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किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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Vision 2050

Indian Institute of Pulse Research

Indian Council of Agricultural Research

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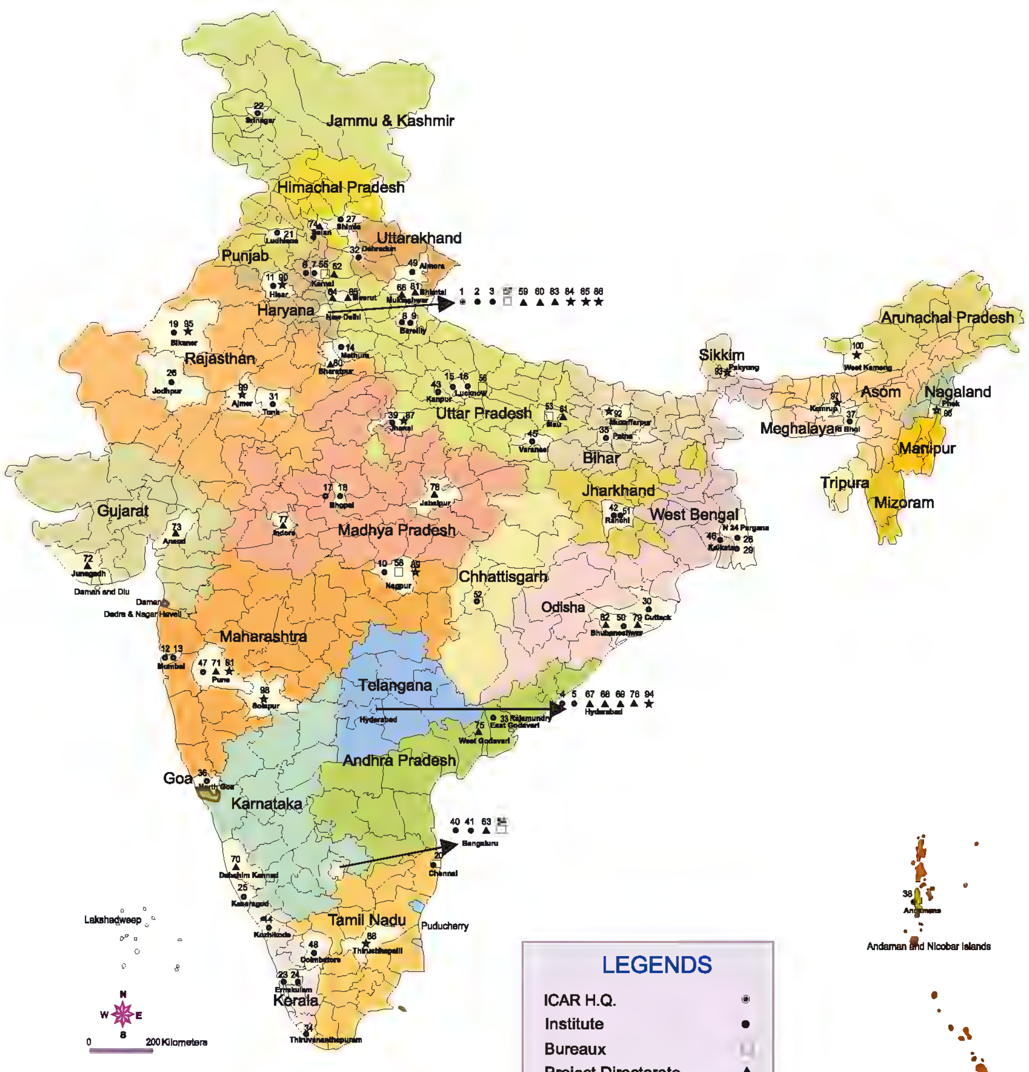

LEGENDS

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- Bureaux
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Vision 2050

Indian Institute of Pulses Research
(Indian Council of Agricultural Research)
Kanpur

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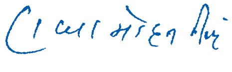
संदेश

भारतीय सभ्यता कृषि विकास की एक आधार रही है और आज भी हमारे देश में एक सुदृढ़ कृषि व्यवस्था मौजूद है जिसका राष्ट्रीय सकल घरेलू उत्पाद और रोजगार में प्रमुख योगदान है। ग्रामीण युवाओं का बड़े पैमाने पर, विशेष रूप से शहरी क्षेत्रों में प्रवास होने के बावजूद, देश की लगभग दो-तिहाई आबादी के लिए आजीविका के साधन के रूप में, प्रत्यक्ष या अप्रत्यक्ष, कृषि की भूमिका में कोई बदलाव होने की उम्मीद नहीं की जाती है। अतः खाद्य, पोषण, पर्यावरण, आजीविका सुरक्षा के लिए तथा समावेशी विकास हासिल करने के लिए कृषि क्षेत्र में स्थायी विकास बहुत जरूरी है।

पिछले 50 वर्षों के दौरान हमारे कृषि अनुसंधान द्वारा सृजित की गई प्रौद्योगिकियों से भारतीय कृषि में बदलाव आया है। तथापि, भौतिक रूप से (मृदा, जल, जलवायु), बायोलोजिकल रूप से (जैव विविधता, हॉस्ट-परजीवी संबंध), अनुसंधान एवं शिक्षा में बदलाव के चलते तथा सूचना, ज्ञान और नीति एवं निवेश (जो कृषि उत्पादन को प्रभावित करने वाले कारक हैं) आज भी एक चुनौती बने हुए हैं। उत्पादन के परिवेश में बदलाव हमेशा ही होते आए हैं, परन्तु जिस गति से यह हो रहे हैं, वह एक चिंता का विषय है जो उपयुक्त प्रौद्योगिकी विकल्पों के आधार पर कृषि प्रणाली को और अधिक मजबूत करने की मांग करते हैं।

पिछली प्रवृत्तियों से सबक लेते हुए हम निश्चित रूप से भावी बेहतर कृषि परिदृश्य की कल्पना कर सकते हैं, जिसके लिए हमें विभिन्न तकनीकों और आकलनों के मॉडलों का उपयोग करना होगा तथा भविष्य के लिए एक ब्लूप्रिंट तैयार करना होगा। इसमें कोई संदेह नहीं है कि विज्ञान, प्रौद्योगिकी, सूचना, ज्ञान-जानकारी, सक्षम मानव संसाधन और निवेशों का बढ़ता प्रयोग भावी वृद्धि और विकास के प्रमुख निर्धारक होंगे।

इस संदर्भ में, भारतीय कृषि अनुसंधान परिषद के संस्थानों के लिए विजन-2050 की रूपरेखा तैयार की गई है। यह आशा की जाती है कि वर्तमान और उभरते परिदृश्य का बेहतर रूप से किया गया मूल्यांकन, मौजूदा नए अवसर और कृषि क्षेत्र की स्थायी वृद्धि और विकास के लिए आगामी दशकों हेतु प्रासंगिक अनुसंधान संबंधी मुद्दे तथा कार्यनीतिक फ्रेमवर्क काफी उपयोगी साबित होंगे।



(राधा मोहन सिंह)

केन्द्रीय कृषि मंत्री, भारत सरकार

Foreword

Indian Council of Agricultural Research, since inception in the year 1929, is spearheading national programmes on agricultural research, higher education and frontline extension through a network of Research Institutes, Agricultural Universities, All India Coordinated Research Projects and Krishi Vigyan Kendras to develop and demonstrate new technologies, as also to develop competent human resource for strengthening agriculture in all its dimensions, in the country. The science and technology-led development in agriculture has resulted in manifold enhancement in productivity and production of different crops and commodities to match the pace of growth in food demand.

Agricultural production environment, being a dynamic entity, has kept evolving continuously. The present phase of changes being encountered by the agricultural sector, such as reducing availability of quality water, nutrient deficiency in soils, climate change, farm energy availability, loss of biodiversity, emergence of new pest and diseases, fragmentation of farms, rural-urban migration, coupled with new IPRs and trade regulations, are some of the new challenges.

These changes impacting agriculture call for a paradigm shift in our research approach. We have to harness the potential of modern science, encourage innovations in technology generation, and provide for an enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy, and technology dissemination need to be given priority. Multi-disciplinary and multi-institutional research will be of paramount importance, given the fact that technology generation is increasingly getting knowledge and capital intensive. Our institutions of agricultural research and education must attain highest levels of excellence in development of technologies and competent human resource to effectively deal with the changing scenario.

Vision-2050 document of ICAR-Indian Institute of Pulses Research (IIPR), Kanpur has been prepared, based on a comprehensive assessment of past and present trends in factors that impact agriculture, to visualise scenario 35 years hence, towards science-led sustainable development of agriculture.

We are hopeful that in the years ahead, Vision-2050 would prove to be valuable in guiding our efforts in agricultural R&D and also for the young scientists who would shoulder the responsibility to generate farm technologies in future for food, nutrition, livelihood and environmental security of the billion plus population of the country, for all times to come.

(S. AYYAPPAN)
Secretary, Department of Agricultural Research & Education (DARE)
and Director-General, Indian Council of Agricultural Research (ICAR)
Krishi Bhavan, Dr Rajendra Prasad Road,
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Preface

The present production of pulses in the country hovers around 19 million tonnes, which falls short of the present domestic requirement of around 21 million tonnes. This shortfall in pulses is mainly due to near stagnation in production during the last decade (1999-2009) on account of poor spread of improved varieties and technologies, abrupt climatic changes, complex disease-pest syndrome, emergence of new biotypes and races of key pests and pathogens, and declining total factor productivity. In order to narrow down the demand supply gap, the country resorts to import pulses to the tune of 2-3 million tonnes every year.

In order to ensure self-sufficiency, the pulse requirement in the country is projected at 39 million tonnes by the year 2050 which necessitates an annual growth rate of 2.2%. This requires a paradigm shift in research, technology generation and dissemination, and commercialization along with capacity building in frontier areas of research. Keeping this in mind, the Institute has crafted **Vision 2050,** a perspective plan for augmenting pulses production in the country through technology upgradation. The major research and developmental issues which need focus are low genetic yield potential, poor and unstable yield, huge post-harvest losses, inadequate adoption of improved technologies and low profitability which need to be tackled through integration of conventional approaches with cutting edge research in area of genomics, molecular marker assisted breeding, transgenics, molecular approaches for stress management, high input use efficiency, quality improvement, resource conservation, value addition and food safety. Exploitation of heterosis and yield genes from wild relatives have also been identified as promising avenues for breaking yield plateaus.

With dramatic changes in global agricultural scenario on account of implementation of WTO and IPR, the country has to produce not only enough pulses but also remain competitive as the global pulses trade has been registering a 5% annual growth. I am sure that this document will act as a road map for implementing pulse programmes for translating vision into reality.

I am highly indebted to Dr. S. Ayyappan, Secretary (DARE) & Director General (ICAR) for providing necessary guidance and support in preparation of this document. I am also grateful to Dr. J. S. Sandhu

Deputy Director General (Crop Sciences), Dr. S.K. Datta (ex-DDG, CS), and Dr B.B. Singh, ADG (O & P) for encouragement and guidance in preparation of this document. I wish to place on record my appreciation for the contribution made by all Project Coordinators and Heads of the Divisions of this Institute, and Drs. P S Basu, Aditya Pratap, MS Venkatesh and M. Akram in preparation of this document and to Shri D.K. Sharma , Kanhaiya Lal, Dr Rajesh Srivastava, Hasmat Ali, and B.K. Verma for the technical assistance.

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Context

Pulses production in India is characterized by diversity of crops and their regional specificity based on adaptation to prevailing agro climatic conditions. This group of crops can utilize limited soil moisture and nutrients more efficiently than cereals and for that reason farmers have chosen them to grow under highly adverse conditions. At present more than 92 per cent of the area under pulses is confined to unirrigated areas and in future also the bulk of pulse production will continue to come from unirrigated areas. Therefore, any plan for increasing pulse production in the country should be based on a long-term approach for improved productivity of these crops under rainfed farming conditions rather than on the use of high inputs. The low productivity of pulses is due to the low input conditions associated with the complex socio-economic and agro climatic problems of rainfed agriculture.

- Pulses are important source of proteins for Indian population
- India is the largest producer & consumers of pulses
- Pulses production achieved all time high record of 19.27 million tonnes in 2013-14
- Pulses promote long term sustainability to the Indian agriculture
- Pulses are water saving crops; >92% of the area under pulses is rainfed

Pulses are an important source of protein for the poor as well as for the vegetarians which constitute major population of the country. These pulses mainly include chickpea, pigeonpea, lentil, mungbean, urdbean and fieldpea. The split grains of pulses called *dal* are excellent source of high quality protein, essential amino and fatty acids, fibers, minerals and vitamins. India is the largest producer as well as consumer of pulses, and is the largest importer in the world.

This is because the demand for pulses far outweighs their domestic production. Even a liberal import of pulses has not been able to supplement the widening gap between their demand and supply. The skyrocketing prices of pulses since 2008 can be attributed to almost stagnated production leading to a decline in per capita availability. The yields of pulses are often subjected to moderate to severe losses due to recurrent drought situation under rainfed due to low or erratic rainfall. Presently about 24 to 25 million hectares of land is under pulses producing about 19 million tons annually. Even though about

2-3 million tons need to be imported every year to meet the demand. The yield (around 780 kg a hectare) of pulses is less than the global average and the per capita availability.

Despite soaring prices of pulses, the country would be still far short of the projected demand of nearly 39 million tonnes over the mid of this century. The demand is bound to increase further with a growing population as well as sustained and inclusive economic growth. Besides government's commitment to ensure food and nutritional security for all, these crops are also important in environmental point of view for long-term sustainability of Indian agriculture as a whole.

The Indian Institute of Pulses Research, Kanpur came up with two broad objectives; ensuring self-sufficiency in the pulse production, nutritional security of the country, and promoting long-term sustainability of the Indian agriculture through inclusion of pulses in various cropping systems.

Highlights of signal achievements of XI Plan

- Achieved all time high record of 19.78 million tonnes of pulses production in the country during 2013-14
- Developed 82 improved varieties of 6 major pulse crops
- Whole genome sequencing of pigeonpea & chickpea was accomplished
- Sixty donors were identified for various morpho-physiological traits, plant types & biotic stress resistance, 13 unique germplasm lines were registered with NBPGR
- Two extra early maturing genotypes of mungbean (IPM 205-7 and IPM 409-4) maturing in less than 52 days were developed
- Identified resource conservation techniques in pulses viz., raised bed planting, drip irrigation and mulching to minimize water loss and enhance water productivity
- Ten heat tolerant genotypes of chickpea were identified
- About 85,000 q breeder seed produced in different pulses during the plan
- Developed & popularized functional participatory seed production model of pulses

The Institute conducts multidisciplinary research of basic, strategic and applied nature under six specialized divisions namely, Crop Improvement, Crop Production, Crop Protection, Plant Biotechnology, Basic and Social Sciences. The Institute is also the headquarters of the All India Coordinated Research Projects on Chickpea, Pigeonpea and MULLaRP (Mungbean, Urdbean, Lentil, Lathyrus, Rajmash and pea) Since its inception as an Institute in the year 1993, numerous significant contributions have been made through its effective R &D activities along with its partner institutes across the country.

The achievements made during XI plan led to increase the production from 14 million tonnes to about 18 million tonnes and it has reached to an all time high production of 19.78 million tonnes in

2013-14. This increase is phenomenal and unprecedented as compared to any plan period. During XI Plan, the major research achievements include development of 82 improved varieties by IIPR as well as its partner institutes, production technologies like raised bed planting, residue management, minimum tillage, use of pre-emergence herbicides, efficient biocontrol measures, *etc*. Efforts were also made for developing national research infrastructure like containment facility for transgenics, phenotyping facility for drought and temperature extremities, laboratories for genomics, molecular breeding, molecular diagnostics of pathogens and seed quality and strong training infrastructure.

Achievements of XI Plan

During the XI Plan period, significant improvement in production and productivity of total pulses has been observed in Jharkhand, Gujarat and Andhra Pradesh. In chickpea, there was a positive growth in area, production and productivity in Andhra Pradesh, Gujarat, and Maharashtra. Production of pigeonpea was enhanced by about 2.53 lakh tonnes in Karnataka, 1.26 lakh tonnes in Gujarat and 1.13 lakh tonnes in Andhra Pradesh. Significant area expansion of pigeonpea by 1.13 lakh ha was noticed in Karnataka, and 0.74 lakh ha in Andhra Pradesh. With the development of short-duration varieties, there was expansion of mungbean in summer season under rice-wheat system in north India. There was a significant increase in area and production of peas in Uttar Pradesh (1.17 lakh ha and 1.8 lakh tonnes). Development and adoption of appropriate varieties led to increase in area, production and yield of lentil in Jharkhand and Rajasthan. A large number of region-specific and widely adapted high yielding varieties of pulses with tolerance to biotic and abiotic stresses have been developed. The whole genome sequencing of pigeonpea and chickpea has widened the scope of targeting loci controlling complex traits such as stress tolerance and yield and nutritional quality improvement paving the way for development of varieties with desired attributes. Bio-intensification of pulse-based cropping systems and resource conservation agrotechniques have been developed. New niches like rice-fallows have been explored with suitable agrotechniques for expansion of pulses. Race specific donors enabled development of multiple-disease resistance in pulses. Under national food security mission and with an active collaboration of ICRISAT, heat tolerant chickpea variety JG 14 has been popularized and widely adopted by farmers. Transgenic development against pod borer in chickpea and pigeonpea is underway. Efficient extension models like pulse-seed-village have been implemented for dissemination of pulse-based technologies for farmers to make the pulse cultivation in the country productive and remunerative.

Vision 2020 envisioned an increase in the production of pulses in the country to minimize the import by strengthening its farmers-oriented R&D activities. During 2013-14, the production of pulses in India, estimated at 19.78 million tonnes, was an all-time record. Among major pulses, chickpea (9.52 million tonnes) recorded all time higher production while pigeonpea (3.17 million tonnes), mungbean (1.60 million tonnes) urdbean (1.70 million tonnes) and lentil (1.13 million tonnes) maintained their production status with little fluctuations. This could be possible primarily due to availability of quality seeds to pulse growers. ICAR has made sincere efforts in producing required quantity of breeder seeds of major pulse crops. During 2011-12, ICAR and State Agricultural Universities together produced 15809 q breeder seed of all pulses which is also all time high and it was subsequently converted into certified seed and made available to farmers. During 2012-13 the country produced 15322 q breeder seed. Apart from availability of quality seeds of high yielding varieties, the strong technology back-up, favourable monsoon, increase in minimum support prices and effective government programmes helped in increasing production of pulses in the country. Six thousand demonstrations were also conducted on farmers' fields to demonstrate the potential of available technologies which provided enough confidence on the existing technologies to farmers, extension workers, state agencies and planners. The Government of India has also launched a massive programme on 60,000 pulses and oilseeds villages. This also encouraged farmers to grow more pulses. Success story of summer mungbean has been well documented and appreciated at various levels. Pulses remained in the main focus in the XI plan period while increasing minimum support price (MSP) by Government declaration.

In order to ensure self sufficiency, the pulse requirement in the country is projected at 39 million tonnes by the year 2050 which necessitates an annual growth rate of 2.14%. This requires a paradigm shift in research, technology generation, dissemination, and commercialization along with capacity building in frontier areas of research. Keeping this in mind, the Institute has developed Vision 2050, a perspective plan for augmenting pulses production in the country through technological interventions. The major R & D issues identified for pulses are low genetic yield potential, poor and unstable yield, huge post-harvest losses to the extent of about 20% including

> To ensure self sufficiency, the projected demand of pulses is 39 million tonnes by 2050 which necessitates an annual growth rate of 2.14%

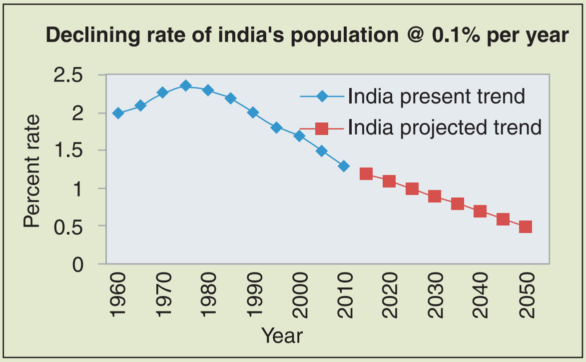
milling and storage pests, inadequate adoption of improved technologies and low profitability which need to be tackled through integration of conventional approaches with cutting edge technologies such as genomics, molecular marker assisted breeding, transgenics, molecular approaches for stress management, high input use efficiency, quality improvement, biofortification, resource conservation technologies, value addition and food safety. Exploitation of heterosis and yield genes from wild relatives has also been identified as a promising avenue for breaking yield plateau.

To meet the projected requirement, the productivity needs to uplift at about 1200 kg per ha and about 3 to 5 million ha additional area has to be brought under pulses besides drastically reducing the post-harvest losses. With dramatic changes in global agricultural scenario on account of implementation of WTO and IPR, pulses have to play a far greater role in providing overall prosperity to the marginal farmers, which would mean better nutritional security by way of meeting dietary protein requirement, improvement in the production base through conservation of natural resources, and high net returns to farmers though value addition and lowering the cost of production with an eye on export. By 2050, the Institute envisions, **"Ensure self sufficiency in**

Projected demand @52g for 1.69 billion people
(28x1.69)/1.21= 32 mt by 2050

Current Population of India	~ 1.21 billion
Expected population by 2050	~ 1.69 billion
Current per capita availability	37 g/capita/day
ICMR recommendation	52 g/capita/day
Present demand (@52 g./capita/day)	28 mt
Projected demand in 2050	39 mt
32 mt (consumption) + 7 mt PHL*, seeds etc.	@20%

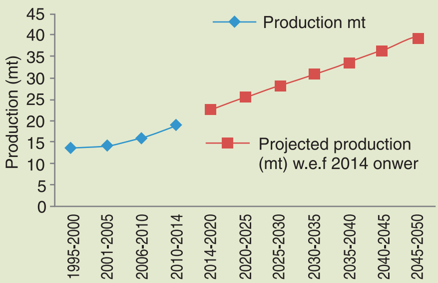
*PHL: Post harvest loss

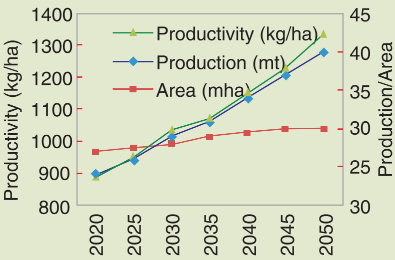


pulse production and improve competitiveness through knowledge based technological interventions for improving nutritional security and sustainability of the production base".

Projections for 2050

To meet projected requirement of 39 million tonnes for 1.69 billion people, an increase of 0.6 mt per annum will be required





Projections for 2050

To meet projected requirement of 39 million tonnes for 1.69 billion people, an increase of 0.6 mt per annum will be required

Potentials areas of pulses under projected expansion plan

S. No.	Potential crop/cropping systems/niche	Specific areas	Potential area (m ha)	Target area (2025) mha	Target area (2050) mha
1.	Intercropping				
	Mungbean with Sugarcane (irrigated) and with Cotton and millets (rainfed uplands)	Western, Central and Eastern U.P., Bihar, Maharashtra, A.P. and T.N.	0.70	0.40	0.60
	Pigeonpea with soybean, sorghum, cotton, millets and groundnut (rainfed upland)	A.P., Malwa Plateau of M.P., Vidarbha of Maharashtra, North Karnataka, T.N.	0.50	0.30	0.50
	Chickpea with barley, mustard, linseed and safflower (rainfed)	South East Rajasthan, Punjab, Haryana, U.P., Bihar, Vidharbha of Maharashtra	0.50	0.20	0.40
	Chickpea/lentil with autumn planted/ratoon sugarcane	Maharashtra, Uttar Pradesh, Bihar	1.00	0.50	0.70
2.	Catch crop: mungbean spring/ summer	Western U.P., Central U.P. Haryana, Punjab, Bihar, WB	1.00	0.70	0.80
3.	Rice fallows				
	Chickpea	Eastern U.P., Bihar, Jharkhand, Orissa, Chattisgarh, W.B.	0.40	0.30	0.35
	Urdbean/mungbean	A.P., Tamil Nadu, Orissa, Karnataka	0.50	0.30	0.40

	Lentil	Eastern U.P., Bihar, West Bengal, Assam, Jhanrkhand	0.30	0.30	0.30
	Lentil/fieldpea	North-East	0.10	0.10	0.10
3.	Kharif fallow	Urd/mung in UP (bundelkhand), M.P.	1.2 0	0.40	0.60
	Total		6.20	3.50	4.75

Challenges

India has high population pressure on land and other resources to meet its food and development needs. Consequently, the natural resource base of land, water and bio-diversity is under severe pressure. Challenges ahead for meeting food demands are formidable considering the non-availability of favourable factors of growth, fast declining factor productivity in major cropping systems and rapidly shrinking resource base. There is a need for second green revolution that is more broad-based, more inclusive and more sustainable; and there is need to produce more without depleting our natural resources any further. Rainfed agriculture contribute more than 80% of the pulses , oilseeds and substantial part of horticulture and animal husbandry products which plays a very important role in our economy, contributing about 60% of the cropped area and 45% of total agricultural produce. The second green revolution must therefore explicitly embrace dry land farming. Though many new technologies have been developed for our rainfed regions, yield gaps continue to be very large and not enough is being done to identify the most suitable farming systems and to ensure that they are effectively integrated with our watershed development programmes. Therefore, there is necessity to develop new methods, technologies and knowledge for better soil and water management practices, improved cropping systems and better crop management.

The area that needs immediate attention is the management of water, which is going to be probably the scarcest factor in the twenty-first century. Our irrigation efficiency is estimated to be around 30% which needs to be raised to at least 50%. This could contribute significantly in increasing agricultural production. Resource conservation technologies that improve input use efficiency, and conserve and protect our natural resources need to be promoted aggressively.

Climate change has emerged as a major challenge to our agriculture. The immediate problems relate to intra-seasonal variability of rainfall, extreme events and unseasonal rains. These aberrations cause heavy crop losses every year. Therefore, there is an urgent need to evolve climate-resilient crop varieties, cropping patterns and management practices. ICAR has implemented a major scheme, National Initiative on Climate Resilient Agriculture (NICRA) and has set up the state-of-the art

National Institute on Abiotic stress Management. The National Mission for Sustainable Agriculture, which is one of the eight missions under our National Action Plan on climate change, also seeks to devise appropriate adaptation and mitigation strategies for ensuring food security, enhancing livelihood opportunities and contributing to economic stability at the national level.

Sustainability of Indian agriculture system as a whole in long run is a major concern due to consistent reduction in the soil fertility and loss of essential soil nutrients on account of exhaustive cropping systems being followed after green revolution. The green revolution in fact pushed pulses and other crops to harsher rainfed environments which led to their poor productivity, besides leading to an imbalance in soil micronutrients. A balanced approach including judicious use of natural resources, protecting soil microflora and lesser application of chemical pesticides and fertilizer are needed to sustain the ecosystem. Pulses improve soil health by enriching nitrogen status, long-term fertility and sustainability of the cropping systems. Therefore, their inclusion in cereal-based cropping systems contributes to soil fertility by enriching organic nitrogen, reducing the demand of chemical fertilizers, enhancing soil microflora as well as supplement protein diet for large population of the country suffering from protein malnutrition or “hidden hunger”. Though substantial progress has been made in evolving techniques to obtain high yields of pulses, their production has stagnated for the last several decades, primarily due to the number of biotic and abiotic constraints under rainfed environments.

In the face of shrinking natural resources and high population growths, enhancing production of pulses is now a major concern for the nation. The current shortfall in pulse availability in the nation is mainly due to less seed replacement rate of improved varieties, poor adoption of improved technologies by the farmers, abrupt climatic changes, complex disease-pest syndrome, and emergence of new biotypes and races of key pests and pathogens and declining total factor productivity. There are no coping mechanisms for rainfall variability. Therefore, reduction in yield as a result of climate change are predicted to be more pronounced for rainfed pulses, especially those cultivated in areas frequently prone to drought. When drought and high temperature interact together, the damaging effect of both the stresses is far more severe than individual effect. India is highly vulnerable to climate change. Intergovernmental Panel on Climate Change (IPCC) projected rise of temperature by 2-3 degrees by 2050 over current levels. The predicted changes in temperature and their associated impacts on water availability, pests, diseases, and extreme weather events are likely to affect substantially the potential of pulse production.

IIPR's Envision R&D to Address the Challenges Through Following Efforts

- Exploitation of germplasm resources including wild accessions for breaking yield barriers
- Transgenic technology to boost production and nutritional quality
- Expansion of pulses in new niches with short duration climate resilient cultivars
- Development of in situ soil moisture conservation & water management using mic-ro-irrigation
- Development of resource conservation techniques
- Development of eco-friendly bio-pesticides/fungicides for control of emerging pests & diseases.
- Aggressive technology demonstration in farmers' fields, linking farmers with profitable markets
- Promotion of value added products & export of pulses like large seeded lentil & kabuli chickpea
- Post harvest management and value addition

Resource Base to Achieve Vision 2050

Considering further limited expansion of cultivated area, the future high demand of pulses must come from increase in yield. Therefore adaptive research and technology assessment, refinement and transfer capabilities of the country need to be strengthened so that the existing technology transfer gaps are bridged. For this, an appropriate network of extension service needs to be created for flowing information between farmers, extension workers, and scientists to promote generation, adoption, and evaluation of location-specific technologies. Ample scope exists for increasing genetic yield potential. Besides maintenance breeding, greater effort should be made towards developing hybrids and

Strength for Effective R&D

- Availability of genetic resources including wild accessions for gene mining to develop biotic and abiotic stress resistant genotypes
- Availability of ample genomic resources
- Well trained scientific manpower
- Well developed experimental farms and state-of-the-art laboratories
- Involvement of international institutions like ICRISAT and ICARDA to develop better technological solutions to make pulse crops more remunerative to farmers.
- National and international linkages

varieties suitable for export purposes. Research on crop management and production aspects need to be intensified to address location specific problems as factor productivity growth is decelerating in major production regimes. Research on pulses must achieve a production breakthrough.

Attention should be given to balanced use of nutrients. Phosphorus deficiency is now the most widespread soil fertility problem. Correcting the distortion in relative prices of primary fertilizers could help correct the imbalances in the use of primary plant nutrients -nitrogen, phosphorus, and potash and use of bio-fertilizers. To improve efficiency of fertilizer use, focus has to be laid upon enhancing location-specific research on efficient fertilizer practices such as balanced use of nutrients, correct timing and placement of fertilizers , use of micronutrient and soil amendments, improvement in soil testing services, development of improved fertilizer supply and distribution systems and development of physical and institutional infrastructure.

All the efforts need to be concentrated on accelerating growth in total factor productivity (TFP), whilst conserving natural resources and promoting ecological integrity of agricultural system. More than half of the required growth in yield to meet the target of demand must be met from research efforts by developing location specific and low input use technologies where the current yields are below the required national average yield.

Literacy has a positive and significant relation with crop productivity and a strong link exists between literacy and farm modernisation. As future agriculture will increasingly be technology-driven and will require modern economic management, high return on education investment is expected. Creating infrastructure in less developed areas, better management of infrastructure and introduction of new technologies can further enhance resource productivity and TFP. Generation and effective assessment and diffusion of packages of appropriate technologies involving system and programme based approach, participatory mechanisms, greater congruency between productivity and sustainability through integrated pest management and integrated soil-water-irrigation-nutrient management should be aggressively promoted to bridge the yield gaps in most pulse crops. Besides this, efforts must be in place to defend the gains and to make new gains particularly through the congruence of gene revolution, informatics revolution, management revolution and eco-technology. Developing location specific technologies and strategy to make grey areas green by adopting three-pronged approach - watershed management, hybrid technology and small farm mechanisation will accelerate growth in TFP. It is necessary to enlarge the efforts for promoting available dry land technologies. Promoting efficient fertiliser practices, improving soil-testing services, strengthening distribution channel of critical inputs specially quality seed and development of physical and institutional infrastructure will help resource-poor farmers. To meet the demand for pulses greater emphasis is needed in almost all the states with particular focus on Madhya Pradesh, Maharashtra, Rajasthan, Gujarat, Andhra Pradesh, Karnataka and Uttar Pradesh which have three-fourths of total pulse area. The target growth in pulse yield from these states annually must be 6 per cent; otherwise the nation will experience shortage of pulses for all times to come. The task of attaining self sufficient in pulses production looks difficult without area expansion and irrigation.

India requires producing more and more food grains particularly pulses from less and less land and water resources. Agriculture is the biggest user of water, accounting for about 80 percent of the water withdrawals. Alarming rates of ground water depletion and serious environmental and social problems with some of the major irrigation projects are there on one hand, while multiple benefits of irrigation water in enhancing production and productivity, food security, poverty alleviation, are well known. In India, water availability per capita was over 5000 cubic metres (m^3) per annum in 1950. It now stands at around 2000 m^3 and is projected to decline to 1500 m^3 by 2025. Further, the deteriorating quality of available water is also a matter of concern. Policy reforms are needed to establish secure water rights to user, decentralization and privatization of water resources, pricing reforms, and the introduction of appropriate water saving technologies. It is necessary that an integrated water use policy is formulated and judiciously implemented. India should critically examine these initiatives and develop its country specific system for judicious and integrated use and management of water.

Resource-poor farmers in the rainfed ecosystems practice less-intensive agriculture, and since their incomes depend on local agriculture, they benefit little from increased food production in irrigated areas. Efforts must be increased at local level to disseminate available dryland technologies and to generate new ones. Necessary impetus should be given on enhancing the efforts for promoting available dryland technologies, as well as increasing the stock of knowledge on newer technologies.

Farming system research to develop location-specific technologies must be intensified in the rainfed areas. To combat ever increasing demand for food and agricultural production and shrinking natural resources, agricultural intensification is the way for future growth of agriculture in the region. Attention should be high on post-harvest handling, agro-processing and value addition technologies not only to reduce the heavy post-harvest losses but also to improve quality through proper storage, packaging, handling and transport. The role of biotechnology in post-harvest management and value addition deserves to be enhanced. IIPR envisions no post harvest losses in pulses by the year 2050.

In the current scenario of globalization and increasing competitiveness, post harvest management and value addition approach will improve the agricultural export contribution of India, which is proportionately quite low. Cost-effectiveness in production and post harvest handling through the application of latest technologies will be a necessity. The agro-processing facilities should preferably be located in the vicinity of production in rural areas, which will greatly promote off-farm employment. Such post harvest processing and value addition centres will encourage production by masses against mass production in factories located in urban areas. Agricultural cooperatives and Gram Panchayats must play a leading role in this effort. In doing so, the needs of small farmers should be kept in mind.

Private investment in agriculture has also been slow and must be stimulated through appropriate policies. Considering that nearly 70 per cent of India still lives in villages, agricultural growth will continue to be the engine of broad based economic growth and development as well as of natural resource conservation, leave alone food security and poverty alleviation. Accelerated investments are needed to facilitate agricultural and rural development. Linking industries with pulses sector is the need of the hour and will be an instrumental tool in pre- and post harvest handling of pulses, increasing their economic value and ensure more returns to the farmers.

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Operating Environment

Vast uncommon opportunities to harness agricultural potential still remain untouched, which can be tapped to achieve future targets. There are serious gaps both in yield potential and technology transfer as the national average yields of most of the commodities are low, which if addressed properly could be harnessed. Pulses, are not part of Public Distribution System (PDS) in the country. Price volatility of pulses adversely affects to poor people. Average economic growth of 6% in the past 10 years alone has led to a change in food habits of middle class Indians. Now, instead of relying only on rice and wheat, the middle class Indians are diversifying their food habits including those of consumption of more pulses and pulse products. This has also affected the availability of pulses for the poor.

With the high growth rate of the economy and rising incomes, demand for food has increased over time. Per capita food availability has grown only 1% over the last decade, while per capita income surged by 5.5%. This has resulted in a mismatch between supply and demand for food that has caused an increase in the prices. As far as pulses are concerned, their productivity increased by only 45% between 1951 and 2008 while the area under pulse production has grown by only 25%, which is lower than any other food grain. Per capita availability of pulses has decreased from 60g/day in 1970-71 to 36g/day in 2007-08. About 30% of farm produce is wasted every year for want of storage, transportation, cold chain and other infrastructure facilities. There are new technologies which can help enhance the yield of pulses by 200 to 300 percent. There is a great scope to produce pulses in the rainfed areas using resource conservation and water harvesting techniques. Providing incentives for growing pulses are also one option. Nitrogen credits to farmers as well as tie-ups with research institutes for better technology will encourage the cultivation of pulses. Introduction of improved varieties that can enhance

- Pulses are currently not part of Public Distribution System (PDS)
- Price volatility adversely affects their annual balanced intake by poor people
- Raising MSP, ensuring procurement & providing incentives to boost production
- Govt. is also spending Rs.837.03 crore on pulses development, increasing allocation 8X in four years.
- The rise in allocation would increase investment in pulses.

productivity will ensure availability of pulses to a larger population at an affordable price.

India has made impressive strides on the agricultural front during the last three decades. Much of the credit for this success should go to the several million small farming families that form the backbone of Indian agriculture and economy. Policy support, production strategies, public investment in infrastructure, research and extension have significantly helped to increase food production and its availability. Interestingly, all increase in the production resulted from yield gains rather than expansion of cultivated area. Availability of food grains per person increased from 452 gm/capita/day to over 476 gm/capita/day, even as the country's population almost doubled, swelling from 548 million to nearly 1000 million. Under the assumption of 3.5% growth in per capita GDP (assuming the income growth at lower side), demand for food grains (including feed, seed, wastage and export) in the year 2050, is projected at the level of 918 mt comprising 243 mt of cereals and 39 mt of pulses. To meet this projected demand, country must attain per hectare yield of 1.2 tonnes in pulses.

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Opportunities

The genetic engineering are expected to play important role in the generation of high yielding, pest and stress resistant varieties of pulse crops. Free and unhindered access of germplasm to breeders worldwide is absolutely crucial to the rapid dissemination and adoption of improved germplasm. This free movement and the dissemination of modern biotechnology innovations to developing countries are hampered by increased protection through patents and private sector investments. There is an urgent need to address this problem of free access to technology in the future.

Increased attention will also have to be given to development of sustainable systems that protect the natural resource base. Recent evidence of resource degradation and declining productivity in some intensively cropped areas is of particular concern. Also population driven intensification of agriculture without the use of external inputs, is leading to a serious problem of decline in soil fertility.

Sustaining global food supplies will depend on continued high levels of investments in research and technology development. It is essential that research capacity has to be increased substantially. In addition to investment in research, investment in infrastructure development, particularly in irrigation, transport and marketing facilities are equally important for sustaining the productivity and profitability of food crops' production. Mobilization of developmental efforts through partnerships involving national and international research institutions, NGOs, farmers' organizations and private sector is essential in order to tackle the problems of food security. Donors and Government must urgently increase funding for agricultural research targeted at the needs of the rural and urban poor, and every effort must be made to ensure the free flow of information, technology and germplasm so that a proper sustainable agriculture can be achieved.

Uncommon Opportunities

- Harnessing vast untapped potential of our soil, water resources & farming systems.
- Technology revolution especially in the areas of molecular biology, biotechnology, space technology, ecology and management.
- Revolution in communication & information technology and
- Linking farmers, extension workers & scientists with national & international databases
- Contract farming and cheap imports

There is higher concentration of poor and hungry people in rainfed areas as compared with those in irrigated zones. Even with 20 percent increase of the irrigation intensity, there is a sharp fall in the proportion of hunger and poverty and it remains there irrespective of further intensification of irrigation. Evidences suggest that extensive irrigation will prove much more effective than adding more and more water, and often wasting it along with the associated degradation of the natural resources. Such a policy will not only reduce poverty and hunger, but will also promote equity and environmental protection and natural resource conservation. An effective water policy and institutional support is needed to ensure judicious and equitable allocation, distribution and exploitation of water and water resources.

Contributions of small and marginal farmers in securing food for ever growing population have increased considerably even though they are most insecure and vulnerable group in the society. The off-farm and non-farm employment opportunities to this group of farmers can play an important role. Knowledge and skill development of rural people both in agriculture and non-agriculture sectors is essential for achieving economic and social goals. A careful balance will therefore be needed to be maintained between the agricultural and non-agricultural employment and farm and non-farm economy, as the two sectors are closely inter-connected.

Raising agricultural productivity requires continuing investments in human resource development, agricultural research and development, improved information and extension, market, roads and related infrastructure development, efficient small-scale, farmer-controlled irrigation technologies, and custom hiring services for costlier mechanical inputs. Such investments would give small farmers the options and flexibility to adjust and respond to market conditions.

Improved agricultural technology, irrigation, livestock sector and literacy will be most important instruments for improving the nutritional security of the farm-households. Watershed development and water conservation techniques will have far reaching implications in increasing agricultural production in the rainfed areas. Need based and location-specific community programs, which promise to raise nutritional security, should be identified and effectively implemented. Development of the post-harvest sector, co-operatives, roads, education, and research and development should be an investment priority.. Small-mechanised tools, which minimise drudgery but do not reduce employment and add value to the working hours, are needed to enhance labour productivity. Special safety nets should be designed and implemented for them. There is need to disseminate widely post-harvest handling and agro-processing and value addition technologies not only to reduce the heavy post-harvest losses but also improve quality through proper storage, packaging, handling and transport.

The globalization of agricultural trade will bring new opportunities for employment and income generation; productivity gains and increased flow of investments into sustainable agriculture and rural development. The liberalization of agricultural markets will be beneficial to developing countries in the long run; it will promote the adoption of new technologies, shift production functions upwards and attract new capital into the deprived sector.

New Technologies

GMO technology enables transfer of traits beyond species, genus and even Kingdoms. Traits like climate resilience, resistance to insect pest and diseases, herbicide tolerance, post harvest losses, reduction of oligo-saccharide content, bio fortification with essential amino acids and reduction of anti-nutritional factors (like *phytase*) are to mention a few. Multi-stacked traits including several traits shall have to be developed. Strategies based on RNA (RNAi, Ribozyme, lnRNA *etc*.) and proteins are also likely to play an important role in the future.

Chromosome Engineering

Recent innovations in chromosome engineering include creation of synthetic chromosomes comprising of all desired traits that can behave normally in mitosis and meiosis. Success in production of homozygous lines by altering the *kinetochore* protein, CENH3 for haploid production in pulses shall open up reverse breeding avenues in pulses. Novel homologous recombination methods will also potentiate many chromosome engineering applications in the future.

Genome Editing

The development of efficient and reliable ways to make precise, targeted changes to the genome shall a go a long way in genetic improvement of pulses. Tools like CRISPR/Cas9, TALEN, Zinc Finger can be engineered for gene addition or deletion in the genome leading to 'knock out' or 'knock in' trait like removal of anti nutritional factors (like BOAA pathway genes in *lathyrus*), enhanced disease resistance in pulses against fungus, bacteria and viruses.

Gene Management

With the unveiling of genome sequence of pulses and re-sequencing genotypes, gene catalogues shall be available correlating to trait for breeding programmes. Integration of transcriptomic, proteomic, ionomic, metabolomic data unified into single platform shall leverage the genetic enhancement of pulses. With the advances in *omics* technology, complete bio molecule profile (DNA, RNA, proteins, metabolites etc) shall be available as compendium for researchers. Hence, manipulation of traits governed by major or minor genes and effects thereof can be easily identified, leading to selective manipulation.

Tinkering BNF

Molecular study of root symbiotic nitrogen fixation and their role in pathogenesis signalling pathways- this knowledge can be used to make a *rhizobial* strain that can resist pathogen infection by expressing certain anti-fungal proteins.

Rhizosphere Engineering

The information and communication exchange in rhizosphere zone is vital for water and nutrient absorption, interaction with beneficial microorganism and biotic and abiotic stresses. Plants have evolved the mechanism to modify the rhizosphere to reduce the impact of these environmental stresses. Understanding these mechanism and finding ways to improve plant health is need of the hour for achieving higher productivity. This can be achieved through the concept called "rhizosphere engineering". The rhizosphere can be modified by selection of suitable crop species and varieties which release root exudates (rhizodeposition), enrichment by introduction of beneficial microorganism like bio control agents and PGPRs etc., bio degradable bio stimulants and transgenic plants. Global research on this area is going on and scientists have got success in developing technology on some aspects and on other aspects research effort is being continued. Rhizosphere engineering will ultimately reduce our dependence on chemicals and help us in achieving sustainable soil health.

New Opportunities

- Intragenesis and Cisgenesis
- Transgenics for quality traits viz., high sulphur containing amino acids
- Exploiting cyberspace and nanotechnology
- Focused identification of germplasm sources (FIGS)
- Biofortification and neutraceuticals
- Nanotechnology for efficient chemical delivery, seed viability and vigour

Resource Use Efficiency

Resource use efficiency in agricultural production has been a major concern in India. Due to decrease in resources (land and water) and increasing demand by other sectors limit the availability of resources for agriculture and that too for pulse crops. Thus, any decrease in marginal returns as predicted by the law of diminishing returns is more or less compensated by the benefits of other technological changes. Therefore, development of resource use efficient genotypes, precisely irrigation water and fertilizer delivery system, slow release fertilizers, integration of bio-fertilizers with other fertilizer sources, pulse based cropping systems including intercropping and other resource conservation agronomic practices may help to utilize available resources to the maximum possible level. While developing resource efficient technology due consideration may be given for "eco-efficient" agriculture.

Designer Seeds

Advantages of seed priming are known since long under rainfed agriculture. Early vigour and yield advantages in pulses are clearly depicted by many researchers. Designer seed concept is one step ahead of seed priming in which seeds are soaked with multi-micronutrients solutions followed by seed coating with bio-fertlizers and PGPR. Further, a hygroscopic material may be used for final coating of seeds which may help to utilize limited soil moisture to a best possible extent for early plant growth and establishment under rainfed ecosystem.

Exploiting Cyberspace

Information technology will underpin future progress and prosperity. Efforts must be made to strengthen the informatics in agriculture by developing databases, linking databases with international databases and adding value to information to facilitate decision making at various levels. Development of production models for various agro ecological regimes to forecast the production potential should assume greater importance. Using the remote sensing and GIS technologies, natural and other agricultural resource should be mapped at micro and macro levels and effectively used for land and water use planning as well as agricultural forecasting, market intelligence and e-business, contingency planning and prediction of disease and pest incidences.

India could learn from the best practices being adopted by other countries in respect to efficient use of resources. For example, Brazil and Argentina are increasing the yield of pulses by innovations in technologies and practices, using their world-class research and development facilities.

The two countries practice no-till cultivation in over 75% of the land under crops for better conservation of moisture and organic matter, prevention of soil degradation and erosion, increase in productivity and decrease in expenditure, making their agriculture sustainable. Brazil has the largest surplus arable land in the world. At the same time, Argentina is a global leader in agricultural process outsourcing and is also a pioneer in the system of Silobag storage of grains. Given the growing demand in India and the challenges faced by our agriculture sector such as depletion of ground water, loss of agricultural land to industrial, residential and commercial use and uncertainties due to the vagaries of monsoon, it would be useful for India to keep track of the agriculture of Brazil and Argentina which complement Indian market. The suggestions are put forth to outsource production to other countries without comprehending socio-economic and political implications. In order to meet the domestic demand, Indian companies can be encouraged to buy land in countries like Canada, Myanmar, Australia and Argentina for growing pulses under long-term supply contracts to Indian agencies. Cultivating pulses abroad and then shipping them back to India is one such idea. The boosting domestic production of pulses could be one approach to make farming more profitable.

Higher prices have to be backed up by creating an environment for the farmers to invest in pulses. IIPR Kanpur along with other research centres has already developed more than 400 improved varieties of pulses. Even then, production of pulses hasn't increased much. It must be realized that even after the heady days of Green Revolution, the production of wheat and rice, the two most important staples, went up not only because of the high-yielding varieties but also because the policy makers had put together two-planks of what is called a 'famine-avoidance' strategy. This strategy is also required to be adopted in pulses, with higher yields, production is expected to go up.

Besides research for vertical growth in pulses, we need to address the issues relating to farmers' preference for the competing crops through development and promotion of crop production and crop protection technologies. Under National Food Security Mission, these aspects have been taken up for more aggressive promotion of available technologies under Accelerated Pulses Production Program to ensure that the farmers are able to harvest better crops. The Government significantly increased the Minimum Support Price of the pulses and strengthened pulses procurement mechanism by designating additional central agencies to support the farmers. In fact, the minimum support price has been doubled in last three years with quantum jump given this year with an increase of more than 50%.

Our import policies are linked to our ability for better crop forecasts and the principle of balancing the farmer's interest in a manner that the prices are not distorted and the Indian farmer continues to get a good return for their produce. We are in the process of evolving a mechanism to work out regular tenders on import of pulses through the State Agencies. This will hopefully help in better planning and management of supply chain. On the technology front, we have been collaborating with international research organizations like ICRISAT and ICARDA to develop better technological solutions to make pulses more productive to the farmers.

Keeping in view the constraints for horizontal increase in area under pulse in India, leasing land abroad for growing pulses and bring the produce back to India is an innovative idea and these efforts need to be supported. With better yields, development of biotic and abiotic stress resistant varieties, increased backup of MSP and exchange of knowledge, the Indian farmer will definitely take to pulses with increased acreage and ease the supply side constraint which the country faces at present. India has high population pressure on land and other resources to meet its food and development needs. The natural resource base of land, water and bio-diversity is under severe pressure. Food demand challenges ahead are formidable considering the non-availability of favourable factors of past growth, fast declining factor productivity in major cropping systems and rapidly shrinking resource base. Vast uncommon opportunities to harness agricultural potential still remain, which can be tapped to achieve future targets. The gaps between potential yield and realized yield of pulses varieties are high which need to be plugged. This could be achieved through technology transfer.

Rainfed dry areas having maximum concentration of resource poor farmers remained largely ignored, aggravating problems of inequity and regional imbalances. This also led to a high concentration of malnourished people in these low productive areas. This era also witnessed rapid loss of soil nutrients, agro-biodiversity including indigenous. In addressing the above issues, a policy statement on agriculture must take note of the following uncommon opportunities:

- Conservation of natural resources and protection of environment.
- Opportunities to harness vast untapped potential of soil and water resources and farming systems
- Technology revolution in the areas of molecular biology, biotechnology, space technology, ecology and management.
- Revolution in communication and information technology and
- Opportunity of linking farmers, extension workers and scientists with the national and international databases ❑

Goals and Targets

Pulses are grown under diverse agro-ecological regions with varying degree of biotic and abiotic constraints. Therefore, the technology should be tailored according to the needs of specific region. To meet the projected requirement of 39 million tons of pulses, the productivity needs to be raised to about 1200 kg per ha and about 4.0-5.0 million ha additional area has to be brought under pulses. Keeping in view the projected demand of pulses by 2050, the IIPR has proposed few flagship projects as follows

- Development of pod borer resistant transgenic pigeonpea and chickpea
- Development of cytoplasmic genetic male sterility (CGMS) based hybrids for enhancement of productivity and stability of yield in pigeonpea.
- Integrated approach for genetic enhancement through pre-breeding
- Basic and Strategic research on Pulses in Rice Fallows.
- IPM for major pulse crops.

Under globalization and increasing competitiveness, post harvest management & value addition will improve agricultural export of the country

- Post-harvest handling, agro-processing & value addition technologies
- Reducing heavy post-harvest losses
- Quality improvement through storage, packaging, handling & transport.
- Research in post-harvest management & value addition

Constraint Analysis for Pulse Production in the Country

- **Decline in Area of Pulses in Indo-Gangetic plains (IGP)**

The Indo-Gangetic plain which used to be the major areas of pulses are now witnessing reduced area under pulse cultivation due to following reasons:

- Creation of extensive irrigation network, leading to cultivation of cereals and cash crops
- Epidemics of *Ascochyta* blight in chickpea
- Incentive for rice-wheat production
- Less economic viability of pulses than cereals

- **Low Genetic Yield Potential**

The harvest index in pulses is relatively low due to following reasons: Narrow genetic base, inefficient plant types, little scope of heterosis breeding due to self-pollinating nature, genetic erosion and linkage drag

- **Low Realized Yield**

Pulses are consistently being grown in harsher environments and resource limited conditions on account of comparatively low farmer's preference and less remuneration than the cereals. The major points explaining low realized yield are as follows:

  - Relegation of pulses from high productivity zone to low productivity zone
  - Largely grown in rainfed areas (87%)
  - Poor crop management

- **Instability in Production**

Variation in pulses production and productivity over the years indicated the large instability of the production system and the major reasons are outlined below:

  - Highly sensitive to environmental fluctuations
  - Being rainfed crop, pulses experience drought at critical growth stages
  - Highly sensitive to abiotic stresses (temperature extremities, excessive moisture & salinity)
  - Vulnerable to a large number of diseases and emergence of new races of pathogens
  - Prone to attack by insect-pests.
  - Unpredictable nature of host-pest relationship due to dynamic changes in the pest behavior under changing climates

- **Climate Change Risk**

Manifestations of climate change affecting production of pulses are:

  - High night temperature adversely affects productivity of winter pulses
  - Drought appears in more intense form as a result of high temperature interaction
  - Unpredictable weather condition coupled with temperature extremities (both high and low) adversely affects reproductive physiology and grain filling in pods
  - Expected changes in the native flora of rhizobium and other useful microbes due to ecological imbalances'.

- **Poor Seed Replacement**

Availability of good quality seeds and high seed replacement rate form the basis of higher productivity. Unfortunately, poor seed replacement rate in pulses is one of the major issues related to low yield. The factors influencing seed replacement rate are mentioned below:

  - Non-conversion of breeder seed to certified seeds
  - Less preference to pulse seed production by central and state seed corporations
  - Lesser participation of private seed companies
  - High volume of some pulse crops (chickpea, fieldpea and rajmash)
  - High storage losses

- **Post Harvest Losses**

About 20 to 30% post harvest losses has been estimated in pulses which remains an issue to be resolved by improving post-harvest machineries. The most important reasons for high amount of post harvest losses in pulses are:

  - Lack of efficient and good quality harvesting and threshing equipments
  - Traditional *dal* mills with low *dal* recovery
  - High infestation with stored grain pests (bruchids)

- **Wide Fluctuation in Prices**

The issues related to wide fluctuation in prices of pulses need to be addressed on priority basis and factors influencing price fluctuation are required to be critically analyzed

  - Unorganized market
  - No policy on assured procurement
  - Poor holding capacity of produce by farmers

- **Poor Availability of Critical Inputs in Productivity Zone**

Presently, poor availability of critical inputs largely influences the productivity of pulses. Among all major critical inputs, seeds are the most demanding input.

  - Seeds, Biofertilizers, Biopesticides (NPV, Trichoderma, NSKE) and Secondary and micro-nutrients

- **Poor Transfer of Technology**

Pulse growers generally belong to poor or marginal farming community and most of the times they do not have access to technologies that are developed in Agricultural Institutes/state Agricultural Universities. Lack of awareness to latest pulse-production technologies is a critical gap leading to low productivity of pulses. The underlying points indicated the reasons behind poor transfer of technology.

- Lack of trained extension personnel and Lack of exposure of farmers to improved technologies
- Poor interface among state departments of agriculture, research organizations and private agencies

The major Research & Development issues & strategies for realizing the Vision 2050 are as follows:

Issue	Strategies
Low genetic yield potential	• Introgression of QTLs for yield and yield contributing traits • Exploitation of heterosis in pigeonpea • Integrated germplasm enhancement approach in all pulses • Prebreeding for broadening the genetic base • Development of physiologically efficient plant types
Low and unstable yield	• Integrated crop management • Development of multiple disease resistant varieties and pyramiding of resistance gene for various races of important diseases • Development of transgenic for resistance to pod borer and tolerance to drought in chickpea and pigeonpea • Development of climate resilient varieties having tolerance to temperature extremities and drought • Development of low cost & eco-friendly biointensive IPM modules • Integrated disease management • Exploitation of PGPR • Integrated drought management • Efficient conservation of rainwater & its utilization • Expansion of pulses in new niches
Huge post harvest losses	• Exploitation of genetic variability for milling characteristics • Development of resistance to stored grain pests • Development of efficient harvesting and threshing equipments • Design and development of efficient *dal* mills • Development of improved technologies for storage
Poor transfer & adoption of improved technology	• Varietal development through farmers' participatory approach • Validation and refinement of technologies through farmers' participation • Development of suitable technology dissemination modules • Development and popularization of Expert Systems
Low profitability and return	• Intensification of conservation agriculture • Development of nutrient and water use efficient genotypes • Mechanization of pulse production • Value addition and by-product utilization • Production of organic pulses • Improvement of nutritional quality through genetic and processing options

Road Map

To bridge the yield gap in pulses, IIPR has envisioned a road map under with two pronged strategy:

- bringing additional area under pulses, and
- increasing productivity

Bringing Additional Area under Pulses

- Diversification of rice-wheat system in Indo-gangetic plains (IGP) through popularization of short duration varieties of pigeonpea, *kabuli* chickpea, fieldpea and summer mungbean
- Bringing additional area under pulses through promoting urdbean/mungbean cultivation in rice fallow in peninsular India and lentil in NEPZ and Chhattisgarh.
- Promotion of pulses in intercropping viz., short duration thermo-insensitive varieties of mungbean/urdbean with spring sugarcane; pre-rabi chickpea with mustard/linseed; pigeonpea with groundnut/soybean/millets, etc.
- Development and popularization of urdbean/mungbean for late planting (mid Aug-early Sept in north India

- **Improving Productivity**
  - Development of saturated linkage maps in major pulses for gene mining, gene cloning and gene mapping
  - Exploitation and utilization of gene-pool from unexplored areas
  - Exploitation of wild relatives for transfer of genes of interest
  - Development of high yielding short duration varieties having multiple and multiracial resistance to diseases
  - Development of new and efficient plant types
  - Development of input use efficient genotypes
  - Exploitation of hybrid vigour in pigeonpea
  - Popularization of improved crop management practices
  - Exploitation of PGPR

- **Improving Yield Stability**
  - Development of transgenic against drought and gram pod borer
  - Gene pyramiding for stable resistance
  - Efficient water management in rainfed areas
  - Rainwater harvesting and recycling through farm ponds and community reservoirs
  - Promoting short duration varieties in drought prone areas
  - Promoting micro irrigation system

- Adoption of moisture conservation practices

- **Development of Resilient Pulse Crops to Climate Adversities**
  - Development of resilient pulse crop varieties to mitigate the impacts of climate change
  - Critical monitoring of diseases and pest dynamics with reference to climate change

- **Production and Supply of Quality Seeds**
  - Active involvement of private sector, NGOs, & farmers' help groups in production of quality seeds
  - Mandatory target to public sector seed corporations
  - Popularization of seed village concept with buyback system
  - More incentive on production of seeds of new varieties
  - Promotion of farmer to farmer exchange of seeds

- **Reducing Post Harvest Losses**
  - Development and popularization of harvesters, threshers and graders
  - Development of stored grain pest resistant varieties
  - Modernization of existing *dal* mills
  - Establishment of processing units in the production zones
  - Development and popularization of low cost safe storage structures

- **Ensuring Attractive Price to Producers**
  - Announcement of MSP well in advance
  - Assured procurement and creation of procurement centres in production zones
  - Popularization of mini *dal* mills at village level
  - Development of organized markets for pulses
  - Linking farmers with markets
  - Promotion of export of pulses like lentil and *kabuli* chickpea
  - Production of value added products and use of by-products

- **Ensuring Timely Availability of Critical Inputs**
  - Advanced forewarning and forecasting systems for pest and disease outbreaks
  - Promotion of IPM technologies against *Helicoverpa*
  - Ensuring timely availability of biopesticides- *Ha*NPV, Trichoderma & herbicides e.g. Pendimethalin

- Seed dressing of fungicides for controlling seed borne diseases
- Providing safe storage structures like Pusa Bin and warehouse facility
- Creation of production units of quality bio-fertilizers and bio-pesticides
- Fortification of fertilizers with specific nutrients like S, Fe, Zn, B etc., in specific regions
- Popularization of sprinklers and micro irrigation techniques in rainfed areas
- Establishment of single window input supply centres for cluster of villages

- **Efficient Transfer of Technology**
  - Organizing farmers training and exposure visits
  - Popularization of improved technology through mass media
  - Close interaction of research organizations, state departments of agriculture and private agencies
  - Market led initiatives for organized village level seed production to exploit the high demand for improved varieties of pulse crops.
  - Exploiting the pulse production as cash crops in unconventional areas like hills, coastal and tribal belts of country.
  - Promotion of farmer led commercial pulse processing units at village level.
  - Promotion of information and communication technologies based pulse knowledge management to increase production and productivity of smallholder farmers.

Strategic Framework

To achieve self sufficiency in pulses, a target of 39 mt has been envisaged by the end of 2050. Keeping in view the availability of land and population growth patterns and technological developments, five-year projections have been made. In every five year interval productivity will have to be enhanced by about 90 kg/ha over the previous one to achieve a final productivity rate of 1200-1300 kg/ha by the end of 2050. Although there is a scope of bringing 6 m ha additional area under pulses, the above-stated projections have been made assuming that practically it will be feasible to increase only 4 mha area under pulses. To achieve the above five yearly targets, the following strategies have been formulated to achieve the targets:

	Goal	Approach	Performance measure
1	Access to diverse genetic material for broadening the genetic base of pulses	Collection & conservation of genetic resources including wild species from diverse agro climates Development of core set of germplasm & identification of trait specific germplasm using FIG strategy Germplasm enhancement through integrated prebreeding approach	Genetic materials with adequate variability for development of new varieties
2	Enhancing genetic potential of yield & quality through conventional breeding approach	Development of high yielding plant types for different agroclimatic zones Breeding for biotic & abiotic stress tolerant including herbicide tolerant genotypes & variety suitable for mechanical harvesting Development of extra large seeded varieties of *kabuli* chickpea and lentil Breeding for improved nutritional quality in pulses including lathyrus	High yielding varieties Varieties with specific traits Large seeded *kabuli* chickpea and lentil Low ODAP lathyrus, High iron & zinc greengram, High protein pulses
3	Breaking yield gap of pulses	Exploitation of hybrid vigour in pigeonpea Genomics enabled improvement: Mapping, tagging & genome sequencing, allele mining and marker assisted selection for biotic and abiotic stress resistance Quality seed production through multiplication of breeder seed, grading, packaging and timely distribution	Hybrid pigeonpea with 30-40% yield superiority Genes identified for rapid selection of breeding lines Production of good quality seeds
4	Improving yield through biotech-nological interventions and molecular tools	Development of transgenic against pod borer in chickpea	Transgenic chickpea and pigeonpea having resistance to pod borer
5	Conservation agriculture for enhancing system productivity & agricultural sustainability	Conservation tillage practices Carbon sequestration potential in pulse production systems Rain water harvesting and recycling for pulse production Technological option to enhance water-use efficiency	Enhanced system productivity & improved soil health Water conservation & judicious use of nutrients for sustainability of production system Conserved soil moisture
6	Nutrient/water management	Application of nano-technology for improving input use efficiency Use of PGPR for enhanced pulse production, enhancing BNF & mitigating drought	Enhanced nutrient/water use efficiency
7	Crop diversification in new niches for increasing total production	Expansion of pulse cultivation and management practices in new niches e.g. rice fallows for increasing total system production Inclusion of short duration pulses such as greengram and blackgram as intercrops	Increased area in blackgram and greengram under rice fallows of Peninsular India Increased area under lentil in rice fallows of eastern India

8.	Farm mechanization, post-harvest management and value addition	Efficient utilization of inputs through precision farming and decision support system Mechanization of pulse production system through farm machineries Improve dal milling efficiency Value addition through developing commercially viable products & by product utilization	Mechanized farming for optimum allocation and allocation of inputs Pulse specific farm machineries and milling to reduce post harvest losses Commercially viable products using pulses
9	Enhancing genetic resources for resistant against major diseases and pests	Identification of resistant donors through mass screening. Development of diagnostic tools & molecular characterization of pathogenic variability Severity assessment of emerging threats of new diseases and pests (fungal, bacterial and viral)	Resistant donors against disease and pests Efficient diagnostic tools for detection of pathogenic variability and predominant races/ strains/pathotype
10	Biointensification of disease and pest management and host-plant interaction	Biointensification of IPM modules for diseases, insect pests and nematodes. Development of semio-chemicals for *Maruca*, pod fly, thrips, and *Mylabris* Host-plant resistance mechanism. Bio-efficacy of specific bio-compounds imparting tolerance to fungal pathogens & pod borer Nano-technology	Eco-friendly Bio-control agents/IPM modules to manage diseases of pulses Modules for specific insects & pests Understanding of the biochemical basis of disease & pest resistance Allelochemicals for controlling fungal pathogens and pod borer
11	Assessment of nutritional and anti-nutritional components, biofortification and improving bioavailability of iron and zinc	Nutritional/anti-nutritional profiling of pulses, varietal screening for quality improvement Identification of biofortified pulse genotypes and biochemical factors controlling bioavailability of Fe and Zinc	Varieties with improved nutritional quality with less anti-nutritional factors Biofortified varieties with higher zinc & iron
12	Improve risk management	Screening and developing climate resilient pulse varieties using physiological tools & multilocation trials Apply remote sensing technology and weather monitoring to characterize climatically vulnerable regions under pulse belts of the country (drought & high temperature) Monitoring disease and pest incidence and dynamics in respect to climate change (database preparation)	Widely adapted genotypes with stable productivity Climate-based projection of impact of temperature rise and drought on productivity Information on changing scenario of diseases & pests & preparedness to manage them accordingly
13	Development of innovative extension models for improving adoption, technology dissemination and assessment of socio-economic constraints	Execution of innovative extension models such as farmers participatory approach, training of Extension personnel, implementing model seed village, technology refinement & demonstrations , for efficient transfer of technologies to the farmers	Large scale adoption of pulses as remunerative crop

14	Assessment of Consumer preference, Marketability, factor controlling price fluctuations , cost-effective pulse cultivation & policy support for stabilizing pulse production	Exploring region specific market survey, consumer preference, factors controlling prices of pulses. Working out cost-benefit ratio of pulse-based cropping systems over cereal-cereal systems Popularization of importance of pulses through media, policy support to increasing MSP	Decision making support system based on market-linked models of pulses consumption pattern Enhanced awareness for pulses as remunerative crop &sustainability of soil health
15	Generation of pulse data base, online information systems and forecasting models for agro-advisory services, ICT and GIS	Development of crop statistical models based on information, AICRP networks, ICT and GIS Development of agro-advisory services based on online Expert system involving disease and pests of major pulses	Information with regards to Genotype x Environment interaction, wider vs. local adaptation, factor analysis of fluctuations of pulses area and productivity Farmer-friendly decision in advance to manage diseases and pests
16	IPR & Human resource development	Developing pulse-based technologies competitive with reference to WTO & IPR regimes Enhanced pulse-based knowledge sharing, teaching training, & skill development.	Patenting of pulse-based information/technology/ machineries Large scale human resources adequately trained with pulse-based knowledge for promoting pulses & self –sufficiency in production

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Way Forward

Moving on from generic issues and looking at the pulse scenario in India, we need to recognize that the domestic supply of pulses is not able to meet the growing demand of our consumers. Availability, price and the dietary preference for specific types of pulses in different parts of the country is largely responsible for this. About 25 million hectares of land is under pulses producing about 19 million tons of annually. We still need to import substantial amount of pulses every year to meet the domestic demand. Our demand outstrips our domestic production because of which we have to resort to imports every year. There is very little surplus available in the world for supply of red gram, black gram and green gram. However, these are the crops that are preferred especially in the Southern and the Central India. It is a challenge for us to ensure supply of these pulses as these crops are primarily taken up for cultivation during monsoon period and are prone to production losses due to moisture stress.

Two major issues have emerged in respect to pulses production in the country. First, the limited genetic potential for high yields and second their vulnerability to pests and diseases. Compared to other food grains crops, yield potential of the pulses has been rather low. Newer varieties of pulses need to be developed so that the crop cycle fits well into cropping systems that the farmers adopt. Another important issue is limited mechanization potential especially for harvesting of the crop. Suitable plant types need to be developed for mechanical harvesting with pods above the canopy and sturdier plants.

Due to the high protein content in pulses, the crop is highly vulnerable to pests and diseases. It is estimated that about 30% of pulses crops is lost on account of pest attacks and diseases every year. Attack by pod borer and pod fly is so severe that the entire standing crop is devastated at several times. Research efforts need to be prioritized in this direction by employing modern biotechnological tools for crops for developing pest resistant varieties of pulses.

Weed is one of the problematic areas for limiting yield both in *kharif* and *rabi* pulses. Manual weeding appears to be difficult in future to manage this weed menace, therefore development of herbicide tolerant pulses as well as varieties suitable for mechanical harvesting is the necessity of the time to minimize the labour-intensive crops.

Major National Schemes to Promote Pulses

- National Food Security Mission (NFSM): 10 lakh hectares area in 1000 blocks to be covered under village level demonstrations for 5 major crops - pigeonpea, chickpea, greengram, blackgram & lentil
- *Rashtriya Krishi Vikas Yojna (RKVY):* Rs 300 crore earmarked for organizing 60,000 pulses & oilseeds villages in the rainfed areas
- Macro Management of Agriculture Scheme, has special components for pulses development.

Policy Reforms

- Establishment of National Pulses Development Board
- Establishment of secure water rights to user
- Decentralization and privatization of water resources
- Introduction of appropriate water saving micro irrigation technologies
- Formulation and integration of water use policy and its judicious implementation.

Another problem peculiar to the Indo Gangetic plains is the menace of large scale grazing by blue bulls. We need to support the efforts of the farmers for higher acreage under pulses crops without contravening the legal provisions of the Wild Life Protection Act which prohibits killing of these animals. There is thus a huge possibility and potential of bringing innovative solutions to save the pulses crops and encourage more intensive promotion of production technologies.

Besides varietal research, we need to address the issues relating to farmers' preference for the competing crops to pulses through development and promotion of crop production and crop protection technologies. Under National Food Security Mission, these aspects have been taken up for more aggressive promotion of available technologies under Accelerated Pulses Production Program to ensure that the farmers are able to harvest better crops. The Government significantly increased the Minimum Support Price of the pulses and strengthened pulses procurement mechanism by designating additional central agencies to support the farmers. In fact, the minimum support price has been doubled in last three year with quantum jump given this year with an increase of more than 50%. Use of drip irrigation in pigeonpea and agronomic practices like transplantation and nipping of branches are showing very encouraging results. Our import policies are linked to our ability for better crop forecasts and the principle of balancing the farmer's interest in a manner that the prices are not distorted and the Indian farmer continues to get a good return for their produce. We are in the process of evolving a mechanism to work out regular tenders on import of pulses through the state agencies. This will hopefully help in better planning and management of supply chain. With better yields, development of pest resistant and resilient varieties and increased MSP support and lessons learnt from exchange of knowledge, the Indian farmer will definitely adopt pulse based cropping systems to produce more pulses with increased acreage. This will significantly ease the supply side constraint which the country faces.

To meet the challenges faced by the pulses sector, research efforts for developing biotic stress resistant and stress tolerant varieties needs to be encouraged along with public-private initiatives for better logistics planning and handling of pulses. The viability of bringing additional land overseas under pulses by lease and exporting them back to India also needs to be looked into where the government could act as a facilitator with private entrepreneurs. Besides the ease of farming operations and low yields of the crop, other limitations are the optimum crop cycle and genetic potential of the crop. The crop cycle should be such as to fit into the overall cropping system that the farmer takes during the year.

Aggressive promotion of available technologies under the Accelerated Pulses Production Programme has been taken up. The pulse procurement mechanism has been strengthened by designating additional central agencies and the minimum support price (MSP) has been significantly increased to more than 50%. Thus, by balancing the farmer's interest in such a way that the domestic prices are not distorted and the Indian farmer continues to get a good return for his produce, the use of new production technologies and agronomic practices, and government support put together could lead to self sufficiency.

It is an established fact that a human body requires a daily intake of about 50 gm of protein. While people in the developed countries and most of the developing countries have a satisfactory intake of protein, in India the per capita daily intake is only about 10 gm. This has direct bearing on health and affects work performance of the people. Out of the 22 amino acids required in the human diet, the body supplies 14. The remaining eight have to come from food. If all the eight amino acids are present in a single food item, it is called a complete protein food. Since all proteins from animal sources are complete proteins, it is easy to meet the dietary protein requirements of people with non-vegetarian food as the main diet. However, for vegetarian population the main sources of protein are leguminous plants to which the pulses belong. However, in general, pulses have lower concentrations of protein than animal sources. Besides, none of the pulses except soybeans are complete proteins. Therefore, combinations of two or more pulses are needed in a vegetarian diet. Dairy products, which are complete proteins, may also be used to supplement pulse proteins in vegetarian diets.

Given the important role that pulses play in the human diet, their availability needs to be increased indigenously. The possibility of improving pulse productivity two to three times through existing varieties and available package of technologies has been demonstrated in scientific experiments. However, it is not done just by following current production practices but through the adoption of entirely new but simple and farmer-friendly technologies and tools that are now not available to Indian farmers.

The underlying problem of Indian agriculture that threatens food security is extremely low productivity. The lesson India has to learn is that instead of subsidising food supply to the people, the subsidised inputs for agriculture such as seeds, fertilizers, chemicals and other inputs are more important which will help farmers grow more food and pulses. Besides developing improved varieties, refinement of existing and development of new technologies is also important. A hybrid variety will not produce if planted in non-fertile beach soil. But it will produce several times more if planted in fertile soil.

India has about 50 million acres of irrigated land and is second only to the United States with 60 million acres. In the U.S. it is possible to raise only one crop a year due to weather constraints. However, many areas in India have the potential to raise three crops a year, provided we learn how to sustain the fertility of the soil. This will be equal to >100 million acres of irrigated land. Keeping this in view, expert land management and maintaining soil fertility needs urgent attention.

Being the largest producer, consumer and importer of pulses in the world, India's role is important for the world as it not only produces around 19 million tonne of pulses, but also imports around 3-4 million tonnes on an annual basis to meet its current demand of 22-23 million tonne. The global pulses production is estimated to be around 60 million tonnes from 90 countries and valued at $100 billion. Though India can produce more to reduce imports but it lacks policy initiatives to make pulses as quality protein ingredient for food. Therefore, specialized policies are required to boost pulses production in India.

- Population growth in India is projected to stabilize @ 0.1% per annum in mid-century while pulses are required to grow @ 2.2% annually.
- Thus Vision-2050 is well projected and target is easily achievable through R & D efforts, policy initiatives and horizontal expansion of pulses cultivation

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