion (productivity enhancement), horizontal expansion (area expansion under pulse cultivation), value addition, and reduction of post-harvest losses in pulses. Different strategies are briefly discussed that can play a crucial role in achieving self-sufficiency in pulses production.

### DEVELOPMENT OF CLIMATE RESILIENT HIGH YIELDING VARIETIES

The impact of climate change is expected to be more pronounced on pulse crops, as they are predominantly grown on marginal lands under rainfed conditions. In recent years, the frequency of climatic extremes such as erratic rainfall, drought, heat waves, frost, and cold stress has increased. In North India, a shift in the cold window during the rabi season and sudden spikes in temperature during February-March adversely affect pod filling and seed setting in rabi pulses. Delays in the onset of the monsoon during the kharif season have resulted in shifts in the sowing time of the succeeding rabi crops, exposing them to terminal abiotic stresses. Among the abiotic stresses, drought and heat are the most critical constraints affecting rabi pulses under rainfed and late-sown conditions, respectively. These stresses are further aggravated by increased cropping intensity and high temperature fluctuations associated with

climate change. To enhance genetic gain, there is a need to develop climate-resilient and high-yielding pulse varieties by leveraging modern breeding tools such as genomics, genome editing, speed breeding, and genomic selection. Other important objectives include enhancing genetic potential through optimization of plant type and improving tolerance to biotic and abiotic stresses.

Dedicated research efforts are required to develop pulse varieties with enhanced tolerance to drought and biotic stresses. In chickpea, for instance, introgression of resistance to biotic and abiotic stresses into elite genetic backgrounds has demonstrated the potential of integrating genomics with conventional breeding to develop superior “climate-smart” varieties (Table 4). A genomic region on linkage group IV of chickpea (CaLG04), known as the ‘QTL hotspot’, harbours multiple QTLs associated with drought tolerance-related traits and accounts for up to 58.2% of phenotypic variation (Varshney et al. 2014). This QTL hotspot has been successfully introgressed into elite chickpea cultivars using marker-assisted backcross breeding, leading to the release of several drought-tolerant varieties in recent years through the All India Coordinated Research Project on Chickpea. Similarly, chickpea introgression lines possessing superior haplotypes of an ABCC3-type ABC transporter gene (CaABCC3), associated with the CaqSW2.4 QTL, which enhances seed weight and yield under drought stress, have also been released. In addition, wilt-resistant chickpea varieties developed through marker-assisted breeding are playing a crucial role in enhancing productivity in wilt-prone areas (Table 3).

Table 3: Chickpea varieties developed through marker-assisted breeding in India

| Variety                                   | Trait             | Recommended areas        |
|---|-------------------|--------------------------|
| BGM 10216 (2020)                          | Drought tolerance | Central Zone             |
| Pusa Chickpea 4005 (2021)                 | Drought tolerance | North Western Plain Zone |
| IPC L4-14 (2021)                          | Drought tolerance | North Western Plain Zone |
| Pusa JG 16 (2022)                         | Drought tolerance | West Central Zone        |
| NC 7 (2023)                               | Drought tolerance | West Central Zone        |
| NC 9 (2024)                               | Drought tolerance | West Central Zone        |
| Pusa Chickpea 20211 (Pusa Chickpea Manav) | Wilt resistant    | Central zone             |
| SA -1 (Super Annigeri 1)                  | Wilt resistant    | South Zone& Central zone |
| IPCMB 19-3 (Samriddhi)                    | Wilt resistant    | Central zone             |

## RESTRUCTURING PLANT TYPE OF PULSES

Pulse crop plant architecture needs to be tailored for higher photosynthetic efficiency, synchronous maturity, machine harvestability, photo-thermal insensitivity, short duration, and adaptability to emerging cropping systems to cope with climate change. For example, short-duration varieties of mungbean (Virat) and chickpea (JG 14 and JG 11) have revolutionized mungbean cultivation during the summer season and chickpea cultivation in non-traditional areas of southern India.

## HIGH-THROUGHPUT PHENOTYPING

Precision phenotyping for biotic and abiotic stresses using high-throughput phenomics platforms is critical for identifying donor lines, genes, and QTLs, and for dissecting the genetic basis of complex traits such as drought and heat tolerance. Integration of AI-based weather forecasting, real-time crop monitoring systems, and computer vision-enabled high-resolution imaging can significantly enhance the timely management of diseases and insect pests.

## HARNESSING ALLELE DIVERSITY FROM CROP WILD RELATIVES

Intensified exploration of crop wild relatives and landraces for novel genes conferring resistance to diseases and pests, tolerance to abiotic stresses, and yield-related traits such as seed size, pod length, and crop duration is essential for broadening the genetic base and harnessing rare but valuable alleles. The low level of genetic variability for different traits within the cultivated pulse species has deterred the development of widely adapted cultivars with resistance to biotic and abiotic stresses. Only a small proportion of the available genetic diversity in the wild populations has been tapped in the *ex situ* collections. The inherent problems associated with growing perennial wild species outside their natural habitats have restricted their assessment for use in pulse improvement programmes. Recently, Kundan (IPCB 2015-132), a desi chickpea variety suitable for mechanical harvesting has released from the interspecific cross of GNG 1581 x ILWC 21.

## EXPLOITATION OF HETEROSIS IN PIGEONPEA

Hybrid pigeonpea offers significant potential for commercialization and for attracting private-sector participation in pulse seed production. Development of locally adapted hybrids with short-

to medium-duration maturity, resistance to major diseases, and preferred seed quality traits is essential to enhance pigeonpea productivity and reduce dependence on imports. Mission-mode efforts are required for the identification of heterotic pools, development of trait-specific stable cytoplasmic male sterile (CMS) lines, and diversification of restorers (Bohra *et al.* 2025, Singh *et al.* 2024). Further research is also needed to standardize hybrid seed production technologies and ensure reliable hybrid seed purity testing systems. Strengthening public-private partnerships will be crucial for scaling up hybrid pigeonpea technology and ensuring its adoption by farmers. Notable progress has already been made in the development of CGMS-based pigeonpea hybrids in India (Table 2).

### NUTRIENT-DENSE PULSES

Considering the rising demand for plant-based proteins and essential micronutrients, mainstreaming nutritional quality traits in pulse breeding has become the need of the hour. Bio-fortified pulse varieties with enhanced protein and micronutrient content can play a vital role in addressing malnutrition and improving nutritional security (Parihar *et al.* 2023). In this context, bio-fortified varieties such as lentil IPL 220 (iron content: 73 ppm; zinc: 51 ppm), lentil L 4717 (iron content: 65 ppm), and chickpea IPC 2005-62 (protein content: 26%) have already been released for commercial cultivation in India. However, the development and deployment of more such nutritionally enriched varieties across other pulse crops are urgently required.

### ENHANCED INPUT USE EFFICIENCY

In order to reduce dependence on fertilizer imports and minimize fertilizer use, the development of pulse varieties with enhanced nutrient acquisition and use efficiency, particularly for phosphorus, is essential for sustaining pulse production in the future and facilitating a transition toward natural and resource-efficient farming systems.

### MANAGEMENT OF ABIOTIC AND BIOTIC STRESS

Pulses are vulnerable to climate shocks due to their nature of cultivation in marginal areas, and the development of climate-resilient varieties with tolerance to drought, waterlogging, frost, and heat stresses will stabilize not only production but also market prices. To ensure the sustainable

and productive cultivation of pulses, effective management strategies for both abiotic and biotic stresses are crucial. These stresses significantly impact yield and quality of the produce. An integrated approach involving a combination of genetic modifications, sustainable agronomic practices, technological innovations, and strategic policy interventions is necessary to address these challenges.

### HORIZONTAL EXPANSION IN RICE FALLOW AREAS

Expansion of pulse cultivation in one-third of the total rice-fallow area can substantially enhance domestic pulse production, with a potential increase of up to 2.85 million tonnes. Quantifying stored soil moisture, expected pond/groundwater availability, and the likely timing of residual rains against crop water requirements will allow selection of appropriate pulse variety. For instance, where the water availability is limited, prioritize short-duration drought tolerant cultivars of pulses (lentil, chickpea, blackgram and greengram). Aligning crop choices to local water budgets materially improves establishment rates and profitability while reducing climate risk (Singh *et al.* 2019).

### INTERCROPPING WITH PULSES

Pulse crops intercropping with sugarcane in states such as Uttar Pradesh and Maharashtra can unlock an additional 3 million hectares of cultivable land, with the potential to produce about 2.4 million tonnes of pulses. Similarly, optimization of the rice-wheat cropping system in states like Uttar Pradesh, Bihar, and Haryana can create opportunities for bringing an additional 4 million hectares under pulse cultivation, potentially increasing production by 2.8 million tonnes. Overall, these interventions could unlock a total additional pulse production of approximately 8.05 million tonnes, thereby significantly advancing India's goal of self-sufficiency in pulses.

### GOOD AGRONOMIC PRACTICES

Integrated nutrient management and need-based application of macro- and micronutrients reduces the cost of cultivation and enhance the return of the farmers. Seed treatment with efficient and competitive strains of *Rhizobium* and phosphate-solubilizing microbes has been reported to enhance the input use efficiency and growth. Since the pulses are mostly grown under rainfed and rice

fallow ecologies, improving the water productivity of pulses and making available lifesaving irrigation is desired for enhancing pulse production.

### POST-EMERGENCE HERBICIDE

Weeds have emerged as a major constraint in pulse production across all agro-ecological regions, causing yield losses of up to 70–80%. Farm labor being the limiting factor, the farmers have to resort to post-emergence herbicides (PEH) for weed control during the critical window of crop: weed competition for attaining the yield potential of the released varieties. Judicious use of post-emergence herbicides in pulse crops can significantly enhance yields and overall production. Effective weed control improves resource-use efficiency by reducing competition for nutrients, water, and light, thereby increasing crop productivity. However, herbicides must be used responsibly and in accordance with recommended guidelines to minimize adverse environmental effects. Integration of chemical weed control with cultural, mechanical, and biological weed management practices can further optimize herbicide use and sustainably enhance pulse productivity.

New generation post emergent herbicides require low dosage and are environmentally safe. For *kharif* pulses (mung, urdbean and pigeonpea), PEH Imazethapyr @ 100 g a.i./ha at 20-25 days after sowing has been found effective in controlling the weed menace. Oxyfluorfen and Topramezone at 14-21 DAS (pre+post) treatment has given good results for weed management in chickpea. In spring/summer pulses (urdbean, mungbean), PEH

Imazethapyr @ 80 g/ha at 20-25 days after sowing has been found effective.

Collaborative research projects involving ICAR-Indian Institute of Pulses Research, Kanpur, ICAR-Indian Agricultural Research Institute, New Delhi, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and other NARS partners screened the released varieties and germplasm accessions of rabi pulses across India and reported the presence of genetic variation for PEH tolerance in chickpea, lentil, and fieldpea. Potential donor lines for tolerance to PEH were identified in chickpea and fieldpea. INGR21142, a pureline selection from chickpea landrace ICC 12315 for Imazethapyr tolerance, and INGR 19075, a fieldpea germplasm accession tolerant to metribuzin has already been registered by ICAR-IIPR, Kanpur (Parihar *et al.* 2018, 2019).

### MECHANIZATION OF THE PULSE CULTIVATION

Mechanization across the entire production cycle—from sowing to harvesting—is essential to optimize farmers' returns and to facilitate expansion of the area under pulse crops. Development of machine-harvestable varieties is a key priority, which requires modification of the conventional short, semi-spreading or spreading plant types into tall, erect or semi-erect architectures. For instance, several chickpea varieties suitable for machine harvesting have been released for commercial cultivation across different agro-climatic zones of India (Table 4). Similar efforts are needed to develop machine-harvestable varieties in other pulse

Table 4. Mechanical harvesting of suitable varieties of chickpea.

| Variety                      | Yield (q/ha) | Maturity period | Recommended areas                     |
|------------------------------|--------------|-----------------|---------------------------------------|
| Phule Vikram (Phule G 08108) | 22-23        | 110-115         | Maharashtra                           |
| RVG 204 (RVSSG 8102)         | 22-23        | 110-115         | Madhya Pradesh                        |
| Jawahar Gram 24 (JG 2016-24) | 22-23        | 112-115         | Central Zone                          |
| Pusa Parvati(BG 3062)        | 23-24        | 110-115         | Central Zone                          |
| AKG 1402(PDKV Super JAKI)    | 20-21        | 95-100          | Maharashtra                           |
| Kundan (IPCB 2015-132)       | 15-20        | 126-131         | North Eastern Plain Zone              |
| Dheera (NBcG 47)             | 20-25        | 90-105          | Andhra Pradesh                        |
| Kota Desi Chana 2            | 17-20        | 94-96           | South zone                            |
| Kota Desi Chana 3            | 15-17        | 126-132         | North Eastern Plain Zone              |
| Gujarat Gram 8               | 16-17        | 125-130         | North Eastern Plain Zone & South zone |
| Nandyal Gram 1267            | 20-21        | 90-95           | South zone                            |
| Pusa Chickpea Aswini         | 26-27        | 140-145         | North Western Plain Zone              |
| Raj Viajy Gram 2023          | 15-16        | 120-125         | North Eastern Plain Zone              |

crops as well. Establishment of “Custom Hiring Centers” in various states, along with supportive policies such as the “Sub-Mission on Agricultural Mechanization,” can substantially enhance the adoption of mechanization, particularly as most pulse growers in India are small and marginal farmers. In addition, the use of unmanned aerial vehicles (UAVs) and drones through custom-hiring services for the application of insecticides, fungicides, and fertilizers can help reduce the cost of cultivation while improving input-use efficiency and operational precision.

### VALUE ADDITION AND REDUCING POST-HARVEST LOSSES

Post-harvest losses in pulses occur at various stages, from harvest to end user. The estimated post-harvest losses in pulses (i.e., pigeon pea, chickpea, black gram, and green gram) ranged from 5.65% in pigeonpea to 6.74% in chickpea. These losses are primarily attributed to factors such as pod shattering during harvesting, spillage during various operations, and mishandling. To minimize these losses and improve the overall efficiency of the pulse value chain, it is crucial to adopt advanced post-harvest technologies and best practices. Value chain approach, keeping in mind the consumers, miller's preferences and post-harvest processing quality, need to be taken up so that farmers get premium price for their produce and open up export markets for Indian pulse growers. Reducing post-harvest loss by 1% further, the potential supply of total pulses could increase by 0.27 MT and 0.41 MT in 2030 and 2047, respectively.

### MORE FOCUS ON MINOR PULSES

Some pulse crops have strong regional importance, such as mothbean, but remain largely neglected in terms of research and development. Mothbean is cultivated on about 1.0 million hectares; however, its productivity remains very low, at less than 300 kg ha<sup>-1</sup>. So far, limited efforts have been made to enhance its yield using modern breeding tools. Within the National Agricultural Research System (NARS), only few breeders are currently working on mothbean, largely using conventional breeding approaches. Similarly, field pea/yellow pea, despite having the highest productivity among pulse crops, constitutes a major share of India's pulse import basket, indicating a clear mismatch between domestic production and demand and underscoring the need for urgent policy interventions. Notably, this crop has recorded the highest yield gains among

pulses during the last decade and has witnessed the development of several high-yielding varieties that are widely preferred by farmers. Strengthening research, seed systems, and supportive policy measures could substantially reduce dependence on imports of field pea/yellow pea.

### MARKET INFRASTRUCTURE

Effective market intelligence is pivotal for enhancing farmers' income, urging the development of domestic marketing linkages and the adoption of electronic trading platforms such as the Electronic National Agriculture Market, or e-NAM.

### DEVELOPMENT OF REGION-SPECIFIC STRATEGIES

Most recently, NITI Aayog has identified potential districts for pulse crop cultivation based on a four-quadrant framework, namely: High Area-High Yield (HA-HY), High Area-Low Yield (HA-LY), Low Area-High Yield (LA-HY), and Low Area-Low Yield (LA-LY). This approach provides a valuable roadmap for achieving self-sufficiency in pulses by strategically integrating vertical and horizontal expansion pathways. In HA-HY districts, a combined focus on productivity enhancement and area consolidation can further boost overall production. HA-LY districts primarily require vertical expansion strategies aimed at yield improvement, while LA-HY districts, despite their limited cultivated area, offer significant scope for horizontal expansion due to their high productivity. In contrast, LA-LY districts necessitate a comprehensive approach involving both area expansion and productivity enhancement. Collectively, these targeted strategic interventions across different district categories present a promising pathway to enhance domestic pulse production and reduce import dependence.

### GOVERNMENT SUPPORT THROUGH PULSES MISSION

To achieve self-reliance in pulses in October 2025, the GOI launched a six-year “Mission for Aatmanirbharta in Pulses” to further this goal. More focus will be on Tur, Urad, and Masoor. This mission aims to (1) develop and ensure commercial availability of climate-resilient variety seeds for farmers, (2) enhance protein content, (3) increase area under pulses cultivation, (4) strengthen post-harvest storage and management system, and (5) assure 100 % procurement of Tur, Urad, and

Masoor by NCCF and NAFED. The central agencies will procure these pulses from farmers who register with them and enter into formal agreements for the next four years, thereby providing market assurance and price stability. Effective implementation of these interventions is expected to significantly boost domestic pulse production. By 2030-31, the mission is expected to expand the area under pulses to 310 lakh hectares, increase production to 350 lakh tonnes, and raise yield to 1130 kg/ha. This increase could not only offset the current import dependence but also bridge the projected demand gap. Collectively, these measures have the potential to establish India as a self-sufficient nation in the pulse sector.

## CONCLUSION

Over the last five decades, India has made significant progress in pulses production, driven largely by improved varieties, advances in production & protection technologies, and supportive policy interventions. The highest-ever pulses production was recorded at 27.30 million tonnes in 2021-22, which subsequently led to a decline in imports. However, unfavourable climatic conditions during recent years (2022-23 and 2024-25) adversely affected pulse production, resulting in increased imports of 7.34 million tonnes to meet domestic demand. In the country import basket, yellow pea contributed the highest, followed by pigeonpea, lentil, and urdbean. Looking ahead, ensuring self-sufficiency in pulses remains a major challenge. The pulse requirements in the country are projected to be 39 million tonnes by 2050, which necessitates an annual growth rate of 2.2%. Further, as per the Working Group Report published by NITI Aayog, the normative demand for pulses is estimated at 43-54 million tonnes by 2030 and 47-59 million tonnes by 2047 under different income growth scenarios. Therefore, achieving self-sufficiency in pulses will require a sustained increase in production that must match the rising demand. To bridge the demand and supply gap, the productivity is projected to increase to 1258 kg/ha in the BAU scenario, and to 1485 kg/ha under the HYG scenario. Similarly, the area under pulses is projected to increase at 1.10 % per annum. If the current trend in the pulses area expansion continues, and yield growth accelerates, there is a strong possibility of achieving self-sufficiency in pulses. To achieve projected yield and production of pulses, India must adopt a multi-pronged strategy with major emphasis on the development of climate-resilient varieties/hybrids through the use of modern tools such as genomics,

genome editing, speed breeding, genomic selection, and high-throughput phenotyping. Additional priorities include horizontal expansion of pulses in rice fallow area, development of climate-smart production technologies, enhanced mechanization, promotion of intercropping systems, value addition, reduction of post-harvest loss, strengthening of market infrastructure, development of site-specific strategies, and ensuring remunerative prices to pulses growers. Moreover, strengthening the outreach programme is essential, enabling researchers to directly engage with farmers in the process of introducing, monitoring and feedback-driven refinement of new technologies. Pulse growers should be supported by digital farm service, artificial intelligence, and drone-based technologies, and be directly linked to markets to help them realize better prices for their produce while also responding to changing consumer food preferences. At the policy level, the GOI must allocate more resources to the pulses sector, especially for improving productivity and promoting pulses-based diversification. Expansion of irrigation infrastructure, provision of high-quality seeds, and the implementation of efficient agricultural management practices will be instrumental in bridging yield gaps and achieving long-term sustainability in pulse production.

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