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Strategies for reducing mismatch between demand and supply of grain legumes

A AMARENDER REDDY[1]

International Crops Research Institute for Semi-Arid Tropics, Hyderabad, Andhra Pradesh 502 324

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ABSTRACT

The paper reviews the supply and demand situation of grain legumes (pulses and oilseeds with special reference to groundnut) and suggests strategies to decrease mismatch between supply and demand. If the current trends of production and demand continue, the likely deficit of grain legumes (both pulses and oilseeds) will increase significantly. There is a need to reduce the existing yield gaps between research station and farmers fields on the one hand and to invest in development of location specific high-yielding varieties with multiple-disease and pest resistant varieties to increase supply. There is a need for renewed focus on extension system with innovative seed systems to increase seed replacement ratio and variety replacement ratio. Finally, the paper comes out with crop and location specific strategies to meet the growing demand by 2020.

Key words: Demand, Grain legumes, Oilseeds, Production, Pulses, Supply, Technology

Grain legumes include all the pulse crops like chickpea, pigeonpea, greengram, lentil, peas, beans etc and also some major oilseed crops like groundnut and soybeans. These are important crops in terms of the daily diet, contribution to human nutrition (both protein and fats) and also in terms of their contribution to farmer's income. They also contribute significantly through enriching the soils with nitrogen fixation and improve soil productivity. Pulses in India have long been considered as the poor man's major source of protein. Pulses are grown on 22-23 million hectares of area with an annual production of 13-17 million tonnes (mt). India accounts for 33% of the world area and 22% of the world production of pulses. The major pulse crops grown in India are chickpea, pigeonpea, lentil, greengram, blackgram and field pea. About 90% of the global pigeonpea, 65% of chickpea and 37% of lentil area falls in India, corresponding to 93%, 68% and 32% of the global production, respectively (FAOSTAT 2011). There is a steep increase in prices of pulses due to supply constraints as demand is increasing due to population increase and increase in income. Due to stagnant production, the net availability of pulses has come down from 70.13 g/day/person in 1951 to 31 g/day/person (Indian Council of Medical Research recommends 65 g/day/capita) in 2008.

Edible oils are daily essential ingredient for cooking all food items and important source of fats. India imports about 50% of its domestic consumption of edible oils annually. Historically, India has been a net importer of edible oils. After a period of stagnation in oilseed production and large edible oil imports, the government of India started the Technology Mission on Oilseeds (TMOs) in 1987, which increased oilseed production and made India self sufficient by the early 1990s. This is now widely known as the "yellow revolution". However yellow revolution did not sustained due to liberal trade policies. More recently under National Food Security Mission (NFSM) both pulses and oilseeds are given high priority in increasing production across the country to curtail growing imports and to reduce protein malnutrition and to make pulses affordable to common man.

Evidence of growing mismatch between demand and supply

A long run price trend shows the changes in equilibrium in demand and supply of a commodity. If price of commodity -A goes faster than prices of commodity –B, it indicates that the supply of commodity –A is inelastic to price changes even though demand increases and *vice versa*. To examine the general price trends in grain legumes and cereals, Fig 1 presents long run trends of prices of pigeonpea (as exemplar of legumes) and wheat (as exemplar of major cereals). The long run price trend of pigeonpea increased faster than the wheat, which indicates that the supply of pigeonpeas are not able to meet the increase in demand at lower costs (prices) due to supply side constraints which include both biotic, abiotic and other socio-economic constraints. This faster increase in equilibrium prices to match the increased demand on the same supply curve (Fig 2). While nominal prices of wheat increased less steeper than pigeonpea eventhough

[1] Special Project Scientist (e mail: a.amarenderreddy@cgiar.org), Research Program Markets Institutions and Policies

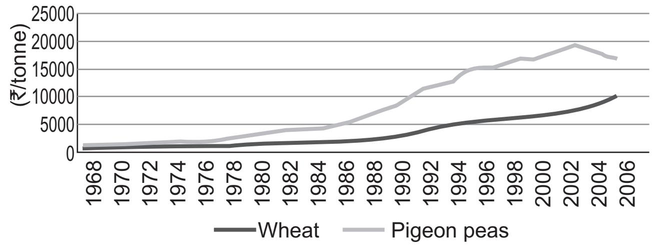

Fig 1 Changes in the relative producer prices (₹/tonne) (five year moving average) of wheat and pigeonpea in India

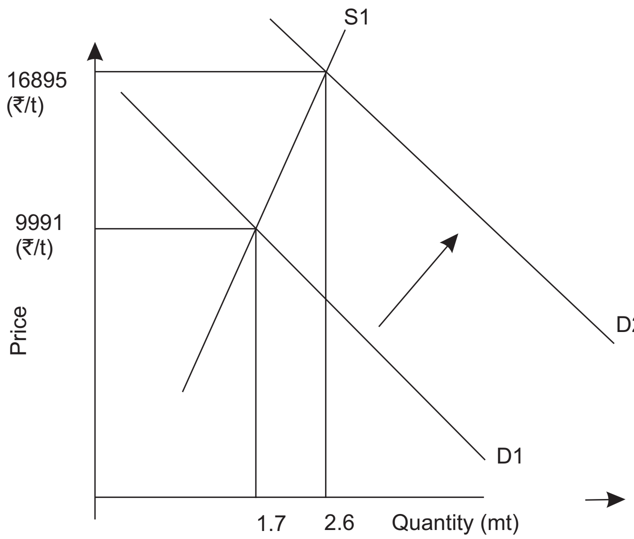

Fig 2 Pigeonpea demand and supply between 1966 and 2011

there is huge increase in demand as there is a right word shift of supply curve due to technological advances (green revolution technology) with lower cost of production, resulted in lower equilibrium price (Fig 3).

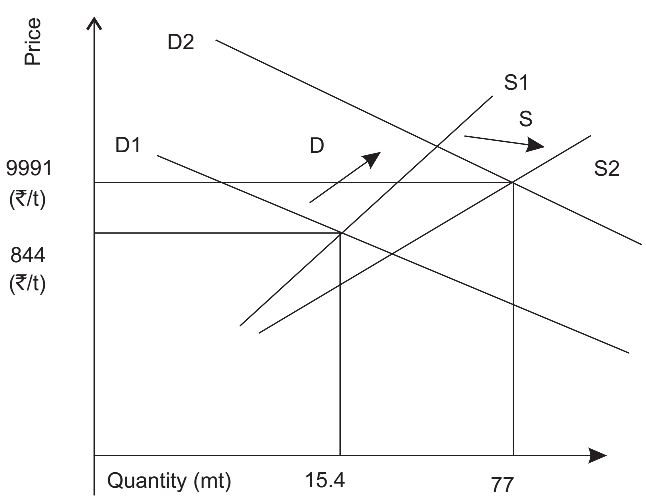

Fig 3 Wheat demand and supply between 1966 and 2011

Past trend in production

During green revolution period from 1966 to 1980s, major cereal production increased significantly at the cost of pulses and oilseeds. For pulses, there is no significant technological breakthrough until now, due to peculiar problems like indeterminate plant type, low response to fertilizers and irrigation. The same is true for oilseeds also until mid-1980s. However, since mid-1980s due to TMOs, the growth rate of oilseeds increased mainly driven by introduction of new crops like soybean and sunflower and integrated approach to oilseeds development with multi-agency approach. Due to renewed emphasis on edible oils and pulses through different government programmes since last decade, the growth rates of edible oils and pulses increased (Table 1). But to reduce the prices to affordable levels there is a need for increased investments in research and development with emphasis on low cost technologies to increase cost competitiveness.

Growing demand for pulses and oilseeds

Demand projections have been made in the past by different scholars under different assumptions related to population growth rates, expenditure elasticities with different base years. Most of these projections are for rice, wheat, total cereals, pulses and oilseeds based on National Sample Survey consumer expenditure data. A comparison of the results of these studies has been presented in Table 1 below with wheat, total cereals, pulses and edible oils. The study by Kumar (1998) used the Food Characteristic Demand System (FCDS) to estimate demand projections. The total demand

Table 1 Compound Growth Rates (%) of area, production and yield of principal crops during 1980–1990, 1990–2000 and 2000–2001

(% per annum)

Crop	1980–81 to 1989–90			1990–91 to 1999–2000			2000–01 to 2010–11		
	A	P	Y	A	P	Y	A	P	Y
Wheat	0.46	3.57	3.10	1.72	3.57	1.83	1.28	2.16	0.87
Chick-pea	–1.41	-0.81	0.61	1.26	2.96	1.68	4.61	6.32	1.64
Pigeon-pea	2.30	2.87	0.56	–0.66	0.89	1.55	1.18	2.05	0.87
Other pulses	0.02	3.05	3.03	–1.61	–1.58	0.04	0.03	0.96	0.94
Total pulses	–0.09	1.52	1.61	–0.60	0.59	0.93	1.62	3.35	1.90
Ground-nut	1.67	3.76	2.06	–2.31	–1.25	1.08	–0.87	1.24	2.13
Soy-bean	17.10	17.96	0.73	10.23	13.06	2.56	5.35	9.14	3.60
Nine oilseeds	2.47	5.36	2.49	0.17	1.42	1.42	2.13	5.16	3.01

Source: Directorate of Economics and Statistics (2011), Department of Agriculture and Cooperation, Ministry of Agriculture, GoI

Table 2 Projected food demand for India, by different studies

(Unit: Million metric tonnes)

Source	Year	Wheat	Pulses	Edible oil
Mittal	2021	64.3	42.5	30.2
(9% GDP growth)	2026	65.9	57.7	40.9
Kumar (1998)	2020	102.8	30.9	

Source: Mittal (2006)

for pulses is projected to be 30.9 mt in 2020. Mittal (2006) projected pulses demand to be 42.5 mt by 2021 and 57.7 mt by 2026 which are at upper end of all the projections. Mittal (2006) also projected edible oil demand to be 30.2 mt by 2021 and 40.9 mt by 2026 (Table 2).

Projections of supply

Very few studies projected supply of pulses and oilseeds for India. Supply projections of different studies have been presented in Table 3. Mittal (2006) calculated supply projections assuming the yield growths to be same as in the past decade with base year 2003–04. It is also assumed that further area expansion will take place. There is a consensus that the supply of pulses is estimated to be of the tune of 17.6 mt in 2021 and 18.4 mt in 2026 under the given assumptions. Oilseed production is projected to go up to 36.9 mt in 2021 and 41.1 mt in 2026 over the base year production of 25.3 mt in 2003–04. The edible oil production is estimated to be 13.19 mt in 2026. Pulses supply projections by Mittal (2006) are falling in between Kumar and Mittal (2003) and Hanchate and Dyson (2004).

In view of increasing demand and consequent rising prices, there is a need for investments in R & D with the aim of reducing cost of production and increasing supply of both pulses and oilseeds (grain legumes) at lower cost (Chand, Jha and Mittal 2004). The gap in supply and demand for pulses and edible oils is expected to be widened in future. It is already reflected in huge imports of edible oils and increased prices of pulses in India. The shortage of edible oils and pulses in the global markets are also reflected in rising real prices. Thus, we need to have necessary technological policy initiatives to increase the supply in future. The deficit of pulses is to the tune of 24.92 mt by 2020 and by 39.31 mt by 2026 as per Mittal (2006) estimations. The projected annual growth rate of pulses and edible oil demand is 6.51% and 5.97% respectively, while growth rate of projected supplies are 0.91% and 2.13% respectively (Table 4). This gives rise to increased gap between supply and demand.

Table 3 Projected domestic supply of selected food items in India

(Unit: Million metric tonnes)

Food items	Base year 2003-04	Supply projection Mittal		Kumar and Mittal	Hanchate and Dyson
		2021	2026	2020	2026
Wheat	72.1	91.6	97.9	111.5	
Pulses	14.9	17.6	18.4	15.2	23.7
Edible oil	8.6 (25.3)	12.5 (36.9)	13.9 (41.1)		

Note: Area and yield growth rates for the period 1994/95 to 2004–05 on the base period triennium ending 1993-94 are used from Agricultural Statistics at a Glance, 2007, Directorate of Economics and Statistics, GOI.

33.9% is the average conversion factor of edible oilseed to edible oil. Figures in the parenthesis are the supply projections for oilseeds.

Source: Mittal (2006)

Prioritizing legume crops for R&D investment based on their share in production

Among pulses chickpea (40.2%) occupy major share, followed by pigeonpea (18%), blackgram(10.6%), greengram(8.6%) and lentil (7.3%). Share of *rabi* pulses crops is much higher (62.5%) than share of *kharif* (37.5%) season crops. While in case of oilseeds share of soybean (38.2%) is highest followed by mustard (25.6%) and groundnut (24.6%). All other crops individually contribute less than 5% of oilseed production. The research and development investments on each crop should be in proportion to the share of the crop in respective category. Keeping this as guiding principle, the share of chickpea in total research and development investments should be higher than pigeonpea followed by blackgram, greengram and lentil. While in oilseeds, share to soybean should be highest followed by mustard and groundnut. Keeping the predominance of private sector in soybean, the public investment should be more in mustard and groundnut.

IMPORTANCE OF GRAIN LEGUMES

Important source of protein

Pulses are a good source of proteins for a majority of the population in Asia especially in south Asia. The 2010 review by Boye *et al*. (2011) provides comprehensive information on protein ranges in pulses, types of pulse proteins, their

Table 4 Supply-demand gap for pulses and oilseeds

(Unit: Million metric tonnes)

Food items	Projected annual growth rate (% annum)		Gap (Supply-demand)	
	Demand	Supply	2021	2026
Wheat	1.42	1.34	27.33	32.04
Total cereals	3.17	1.45	–2.94	–16.97
Pulses	6.51	0.91	–24.92	–39.31
Edible oil	5.97	2.13	–17.68	–26.99

Note: 33.9% is the average conversion factor of edible oilseed to edible oil. Demand scenario of GDP growth at 9% is considered here: growth rates are between base year and 2026

Source: Mittal (2006)

Table 5 Share of different pulse crops and oilseed crops in total production

Crop	Five year average 2002–2006		Crop	Five year average 2007–2011	
	Production	% in total pulses		Production	% in total oilseeds
Chickpea	53.0	40.2	Soybean	10.5	38.2
Pigeonpea	23.8	18.0	Mustard	6.9	25.2
Blackgram	14.0	10.6	Groundnut	6.7	24.6
Greengram	11.4	8.6	Sunflower	1.1	3.9
Lentil	9.7	7.3	Castor	1.1	3.9
Peas and beans	6.8	5.2	Sesamum	0.7	2.5
Lathyrus	3.9	2.9	Safflower	0.2	0.7
Moth	3.2	2.4	Linseed	0.2	0.6
Kulthi	2.7	2.1	Niger	0.1	0.4
Kharif	49.5	37.5	*Kharif*	18.3	66.7
Rabi	82.4	62.5	*Rabi*	9.1	33.3
Total	131.8	100.0	Total	27.38	100

Source: Directorate of Economics and Statistics (2011)

functional properties, and the effects of processing. Briefly, the amount of protein in pulses is ~17–35% on a dry weight basis. Proteins are essential for human health and better living, and hence pulses consumption is very important. The contributions of pulses in the total intake of protein vary across countries within Asia due to differences in tastes and preferences as well as prices of competing sources of protein like meat and meat products. Average protein consumption in South Asia is 58.2 g/capita/day and for South East Asia are 62.1 g/capita/day. Pulses contribute 11% of total intake of proteins in South Asia. The contribution of pulses is much higher in India and Myanmar. In India frequency of pulses consumption is much higher among any other sources of protein in all sections of society, which indicates the importance of pulses in their daily food habits and lifestyle (Table 6).

Source of healthy protein and fats

The prevalence of obesity has reached epidemic proportions, finding effective solutions to reduce obesity is a public health priority. One part of the solution could be for individuals to increase consumption of pulses like dry beans, peas, chickpeas, and lentils, because they have nutritional attributes assumed to benefit weight control, including slowly digestible carbohydrates, high fiber and protein contents, and moderate energy density when compared to other protein rich sources like meat and meat products (Table 7). Grain legumes (especially soybean oil and groundnut oil) are major source of vegetable fats in India, which together contributes to about 16% of total fat intake. Lentil, red gram and blackgram are most important pulse consumed in rice–wheat farming system, while red gram and blackgram are most important in rice based cropping systems. In rainfed mixed farming system, red gram and greengram are predominant pulses consumed. However, in terms of total quantity of pulses consumed there is no significant difference among regions.

Wide diversity in consumption of pulses (diverse tastes)

The average consumption of pulses is 27 g/day/person in rural India (Table 8). Table shows the wide diversity in the consumption of pulse crops in terms of quantity and variety among different states. The major pulses-consuming states are Uttar Pradesh (35 g), Maharashtra (32.67 g) and Karnataka (31.67 g). The consumption of redgram (7.67 g) was highest, followed by lentil dal (4.67 g) and gram (3.67 g). The major red gram consuming states are Karnataka, Maharashtra and

Table 6 Percentage of persons consuming pulses/fish/chicken/meat at least once a week by background characteristics, India, 2005–06

Background characteristics		Female		Male		Women thin (BMI <18.5)	Men thin (BMI<18.5)
		Pulses or beans	Fish or chicken/meat	Pulses or beans	Fish or chicke/meat		
Age	15-19	89.9	33.4	90.1	37.8	46.8	58.1
	20-29	90.0	36.9	91.0	43.7	38.1	33.0
	30-39	89.0	35.2	91.3	41.2	31.0	25.5
	40-49	89.0	34.9	90.1	39.1	26.4	26.2
Residence	Urban	91.5	41.2	93.0	47.3	25.0	26.5
	Rural	88.6	32.5	89.4	37.3	40.6	38.4
Wealthindex	Lowest	84.5	27.0	85.5	31.3	51.5	48.3
	Second	89.2	32.2	89.5	36.3	46.3	42.4
	Middle	88.5	37.8	89.8	42.9	38.3	37.4
	Fourth	90.8	41.5	92.1	49.1	28.9	29.6
	Highest	93.3	36.7	94.7	41.6	18.2	19.1
Total		89.5	35.4	90.7	40.9	35.6	33.7

Sources: National Family Health Survey (2006)

Table 7 Protein and fat intake (g/capita/day) in Asia and contribution of grain legumes/pulses

Item	Food supply (kcal/a/day)	Protein supply (g/capita/day)	Fat supply quantity (g/capita/day)	% of contribution to total by grain legumes		
				Calories	Proteins	Fats
Beans	30	1.9	0.1	1.3	3.3	0.2
Peas	18	1.2	0.1	0.8	2.1	0.2
Pulses, other	75	4.2	0.8	3.2	7.3	1.7
Soybeans	7	0.8	0.4	0.3	1.4	0.8
Groundnuts (Shelled Eq)	6	0.3	0.5	0.3	0.5	1.0
Soybean oil	36		4.1	1.5	0.0	8.5
Groundnut oil	26		3.0	1.1	0.0	6.2
Pulses total	122	7.3	1.0	5.2	12.7	2.1
Total grain legumes	197	8.4	9	8.4	14.6	18.6
Grand total	2352	57.4	48.4			

FAOSTAT(2011)

Andhra Pradesh. The major gram consuming states are Punjab, Haryana and Rajasthan. In Gujarat mostly greengram was consumed, and in Asom, Bihar and West Bengal lentil dal has been predominant. Blackgram is a major food item in Tamil Nadu and Uttar Pradesh. This shows diversity in the consumption of pulse crops in terms of quantity and variety among different states within India (Reddy 2004). This wide diversity within pulses in terms of varieties/crops shows tastes across regions/socio-economic groups of communities.

Income and price elasticity of demand is much higher for pulses and oilseeds both among rich and poor, which indicates that, as the prices comes down with the result of technological advancement and incomes increases as expected in the future, the demand for pulses and oilseeds will increase significantly.

Consumption among poor

A case study of Maharashtra (Table 9) for 1993–94 shows that pulses consumption was less among the poor (32 g/consumer unit/day) than the rich (54 g). It was also less among landless and marginal farmers (40 g) than among large landholders (55 g). Pulses are a good source of protein for a majority of the population in rural India. The contributions of various food items in the total intake of protein vary across income groups and states due to differences in tastes and preferences as well as purchasing power. This ultimately affects the total intake of nutrients. This section tries to explore the differences in share of the principal sources of proteins and their impact on the food and nutritional security of different income classes at the all-India and state levels. Keeping the cheapest source of protein, it is important to increase consumption of pulses among the socially and economically backward classes.

Increasing need of consuming pulses as cheapest source of protein

In India, grain legumes contribute a significant source of nutrition (Yadav *et al.* 2007). Out of the total consumption, 8.4% of calories, 14.6% of proteins and 18.6% of fats are from grain legumes (Table 7). The pulses and oilseeds together contribute more than 12% house low budget, which is a

Table 8 Percapita consumption of pulses in rural areas (g/capita/day)

Crop	Per capita pulse consumption (top three states)			All-India
Gram	Punjab (5.33)	Kerala (2.67)	Haryana (2.0)	1.00
Red gram	Karnataka (15.0)	Maharashtra (14.33)	AP(13.0)	7.67
Gram split	Haryana (6.67)	Punjab (5.67)	Rajasthan (5.67)	2.67
Greengram	Gujarat (9.33)	Punjab (8.0)	Rajasthan (6.33)	3.33
Lentil	Asom (12.33)	Bihar (10.67)	WB (9.33)	4.67
Blackgram	TN (7.0)	UP (6.0)	Kerala (4.33)	3.00
Khesari	Bihar (2.33)	WB (2.0)	MP (1.67)	0.67
Peas	Maharashtra (0.67)	UP (0.67)	Kerala (0.67)	0.67
Soybean	Asom (0.33)			
Other pulses	Karnataka (5.67)	Punjab (2.33)	TN (2.00)	1.33
Pulse products	Haryana (6.00)	Rajasthan (4.00)	Punjab (3.00)	1.67
Total pulses	UP (35.0)	Maharashtra (32.67)	Karnataka (31.67)	27.0

Reddy AA (2004)

Table 9 Status of nutrient intake and population deficit in intake in rural India (1993–94)

Social group	Consumption of pulses (g/capita/day)	Protein intake (g/capita/day)	Percentage of population deficient
Income group			
Very-poor	32	57	32
Moderately poor	40	66	14
Non-poor-lower	45	73	9
Non-poor-higher	54	87	3
Landholding class			
Landless	41	65	59
Sub-marginal	39	65	50
Marginal	41	69	48
Small	46	75	40
Medium	51	80	26
Large	55	88	19

Notes: Cut-off point for estimating protein deficiency is 60 grams of protein per day.

(1) Very poor < ₹ 190, Moderately poor ₹ 190-265, Non-poor (lower), ₹ 265-355, Non-poor (higher) ₹ 355 and above.

(2) Landless 0 acres, Sub-marginal < 1 acre, Marginal 1-2.5 acres, small 2.5-5.0 acres, Medium 5.0-10.0 acres, Large > 10.0 acres.

Source: Reddy 2004.

significant amount for poor households (Table 10). The budget share of pulses and oilseeds for rich is slightly lower than for the poor, but still it is higher than 10%. Eventhough budget share of pulses and oilseeds among poor is more, the quantity consumed is far less than (about half that of rich) the rich, which indicates the scope for increasing the consumption in future (Table 11).

Further both income elasticity of demand and price elasticity of demand are higher for poor consumers than rich consumers for both pulses and oilseeds (Table 12). It shows any reduction in prices and increase in incomes (increase in per capita GDP) will benefit poor consumers significantly more than the rich consumers; hence investment in R & D of pulses research targeted to reducing cost of production will be more beneficial to poor consumers.

Table 10 Budget shares (per cent) of different expenditure groups in 1999

Groups	Poor	Rich	All
Rural			
Pulses	6.35	5.39	5.59
Edible	6.17	5.38	5.56
Urban			
Pulses	6.28	5.02	5.46
Edible	6.39	5.62	5.89
All India			
Pulses	6.33	5.23	5.54
Edible	6.26	5.49	5.68

Source: Mittal (2006)

Table 11 Consumption trends among rich and poor (Unit: Kg)

	Poor	Rich	All
1983			
Pulses	6.63	12.65	10.14
Oil	2.32	5.39	4.1
1999			
Pulses	6.16	12.14	10.55
Oil	4.1	10.11	8.71
Projected 2020			
Pulses			20.21
Edible oil			13.98

Source: Mittal (2006)

It is interesting to note that, pulses having higher positive cross elasticity of demand with meat, fish and eggs, vegetables and milk as they are substitutes, while negative cross elasticity with cereals (Table 13, Table 14). As expected cross-elasticity of demand among different edible oils is much higher. Cross-elasticity of groundnut oil with mustard is 0.40, with palmoil is 0.28 and with soyoil is 0.19 but with sunflower oil, it is not significant. The same higher cross-elasticity among different pulses (chickpea, pigeonpea, greengram, blackgram and lentil) exists in India as they are all close substitutes for each other based on their availability and relative prices.

Yield gap analysis

Table 15 shows that there exists a huge gap between the average yield achieved in India at TE 2009–10 and the yield that have been achieved by other countries. This can be an indicator of the yield potential that is achievable through technological enhancement. If we strive to achieve a part of these potential yield levels, then the increasing demand requirements of the country can be met in future.

Cost of production and yield gap due to different components of package of practices

Under farmers' practices, the total cost was ₹ 7 830/ha with variable cost as ₹ 3 690/ha (~ 47% of the total cost) in year 2005 for lentil (Reddy and Reddy 2010). Most of the operations, including land preparation, were performed manually. Seed rate was 30 kg/ha, but most of the farmers practised less than the recommended seed rate. Fertilizer was either applied in suboptimal doses or was not applied at all. Generally, farmers did not spray any insecticide and fungicide; many farmers practised manual weeding. Most of the operations were carried out by the family labour with the help of neighbouring farmers on exchange basis. Only harvesting and threshing was done on contract basis, with payment in kind (1:11 of the harvested grain was given for

Table 12 Income and own price elasticities of demand for edible oils

Groups	Rural			Urban			All India			Rural	Urban
	Poor	Rich	All	Poor	Rich	All	Poor	Rich	All		
Income elasticity of demand for major food groups in India, 1999											
Cereals	0.31	0.17	0.21	0.23	0.04	0.09	0.28	0.11	0.17		
Pulses	0.91	0.53	0.62	0.79	0.51	0.57	0.83	0.52	0.59		
Oil	0.92	0.46	0.57	0.8	0.46	0.53	0.85	0.45	0.55	1.17	1.1.4
Own-price elasticity of demand for major food groups in India, 1999											
Cereals	–0.53	–0.48	–0.5	–0.5	–0.42	–0.44	–0.52	–0.45	–0.48		
Pulses	–0.76	–0.76	–0.77	–0.82	–0.75	–0.77	–0.79	–0.75	–0.77		
Oil	–0.8	–0.77	–0.78	–0.84	–0.79	–0.81	–0.82	–0.78	–0.8	–0.68	–0.85

Note: Mittal (2006); last two column are for the year 1993–94 estimates from K N Murthy (2000)

Table 13 Cross price elasticity of demand for pulses and oilseeds in India, 1999

Group	Cereals	Pulses	Vegetables & fruits	Milk	Oil	Sugar	Meat, fish & egg
All India							
Pulses	–0.35		0.08	0.02	–0.06	0.01	0.12
Oil	–0.29	–0.05	0.02	0.14		–0.04	0.13

Source: Mittal (2006)

Table 14 Own and cross price elasticities of demand for edible oils

Commodity	Ground	Sony oil	Rape oil	Palm oil	Sun oil
Ground oil	–1.03	0.19	0.40	0.28	0.00
Sony oil	0.27	–1.86	1.66	0.15	0.00
Rape oil	.35	0.78	–1.43	0.16	0.21
Palm oil	0.37	0.12	.21	–1.62	–0.34
Sun oil	0.00	0.00	1.18	–0.90	–1.03

Source: Srinivasan (2004)

Table 15 Average yield and yield potential at TE 2009–10

(Unit: Tonnes/ha)

Food items	Yield (India)	Average yield of top 5 countries	Potential yield (highest in the world)
Wheat	2.98	8.15	8.49 (Ireland)
Pulses	0.69	4.40	4.67 (Ireland)
Edible oilseed	0.81	5.32	6.71 (Israel)

Source: Computed from FAO Statistics.FAOSTAT(2011) http://faostat.fao.org/

Countries in parenthesis are the ones which have the highest yield for the specified food item.

Source: Mittal (2006)

harvesting and threshing). Almost the entire crop was cultivated under residual moisture with no irrigation. Most of the farmers used their own seeds or procured them from the neighbouring farmers. Seed replacement rate was very low (less than 5%). There was no availability of certified seeds at private seed shops or government seed agencies. The average yield obtained in the study area was 880 kg/ha. At a selling price of ₹ 16/kg, the gross revenue was ₹ 16 080/ha and net profit over total cost was ₹ 8 250/ha. The cost of production of lentil was about ₹ 890/q. The variability in yield was quite high depending on residual moisture during crop growth, temperature and disease and pest attack. The trend is similar for other pulses and oilseeds crops in the region.

The recommended practices were divided under six heads: (i) Improved variety, (ii) Weed management, (iii) Fertilizer management, (iv) *Rhizobium* management, (v) Disease management, and (vi) Irrigation management. All packages and cost benefit analysis were worked out for on-farm demonstrations with recommended practices and are presented in Table 16. In demonstrations, except the package under test, all other practices were as per farmers' practice. However, only 10 farmers practised the entire package and it was marked as "package technology". Response to disease management was higher in both increases in yield (46%) and in net return (82%), followed by improved variety with increase in yield by 25% and net returns by 49%. Overall, responses to all management practices individually and in package form were economically viable as increase in net returns are in the range of 17% for weed management to 82% for disease management. For the package as a whole, the yield increased by 59% and net returns by about 88% with additional cost of just ₹ 3 689. The results are more or less similar for other crops.

Estimations of crop loss due to insect pests and diseases

Grain legume crops also effected by different pests and diseases during crop growing stage and also after harvest of the crop. The approximate estimates of the loss in crop yield due to disease and insect pests are estimated by some studies. Most of the studies estimated the losses in the range between 15% to 20%. Results from a study by Dhaliwal *et al.* (2010) are presented in Table 17. The average loss is estimated in

Table 16 Yield gap under different management practices between improved practice and farmers' practice in lentil cultivation: 2005

Type of management practice	Yield			Incremental	Net return (₹/ha)		
	Farmers practice	Improved practice	Yield gap (%)	cost of improved package (₹/ha)	Farmers practice	Improved practice	Net return gap (%)
Variety	981	1 224	24.8	750	7 195	10 741	49.3
Weed management	1 100	1 363	23.9	560	11 172	13 047	16.8
Fertilizer management	1 310	1 553	18.5	475	9 380	12 000	27.9
Rhizobium management	1 236	1 459	18	574	11 560	14 540	25.8
Irrigation management	1 024	1 227	19.8	600	7 892	10 332	30.9
Disease management	780	1 138	45.9	600	7 415	13 490	81.9
Package technology	1 037	1 656	59.7	3 689	8 794	16 500	87.6

Notes: Variety (Improved Practice (IP): Improved variety; Farmers' Practices (FP); Weed management (Improved Practices (IP) P-Pendimethalin @1.25 kg a.i./ha; Farmers' Practice(FP) one hand weeding 25-30 DAS); Fertilizer management (IP-100 kg DAP+100 kg gypsum/ha; FP-100 kg DAP/ha); *Rhizobium* management (IP-inoculation with *rhizobium* culture; FP- No inoculation); Disease management (IP-chemical control; FP-No control); Irrigation management (IP-one irrigation at flowering; FP- No irrigation)

Source: Reddy and Reddy (2010)

Table 17 Estimation of crop losses caused by insect pests to grain legumes

Crop	Actual production (mt)	Approximate estimated loss in yield		Hypothetical production in absence of losses (mt)	Monetary value of estimated losses (million ₹)
		Percentage	Total (mt)		
Rapeseed-mustard	5.8	20	1.5	7.3	26 100
Groundnut	9.2	15	1.6	10.8	25 165
Other oilseeds	14.7	15	2.6	17.3	35 851
\Pulses	14.8	15	2.6	17.4	43 551

*Production and minimum support price (MSP) fixed by Government of India for the year 2007–08

Source: Dhaliwal *et al* (2010)

the range of 15 to 20%. It means, India can increase pulses and oilseed availability by 15 to 20% with investments in appropriate crop protection research and development. This is an important way to reduce the gap between demand and supply.

Most of the times, crops are exposed to many diseases and pests at a time in field conditions. As a strategy to cope with this situation, cultivars having combined resistance to most frequent and major biotic and abiotic stress factors needs to be developed. While some stress factors, such as insect pests and micronutrients deficiencies, can be managed by means other than host resistance, the successful management of crop diseases most often requires the availability of resistant cultivars (Nene 1988). The successful development of multiple resistant varieties in different crops is given in Table 18. The scope for development of multiple resistant varieties increased after recent advances in genomics and needs to be exploited further.

Cost-benefit analysis of pulses based cropping systems

Most of the times grain legumes (pulses, groundnut and soybean) are cultivated as mixed crops or catch crop between two cereal crops. If a crop rotation, mixed cropping system having a legume crop as one of the crop, then we can call that cropping system as legume based cropping system. A comparison of economics of legume-based cropping systems with non-legume-based cropping systems has been given in Table 19. The figures clearly depict that legume-based cropping systems were less input-intensive. Input utilization (fertilizers, pesticides, labour and water) was less for the pulse based cropping systems. The benefit-cost ratio was almost same (1.8) for both the cropping systems. Both gross returns and net returns per unit area were higher for non-legume-based cropping systems (as they are mostly irrigated and high input-intensive) but returns to each rupee invested on irrigation were higher for legume-based cropping systems (8.6) compared to non-legume based cropping systems (7.7). Overall, legume-based cropping systems are more suitable for resource-poor farmers and water scarce regions in the study area. However, returns to pesticide use and irrigation are higher for the legume-based cropping systems and hence, policy options have to be evolved to increase application of pesticide, fertilizer and irrigation under legume-based cropping systems. The legume-based cropping systems are also environmentally sustainable and increase the productivity of cropping systems by increasing yield of subsequent crops (Reddy and Reddy 2010).

Supply response

The inelastic supply curve of pulses and legume oilseeds like groundnut both in the short and long run is a major problem in India as explained in the introduction, eventhough area is responsive to prices, yield is inelastic. In the short run the area share of chickpea is higher at 21%, while in the long

Table 18 Some examples of multiple disease resistance in pigeonpeas

Cultivars/lines	Resistant to
Pigeonpea	
ICP 7198, 8024, 8860 to 8862, PR 5149, ICPL 83-227	Wilt, sterility mosaic
ICP 11302 to 11304	Wilt, sterility mosaic, phytophthora blight
ICP 8861, 8862, 10960	Wilt, sterility mosaic, alternaria blight
64-16A	Rust, leaf spots
Cowpea	
VITA 1	Brown blotch, root-knot
VITA 4	Bacterial blight, scab, *Septoria* sp., *Colletotrichum* sp
Iron	Fusarium wilt, root-knot, anthracnose, rust, *Cercospora* leaf spot, cowpea banding mosaic, CPMV, southern bean mosaic
Chickpea	
ICC 12237-12269	Fusarium wilt, dry root rot, black root rot
ICC 1069	Fusarium wilt, ascochyta blight, botrytis gray mold
ICC 10466	Fusarium wilt, dry root rot, stunt
ICC 88, 959, 4918, 8933, 9001	Fusarium wilt, sclerotinia rot

Nene Y L. 1988. Multiple-disease resistance in grain legumes. *Ann. Rev. Phytopathol.* 26(203-217)

Table 19 Economics of legume-based cropping systems vs non-legume-based cropping systems

Crop rotation	Gross return (000 ₹/ha)	Cost (000 ₹/ha)	Net Return (000 ₹/ha)	B/C Ratio	Fertilizer (000 ₹/ha)	Pesticide (000 ₹/ha)	Labour (mandays)	Irrigation Chagrges (000 ₹/ha)	GR/ Unit water
Non-legume-based with assured irrigation									
Pigeonpea–coriander–chilli	81	32.6	48.4	2.49	3.7	0.6	234	7.5	10.8
Maize–potato–cucurbit	88	35.5	52.5	2.48	4.2	2	289	8.7	10.1
Pigeonpea–coriander–tomato	64.5	30.1	34.4	2.15	1.6		229	4.9	13.2
Maize–potato–wheat	78.2	41.8	36.4	1.87	4.8	2	302	7.6	10.3
Sugarcane	58.8	34.1	24.7	1.73	6.4	0.6	140	8.4	7
Pigeonpea–wheat	31.2	22.3	8.9	1.4	1.8		132	6.3	4.9
Jowar–wheat	29.4	21.6	7.7	1.36	1.8		132	5.6	5.2
Paddy–wheat	45.2	38.5	6.7	1.17	3.2	1	222	12.6	3.6
Mean	59.5	32	27.5	1.86	3.4	0.8	210	7.7	7.7
Legume-based cropping system with little or no irrigation									
Pigeonpea+sorghum	25.8	6.5	19.3	3.94	0	0.2	74	0.7	36.9
Maize–lentil	37	10	27	3.71	0.3	0.5	72	0.7	52.9
Greengram–lentil	42.5	13.7	28.9	3.11	0.2	0.5	122	0.7	60.8
Blackgram–potato–tomato	89.5	41.8	47.7	2.14	3.4	2	366	4.8	18.6
Blac gram–wheat	45	25.3	19.7	1.78	1.7		182	5.6	8
Greengram–wheat	43.5	25.3	18.2	1.72	1.7		182	5.6	7.8
Pigeonpea–wheat–greengram	51.5	32.7	18.8	1.57	1.7	0.3	268	6.5	7.9
Paddy–lentil	41.4	26.9	14.5	1.54	1.7	1.5	162	7.7	5.4
Paddy–veg.pea	52	35	17	1.49	2.7	1.7	221	12.6	4.1
Paddy–wheat–greengram	60.2	46.1	14.1	1.31	3.2	1	308	12.6	4.8
Mean	48.8	26.3	22.5	1.86	1.7	0.8	196	5.8	8.5

Source: Reddy and Reddy (2010)

run, yield contributes only 5% of total response of supply to price change. In the long run, area response is 95% of production increase, which indicates that in the long run there is no technological improvement in the pulses in India (Table 20). In the case of oilseeds (groundnut), in the long run, the contribution of yield is much higher than pulses.

Reasons for long run inelastic supply in India

Since 1966, pulse crops have been neglected with agricultural policy environment favouring spread of green

Table 20 Short run and long run price elasticity of supply (1990–91 to 2004–05)

Particulars	Area	Yield	Production
Wheat			
Short run	0.071	0.097	0.168
Long run	0..256	0.105	.361
Chickpea			
Short run	0.216	0.041	0.257
Long run	0.780	0.044	0.824
Groundnut			
Short run	0.082	0.109	0.191
Long run	0.216	0.116	0.332

Mythili (2008)

revolution technology in few crops like paddy and wheat for food security reasons in many developing countries including India. This input-intensive technology further enhanced already existing yield gap between major cereals and pulses. Due to prolonged neglect for several decades, yield levels of pulse crops are stagnant (increased only by 12.2% from 1966 to 2009 as against 162.6% increase in yield of wheat). Table 21 depicts the changes in real prices between TE 1969 and TE 2009 for pulses and competing crops. The real price steeply increased for chickpeas increased by 42% compared to a decline for wheat (–10.2%), maize (–18.9%) and millets (–17.4%), mainly due to low supply response (inelastic supply curve) of pulse crops. The rising real prices indicate the unmet demand for pulses with the current supply levels in India. With the increase in supply and decline in real prices, there is a likely possibility of more consumers prefer to consume more pulses, which will increase demand.

As a result of widened gap between yields of pulses and major cereals (the yield of wheat increased from 1.6 times that of pulses in 1969 to 3.8 times in 2009) the relative profitability and competitiveness of pulse crops reduced even though prices increased due to shortage of supply (due to inelastic supply). Another important reason for decreased preference for pulses by farmers is continued high instability in yields of pulse crops (instability is 16.5% during 1989–2009, as against instability in wheat at 5.1%) than major cereal crops. The main reason for inelastic supply of pulses are (i) scattered and thin distribution of various types of pulse crops on mostly marginal and low productive lands, with each crop contributing a small share in total pulses area is the biggest hurdle for all stakeholders (researchers/extension/development/credit/market support agencies in both public and private sector) to enhance yields and provide right policy environment, (ii) low institutional support due to the above reason, (iii) indeterminate plant type of many pulse crops with low yield potential, (iv) low input responsiveness, (v) near stagnation in yield and technology and hence profitability of pulse crops relative to other competing crops resulted in shifting of pulses to low-productive and marginal lands, (vi) high frequency of crop failure and yield instability due to pests and diseases and drought and floods, (vii) low priority by policy makers due to marginal importance of each crop at local level to have significant impact, although they contribute lot to national economy (Materne and Reddy 2007). As a result area under paddy and wheat increased in high-productive zones along with high doses of inputs like fertilizer and pesticides and pulse crops shifted to marginalized lands with no or little inputs and consequent low supply response even though prices are high. The same is applicable to oilseed crops like groundnut.

Table 21 Trends in real prices (Rs/quintal) of food grains in India

Crop	% change in real prices between 1969–2009	% change in production between 1969 and 2009	Yield TE 2009 (kg/ha)
Millets	–17.4	29	957
Maize	–18.9	214	2 251
Wheat	–10.2	405	2 806
Chickpea	42.0	37.6	834.1
Pigeon pea	32.9	63.4	715.4

Source: FAOSTAT(2011); prices were deflated by CPI for agricultural labourer with 1986/87 base year

High instability in area, production and yield of grain legumes

In addition to inelastic supply response to prices, the production of pulses and oilseeds (here groundnut) is highly unstable. Between cereals and pulses, the latter shows higher instability in all the periods and in all respects. Instability in production and productivity of oilseeds remained higher than pulses after 1968. Instability in area under pulses turned out to be much higher in the first phase of green revolution compared to pre green revolution period and remained at almost same level during 1989 to 2007. While instability in yield decreased from 12.91% to 9.76% due to the adoption of pest and disease resistant varieties and adoption of plant protection technologies (Table 22, Devraj *et al*. 2007, Reddy 2006).

Instability in area under oilseeds increased by 9% between pre green revolution and first phase of green revolution and further by 14% during recent period. Instability in yield during the corresponding periods increased by about 8% and 22%. Oilseed production witnessed increase in instability from 12.74 during 1951–66 to 17.06 during 1968–88 and further to 18.36 during 1989–2007. Yield of cereals and pulses was more stable after pre green revolution period, whereas opposite holds true for oilseeds. The increased instability in area, yield and production due to the uncertain trade policy followed by the government after the opening up of the economy in early 1990s. In the case of pulses first

Table 22 Instability in area, production and yield of major crop groups in different periods at all India level (%)

Crop group	Area			Production			Yield		
	1951–1966	1968–1988	1989–2007	1951–1966	1968–1988	1989–2007	1951–1966	1968–1988	1989–2007
Cereals	2.3	3	2.95	9.58	9.43	8.21	7.75	7.33	5.51
Pulses	4.35	5.96	6	14.7	13.9	14.18	12.91	10.54	9.76
Oilseeds	5.01	5.51	6.3	12.74	17.06	18.36	12.07	13.01	15.89
Gram	8.05	10.42	15.69	20.14	21.68	21.56	17.95	16.94	10.91
Pigeonpea	3.71	5.31	3.72	18.81	14.34	16.91	18.97	14.28	15.97
Groundnut	9.52	4.12	5.85	14.07	23	29.81	15.19	20.18	28.27

Source: Chand (2008)

phase of green revolution experienced a decline in instability to the extent of 5.4% but post 1988 period witnessed an increase of 2%.

Among pulses, instability in area under gram increased over time but instability in its yield declined sharply after 1988. Because of these counteracting factors, instability in production of gram in all the three periods remained around 21%. Area under pigeonpea shows remarkably low instability but its yield show quite high year to year variability. There was decline in variability in pigeonpea output from 18.8 during 1951–66 to 14.34 during 1968–88 which again increased to 16.91 during 1989–2007.

Variability of groundnut shows two interesting features. One, variability in its area declined to less than half, during first phase of green revolution and then increased by 42% after 1988. Variability in its productivity increased from 15.19 during 1951–66 to 20.18 during 1968–88 and, further to 28.27 during 1989–2007. Almost similar increase was experienced in the case of production.

Though the higher instability is due to the neglect of pulses and oilseeds in providing stable policies over long period, it can be addressed through the technological interventions like development and wider adoption of pest and disease resistant varieties, drought and flood tolerant varieties, short duration varieties.

Reasons for persistent demand and supply gap and high instability in production

Even with the best efforts, pulses production and productivity has been stagnant. Due to the low productivity-low input nature, pulses are grown as residual/alternate crops on marginal lands after taking care of food/income needs from high productivity-high input crops like paddy and wheat by most farmers. Also, they grow as rainfed crops with little or no modern yield enhancing inputs. The low priority accorded to pulse crops may be related to their relatively low status in the cropping system. As a crop of secondary importance, in many of these systems, pulse crops do not attract much of the farmer's crop management attention. In addition to this, these crops are adversely affected by a number of biotic and abiotic stresses, which are responsible for a large extent of the instability and low yields. The following section deals with different technology constraints in pulses production, and strategies to overcome them (Reddy 2009, Reddy 2005).

Abiotic constraints: There has been a high degree of risk in pulses production (Table 23, Table 24). More than 87% of the area under pulses is presently rainfed. The mean rainfall of major pulse growing states such as Madhya Pradesh (MP), Uttar Pradesh (UP), Gujarat and Maharashtra is about 1 000 mm and the coefficient of variation of the rainfall is 20-25%. Moisture stress is the oft-cited reason for crop failures. Terminal drought and heat stress results in forced maturity with low yields. Drought stress alone may reduce seed yields by 50% in the tropics. A quantum jump in productivity can be achieved by applying life saving irrigation especially in *rabi* pulses grown on residual moisture. Two genes – "efl-1" and "ppd" have been identified for early flowering and maturity to escape drought stress (ICCV 2 in south India). In collaboration with ICAR, ICRISAT has developed a unique short-duration (chickpea) variety ICPL 87. In a detailed impact study, Bantilan and Parthasarathy (1998) found that the variety/management package resulted in an average 93% yield increase over the system it replaced. This could have been tackled on two fronts – development of varieties tolerant to moisture stress and bringing more area under irrigation. Irrigated area under pulses has virtually remained stagnant at 13% of the total area. Availability of adequate soil moisture for crop growth depends on rainfall, water holding capacity and depth of soil in rainfed areas. In south India, water holding capacity of the soil often limits grain yield to the extent of 50% of that possible under irrigation on Alfisols. On the contrary, on vertisol soils, higher water holding capacity causes growth reduction up to 5-20%. Higher evapo-transpiration in south India during the *rabi* season causes severe constraints to chickpea yield under drought. Another major problem is salinity and alkalinity of soils. Salinity and alkalinity is high both in semi-arid tropics and in the Indo-Gangetic plains in irrigated areas, which is a cause for concern, as most pulses are susceptible to salinity and alkalinity. Grain yield is also influenced by temperature. Cold is an abiotic stress, limiting the grain yield of pulse crops. All hot season pulses are sensitive to low temperatures, but generally these are not exposed to low temperatures. On the other

Table 23 Important biotic and abiotic stresses identified in major pulse crops of India

Crop	Season	Stress	
		Biotic	Abiotic
Chickpea	Timely sown	FW, root rot, chickpea stunt, BGM, pod-borer	Low temperature
	Early sown	FW, root rot, AB, stunt, pod borer	Terminal drought, salt stress
	Late sown	FW, pod borer	Terminal drought, cold
Pigeonpea	Kharif-early	FW, PB, pod- borer complex	water logging
	Medium late	FW, SM, pod-borer complex	Cold, terminal drought, water logging
	Pre-rabi	FW, ALB, podfly	Cold, terminal drought
Greengram	*Kharif*	MYMV, CLS, WB, sucking insect pests	Pre-harvest sprouting, terminal drought
	Zaid	MYMV, CLS, WB, sucking insect pests	Pre-harvest sprouting, temperature stress, drought
	Rabi	PM, rust, CLS	Terminal drought
Blackgram	*Kharif*	MYMV, anthracnose, WB, LCV	Terminal drought
	Zaid	MYMV, root and stem rot, stem agromyza	Pre-harvest sprouting, temperature stress, drought
	Rabi/rice fallow	spot	Terminal drought
Lentil		FW, root rot, rust	Moisture, temperature

FW, fusarium wilt; PB, phytophthora blight; SM, sterility mosaic; ALB, alternaria leaf blight; MYMV, greengram; bean yellow mosaic virus; BGM, botrytis grey mould; AB, ascochyta blight; *Source:* Reddy 2009

Table 24 Ranking of biotic and abiotic stress based on farmers perception

Crops	Highest frequency pest and diseases			Highest damage pest and diseases			Flower drop/frost/ waterlogging		
	1	2	3	1	2	3	1	2	3
Chickpea	Wilt	Pod borer		Pod borer	Wilt		Frost	Heavy rain	
Pigeonpea	Wilt	Leaf roller	Pod borer	Pod borer	Wilt	Leaf roller	Waterlogging	Flower drop	Frost
Greengram	YMV	Pod borer		Pod borer	YMV		Waterlogging	Heavy rain at harvest	
Blackgram	YMV	Pod borer		Pod borer	YMV		Waterlogging	Heavy rain at harvest	

Source: Reddy (2006). Impact of IIPR Research

hand, cool season pulses (chickpea) are often subjected to chilling temperatures especially in areas of north India. However there has not been much improvement in the development of chilling and frost tolerant varieties. Poor drainage/water stagnation during the rainy season causes heavy losses to pigeonpea on account of low plant stand and increased incidence of phytophthora blight disease, particularly in the states of UP, Bihar, West Bengal, Chhattisgarh, MP and Jharkhand. Ridge planting has been found very effective in ensuring optimal plant stand and consequently higher yield. A simple ridger already available can effectively be used for this purpose. Since most pulse crops are drought tolerant and grown as rainfed, most of the research efforts have been confined to develop genotypes and associated production technologies to suit dryland conditions. Consequently, germplasm suited to high rainfall and irrigated conditions are lacking.

Biotic constraints: More than 250 insect species are reported to affect pulses in India. Among these, nearly one dozen cause heavy crop losses. On an average 2-2.4 million tonnes of pulses with a monetary value of nearly ₹ 6 000 crore are lost annually due to ravages of insect pest complex. Among them, pod borer (*Helicovera armigera)* causes the most harm, followed by pod fly, wilt and root rot. Recently many successful trials have been conducted to control pod borer through using nuclear polyhedrosis virus (HaNPCV), which has been found to be more efficacious in bringing about higher and quick mortality. In on-farm trials, *Bacillus thruringiensis* Berliner *(Bt)* var *kurstaki* has also been tested on pod borer, and field demonstrations resulted in 10-12% reduction in avoidable loss as against 11% in the use of a chemical pesticide. However, the successful release of Bt chickpea/pigeonpea varieties from either public or private research will take some more years. Another important pest affecting pulses are nematodes, among which root-knot nematodes are important in terms of spread and damage to crop yield, which have been effectively controlled by bio-agents. Trials at the Indian Institute of Pulses Research (IIPR) in infested fields have shown avoidable yield losses ranging 10-40% in irrigated and 15-30% in rainfed areas from control of nematodes by utilizing bio-agents (seed treatment with *Trichoderma* sp) and chemicals. Recent developments of these bio-pesticides can also reduce harmful chemical residue in grains, which ultimately improve the quality of foodgrains. Research in insect pests has been concentrated only on *Helicoverpa armigera*, multiple resistance varieties need to be developed in future to simultaneously control many pests. Among important diseases, wilt in chickpea, sterility mosaic virus (SMV) in pigeonpea, yellow mosaic virus (YMV) and powdery mildew (PM) are common and more damaging. A few varieties possessing vertical resistance to one or two diseases such as wilt resistance in chickpea (ICP 8863) released by ICRISAT have had the highest impact in terms of adoption. Its adoption in northern part of Karnataka state, the primary target zone, has increased from 5% in 1987 to almost 80% now. It has resulted in stabilisation of production, expansion of crop area and increased incomes. Other varieties such as JD 315, KWR 108, ICCV 10 and H 822 have had limited success; SMV resistance in pigeonpea (Bihar and Pusa 9), YMV resistance in greengram, bean (PDM 84139, PDM 54, Narendra Greengram 1, Pant Greengram 1, -2 and -4) and blackgram, bean (Pant U 19, Uttara, Narendra and Urd 1), PM resistance in pea (HFP 4, Shika, IM 9102 and DMR 11) and rust resistant in lentil (DPL 62,DPL 84 and Pant L 406) varieties have been developed.

Physiological limitations: There is a general feeling that pulses (C-3 plants) suffer from inherently low yield potential and are a physiologically inefficient group of plants compared to cereals (C-4 plants) such as sorghum and maize. However Aggarwal *et al.* (1997), reviewed the comparative advantages of C-3 and C-4 group of plants and argued that C-3 and C-4 plants seem to compete on fairly even terms in hot dry environments. The fact that C-3 plants usually do better in cool climates suggests that C-3 plants are better for *rabi* season. However, the disturbing future is that the harvest index (HI) in pulses is low compared to cereals. HI is defined as seed yield per unit of recoverable biomass. In pulses it is only 15-20% compared to 45-50% in case of cereals such as wheat and rice. Low HI results from excessive vegetative growth, but can be overcome by early partitioning of dry matter into seeds (Saxena and Johansen 1990) and evolving biotechnology and genomic tools to incorporate good features of C-4 plants into C-3 plants. Pulses in general have a high rate of flower drop. In pigeonpea, over 80% of the flowers produced in a plant are shed; by decreasing flower drop, yield can be increased considerably. This can be done either by breeding lines which retain a large proportion of flowers producing pods or through physiological manipulations, such as spray of hormones which reduce flower drop. Physiological studies at ICRISAT, involving removal of flowers and young pods of pigeonpea, have shown that plants compensate for the loss of flowers and young pods by setting pods from later formed owners, which otherwise would have dropped. This compensatory mechanism provides substantial plasticity of adaptation to intermittent adverse conditions such as moisture stress or insect attack, which are common in warm rainfed areas of south India. Recent increase in yield levels in pigeonpea is due to release of long duration (annual) varieties, which maximise utilisation of assimilates in filling the available sink of a large number of flowers (Saxena and Nadarajan 2010).

Socio-economic and geographical constraints: Pulses production in India is characterised by a very high degree of diversity as indicated both by the number of crops, and their spatial distribution into varied agro-climatic conditions (Reddy *et al*. 2011, Reddy 2005). Most of these crops are region-specific in the sense that a single state or a cluster of few states accounts for the bulk of the area and production of a specific pulse crop. Pulses such as pea, lentil, khesari and even chickpea indicate their regional distribution pattern. This diversity has several implications. In the first place, it places serious limitation to a single national policy for the promotion of pulses production in the country, and for the promotion of regional crop specific strategies to pulses development programmes. However, in view of the meager resources available to pulses development as a group, this diversified approach may mean spreading the resources too thinly and in turn making the effort inconsequential. This dilemma may partly explain the absence of any major thrust on research on pulses based systems. Eventhough rice-pulse crop sequence is better than the rice-wheat cropping system its adoption is low in many north-Indian states. Overall, pulse based cropping systems are more suitable for resource poor farmers and water scarce regions. Hence policy options have to be evolved to incorporate at least one pulse crop in cropping systems to enhance returns from irrigated farming systems. However, these findings are only applicable in irrigated conditions. It should be noted that the scope for introduction of pulse crops in rice-fallows (mostly un-irrigated) needs to be exploited with supplemental irrigation, considering the higher profitability and scope for pulse crops as *rabi* crop in the cropping systems. Table 8 depicts the extent of rice-fallows, which can be put under pulse crops in the *rabi* season. There is vast area of fallow land in MP (78% of *kharif* rice area, which accounts for 4.4 million ha), Bihar (2.2 million ha) and in West Bengal (1.7 million ha), which are most suitable for pulses cultivation.

The major future expansion of area under pulse crops may take place in rice fallows, where there is no other crop to compete, however there are limitations on the successful propagation of these crops in this system. Most of the farmers in south India, where large areas of rice fallows are located, are not aware of the potential economic benefits of using fallows for legume cultivation. In many cases, the farmers were found to have not only inadequate but also incorrect information about recommended pulse production technology. Governments should provide various incentives to increase area under pulses in rice fallows.

Other issues in increasing production

Lack of seed availability: In any crop, generally an increase in the production and productivity is brought about by the wider availability and adoption of improved varieties of seeds. Nearly 400 improved varieties of different pulse crops have been released for cultivation since the inception of coordinated pulses improvement programme in 1967. But at present, only 124 varieties are in the production chain. Among them a dozen are popular among farmers. The wide gap between the requirement of certified/quality seeds and its distribution in India is a matter of great concern. The seed replacement ratio is very low (2-5%), while the required seed replacement ratio is 10%. By the year 2025, 4 487.2 q of breeder seeds, 59838.3 q of foundation seeds and 748 000 q of certified seeds of chickpea, and 49.4 q of breeder seeds, 2201 q of foundation seeds and 91740 q of certified seeds of pigeonpea will be required (Reddy 2005). Under National Food Security Mission (NFSM), breeder and foundation seed production has been entrusted to IIPR (Kanpur), while production of certified seeds is entrusted to National Seeds Corporation and other state organizations for timely supply to farmers at affordable prices (Reddy 2005).

Lack of cash and credit: Cash is a key element for enabling small farmers to shift from low input-low output to high input-high output agriculture. But access to credit by these farmers is low because of their low asset base and low risk bearing ability. Further, credit facilities for pulse crops both from formal and informal sources are limited due to unstable returns.

Marketing: Markets for legumes are thin and fragmented due to scattered production and consumption across states. Farmers/village traders sell their marketed surplus immediately after harvest, while some large traders/wholesalers trade between major markets and hoard pulses to take advantage of speculative gains in the off-season. Due to this, farmers do not benefit from the higher market prices of pulses. Also, for certain pulses like khesari, demand is localised and markets are underdeveloped. In recent years, there have been improvements in market information and infrastructure, and the price spread between consumer price and producer price is reducing, especially in the harvest season.

Crop-specific strategies

After reviewing the all India coordinated pulses projects and also research work at IIPR Kanpur, the following crop specific strategies to increase area under pulses is suggested:

Chickpea: There is a remote possibility for increasing area under chickpea in north India. The past trends indicate that as soon as the area develops irrigation facilities, the chickpea area gets diverted to other more remunerative crops like wheat, mustard, sunflower, sugarcane, potato, etc. There are some possibilities of increasing the area under chickpea in the states of Maharashtra, Karnataka, Andhra Pradesh and Gujarat in partial replacement of *rabi* sorghum and also rice fallows. If a thrust is given, it should be possible to cover about 0.3-0.4 million hectare area under this crop.

Pigeonpea: There are four distinct possibilities of increasing area under this crop (i) Popularisation of short duration varieties of pigeonpea in sequence with wheat under irrigated conditions in the states of UP, Haryana, Punjab and northern parts of MP. (ii) Replacement of uneconomic crops like cotton in Gujarat and Karnataka and millets such as sorghum, pearl millet, finger millet, etc, in Andhra Pradesh, Maharashtra and Tamil Nadu. (iii) Popularisation of *rabi* pigeonpea in the states of Odisha, Gujarat, West Bengal, Bihar and eastern UP, and (iv) There is a very large scope of increasing area through inter-cropping of pigeonpea with soybean in MP, Maharashtra and Rajasthan; and with cotton, sorghum, pearl millet and groundnut in the states of AP, Maharashtra, Karnataka, Gujarat, MP and UP. It is expected to get additional coverage under pigeonpea by at least 1 million hectares by the turn of the century.

Blackgram and greengram: There should be propagation of blackgram/greengram as a summer crop after the harvest of *rabi* crop specially potato, sugarcane, mustard and wheat under irrigated conditions in the states of Bihar, UP, Punjab, Haryana, West Bengal, Odisha, Andhra Pradesh, Karnataka and MP and also after the harvest of *kharif* paddy in the states of Andhra Pradesh, Odisha, Karnataka and West Bengal. There is some scope in *kharif* fallows before the sowing of *rabi* sorghum, rapeseed, mustard, safflower, rainfed wheat, *rabi* sunflower in the states of Andhra Pradesh, Maharashtra, Karnataka, Tamil Nadu, MP, UP, Bihar and Gujarat. In some regions, there is scope for intercropping with spring planted sugarcane, with maize, sorghum and pigeonpea, etc. All these practices have the potential to bring an additional area under both these pulse crops to the extent of about 2 million hectares.

Lentil: There has been a constant increase in area under lentil. Further, there are possibilities for expansion of area under this crop especially after the harvest of paddy crop in rainfed areas in UP, Bihar and West Bengal. It is presumed that an area of about 0.2 million hectares can be brought under this.

Peas: There are remote possibilities of expansion of area under this crop. Like chickpea, this crop also faces competition with wheat in irrigated areas. However, there is still some scope for area expansion under this crop in UP, MP and Bihar at the tail end areas of canals where enough water is not available for growing wheat crop.

Rajmash and broadbeans: These crops possess a very high yield potential with the use of high levels of inputs like fertiliser and irrigation. Yield levels up to 2.5 tonnes/hectare can easily be obtained in these crops. The potential areas are eastern UP, Bihar, West Bengal, Odisha, MP, Maharashtra and Gujarat. It may be possible to cover about 0.1 million hectares area in four to five years time. However, these crops have a limited preference from consumers.

Farmer's perception about varieties and crops

A field survey has been conducted in six villages namely Khadakpur,Devpalpur, Atwa,Trilokpur, Gabraha villages of Chowbaypur block and Shyampur village of Sarwankheda block in Uttar Pradesh during 2006 to know the perception about pulse crops. All these villages are located within 40 km from the Indian Institute of Pulses Research (IIPR/Kanpur). Farmers prefer Narendra 1 among all pigeonpea (late) varieties, UPAS 120 among all pigeonpea (early) varieties, among greengram varieties farmers most preferred variety is PDM 139, while IPU 94-1 is the most preferred blackgram variety. Among all chickpea varieties, DCP 92-3 is the most preferred variety. All improved varieties of greengram and blackgram cultivated by farmers are resistant to wilt, but in case of chickpea and pigeonpea improved varieties are moderately susceptible. But in case of pod borer there is no resistant variety in both pigeonpea and chickpea which are mainly affected by pod borer. Even in case of greengram bean and blackgram also there is no resistant variety for pod borer.

Some results of the farmers' level of technology are given in this section (Reddy 2006). Farmers have been applying sub-optimal doses of fertilisers, pesticides and number of irrigations for pulses after meeting the requirements of wheat, paddy and vegetable crops. For pigeonpea and chickpea, most farmers applied 40 kg/ha urea. To address the problem of wilt and pod borer, farmers used pesticides. Only occasionally some farmers applied farmyard manure at the rate of 2 tonnes/ha. For *kharif* pulses generally there is no application of irrigation. For *rabi*/spring pulses grown only in irrigated conditions, the number of irrigations depends on the availability and cost of irrigation. Generally the numbers of irrigations given at critical stages have been thus: for lentil three times, for chickpea two times, for fieldpea two times, for blackgram/greengram (spring) three to four times have been given at critical stages. Economic returns far exceed the cost of irrigation and fertilisers, while the response for pesticide on pod borer and wilt is not certain. The improved variety of pigeonpea (early) (UPAS 120) has recorded a yield increase of 44.4% over local varieties, chickpea variety (BG 256) recorded a yield increase of 43.6% over local varieties, and field pea (HFP 4) recorded the highest yield increase, i e 54.5%. Improved varieties of lentil, greengram and blackgram showed yield increases of around 30-35%. Overall with the adoption of improved varieties, gross returns increased more than the increase in costs, thereby increasing

Table 25 Ranking of reasons for continuation and discontinuation of pulse crops

Reasons for continuation	Pigeonpea (early)	Pigeonpea (late)	Greengram (spring)	Chickpea	Greengram (kharif)
High yield			3		
Remunerative price	3	2	4	4	
Low cost				5	3
Availability of improved seed	5	4			
Suit to soil/agro-climate					2
Less irrigation requirement	2	1		1	4
Less fertilizer		5			
Less pest and disease attack			5		
Awareness					5
Suitable to low resource				3	1
Short duration	1				
Utilisation of resources in spring			1		
Less risk			2		
Domestic consumption needs	4	3		2	
Discontinuation reasons					
Low yield				3	2
Better alternative vegetables)	2 (maize-sorghum)	5 (early PP)	(vegetable crop)	4 (wheat)	(early PP, vegetable)
High cost			5		
More irrigation			2		
More pest and disease	3	3		2	5
No knowledge			4		
Technically not feasible			3		
Long duration	4				
More risk	5	4		5	4
Grain quality					3
Blue bull attack	1	1	1	1	1

the cost-benefit ratio. In pigeonpea (late), it was found that 51.1% of the farmers used improved seeds, 42.2% used fertilisers, 25.4% used insect pest control, and 17.7% used seed inoculation with fungicides and 22.2% followed seed treatment with rhizobium culture. Non-availability of improved varieties and rhizobium culture are major reasons for their non-adoption (Table 25).

CONCLUSIONS

In short, to increase area and production of pulse crops and oilseeds (groundnut) we need crop specific and region specific approaches, which should be adopted in the overall framework of systems approach. The major thrust areas to be addressed are as follows: (i) Replacement of cereal crops in the prevailing rice-wheat cropping systems with high yield varieties of pulses and oilseeds. (ii) Inclusion of short duration varieties of pulses as catch crop. Replacement of pigeonpea (late) with pigeonpea (early); introduction of blackgram/ greengram (spring) will increase cropping intensity even up to 300%. (iii) Use of genomics and biotechnology tools for development of multiple disease and pest resistant varieties to reduce yield loss of standing crop and to increase yields. (iv) Evidence shows that, growing a single pulse crop per year by farmers contributed significantly to nutritional security of farm families in terms of household consumption in addition to earning income. (v) Reducing storage losses and improving market information and infrastructure. (vi) Developing high nitrogen fixing varieties, which will play a crucial role in sustainable agriculture, and (vii) Technology dissemination and input delivery mechanisms were too weak for grain legumes. Coordination of research, extension and farmers to encourage farmer's participatory research. (viii) Linking MSP to market prices can bridge the gap between demand and supply. (ix) Development of market information systems for pulses and oilseeds, which are neglected traditionally.

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