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Status, adoption gap and way forward of pulses production in India

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ABSTRACT

Pulses are generally grown under rainfed, highly unstable and complex production environments, substantial variability in soil and environmental factors, high year to year output variability, and variation in soil moisture. One is required to emphasize the need for identifying and quantifying level of adoption and its determinants across agroclimatic regions. The net availability of pulses has come down from 60 g/day/capita in 1951 to 41.6 g/day/capita in 2012-13 due to stagnant production and rapid increase in population. Among so many, the most important way to increase production in the short-run is to reduce yield gaps between research station, on-farm demonstration and farmer's fields. The yield gap and constraint analysis was carried out for pigeonpea and chickpea in high potential high gap states and districts of India. The results showed high to medium level of adoption gaps in almost all the recommendation domains in both the crops. Nearly 80 percent of the respondents had not adopted manurial aspects of the crop and 76 percent had not gone for any plant protection measures. Only 29% adopted the recommended varieties and nearly 60% adopted agronomic practices like line sowing, weed management, spacing, presowing irrigation and proper land preparation. It can be recommended that in order to have the latest information on pulse improvements from researchers, it will be necessary to have appropriate training for the extension workers and subsequently to farmers with availability of matc11hing input supply system.

Key words: Adoption, Area potential gap matrix, Chickenpea, Constraints, Pigeonpea, Productivity, Pulses

Over decades, pulse production has been neglected in India due to promotion of wheat and paddy. The research and technological innovation in pulse crops were meager as compared to wheat and paddy. It is generally agreed by the researchers that very little biodiversity exists in case of pulses to develop new varieties with desirable characteristics like high yield and resistance to biotic and abiotic stresses (Reddy 2004). But even with available varieties and technologies pulses production can be doubled (Reddy 2005**).** About 400 improved varieties of pulses have been released for cultivation since the inception of All India Coordinated Pulse Improvement Programme in 1967, but only 124 varieties are in the production chain and only a dozen are popular among the farmers (Reddy 2009).To achieve higher production and productivity of pulse crops, extension personnel should disseminate the available technology related to plant protection measure with emphasis on providing knowledge and skills to farmers (Kumar *et al*. 2010).There is definitely scope for improvement in research, but even available technology is not reaching to the farmers. The technology gap in pigeonpea and chickpea was reported more than extension gap at farmers' field (Kumbhare *et al.* 2014)**.** Most professionals assume they know what farmers want and need but are often wrong. Conversely, identifying farmers' priorities and helping farmers meet them leads to innovations which are adopted. There can be a number of underlying reasons for not doing the required to realize on farm economic potential such as; capital constraints, profit seeking behaviour, lack of information about technologies, risk bearing ability, institutional and social infrastructures etc. In fact, these are the underlying determinants of yield gaps and need to be understood for making appropriate policy prescriptions. The primary focus must be to better understand the factors that are responsible for the non-adoption of the innovation so that conditions may be modified. The most important way to increase production quickly is to reduce the yield gaps between research station, on-farm demonstration and farmer's fields in pulses (Reddy *et al*. 2007). The key difficulties to achieve synergy between the natural and human sciences in technology transfer are found in the paradigm used in applied agricultural research, and the mandate, culture and organisation of research institutions that underpins this. During last two decades an

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increasing amount of adaptive research, with participatory methods in farmers' fields by understanding farmers' priority problems, identifying a range of prototype solutions, working with farmers to choose among these alternatives and adapt chosen options to their local circumstances has been witnessed. The roles of extension as that of capacity development, which include training, strengthen innovations' process, build linkages between farmers' and other agencies as well as institutional and organizational development to support the bargaining position of farmers (Hall *et al*. 2005). Co-existence need for strong pulse research and extension has been advocated in wake of non-adoption of proper high potential, pest and disease resistant genotypes, *Rhizobium* inoculation, proper seed rate, integrated nutrient and pest management practices, proper grading and storing practices (Nain *et al.* 2014).

The major pulse crops of India are redgram or pigeonpea (*Tur, Arhar*), chickpea or gram, blackgram (*Urdbean*), greengram (*Mungbean*) and lentil (*Masur*). Minor pulses includes *Rajmash* and other beans like; cowpea, horsegram, moth, *khesari dal*, etc. Among these, pigeonpea and chickpea are the most important pulse crops. Pigeonpea originated in Asian continent and said to be native to India in as long as 3000 years ago (CRN India). The main pigeonpea producing states are Maharashtra, Uttar Pradesh, Karnataka, Madhya Pradesh, Gujarat, Rajasthan, Haryana, Punjab, Tamil Nadu, Odisha and Bihar. The domestic consumption of pigeonpea in India is around 3.4 million tones well ahead of the domestic production. Chickpea is another ancient pulse crop that marked its origination even before 10000 BC when it was used by the 'hunter-gatherer societies' for eating and sustaining their communities. The regions of Turkey and the ancient city of Jericho, domesticated this crop around 7500 BC and since then, it started getting popular (CRN India). Chickpea producing states in India are Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra and Andhra Pradesh. Although India is largest producer of chickpea, it is also the largest importer in the world from Canada, Australia, Iran, Myanmar, Tanzania, Pakistan, Turkey and France to fulfill the domestic demand (Reddy *et al*. 2007).It has been observed that the area, production and yield of pigeonpea and chickpea has not increased significantly even after 62 years from 1950-51 to 2012-13. On the other hand the area, production and yield of paddy and wheat have increased many folds during this period. Farmers allege that spurious fungicides, pesticides and fertilizer and low quality seeds are being supplied to them at exorbitant rates. However, the government says adequate steps are being taken to save the worsening conditions. It is inevitable to draw the empirical answers to the research question that why there is more yield gap of pulses in comparison to cereals and the levels and reasons for non-adoption of recommended practices in pulses. Therefore, yield gap analysis was carried out for pigeonpea (*Cajanus cajan)* and chickpea (*Cicer arietinum*) in high potential high gap states and districts of India with the specific objective to analyse the pulse production scenario in India and status of adoption of recommended technologies for production of pulse crops and the causes of non-adoption.

MATERIALS AND METHODS

Primary and secondary data sets were used to analyze the status, adoption gap and constraints thereof. The secondary data source for this paper has been drawn from Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India and Food and Agricultural organisation. To collect the primary data on adoption status of scientific production technologies, the respondents were selected with multistage sampling plan. At first stage the Indian pulse (pigeonpea and chickpea) growing states were classified on the basis of area-potential-gap matrix to select two states randomly from 'high potential high gap' category of each crop as suqqested by Nain *et al.* 2014. The identified states for pigeonpea included Maharashtra and Andhra Pradesh, whereas for chickpea Uttar Pradesh and Madhya Pradesh were identified. At second stage the districts of identified states were classified on the basis of area potential gap matrix (As for states). This way Mahbubnagar and Parkasham districts from Andhra Pradesh, Yavatmal and Akola from Maharashtra, Rambainagar and Jalon from Uttar Pradesh, and Tikamgarh and Gwalior from Madhya Pradesh were finalized for data collection from 'high potential high gap' districts of the crop.

The technological recommendations for these two crops were used to ascertain the adoption gaps at farmers' level. The farmers were categorized in three as; adopting the technology as recommended (adopters), practicing different than recommended (partial adopters) and farmers not practicing at all (non-adopters)**.** The adoption status was analysed on six broad parameters, viz. Analysis of farm resources, Seed components, Agronomical components, Manurial components, Plant protection components and Harvesting and storage components. The components were further classified into sub components for the purpose of data collection, analysis and reporting. The constraints in production of two major pulses were related to input, infrastructure, know-how and other constraints were accordingly analysed from the selected farmers. In addition, secondary data of per capita availability, area, production and yield of pigeonpea and chickpea in different countries was collected and inferences have been drawn. The constraints have been studied under the major heads; input, know how, infrastructure and other related constraints in pulse production. The percentage of farmers perceiving the particular constraint was calculated and rank ordered accordingly.

RESULTS AND DISCUSSION

The results along with relevant discussion have been presented in three broad heads namely pulse production scenario, adoption status of recommended technologies of pulses and constraints in pulse production.

Pulse production scenario

It is evident from the time series data in Table 1 that area of pigeonpea has increased (101.4%) from 2.18 million hectare in 1951 to 4.65 million hectares in 2012-13 but the yield has decreased from 788 kg/ha to 806 kg/ha (2.2%). In case of chickpea, the area during 1951 was 7.57 million hectare and increased (9.9%) to 8.32 million hectare in 2011-12 but the yield has increased from 482 kg/ha to 1020 kg/ha (+111%). It indicated that the yield pattern of pigeon pea is not much in increasing order but in case of chickpea it was in increasing order with very slow rate in contrast to yield growth of wheat and paddy. The increase in yield of paddy has been more than three times, i.e. 668 kg/ha in 1951 and 2 393 kg/ha during 2012-13 (258.2%). Interestingly, the area under wheat during 1951 was only 9.75 million ha which increased almost three times, i.e. 29.65 million ha during 2012-13 and yield increase during the same period was 370.4%. Inference may be drawn that the rate of increase in area, production and yield of major cereals was much higher in comparison to pulses during 1951 to 2012-13.

The Table 2 presents the net availability of foodgrains/ person/day in grams so that the importance of pulse crops may be realized by the researchers, producers, consumers, planners and policy makers. The net availability of cereals per person in 1951 was 334.2 which increased to 408.2 per person per day in 2012. But the net availability of pulses was 60.7 per person per day and reduced to only 41.6 person/day during the same period. It is all because of high demand and low supply of pulses. It may be inferred that the availability of pulses per person per day is really alarming. India is surplus in cereals but deficit in pulses to meet the domestic requirement, hence bound to import from other countries and invest the foreign reserve.

The net availability of cereals was increased from 122 kg/person in 1951 to 149 kg/person/annum in 2012 but the net availability of pulses decreased from 22.1 kg/person to 15.2 kg/person/annum. Though the cost of cultivation of pigeonpea and chickpea is much less in contrast to paddy and wheat but still farmers prefer wheat and paddy in comparison to chickpea and pigeonpea. The mindset of the farmers needs to be changed and the multiple benefits of pulses cultivation need to be educated vigorously. The trend of total food grain availability was in increasing order from 144.1 kg/year/person in 1951 to 164.2 kg/year/person in 2012.

Table 3 and 4 presents the area, production and yield of pigeonpea and chickpea of different countries. It is evident that India is occupying 74.76% of area of the world under pigeonpea and contributes 63.74% of the world production.

Table 2 Per capita net availability of foodgrains (Grams per day) in India

Year	Cereals		Pulses		Total Foodgrains	
	Gram/ day	Kg/ year	Gram/ day	Kg/ year	Gram/ day	Kg/ year
1951	334.2	122.0	60.7	22.1	394.9	144.1
1956	360.4	131.9	70.3	25.7	430.7	157.6
1961	399.7	145.9	69.0	25.2	468.7	171.1
1966	359.9	131.4	48.2	17.6	408.1	149.0
1971	417.6	152.4	51.2	18.7	468.8	171.1
1976	373.8	13.8	50.5	18.5	424.3	155.3
1981	417.3	152.3	37.5	13.7	454.8	166.0
1986	415.3	151.6	38.1	13.9	453.4	165.5
1991	468.5	171.0	41.6	15.2	510.1	186.2
1996	442.5	161.5	32.7	12.0	475.2	173.5
2001	386.2	141.0	30.0	10.9	416.2	151.9
2006	412.8	150.7	32.5	11.8	445.3	162.5
2009	407.0	148.6	37.0	13.5	444.0	162.1
2010	407.0	148.6	31.6	11.5	438.6	160.1
2011	410.6	149.9	43.0	15.7	453.7	165.6
2012	408.2	149.0	41.6	15.2	449.8	164.2

Source: Directorate of Economics and statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India

Table 1 Area, production and productivity of selected pulses and competeting cereals

Year	Area (Million ha)				Production (Million tonnes)				Yield (Kg h)			
	Pigeon-pea	Chick pea	Wheat	Paddy	Pigeon-pea	Chickpea	Wheat	Paddy	Pigeon-pea	Chickpea	Wheat	Paddy
1950-51	2.18	7.57	9.75	30.81	1.72	3.65	6.46	20.58	788	482	663	668
1960-61	2.43	9.28	12.93	34.13	2.07	6.25	11.00	34.58	849	674	851	1013
1970-71	2.66	7.84	18.24	37.59	1.88	5.20	23.83	42.22	709	663	1307	1123
1980-81	2.84	6.58	22.28	40.15	1.96	4.33	36.31	53.63	689	657	1630	1336
1990-91	3.59	7.52	24.17	42.69	2.41	5.36	55.14	74.29	673	712	2281	1740
2000-01	3.63	5.19	25.73	44.71	2.25	3.86	69.68	84.98	618	744	2708	1901
2008-09	3.38	7.89	27.75	45.54	2.31	7.05	80.68	99.18	678	885	2907	2178
2009-10	3.47	8.17	28.46	41.92	2.55	7.35	80.71	89.09	723	895	2839	2130
2010-11	3.86	9.19	29.25	42.56	2.90	8.22	85.93	95.33	751	895	2989	2240
2011-12	4.39	8.32	29.90	39.47	2.79	7.58	93.90	87.10	662	928	3177	2393
2012-13	4.65	8.32	29.65	43.50	3.07	8.88	92.46	104.40	806	1020	3119	2472

Source: Directorate of Economics and statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India

But looking the yield in comparison to many other countries like; Myanmar (1 385 kg/ha), Malawi (1 327 kg/ha) Uganda (895 kg/ha), and Nepal (943 kg/ha) the yield of India was only 650 kg/ha. If the yield of pigeonpea in India is increased up to 1 264.4 kg/ha like Myanmar the increase will be of 735 kg/ha and total increase with 4.39 million/ha land will be of 3 226 651 tonnes. This way, not only the per capita availability will be increased but also reduced the level of import. Similarly Table 5 shows that India occupies 67.41% share of total area and 61.45% production of world's chickpea. But the yield 920 kg h is much low in contrast to many countries like Mexico (1 817 kg h), Myanmar (1 463 kg h), Turkey (1 195 kg h) and Australia (1 418 kg/ha). If India increases its level of yield like Mexico, i.e. 1 817 kg/ha, the gain will be of 897 kg/ha which accounts for addition of 7 463 040 tonnes. This will not only increase the availability per person but also reduce the cost of pulses to a great extent.

Table 3 Area, production and yield of pigeonpea across the world during 2013

Country	Area (ha)	% share	Production (Tonnes)	% share	Yield (kg/ha)
India	4 650 000	74.76	3 022 700	63.74	650
Kenya	130 000	2.09	73 183	1.54	563
Malawi	217 068	3.49	287 983	6.07	1 327
Myanmar	650 000	10.45	900 000	18.98	1 385
Nepal	17 459	0.28	16 459	0.35	943
Uganda	105 000	1.69	93 930	1.98	895
Others	450 348	7.24	347 873	7.34	NA
World	6 219 875	100	4 742 128	100.00	762

Source: FAOSTAT(2015).

Table 4 Area, production and yield of chickpea across the world in 2013

Country	Area (In ha)	% share	Production (Tonnes)	% share	Yield (kg/ha)
India	8 320 000	61.45	8 832 500	67.41	920
Australia	573 600	4.24	813 300	6.21	1 418
Ethiopia	122 248	0.90	249 465	1.90	2 041
Iran	550 000	4.06	295 000	2.25	536
Mexico	115 551	0.85	209 941	1.60	1 817
Myanmar	335 000	2.47	490 000	3.73	1 463
Pakistan	992 000	7.33	751 000	5.73	757
Turkey	423 557	3.13	506 000	3.86	1 195
Others	201 698	15.57	954 827	7.28	NA
World	13 540 398	100	13 102 023	100	967.6

Source: FAOSTAT(2015)

Table 5 presents the minimum support price of selected cereals and pulses from 2004 to 2013-14. It is evident from the table that the minimum support price of pulses like pigeonpea and chickpea is more than twice higher from the cereals like wheat and paddy. The total cost of cultivation of cereals like wheat and paddy is also much more than pulses like pigeonpea and chickpea. Hence, profitability will be much more in case of pulses than cereals to the farmers. The pulse production also enhances soil fertility resulting less fertilizer requirement in succeeding crop in the same filed. There is also much scope of increasing yield as yield gap is very wide. There is need to educate the total economics and profitability of pulses in comparison to cereals and put extra effort for pulse production.

Table 6 presents the imports of different commodities from 2001-02 to 2012-13 with its value. It is evident that out of four commodities presented in the table the import quantity and value of pulses is much higher than other commodities like wheat and rice. During 2012-13 the total import of pulses was 3 837.58 thousand tonnes of worth of ₹ 12 738.64 crore. If India produces the pulses as per its potential, the import will be reduced, per capita availability of pulses will increase and foreign investment in pulse import may be reduced to a great extent which will ultimately contribute in the national economy.

Adoption status of recommended technologies of pulses

Results of the adoption status have been discussed under six broad components of the production technologies of pigeonpea and chickpea namely analysis of farm resources, seed components, agronomical components, manurial components, plant protection components, and harvesting and storage components as shown in Table 7.

It is clear from the data that over 99.2 per cent in chickpea and 94 percent in pigeon pea production had not adopted soil and water testing technology of the crop

Table 5 Minimum support prices of selected cereals and pulses in Indian rupees

Crop	2004-5	2005-6	2006-7	2007-8	2008-9	2009-10	2010-11	2011-12	2012-13	2013-14
Paddy	590	600	610	880	880	980	1030	1110	1280	1345
Maize	525	540	540	620	840	840	880	980	1175	1310
Pigeonpea	1390	1400	1410	1550	2000	2300	3000	3200	3850	4300
Greengram	1410	1520	1520	1700	2520	2760	3170	3500	4400	4500
Blackgram	1410	1520	1520	1700	2520	2520	2900	3300	4300	4300
Wheat	640	650	750	1000	1080	1100	1120	1285	1350	1400
Barley	540	550	565	650	680	750	780	980	980	1100
Chickpea	1425	1435	1445	1600	1730	1760	2100	2800	3000	3100
Lentil	1525	1535	1545	1700	1870	1870	2250	2800	2900	2950

Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Government of India

Table 6 India's imports of major foodgrains (Quantity: '000 tonnes, Value in crore rupees)

Commodity	2001-2	2002-3	2003-4	2004-5	2005-6	2006-7	2007-8	2008-9	2009-10	2010-11	2011-12	2012-13
Pulse	2217.82	1992.29	1723.33	1339.45	1695.95	2270.97	2835.05	2474.11	3509.58	2591.25	3364.80	3837.56
	(3160.16)	(2737.05)	(2284.87)	(1777.58)	(2476.25)	(2891.91)	(5374.94)	(6246.40)	(9813.37)	(6979.95)	(8931.24)	(12738.64)
Wheat	1.35		0.46			6079.56	1793.21	0.01	164.38	184.28	0.02	2.94
	(0.84)		(0.25)			(5850.49)	(2657.51)	(0.01)	(231.90)	(236.37)	(0.08)	(0.63)
Rice	0.06	0.87	0.54		0.26	0.16	0.15	0.09	0.06	0.21	1.06	0.70
	(0.07)	(1.09)	(0.27)		(0.34)	(0.41)	(0.42)	(0.06)	(0.37)	(1.12)	(5.48)	(5.94)
Other cereals	40.76	1.12	1.53	6.65	27.88	7.96	10.42	20.60	33.69	30.49	15.36	45.15
	(3.58)	(0.67)	(1.87)	(6.56)	(30.09)	(11.73)	(19.34)	(45.46)	(76.33)	(59.24)	(30.04)	(110.90)

Value is presented in parenthesis, Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Government of India

Table 7 Distribution of farmers' in percentage according to adoption of recommendations of pulse crops

Component/ Sub-components	Adopting recommended (%)		Adopting different than recommended (%)		Not adopting at all (%)	
	Chick-pea	Pigeon-pea	Chick-pea	Pigeon-pea	Chick-pea	Pigeon-pea
Analysis of farm resources						
Soil testing	1.7	7.5	0.0	0.0	98.3	92.5
Water testing	0.0	3.3	0.0	0.0	100.0	96.7
Average	0.8	5.4	0.0	0.0	99.2	94.6
Seed components						
Variety selection	64.1	40.0	4.2	0.0	31.6	60.0
Seed rate	61.5	28.3	38.3	7.5	0	64.2
Seed treatment	3.3	7.5	12.2	10.0	84.5	82.5
Average	43.0	25.3	18.2	5.8	38.7	68.9
Agronomic components						
Pre sowing Irrigation	30.8	24.2	24.3	11.7	44.9	64.2
Land pre-paration	94.1	100.0	0.8	0.0	51.4	0.0
Time of sowing	30.1	65.8	69.9	20.8	0.0	13.3
Method of sowing (line sowing)	95.8	92.5	2.6	4.2	1.7	3.3
Spacing	12.2	37.5	86.2	62.5	1.7	0.0
Weed Management						
Cultural control	70.4	46.7	1.3	0.0	28.3	53.4
Chemical control	18.3	40.8	7.2	12.5	74.5	46.7
Water/Irrigation management	16.7	55.8	58.3	8.3	25.1	35.8
Average	46.0	58.3	31.3	15.0	22.6	26.7
Manurial components						
Use of manures (FYM and compost)	17.9	1.8	25.4	0.0	56.7	98.2
Use of chemical fertilizers						
Phosphorous	23.1	20.8	28.7	47.5	48.2	31.7
Potash	0.0	0.0	0.0	0.0	100.0	100.0

Contd.

Table 7 (*Concluded*)

Component/ Sub-components	Adopting recommended (%)		Adopting different than recommended (%)		Not adopting at all (%)	
	Chick-pea	Pigeon-pea	Chick-pea	Pigeon-pea	Chick-pea	Pigeon-pea
Nitrogen	42.1	37.5	31.5	36.7	26.4	25.8
Time of application	24.9	16.7	51.8	83.3	23.3	0.0
Biofertilizer	0.0	0.0	0.0	0.0	100.0	100.0
Average	18.0	12.8	22.9	27.9	59.0	59.3
Plant protection components						
Insect pest management						
Chemical control	13.3	27.5	13.3	14.2	73.3	58.3
IPM	0.0	0.0	0.0	3.3	100.0	96.7
Disease management	16.4	28.33	10.0	14.2	73.6	57.5
Average	9.9	18.6	11.1	10.6	79.0	70.8
Harvesting and storage components						
Harvesting and threshing	100.0	100.0	0.0	0.0	0.0	0.0
Grading	13.1	9.2	6.7	0.0	80.3	90.8
Storage	28.7	27.5	20.0	70.0	51.3	2.5
Average	47.3	45.6	8.9	23.3	43.8	31.1

production although it was recommended. Soil and water testing has assumed importance in view of the widespread natural resource degradation leading to increased production costs, unsustainable resource use, environmental pollution and health of ecosystems. Results of soil and water tests may permit management of both the important resources for agricultural production without excessively disturbing the soil, while protecting it from the processes that contribute to degradation compaction, aggregate breakdown, etc. It is worth to highlight that only 3.3% and 7.5% of farmers' ever got their water and soil tested for their suitability for pulse production. It is projected that availability of water for agricultural use in India may be reduced by 21% by 2020; resulting in drop of yields hence the judicious use after its proper quality testing is called for.

It is evident from data that only 40% of pigeonpea farmers and 64% chickpea farmers adopted improved varieties and only 61.5% in chickpea and 28.3% in pigeonpea adopted the recommended seed rate. On the other hand Arunachalam *et al*. (1995) reported that adoption of the combined inclusion of non-monetary/low cost inputs such as improved red gram variety, increased plant population sowing with the onset of monsoon rain etc. resulted in higher grain yield in red gram . Regarding the seed treatment, only 3.3% of chickpea farmers and 7.5% of pigeonpea farmers treated the seed before sowing. A study by Subba Rao (1995) concluded that treatment of seed with only *Rhizobium* culture helped in 41 to 90 kg/ha nitrogen fixation in pigeon pea and 41 to 270 kg/ha in chickpea.The farmers thus by not adopting the proper variety , seed rate and its treatment are losing the huge quantities of legume yields leading to financial as well as food security.

Agronomic components as a whole were adopted by 46% of farmers in chickpea and 58.3% in pigeonpea production as recommended, whereas other followed as per their wish and will. However 31% of chickpea growers and 15% of pigeon pea grower adopted agronomic practices other than recommended (in excess or lesser than the recommended).Ramakrishna *et al.* (2005) reported that the improved production technologies gave higher yields and recorded 204% higher yields than that obtained with the farmers' practice. As such there is a large scope for reducing the yield gap only through management of non-monetary inputs (Reddy *et al.* 2007). Weed control, pre sowing irrigation and irrigation management were not adopted by large number of respondents as per scientific recommendations which have direct bearing on the dry matter production of the crop and need serious concern. Farmers viewed that both the crops are mostly grown in rain fed conditions and on poor soils hence non availability of irrigation water restrict the pre sowing irrigation and also irrigation management at critical stages. Secondly, the farmers use the weeds of the crops as fodder for animals as such systematic weed control is hardly practiced. In Andhra Pradesh most of the farmers grow pigeon pea as intercrop with fodder crops like sorghum and maize permitting no or little scope for weed control.

It is clear that 98.2 percent of pigeonpea farmers and further at 56.7 percent of chickpea farmers had not applied any compost or farmyard manure to their field. None of the farmer used any bio fertilizer or *Rhizobium* inoculums for enhancing nitrogen fixation and application of potassic fertilizer. Although, low input agriculture is considered valuable for marginal lands (Sanchez 2002) but Puste and Jana (1995) advocated that the yield attributes and seed yield of Pigeon pea were significantly influenced by phosphorus and zinc application with a maximum benefit-cost ratio of 4.12. Also, Yadav *et al.* (1997) reported that with the application of 100% recommended fertilizer, sole Pigeon pea gave a grain yield of 2.12 tonnes/ha and a benefit cost ratio of 2.94. It has been argued that the productivity of the best farmlands should be maximized with efficient uses of inputs (Vitousel 1994, Reddy *et al.* 2007 and Smil 2001). Balanced fertilizer application at proper timing has to go a long way for the plant stature and ultimately quantities of grain yield as such the most important work for agro ecologists in this case is not to transition away from dependence on synthetic N, but rather to increase the uptake efficiency of all N inputs and especially fertilizer applications (Cassman *et al*. 1998 and Matson *et al*. 1998).

Data shows that 73.3 percent of farmer'in chickpea and 58.3 percent in case of pigeonpea had not adopted any plant protection method against the attack of diseases and insects. The annual yield loss is estimated to be 20% in pigeonpea, 15% in chickpea and 30% in *urd* bean and *mungbean*. On an average 2.5 to 3.0 million tonnes of pulses are lost annually due to pests (Ali 1998). Only three per cent of the chickpea farmers somehow had adopted partial integrated pest management technology. On the whole majority of farmers had not paid any serious attention towards diseases and insects management. Major reason depicted by farmers was that the crop height and the density at pod formation stage restrict the spraying operations due to lack of proper machinery to spray on crop safely (without adverse effect on the person spraying the pesticide)

The infestation of storage pests depend on various factors by like moisture content of the grain, relative humidity, temperature , storage structure , storage period ,processing, unhygienic condition, fumigation frequency, etc. (Jeswani and Baldev 1988). Post-harvest losses during storage due to attacks by the pulse beetle and other store grain pests in chickpea and pigeonpea were reported up to 32.7% and 22.06% respectively, whereas germination losses were 11.75% and 11% respectively (Kumar *et. Al*. 2011). Table 7 further shows that only 28.7 percent of chickpea growers and 27.5 percent of pigeonpea growers followed the storage technology and only 13.1 and 9.2 percent of chickpea and pigeonpea growers graded the produce as recommended after its harvesting, indicating sufficient scope for post-harvest losses in terms of grain quality as well as sale price.

Constraints in pulse production

There are several constraints in pulse production in general and pigeonpea and chickpea in particular. These crops are generally treated as second rate crops in comparison to paddy during *kharif* and wheat during *rab*i by the farmers. The first grade well fertile, irrigated lands are allocated for paddy and wheat and sub-standard un-irrigated land is generally left for these pulse crops. Farmers used to find good quality and best variety seed for paddy and wheat but generally grow their own saved seed for pulses. It indicates that there is less systematic efforts by the researchers to develop varieties of these pulses for different agro climatic zones as compared to wheat and paddy. As far as the fertilizers are concerned, farmers use almost all types of required fertilizers for wheat and paddy but hardly use any fertilizer for pulse crops. Farmers are unable to use recommended doses of fertilizers due to lack of soil testing laboratories in remote villages. The Government support may be required to establish at least one soil testing lab in the cluster of about ten villages. It will not only create employment opportunities but a lot of fertilizer may also be saved which is being used by farmers without knowing the actual requirement of the fertilizers. The study of ICRISAT reported that seed replacement rate in India is as low as 4% (Rao 2010). The farmers generally sow pigeonpea and chickpea through broadcasting method despite informing them the advantages of line sowing. However, lack of machinery to maintain proper distance for sowing leaves no option to go for broadcasting method. It is suggested that ridge planting for proper plant population may be followed for higher yields. The agricultural engineers should develop machineries suiting to the requirement of pulses. Pod borer (*Helicoverpa armigera*) is very harmful insect of chickpea and reported to damage 20 to 40 per cent crop. The population of pod borer can be managed by intercropping of mustard and coriander or linseed and pheromone traps (Reena et.al. 2009). The losses in pigeonpea crop on farmer's field are about 20 to 100 per cent (Rao 1993). The common practice is to spray the chemicals three to six times as per calendar to control pod borer of pigeonpea (ICRISAT). But researchers have hardly realized that at full grown stage the height of crop is about 5-6 feet and field becomes very dense restricting the entry in the field for spraying the insecticide. For threshing also chickpea may be threshed by the wheat thresher but farmers are bound to thresh manually in case of pigeonpea. Agricultural engineers need to focus on designing economical machinery and equipments suited for pulses for labour and time saving.

The constraints perceived by the pulse growing farmers are presented in Table 8. As far as the input related constraints are concerned, non-availability of recommended varieties on time locally was the major constraint. About 52% of the farmers reported "non-availability of bio-fertilizers locally" and ranked as second major constraint. About 60% farmers of Maharashtra and 50% from Andhra Pradesh reported non availability of irrigation facility for the crop and ranked as third. The climatic conditions also affect heavily the production of pigeonpea and chickpea. Normal monsoon is helpful but heavy rain or low or no rain always damages this crop. Among know-how related constraints, recommended bio-fertilizer was ranked first. About 40% respondents of Uttar Pradesh and 30% of Andhra Pradesh reported know–how related constraints of insect pests and recommended insecticides and biological plant protection methods. Infrastructure related constrained experienced by the respondents shows that "Lack of literature in simple language" was ranked 1st by the respondents. Insufficient training programme was however, rated last by the respondents. Crop damage by wild animals and high cost of input were the major constraint among other related constraints. However, high cost of labour was ranked third by the respondents of Maharashtra, low market price by the respondents of Uttar Pradesh and lack of proper information source by the respondents of Andhra Pradesh.

Each component of improved technology is equally important. The presence of technical inefficiency on farmers' fields implies that the right kind of technology is either not available or not adopted. This suggests that extension services need to inform the farmers about new options and to develop the management skills by training them regarding the synergistic effects of various components. World development report 2008 provides

Table 8 Constraints in pulse production

Constraints	% of farmers	Rank
Input related Constraints		
Poor land quality	29.00	IV
Non availability of recommended variety and their seed	50.66	I
Non Availability of Soil testing labs	20.00	VII
Non availability of quality seed locally	25.00	V
Non availability of irrigation facility	43.33	III
Non availability of bio-fertilizers locally	48.33	II
Non availability of chemical fertilizers	23.33	VI
Non availability of insecticides and proper recommendation on time	15.00	VIII
Know-how related constraints		
Recommended variety for the area	33.66	II
Recommended seed rate	30.00	V
Recommended methods of seed treatment	30.00	V
Recommended spacing (Pant to plant and row to row)	18.33	X
Recommended bio-fertilizers	40.33	I
Knowledge regarding Pre-sowing irrigation	27.33	VIII
Recommended fertilizer doses	28.55	VI
Number and critical stages of irrigation	11.00	XI
Recommended herbicides and their usage	32.33	IV
Biological plant protection methods	25.00	IX
Knowledge about insect pests and recommended insecticide	33.33	III
Knowledge about diseases and control methods	27.66	VII
Infrastructure related constraints		
Weak extension at village level	13.33	VII
Un-aware of services and supplies by Government	28.00	IV
Insufficient training programme/technical guidance	24.66	V
Lack of literature in simple language	56.66	I
Lack of marketing facilities	22.00	VI
Lack of storage facilities	42.66	III
Non availability of suitable technologies	44.00	II
Other constraints		
High cost of inputs	60.00	II
High cost of labour	31.33	V
Non availability of credit facilities	18.33	VIII
Lack of subsidy for inputs	25.00	VII
Lack of proper information sources	30.66	VI
Low market price/low profit	31.66	IV
Crop damage by wild animals	66.66	I
Theft of crop at the time of maturity	34.33	III

evidence that investment in agricultural research resulted in an average rate of return of 43% in 700 development projects in developing countries and for every one per cent agricultural growth, rural poverty falls by 1.83 per cent indicating indirect link between agricultural research and poverty reduction. Hence more investment in pulse research programme is needed. Technological drivers like adoption of modern technology and institutional support have to go a long way in achieving self-sufficiency in pulses (Ali and Gupta 2012).

A number of key technological economic and political factors can influence the pulse production. Horizontal expansion through short duration pulse production, genetic enhancement, development of new types of inputs implements and machinery, development of varieties for intercropping system, introduction of INM, development of varieties resistant to *Helicoverpa* and wilt diseases are some of the research and development agenda to be addressed immediately. In order to have the latest information on pulse improvements from researchers, it will be necessary to have appropriate training for the extension workers and subsequently to farmers with availability of matching input supply system. Instead of delaying extension efforts for the research results, extension workers may transfer farmers' innovative practices to other farmers and locations. If variability of yields from the same seeds is found in different locations and at farmer to farmer field in the same location, pulse breeding research for development and/or introduction of location specific high yielding variety may be recommended. Multiplication of large quantity of quality seeds, their safe storage and distribution, timely dissemination of information on plant protection need allotment of increased funds for pulse research. Fitting of pulse crops in new and non-conventional cropping systems, providing support prices are some of the areas that need policy attention. For the successful designing of strategies to alleviate instability in legume production, it is essential to blend and direct recommendations, with the broad objective of improved welfare of the target population, to researchers, policy-makers and extension workers.

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