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Pulses as a candidate crops

for doubling farmers' income

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Pulses constitute an important component of prevailing cropping sequences followed by across the country with region specific variations in preferences and suitability to agro-production situation. Chickpea, pigeonpea, urdbean, mungbean, lentil, fieldpea, cowpea and lathyrus are the major pulse crops grown in the country. With the synergistic efforts of all the concerned stakeholders in supporting policy framework, the county could achieve record production of pulses to the tune of 22.94 MT from more than 28 million ha area during 2016-17.

Key words: Crop, Farmer, Income, Pulses

PULSES form an important component of basic Indian diet, though variations with respect to the choice, food habits and availability of pulses across the country are in place. These are consumed in split form and prepared as a curry called '*dhal*' or '*dal*' that is an important source of dietary proteins for Indian masses. They are widely acknowledged as super foods with double the protein in wheat and three-fold that in rice. Besides, they are also rich in complex carbohydrates, micro-nutrients, protein and B-vitamins and minerals like folate, iron, calcium, magnesium, zinc and potassium. Long shelf-life without loss of nutritional value, low prices coupled with wider availability make pulses an affordable source of protein and minerals and contribute to food security at all levels of society in India. Besides adding to the human nutrition, pulse crops serve as a source of fodder and fuel for the farm-families.

Pulses are the crops endowed with the virtues of efficient utilization of available limited soil moisture and nutrients as well as producing beneficial impact on physical and chemical properties of soil; they are basic for a sustainable crop production system. These crops not only fix the atmospheric nitrogen for their growth and thereby reducing the dependence on external nitrogen source, but also contribute towards increasing the availability of nitrogen for subsequent crop (through residual effect). They are rightly termed as mini nitrogen-factories.

Integration of pulse crop in crop rotation helps in sustainably enhancing overall productivity and profitability of the cropping system. Introduction of pulses in the system also favours the growth of soil microbes, decreasing the risk of plant diseases and use of pesticides. Their integration in the crop rotation with cereals also helps in breaking the pest cycles, thereby contributing to improvement in the overall system productivity. Inclusion of pulses in crop rotations reduces the risks of soil erosion and depletion. Pulses as a cover crops contribute significantly towards higher rates of accumulation of soil carbon than cereals or grasses; and pulses inclusive crop rotations have a higher soil carbon (C) sequestration potential than that of monocrop systems. Despite inheriting these beneficial effects, pulses are primarily adopted as rainfed crops with the minimal support from external input use conditions that results in low productivity and production falling short of demand figures at the national level.

Pulses : the hampering factors

The pulse requirement in the country is projected at 32 million tonne by 2030 A.D. and 39 million tonne by 2050 A.D. at an annual growth rate of 2.2% requiring an all round efforts and strategic steps in research, generating innovations, its dissemination and commercialization along with capacity building. Keeping in view the availability of land, population growth rate and technological innovations, projections were made. For every 5-year interval productivity will have to be enhanced by an average of about 80 kg/ha over the previous one to achieve a final productivity rate of 950 kg/ha by the end of 2025 A.D. and 1,335 kg/ha by the end of 2050 A.D. following inclusion of about 4 million ha additional area under pulses.

In most of the pulses, there is large gap between the potential yield and the realized yield in the field condition. The actual productivity of different pulses is considerably lower than their potential yield as well as that realized on farm demonstrations

Table 1. Yield gap in different pulse crops

Sl No.	Crop	Improved practice (kg/ha)	Farmers' practice (kg/ha)	increase (%)
1.	Chickpea	1,435	1,129	32.2
2.	Pigeonpea	1,433	1,084	27.02
3.	Mungbean (*kharif*)	804	634	26.9
4.	Urdbean	955	702	36.17
5.	Lentil	1,047	816	28.37
6.	Field pea	1,394	1,101	26.63
7.	*Rajmash*	1,368	1,051	30.15

Source: *FLD data 2007-2013*, IIPR, Kanpur

of improved technologies. (Table 1). Pushing of pulse to the poor and marginalized areas with low resource conditions is one of the most important reasons behind poor productivity in pulses in the country. About 87% area under pulse cultivation in the country is under rainfed system. Besides poor seed replacement rates, low adoption of improved production technologies add to the poor productivity of pulses at farmers level.

Besides poor yield realization, ever-increasing population, abrupt climatic changes, disease-pest complex, socio-economic situations of pulse cultivators, poor storage facilities etc add to the deficit pulse availability in the country. Besides this, high influence of environmental factors coupled with poor quality of seed used is the major production constraint in pulse crops.Biotic factors cause significant yield losses in pulses. Among diseases, *Fusarium* wilt coupled with root rot complex is probably the most widespread disease causing substantial yield losses in chickpea. Similarly, *Fusarium* wilt, sterility mosaic and *Phytophthora* blight in pigeonpea, yellow mosaic, *Cercospora* leaf spot and powdery mildew in both mungbean and urdbean and the rust and wilt in lentil cause considerable losses. Besides weed problem, gram pod borer in chickpea and pigeonpea, pod fly in pigeonpea, whitefly, jassids and thrips in dry beans cause severe damage to crops among pests. Similarly, among abiotic stresses, drought and high temperature at terminal stage, cold as well as sudden drop in temperature coupled with fog during the reproductive phase and soil salinity/alkalinity wreak a havoc towards potential expression of crops.

Doubling farmers' income: contribution of pulses

Pulses as a candidate crop, contributes immensely towards doubling farmers' income through diminishing cost of production, scaling per unit productivity, efficient marketing networks and successful technology delivery mechanisms by giving emphasis sustainable intensification and crop diversification, climate resilient production technologies backed with strong research outputs in pulses can contribute towards doubling the farmers' income. To cite the case of chickpea subsector, it has achieved tremendous boost over the years due to several causative factors (Refer Box).

On this account, the following important aspects could reinforce our efforts in doubling farmers income by 2022A.D.

Diminishing cost of production

On-shelf technological options: Provisions for large scale adoption of on-shelf technological options/ interventions for improving input use efficiency in pulse production need to be ensured for retreating the cost of production. Scientific evidences suggest that existing vast gap grain yield of pulses can be bridged with site-specific technological modules including appropriate varieties and matching production technologies. These could be a single or an appropriate combination of need-based suitable and efficient technologies.

Targeting at self-sufficiency in pulses, more than 1,100 high-yielding varieties of different pulse crops have been released and notified for their cultivation in the country. These include developing high-yielding varieties with resistance to one or more biotic and abiotic stress(es), early maturity (chickpea, pigeonpea, lentil, mungbean and urdbean) and biofortified (better absorption in human system). Some of the land mark varieties of pulses with specific features and unique characteristics include IPL 220 (high Fe and Zn fortified lentil variety), IPH 09-5 (early duration pigeonpea

Three and half decade growth of chickpea in India from 1970-71 to 2015-16

- Short duration varieties (JAKI 9218, JG 14, Rajas, Pusa 547, RVG 202, RVG 203, JGK 1, KAK 2, Shubhra) for horizontal expansion of chickpea in southern states
- Disease resistance varieties against *Fusarium* wilt (GNG 1581, DCP 92-3, HC 1, KWR 108, JG 16, Digvijay, Gujarat Gram 2, BG 391, BGD 78, Ujjawal, GLK 26155, HK 05-169) and *Ascochyta* Blight (GNG 469 Himachal Chana 1 and PBG 5)
- Heat tolerant varieties (JG 14, JSC 55, JSC 56) for late sown condition and Drought tolerant varieties (RSG 888, Vijay) for rainfed conditions
- Extra large-seeded (MNK 1, PKV Kabuli 4-1, Phule G 0517) and large seeded kabuli varieties (Shubhra, Ujjawal, KAK 2, GLK 26155) for export purpose
- Improved agronomy through appropriate land configuration, supplementary/life saving irrigation, micro-irrigation, precision tillage, pre- and post-emergence herbicides, cropping system/intercropping, conservation agriculture, and farm mechanization
- Machine harvestable (GBM 2, NBeG 47, HC 5) varieties

hybrid), IPM 205-7 (Virat, a extra early mungbean variety) and IPFD 10-12 (green seeded field pea varieties). Other varieties of prominence so far as pulses cultivation in different parts of the country concerned include IPC 2004-01, IPC 2004-98, IPC 2005-62 and IPC 2006-774 in chickpea; IPFD 10-12, IPFD 11-5, IPFD 12-2 and IPFD 6-3 in field pea; IPL 316, IPL 526 and IPL 520 in lentil; IPM 410-3 and IPM 205-7 in mungbean, IPA 203 in pigeonpea, and IPU 07-3 urdbean. Similarly, diagnostic Kits 'LYMVs PCR Diagnostic Kit' developed for identification of viruses causing yellow mosaic disease and Multiplex-PCR 'LYMVs Mplex' for the accurate identification of the viruses causing yellow mosaic virus in pulses have been useful towards enhancing the net returns of pulse growers.

Amalgamated with these varietal interventions are matching production and protection technologies like improved cropping systems like, rice-wheat-mungbean, pigeonpea-wheat and maize/ sorghum/pearl millet-chickpea/lentil, seed inoculation with improved *Rhizobium* and PSB strains, balance fertilization, resource conservation aided technologies/practices like, residue retention, crop sequence, tillage and suitable herbicides for efficient weed control, other resource saving practices like broad bed furrow system or raised bed planting, and ridge and furrow system and seed priming.

Promoting life saving and supplementary irrigation: Life saving and supplemental irrigation to the crops with low consumptive water use has the desired potential to double existing yield levels. Extensive studies confirmed that providing single irrigation at the most critical crop stage in water scarcity/rainfed areas, the yield of pulses and other crops can be scaled up by 50% or more. Besides, resource conservation and related technologies (RCTs) involving efficient crops and its rotation, conservation tillage (zero/ reduced) and residue retention combined with efficient weed control could help in realizing water savings to the level of 20 to 45% at the field level under most conditions. Farmers need to be sensitized and educated for efficient water usages (acquisition, storage and application) and its systems including water efficient techniques like, micro-irrigation techniques (sprinklers and trickle drip irrigation) for their popularization and large-scale adoption by farmers.

Sprinkler irrigation is gaining popularity among farming community as it has enormous potential for saving irrigation water and expanding area under saved irrigation especially in regions with limited water availability. Government policy initiatives under NFSM and other schemes ensuring promotion of sprinkler sets for pulse/ food crops cultivation by providing subsidy to the tune of ₹ 10,000/ha or 50% of the cost is a well thought out option offered to farmers which could be put to use on large-scale to have a real impact on farmers' income.

Similarly, drip irrigation and fertigation holds promise for widely spaced crops, like pigeonpea which have the potential for expanding irrigation area by 30 to 50% and could ultimately impact the returns accrued to farmers.

Site specific management of nutrients and other agro-chemicals: Inputs including nutrients/herbicides/ pesticides based on recommendations of soil-and plant-health indicators (like soil-health cards, monitoring life systems and application based on critical or threshold level concepts) would work towards reducing the cost of production and enhancing farm income besides scaling use efficiency of the inputs. Since most of the management considerations are location/site specific, better crop(s) productivities and /or lower cost of production can be realized with such site specific management of key inputs. Moreover, timely availability of critical inputs, like bio-fertilizers, sulphur, zinc, gypsum, boron, bio-pesticides etc. at field level play a crucial role for enhancing crop productivity.

Quality assurance in agro-chemicals: Agro-chemicals used for plant protection play an important role in enhancing crop productivity and farm income. Quality assurance of these chemicals be it for plant-protection against pests, diseases or weeds, available for pulse crops need to be focused with suitable regulatory interventions and strengthening quality enforcement. This would help in reducing both chemicals and costs of cultivation and thus, helps in realizing expected production and income.

Early season weed control : Weeds do compete with crop plants for resources viz., nutrients, moistures, light and space; and also secrete allele-chemicals that adversely affect the growth and development of crops. Severe crop-weed competition, during early stages and later (mostly limited to 15-60 days after sowing depending soil/crop/season), results in deterioration in both quantity and quality of the produce. These losses in the yield of pulses varying between 15 and 50% depending upon the season, crop and emergence is significant and may render the cultivation of pulses non-remunerative. Therefore, early season weed control in pulses is specifically important due to its very nature (relatively low growth habit and open canopy early in the growing season). Weed management by manual means although effective, yet its prohibitive costs eats out the income/returns accrued (may go nearly one-third of total cost of production of field crops). Hence, use of herbicides should be promoted keeping in view of its economics and effectiveness in management of weeds in pulse crops. Although its usage is currently low (about 14 %) of the total agro-chemicals used in agriculture in India), it needs to be promoted and adopted so as to reduce cost of cultivation and scaling the farm income through enhanced efficiency in input use and farm output.

Farm mechanization - another cost/ labour cutting option: Enhanced use of the farm machines/implements (mechanization) in pulses cultivation provides well proven option for improving per unit productivity and net returns to farmers by way of reducing the cost of cultivation.

Scientific agronomic practices like deep ploughing or sub-soiling, ridge planting, line-sowing, raised bed and BBF method of planting, inter-culturing and machine harvesting have proved to reduce cost of cultivation and enhance the productivity level of farm. Besides, mechanization has the proven benefits of improved labour efficiency and productivity, efficient use of expensive farm inputs, reduction of human drudgery and timeliness of operations. Therefore, promotion of farm machinery/implements on service mode (custom hiring or contract) could enable wider adoption of farm mechanization economically and efficiently even amongst small and resource poor farmers.

Facilitation of establishment of centres offering these services to farmers willing to pay for, at approachable distance, can contribute towards turning pulses production more remunerative proposition for farmers. Certain measures such as land consolidation, availability of subsidy for purchase/use of farm implements and requisite facility for care and maintenance of these machines etc. are pre-requisites for promotion and adoption of farm mechanization on large-scale.

Therefore, since economics is a major consideration for success of any technology or practice, greater emphasis is made towards decreasing cost of cultivation and increasing farm out put/income through mechanical harvesting of chickpea (varieties, GBM 2, NBeG 47 and HC 5 with >20 cm ground clearance) and *dal* recovery by IIPR Mini Dal Mill.

Possible horizontal expansion

Pulses offer ample scope for area expansion under selected niches with additional benefits of enhanced soil properties and fertility to the cropping system. Area expansion can be through additional area and raising cropping intensity through cropping system intensification and diversification. Although there is difficulty in area expansion due to lack of irrigation and other factors, yet this is possible with scientific management of crop and natural resources involving efficient water harvesting, storage and its utilization, and scaling resource use efficiency.

Presently, chickpea alone shares about 45% of the total pulses production of the country followed by pigeonpea, mungbean, urdbean and other pulses. However, irrigated pulses comprising greengram, blackgram and field pea can largely compensate the projected yield gap. There is an ample scope of horizontal expansion of greengram and blackgram in Indo-Gangetic plains during spring/summer season as well in rice fallows of southern India. Recently developed short duration varieties of pulses enabled extensive cultivation of chickpea in central and south India, and summer mungbean in Rajasthan and western Uttar Pradesh. The geographical shift in pulses to Southern and Central India is an indication of their potentialities to adapt to diverse climatic conditions (favouring their production) thus enabling their future expansion in new niches. High production of pulses during last few years could also be made possible due to factors like availability of quality seeds and proven technological back up.

Tapping rice fallows for pulses: Rice fallows are the low land (many a time upland also) rainfed monocropped ecologies covering rice as the major crop especially during *kharif*. This area remains fallow or uncropped due to inadequate or excess soil moisture at planting for winter crops. The rice fallows occupy about 11.695 million ha of area in the country spread across the Eastern region (covering states of Asom, Bihar, Jharkhand, West Bengal and Odisha), Central region (includes states of Madhya Pradesh and Chhattisgarh) and Coastal peninsula (covering Andhra Pradesh, Telengana, and Tamil Nadu). Two cropping systems *viz*., relay cropping of pulses in standing rice, and crop rotation after harvest of rice have potential for popularization and adoption depending on agro-ecosystem involved. Yet, these constrained areas require an understanding of ecology, constraints analysis and situation specific remedies. Rice fallow regions of the country are primarily inhabited by poor people with small-land holding (< 2 ha) with poor irrigation facilities and meagre access to needed critical farm inputs. The rice fallow areas accounts for most of the poor with weak social and economic development. Under developed agriculture, lack of opportunities for employment in farm and non-farm sector, and poor infrastructure/credit facilities to promote agricultural development are the characteristic features of these areas.

Pulses cultivation being less resource intensive and easily fit into cropping systems, it could contribute adequately towards improving farm income of small-and marginal-farm households. Promotion of pulses, like chickpea, lentil and lathyrus in rice fallows in eastern and central regions of country could have immense potential in enhancing production/availability of pulses in the country as well augmenting the economic returns for involved farm families. Cropping system intensification through pulse crops would also supplement the nutritional requirements of farm families growing rice over seasons/years. On similar manner, bringing additional area under pulses through promoting urd bean/mung bean cultivation in rice fallows in humid peninsular India offers a good scope for enhancing the returns of farmers through additional income from these crops. Lentil crop offers good scope in late vacated paddy fields in rice fallow where, lentil varieties like PL-406, PL-639, Arun are suitable. Lathyrus (LSD-1, LSD-3, LSD-6,Bio L -212 i.e., Ratan) is also most commonly grown in rice, which are tolerant to water stress, low ODAP with bold-seeded. Lathyrus crop can easily give 3-4 quintals under this cultivation, brining additional income to farm households. Normally, this crop takes the advantage of residual fertility and thrives on residual moisture. In this context, promotion of matching pulses production technologies in rice fallow area holds the key for tapping these resource poor regions for catering to the ever growing demand of pulses in the

country and making it self-sufficient. Here, development and diffusion of early-maturing pulse varieties supplemented with supporting agro-technological interventions like resource conservation technologies, seed priming (to facilitate germination even in low moisture regimes), micro-irrigation, foliar spray and integration of appropriate site-specific techs certainly have advantages. Some other potential management considerations involving suitable relay cropping system, residue retention, mulching and life saving irrigations could help in improving pulses productivity under challenging rice fallow conditions.

According to an estimate, rice fallows offer area expansion up to a minimum of 2 to 4 million ha under *rabi* pulses. Assuming an average productivity of >700 kg/ha, the area has the potential to produce 1.5 to 3.0 million tonne of pulses, thereby bringing additional income to this disadvantaged regions with technological backup (in respect of suitable short-duration varieties, appropriate input/nutrient recommendations and other matching production technologies). This could contribute towards achieving the target of scaling farm production and doubling farmers' income.

Cropping system intensification : Harnessing the short crop window of about two months or so in between major *rabi* and *kharif* crops in cropping sequence through inclusion of spring/summer mungbean / urdbean offers a viable opportunity for generation of additional income to the farmer. Growing these crops could intensify the existing system besides other benefits of reduction in the use of fertilizers for subsequent crops due to residual fertility, leaf fall and residue retention. It is estimated that about 1.65 m ha area vacated by wheat, peas, potato, sugarcane and lentil can well be translated to cultivation of short-duration (60 to 65 day) spring/summer mungbean in the northern and eastern states covering Punjab, Haryana, Uttar Pradesh, Bihar, Jharkhand, West Bengal, Odisha and north-eastern hills region states with irrigation facilities. Strong technological backup by National Agriculture Research System of the country by developing of high yielding, disease resistant, short duration mungbean (such as IPM 205-7 (Virat), IPM 2-3, Basanti, PDM 11, SML 668) and urdbean varieties (PDU 1, Narendra Urd 1, Shekhar 2, Mash 479) suitable for crop intensification have helped farmers realize additional economic benefits in Punjab, Haryana and West U.P following potato and mustard. Similarly, mungbean (Pant Mung 2, PDM 11, Narendra Mung 1) and urdbean varieties (PDU 1, Azad urd 1, Pant Urd 19 and Sulata) could further up-scale mungbean and urdbean area/ productivity in the spring season in eastern part of Indo-Gangetic plains of India. Therefore, cropping system intensification through introduction of short duration crop sandwiching traditional crops could possibly enhance both production and farm income.

Cropping system intensification through inter-/mixed-crop Promotion of pulses as an intercrop or mixed crop viz., short duration thermo-insensitive varieties of mungbean/ urdbean with spring sugarcane, pre-*rabi* chickpea with mustard/linseed, pigeonpea with groundnut/soybean/ millets, long duration paired row planted pigeonpea with *jowar/bajra/* urdbean and soybean with pigeonpea/urdbean (in Central zone) offer further scope for additional production/income as well as nutritional security to farmers from the cultivated holdings. Some of these systems involving pulses are recommended for different states (Table 2).

Pigeonpea on rice bunds

Pigeonpea offer an option as additional crop that can be grown in rice bunds which are mostly unutilized during the *kharif* once rice is planted. These bunds provide some sorts of miniature upland condition favouring growth of pigeonpea once the crop is established. These bunds can be seeded with pigeonpea seeds or can be transplanted with its seedling. Little care is required for its management. It is estimated that a minimum of 20 to 30 thousand ha of area in Chhattisgarh, Madhya Pradesh, Odisha, West Bengal and Jharkhand consisting of rice bunds could be planted with pigeonpea for additional yield and income. Thus, by utilizing rice bunds, higher production/availability of pigeonpea for consumption as well as enhanced farm returns to farmers can be ensured.

Promotion of utera cultivation in rice fields

In a typical utera system, few crops such as upland paddy, *jowar*, pigeonpea, *urd* etc are mixed and sown in a piece of land (main aim is saving the seed) where these crops are again harvested (at maturity) one after another. Utera cultivation is a common practice and traditionally followed in tribal regions of Madhya Pradesh, Chhattisgarh, Bihar, and Jharkhand; and can contribute to additional production and income to farmer.

Enhancing income with scaling productivity

Technological interventions: Technological interventions available following research in pulses offer viable options for scaling existing grain yields, better stress tolerance (abiotic) and efficient crop protection (against biotic stress). Large-scale

Table 2. Intercropping systems capable of large scale promotion and adoption

Intercropping systems	States
Soybean + pigeonpea/urdbean	Madhya Pradesh, Maharashtra
Pearl millet/sorghum + pigeonpea	Karnataka, Andhra Pradesh, Gujarat, Maharashtra
Groundnut + pigeonpea	Gujarat
Groundnut/sorghum/pearl millet + urd bean/ mung bean/ cowpea	Bihar, Maharashtra, Madhya Pradesh, Karnataka, Gujarat, Uttar Pradesh, Rajasthan
Sugarcane + cowpea/mungbean/urdbean	Uttar Pradesh, Maharashtra, Karnataka Andhra Pradesh, Tamil Nadu
Cotton + urdbean/mungbean/cowpea	Punjab, Haryana, Madhya Pradesh, Gujarat, Andhra Pradesh, Maharashtra

promotion and adoption of these scientific technologies by farmers needs to be ascertained for realizing desired and targeted goals in production and income.

Quality seed: Assured availability of quality seed of suitable crop/variety at appropriate time is the key to success in pulses husbandry. This could be one the major factors for enhancing productivity and farm income from pulses in the country. In this context, strengthened breeder seed production and creation of seed hubs in major pulse producing regions of the country are welcome policy interventions aimed at both increased productivity of pulses as well as enhancing farmers' income. However, improving farmers' access to the quality seed produced by these hubs remains the key for translating these efforts for income enhancement for farmers. Therefore, advance planning for each state rolling seed plan, production of sufficient quantity of breeder seed and their conversion into foundation and certified seed, maintenance of seed buffer, public-private partnership and farmers' participatory seed production could scale-up productivity environment in pulses.

Biofertilizers : Rhizobia can provide 25 to 30% chemical fertilizer equivalent N in pulse crops, and contribute to plant growth. Provisions for skill enhancement programmes in rhizobium application, seed production, seed treatment, production and application of biocontrol agents, could be made for ensuring better acceptance of these critical production technologies among farm families. Similarly, biopesticides has a definite role in protection of plants (being economic and effective). For example, seed inoculation *Trichoderma* at sowing could be immensely helpful against several soil/seed-borne pathogens.

Policy interventions

Linking pulses to welfare schemes : Improving food and nutritional security of citizens is highly prioritized effort of government and implementation of various welfare schemes are in place for the purpose. As pulses offer low-cost protein source, their inclusion as a component of diverse welfare interventions of government cab contribute towards improving the food and nutritional status of people especially women and children. The schemes such as Public Distribution System, Mid-Day Meal, Integrated Child Development Services (ICDS) where pulses could made a part, would address the issues of protein energy malnutrition among the vulnerable population. This could also additionally open up an assured market for pulse farmers in the country rendering them a better price realization for their own produce and avoiding glut, distress sale situation. In an effort to make the policies more sensitive to balanced nutrition, the states of Andhra Pradesh, Tamil Nadu, Himachal Pradesh, Punjab and Chhatisgarh have diversified their Public Distribution System with inclusion of pulses as a means to curb the nutritional deficiency among the poor. Further expansion of this inclusion at national level across different schemes like *Antyodaya Anna Yojana*, Targeted Public Distribution System etc would work towards a better reach of the poor to this rich source of vegetarian protein as well as providing a income boost to the pulse growers of the country.

Building farmers' associations/ institutions: The marketing system of pulses in India is marked by presence of various intermediaries including aggregator, wholesaler, commission agent, processors and retailers in the marketing chain causing wide spread of market margins; and as a result, the share of pulse producers in margin is lowered considerably. Moreover, higher market price of pulses fails to translate into proportionate returns to farmers due to this wide spread of margin across different intermediaries involved in sale of pulses. Therefore, a better integration of the components in the marketing of pulses would assist farmers for a better margin as well as availability of produce at reasonable price to consumer. Farmers at individual level lack the power to bargain in context of small-scale surplus available for marketing. Here, is the role of farmers' organizations that can be made into groups and institutions like registered societies or producer organization. By this mini-arrangement, it would help them to combine the small surpluses into larger pool, thus earning a collective greater bargaining power, and additional income (through larger market margins) resulting in encouragement for better resource allocation at household level for pulse production.

Post-harvest processing :Processing of pulses accounts for biggest share in the overall marketing cost. Encouraging processing of pulses at village level, with strong support from the stakeholders in terms of *in situ* processing technologies as well market intelligence for identification of appropriate markets to sale, would contribute in improving the farmers' share in actual consumer's price and its realization. In India, more than three-fourths of pulses produced are processed into *dhal*. Processing of pulses into *dhal* or other varieties of products adds higher value to the farmers. However, losses and wastage due to processing are estimated to be as high as 10 to 15%, reducing these losses with efficient processing units can add to additional returns to the pulse producers. Therefore, it is suggested to create community-based small-scale pulse efficient milling units especially at the village level which would not only lead to reduction in processing losses, but also in promoting off-farm employment as well as additional income to pulses growers. Enhancing farmers' access to the available technological options relating to small-scale pulse processing combined with suitable infrastructural arrangements, like power supply, capital investments, taxation policies and others could have direct bearing on profit sharing. Hence, necessary arrangements for scaling-up skill development in processing are a must which would really work towards preventing farmers from selling their produce to the aggregator or large-scale pulse processor, and thereby giving them the major share of income and return.

Need-based support in storage infrastructure

An occurrence of large losses of grains during harvest of crop and post-harvest storage (25 to 30%) is a major concern. Hence, post-harvest storage and value addition through post-harvest technology is an indispensable component and needed to be performed so as to add quality/price to the product. Pulses during storage are vulnerable to diverse and multiple stored grains pests due to use of traditional storage structures and lack of scientific storage facilities at domestic level. Besides, several abiotic (moisture content/relative humidity, temperature) and biotic (insect, rodents, birds, fungi, mites and bacteria) factors are responsible for deterioration of stored pulses. As a result, it leads to higher losses both in quality and weight of produce due to unsuitable storage infrastructures.

Therefore, special provisions for storage of pulses by the growers in the government rural storage schemes, such as rural godowns, *mandi* godowns, storage structures of central warehousing corporation, state warehousing corporations and cooperative can help the farmer from suffering from distress sale after harvest and realize a better price for their produce. Investment in storage would thus, ensure quality seed supply and maintaining a buffer stock. Creation of seed storage facility is more essential in coastal belt or states receiving higher rainfall (accompanied with high relative humidity). Encouraging farmers for seed storage in such stores on payment basis could be a viable strategy. Credit facilities can also be extended to the farmers on the basis of seed/grain stored in such places. Certain organizations/institutions have developed improved structures for pulses storage with various capacities like 'Hapur Kothi', 'Pusa bin', 'Nanda bin' and 'PKV bin' which need to the popularized among the farmers.

Supporting with MSP and procurement policies

Increase in minimum support price (MSP) and bonus on pulse production acts as an incentive to the farmers provided the commodity is purchased at MSP. Following government interventions, the MSP of pulses has been increased significantly during 2016-17 encouraging farmers for pulses cultivation (Table 3). These have accelerated both area and production of pulses in India over the years.

Table 3. MSP (₹/q) of major pulse crops in India during last 3 years

Crops	(2014-15)	(2015-16)	(2016-17)
Pigeonpea	4,350	4,425*	4,625**
Mungbean	4,600	4,650*	4,800**
Urdbean	4,350	4,425*	4,575**
Chickpea	3,175	3,425#	4,000
Lentil	3,075	3,325#	3,950

*Bonus of ₹ 200/q over and above MSP; #Bonus of ₹ 75/q is payable over and above MSP; ** Bonus of ₹ 425/q is payable over and above MSP.

Increase in MSP and declaring it at sowing of crop has been adopted as a strategy by the Government of India to give a desired boost to the commodity for its higher production. This is taken granted by farmers as a priority crop as growing of this is being reinforced through imposition of policy incentives in the form of MSP/bonus etc. by the governments. For example, during 2015-16, MSP for pigeonpea was enhanced including bonus ranging from ₹ 200 to 425/q. Thus, MSP-meant to give farmers an assured market price could encourage farmers for higher allocation of their resources for pulses production. MSP-fixation procedures need to take into account considerations, like the risk, uncertainties etc. involved in production of pulses for realistic estimation of production cost. Besides, identification of registered agencies for procurement and storage at approachable distance is a must towards income enhancement of farmers. The recent experience of wheat procurement by Uttar Pradesh State Government during 2017 through establishment of 5,000 purchase centres need to be extended to pulses in other states/regions for augmenting farmers' income through assured market and better price.

Containing the externalities

The damage caused to pulses by external factors such as wild animals and blue bulls is enormous in certain regions of the country including the major pulse growing states like Uttar Pradesh, Bihar, Madhya Pradesh, Jharkhand, Rajasthan, Chhattisgarh and Haryana leading to huge economic losses to farmers. Being preferred by blue bulls, the area under pulses is shifting to other crops. Policy interventions are required involving both within and outside the state and multiple state governments/agencies for containing the damage to pulse crops and thus additional income to farmers.

Input support

Government interventions for promotion of pulses production in the country include assistances for a strong support for critical inputs, like seed, nutrients, rhizobium and PSB, sprinkler sets, pump sets, and plant protection chemicals. Besides, subsidies for farmers for mechanization of pulse production also need to be provided. Efforts also need to be directed for improving the farmers' functional access to draw benefit from these schemes.

Tapping for special niche segment

Kabuli chickpea and *rajmash* are high value pulses that cater to a special market segment in domestic market. Besides the prohibition on exports of pulses from India is not applicable to export of these commodities. Thus, these special niche segments could be explored by farmers for enhancing their income further. Large-scale promotion of kabuli chickpea in irrigated tracts of central India, and rajmash in higher elevations especially hills offers new opportunities for tapping the untapped potential of these commodities through demand in international markets.

Another un-reach destination is organic food production, and its market in India which is estimated to grow at 25 to 30% although the awareness about it is still low. Organic pulse production in selected ecologies in India needs to be promoted for harnessing the demand of organic pulses in national as well as international markets for augmenting farm returns further.

Both knowledge and skill enhancement of farmers are handy for promotion of organic pulse production.

Strengthening the technology transfer mechanism

The large ratios of number of extension personnel to number of farmers and number operational land holdings operating with diverse information needs in the country really hinders the e-implementation of well conceived technology transfer programmes. The agricultural extension machinery in the country witnesses presence of pluralistic extension and advisory service providers in the country with presence of public and private sectors. Engagement of ICT (information and communication technology) can supplement the extension efforts in cater to the wide information needs of farmers besides addressing the issue of manpower constraint to a great extent. ICT tools are proving to be highly effective and efficient tools in disseminating needed information in real time.

Creation of ICT-based platforms for carrying the research outputs could offer solution for decreasing the time lag in technology generation and their application in real field conditions. Transfer of information on pulse production technologies through voice-based SMS advisory service, on-line applications and farmers friendly web sites could also add in enhancing the efforts for doubling the farmers income. Besides these, skill enhancement training exposure visits, front-line demonstrations of technologies can also work for rapid dissemination and adoption of suitable agro-technologies at farmers' level. All these have significant impact and bearing on scaling productivity levels in pulses.

SUMMARY

In presence of newer and continuous challenges such as growing population with high demand for protein, shrinking agricultural land, unfavorable climate change coupled with increasing incidence of biotic and abiotic stresses, pulses as a candidate crop could contribute immensely towards doubling farmers income through effective efforts oriented towards diminishing cost of production through efficient technological options, site specific management of agro-inputs, quality assurances of these and employing resource saving measures. Enhancing income of farmers with scaling productivity through sound technological backups, quality seed/input availability. Possible horizontal expansion in pulses through acquiring new niches (rice fallows and others), cropping system intensification (inter-/mixed-and rotation) and utera cultivation can also significantly enhance the income level of farmers of targeted area. Reducing the cost of cultivation, scaling per unit productivity, efficient marketing networks and successful technology delivery mechanisms with due emphasis on sustainable intensification and crop diversification, climate resilient production technologies backed with strong research outputs in pulses that can contribute immensely towards doubling the farmers income.

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Attracting and Retaining Youth in Agriculture (ARYA)

Realizing the importance of rural youth in agricultural development especially from the point of view of food security of the country, ICAR has initiated a program on "Attracting and Retaining Youth in Agriculture.

The objectives of ARYA project are:

(i) To attract and empower the youth in rural areas to take various agriculture, allied and service sector enterprises for sustainable income and gainful employment in selected district;

(ii) To enable the farm youth to establish net work groups to take up resource and capital intensive activities like processing, value addition and marketing; and

(iii) To demonstrate functional linkage with different institutions and stakeholders for convergence of opportunities available under various schemes/program for sustainable of youth.

ARYA project will be implemented in 25 states through KVKs, one district, 200-300 rural youth will be identified for their skill development in entrepreneurial activities and establishment of related micro-enterprise units in the area of Apiary, Mushroom, Seed processing, Soil testing, Poultry, Dairy, Goatry, Carp-hatchery, Vermi-compost etc. KVKs will involve the Agricultural Universities and ICAR Institutes as technology partners. At KVKs also one or two enterprise units will be established so that they serve as entrepreneurial training units for farmers. The purpose is to establish economic models for youth in the villages so that youths get attracted in agriculture and overall rural situation is improved.

The trained youth groups will function as role model for other youths and will demonstrate the potentiality of the agri-based enterprises which will help in improving their confidence levels and encourage them to pursue farming as profession, generate additional employment opportunities to absorb under employed and unemployed rural in secondary agriculture and service related activities in rural areas.