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Adoption gap as the determinant of instability in Indian legume production

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ABSTRACT

The underlying determinants of yield gaps need to be understood for making appropriate policy prescriptions to increase production in the short-run and to eliminate or reduce yield gaps between research station, on-farm demonstration and farmer's fields. Suitable technologies extended to the farmers are readily adopted by some while others may not be interested. It emphasizes the need for identifying and quantifying level of adoption and its determinants across agro climatic regions. As such adoption gap analysis was carried out for pigeon pea and chickpea in high potential high gap states and districts of India. The recommendation domain was used in the study to ascertain the adoption gaps at farmers' level. The results showed that high to medium level of adoption gaps were observed 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 per cent adopted the recommended varieties and nearly 60 per cent adopted agronomic practices. On the basis of the results obtained it can be recommended 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.

Key words: Adoption status, area potential gap matrix, recommended pulse production technology

Legumes are generally grown under rain fed, highly unstable, complex production environments and substantial variability in soil and environmental factors. Due to 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 agro climatic regions. In India, the irrigated area under pulses was only 12 per cent, while under wheat and paddy it was more than 60 per cent of the total area. Another critical input, credit was Rs 85 /ha for pulses, whereas it was Rs. 458/ha for paddy and Rs. 90/ha for wheat in 2001 (Materne and Reddy 2007, Reddy, 2009). Also, legumes are generally grown as mixed and intercrop with a large number of crops and by-products which are heterogeneous over large areas. These cropping systems may be unstable due to technological and infrastructural changes. Market demand could place constraints on sustained increases in legume supplies as farmers subsequently react to their depressed relative prices. The net availability of pulses has come down from 60 g/day/capita in 1951 to 31 g/day/capita in 2009 (ICMR recommends 65 g/day/capita) due to stagnant/decreasing production and rapid increase in population. The demand for pulses during 2030 AD would be around 26 million tones in India with an expected annual growth rate of 3.3 per cent per annum. To achieve this, the present productivity level of 0.6tha^{-1} has to be increased to 0.99 tha^{-1}.

Farmers allege that spurious fungicides, pesticides and fertiliser 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. 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. Once technologies are developed and found to be economically and technically feasible, they are extended to the farmers. Some farmers may readily adopt these while others may not. 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. 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). Feedback to the technical institutions may play an important role to make further corrections in technology demonstration mechanism (Singh et al 2013). A basic adoption study involving factors, input utilization pattern, reasons for non adoption etc. having direct influence on pulse production enterprise may help avoid the cost associated with wrong decision and also ensure the profitability of the venture. Therefore, adoption gap analysis was carried out for pigeon pea (*Cajanus cajan)* and chickpea (*Cicer arietinum*) in high potential high gap states and districts of India with the specific objective to analyse the status of adoption of recommended technologies for production of leguminous crops.

MATERIALS AND METHODS

The selection of respondents was being done following multistage sampling plan. At first stage the Indian pulse (pigeon pea and chickpea) growing states were classified on the basis of area potential gap matrix to select two states randomly were identified from 'high potential high gap' category of each crop as shown in table 1. The identified states for Pigeon pea included Maharashtra and A.P. whereas for chickpea U.P. and M.P. 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 A.P., Yavatmal and Akola from Maharashtra, Rambainagar and Jalon from U.P, and Tikamgarh and Gwalior from M.P. were finalized for data collection from 'high gap high potential' districts of the crop. Finally, 76 farmers from Ganeshganj, Surajpur and Manikpura villages of M.P. and Lamsar, Dhamna ,Kuitkhara and Sariapur from U.P. for chickpeawere selected. Similiarly, 120 farmers from Darplly, Machnapally ,Timayapalem and Kunikupadu from A.P. and Kesurli, Mandaar, Gorva and Eranda of Maharashtra were interviewed for analyzing the status of adoption of recommended technologies of pigeon pea production.

The technological recommendations for these two crops were used in the study 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 were 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.

RESULTS AND DISCUSSION

Results of the adoption status have been discussed under six broad components of the production technologies of Pigeon pea and chickpea namely analysis of farm resources, seed components, agronomical components, manurial components, plant protection components, and harvesting and storage components as follows:

Analysis of farm resources: Table 1 depicts the per cent of farmers adopting the analysis of their farm resources for pulse production. It is clear from the data that over 99 per cent in chickpea and 94 per cent in pigeon pea production had not adopted soil and water testing technology of the crop 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 per cent and 7.5 per cent 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 per cent by 2020, resulting in drop of yields hence the judicious use after its proper quality testing is called for.

Seed components: Adoption of high yielding varieties, their seed rate to maintain the optimum plant population and the

Table 1. Distribution of pulse growing states on the basis of area –potential- gap matrix

Crop	High potential low gap (yield gap in %)	High potential high gap (yield gap in %)	Low potential low gap (yield gap in %)	Low potential High gap (yield gap in %)
Pigeon pea	Bihar (28.63)	Maharashtra (41.38)	Orissa (2.94)	Tamil Nadu (33.0)
		U. P. (42.13)	Karnataka (31.40)	M.P.(37.96)
		A.P. (50.34)	Jharkhand (21.18)	
		Gujarat (35.54%)		
Chickpea	A.P. (34.12)	U.P. (53.49)	Bihar (36.04)	Haryana (63.85)
		Gujarat (62.94)	Orissa (18.54)	Maharashtra(46.70)
		M.P. (60.43)	Chhattisgarh(12.60)	Karnataka (48.86)
		Rajasthan (71.18)		

Table 2. Adoption of Analysis of farm resources by the farmers

Sr. No.	Sub-Components	Adopting recommended (%)		Adopting different than recommended (%)		Not adopting at all (%)	
		Chickpea	Pigeon pea	Chickpea	Pigeon pea	Chickpea	Pigeon pea
1	Soil Testing	1.7	7.5	0.0	0.0	98.3	92.5
2	Water testing	0.0	3.3	0.0	0.0	100.0	96.7
		0.8	**5.4**	**0.0**	**0.0**	**99.2**	**94.6**

seed treatment for nitrogen fixing bacteria and minimizing the diseases and insects attack were studied under the seed components. It is evident from table 3 that only 40 per cent of pigeon pea farmers and 64 per cent chickpea farmers adopted improved varieties and only 61.5 per cent in chickpea and 28.3 per cent in pigeon pea 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 (1,00,000 plants/ha) sowing with the onset of monsoon rain etc. resulted in higher seed yield in red gram . Regarding the seed treatment, only 3.3 per cent of chickpea farmers and 7.5 per cent of pigeon pea 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 revealed in table 4, agronomic components were adopted by 46 per cent in chickpea and 58.3 per cent in pigeon pea production as recommended whereas other followed as per their wish and will. However, 31 per cent of chickpea growers and 15 per cent 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 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. Table 4 further reveals that the 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. During the informal discussion 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.

Manurial components: Pursuant to table 5 it is clear that 98 per cent of pigeon pea farmers and 57 per cent of chickpea farmers had not applied any compost or farm yard 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 tha^{-1} 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 (Vitousek 1994 , 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

Table 3. Adoption of Seed components by the farmers

Sr. No.	Sub-Components	Adopting recommended (%)		Adopting different than recommended (%)		Not adopting at all (%)	
		Chickpea	Pigeon pea	Chickpea	Pigeon pea	Chickpea	Pigeon pea
1	Variety selection	64.1	40.0	4.2	0.0	31.6	60.0
2	Seed rate	61.5	28.3	38.3	7.5	0	64.2
3	Seed treatment	3.3	7.5	12.2	10.0	84.5	82.5
		43.0	**25.3**	**18.2**	**5.8**	**38.7**	**68.9**

Table 4. Adoption of Agronomic components by the farmers

Sr. No.	Sub-Components	Adopting recommended (%)		Adopting different than recommended (%)		Not adopting at all (%)	
		Chickpea	Pigeon pea	Chickpea	Pigeon pea	Chickpea	Pigeon pea
1	Pre sowing irrigation	30.8	24.2	24.3	11.7	44.9	64.2
2	Land preparation	94.1	100.0	0.8	0.0	51.4	0.0
3	Time of sowing	30.1	65.8	69.9	20.8	0.0	13.3
4	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
5	Weed management						
a	Cultural weed control	70.4	46.7	1.3	0.0	28.3	53.4
b	Chemical weed control	18.3	40.8	7.2	12.5	74.5	46.7
6.	Water/ irrigation management	16.7	55.8	58.3	8.3	25.1	35.8
		46.0	**58.3**	**31.3**	**15.0**	**22.6**	**26.7**

Table 5. Adoption of Manurial components by the farmers

Sr. No.	Sub-Components	Adopting recommended (%)		Adopting different than recommended (%)		Not adopting at all (%)	
		Chickpea	Pigeon pea	Chickpea	Pigeon pea	Chickpea	Pigeon pea
1	Use of manures (FYM & Compost)	17.9	1.8	25.4	0.0	56.7	98.2
2	Use of chemical fertilizers						
a	Phosphorous	23.1	20.8	28.7	47.5	48.2	31.7
b	Potash	0.0	0.0	0.0	0.0	100.0	100.0
c	Nitrogen	42.1	37.5	31.5	36.7	26.4	25.8
d	Time of application	24.9	16.7	51.8	83.3	23.3	0.0
3	Bio fertilizer	0.0	0.0	0.0	0.0	100.0	100.0
		18.0	**12.8**	**22.9**	**27.9**	**59.0**	**59.3**

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 , Matson *et al.* 1998).

Plant protection components: Table 6 shows that 73 per cent in chickpea and 58 per cent in case of pigeon pea had not adopted any plant protection method against the attack of diseases and insects, whereas, a variety of insect pests infest pulses and the annual yield loss is estimated to be 20 per cent in Pigeon pea, 15 per cent in chickpea and 30 per cent in urd bean and mung bean. On an average 2.5 to 3.0 million tones 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. To achieve this extension personnel should disseminate the technology related to plant protection measure with emphasis on providing knowledge and skills to farmers as advocated by Kumar *et al*, 2010.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 the crop safely (without adverse effect on the person spraying the pesticide).

Harvesting and storage components: Pests of chickpea and Pigeon pea damage seed viability and nutritive value of the produce. The infestation of these pests depend on various factor 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 Pigeon pea 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 shows that only 29 per cent of chickpea growers and 28 per cent of Pigeon pea growers followed the storage technology and only 13 and nine percent of chickpea and pigeon pea 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.

The result of the study clearly shows the presence of technical inefficiency on farmers' fields which may be due to either non availability of the right kind of technology or its non adoption by the farmers. The grey areas found in the present study included the analysis of farm resources (water and soil), diseases and pest management and seed components respectively. Only agronomic components were adopted at medium level. The findings are similar to that reported by Avinashilingam and Singh,2013 whereas more than half (55%) of the respondents were found to have low level of adoption. 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

Table 6. Adoption of Plant protection components by the farmers

Sr. No.	Sub-Components	Adopting recommended (%)		Adopting different than recommended (%)		Not adopting at all (%)	
		Chickpea	Pigeon pea	Chickpea	Pigeon pea	Chickpea	Pigeon pea
1	Insect pest management						
a	Chemical control	13.3	27.5	13.3	14.2	73.3	58.3
b	IPM	0.0	0.0	0.0	3.3	100.0	96.7
2	Disease management	16.4	28.33	10.0	14.2	73.6	57.5
		9.9	**18.6**	**11.1**	**10.6**	**79.0**	**70.8**

Table 7. Adoption of Harvesting and storage components by the farmers

Sr. No.	Sub-Components	Adopting recommended (%)		Adopting different than recommended (%)		Not adopting at all (%)	
		Chickpea	Pigeon pea	Chickpea	Pigeon pea	Chickpea	Pigeon pea
1	Harvesting & Threshing	100.0	100.0	0.0	0.0	0.0	0.0
2	Grading	13.1	9.2	6.7	0.0	80.3	90.8
3	Storage	28.7	27.5	20.0	70.0	51.3	2.5
		47.3	**45.6**	**8.9**	**23.3**	**43.8**	**31.1**

effects of various components. Researchers need to be active participants in the early adoption process to nurture new technology until market selection begins to work (Nain et al 2012). The 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 suggest that the strong pulse research and extension need to co-exist. During the informal discussion the issues such as lack of availability and knowledge of varieties for intercropping system and resistant to *Helicoverpa* and wilt diseases, non availability of proper implements and machinery for intercultural and plant protection operations, non availability of soil and water testing facility locally were aroused which implies that multiplication of large quantity of quality seeds, their safe storage and distribution, timely dissemination of information on plant protection, pulse breeding research for development and/or introduction of location specific high yielding variety need to be stressed through increased funding need to be stressed upon. 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.

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