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Total Factor Productivity of Major Pulse Crops in India: Implications for Technology Policy and Nutritional Security

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Abstract

Improving TFP of pulse crops, the major sources of protein, is important to achieve food and nutritional security in India. In this context the paper has examined the consumption pattern of pulses in India and has estimated the TFP growth of major pulses (chickpea, pigeon pea, green gram and black gram) in the country. The study carried out for the period of 1994-95 to 2012-13, has used Malmquist productivity approach to estimate the TFP. The study has also explored the role of technology change in improving pulse productivity by studying the case of chickpea in Andhra Pradesh. The study has noted that per capita consumption of pulses has declined over the years. The consumption of pulses is far less by the lowest income group vis-a-vis the highest income group households. The yield of pulses in general has stagnated over the years. Among the pulses studied, only chickpea and green gram have exhibited improvement in TFP. The study has revealed that pulses are the cheapest source of proteins among all foods and therefore, have a significant place in improving nutrition at individual level as well as country level. It is the development of short-duration and heat-tolerant varieties and better management that have helped in yield improvement. The case study on chickpea in Andhra Pradesh has shown that productivity improvement is directly related to the share of improved varieties adoption. The study has concluded that the development of affordable technologies suitable for marginal environments and emerging cropping patterns would help improve the productivity of pulses in India, thereby may contribute to addressing the under-consumption of protein.

Key words: TFP growth, pulses, protein, technology, India

JEL Classification: I150, O330, Q16, Q180

Introduction

Pulses remain the major source of protein for a predominantly vegetarian population of India, and therefore, there has been a consistent high demand for pulses. To meet this demand, there have been many concerted efforts to boost the production of pulses in the country. As a result, the total production of pulses in India increased from 12.9 million tonnes (Mt) in 1989-90 to 18.3 Mt in 2014-15 (DES, 2015). However, the domestic production is not sufficient to meet the internal demand and India has to import about 3-5 Mt of pulses every year. In 2015-16, the total import of pulses exceeded 5.2 Mt accounting for about ₹ 26,000 crore (US $ 3.95 billion). It is estimated that India's domestic demand for pulses would be about 24 to 25 Mt by 2021 (Ali and Gupta, 2012). The prospects of meeting the burgeoning demand-supply gap through import are limited, as only a few counties in the world produce exportable levels of pulses running into several million tonnes. In 2014-15, India imported pulses from a small group of countries including Canada (80 % of peas and lentils), Australia (45% of chickpea), Myanmar (85% of green gram /black gram and 52% of pigeon pea), Russia (40% of chickpea) and

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Mozambique and Tanzania (15-20% of pigeon pea). The import from countries like Canada and Australia is costly on account of high unit prices and transportation costs, making it unaffordable to the domestic consumers. Most of the pulses import from Canada consisted of peas (*Pisum sativum*), a poor substitute for pigeon pea, with lower consumer acceptability. Sourcing pulses from other countries would be at higher prices, as the world export supply of pulses is not sufficient (only 12 Mt) to cater to the demands of India.

It is estimated that to meet the demand for pulses by 2021, their productivity would have to be increased to the level of 853 kg/ha, requiring an additional production of 41.2 kg/ha (Kumar *et al*., 2009). Under this background, the present paper has estimated the total factor productivity (TFP) growth of major pulses (chickpea, pigeon pea, green gram and black gram) in India and, has decomposed the TFP changes into its associated components, viz technology change and efficiency change. The study has also examined the role of technology in productivity improvement through a case study of chickpea in Andhra Pradesh.

Technology growth and TFP Studies in in India

During 1957-1987, the growth in TFP contributed 1.1-1.3 per cent per year to crop production growth in India. An additional 1.1 per cent was contributed by the conventional inputs. Thus, input use along with growth in TFP have contributed almost 2.3 per cent to the annual crop production growth (Evenson *et al*., 1999). The share of TFP growth for crops in the productivity growth has been estimated to be about 50.2 per cent between 1966 and 1976, 48.8 per cent between 1977 and 1987 (Evenson *et al*., 1999); and 66.5 per cent for crops and 72.2 per cent for livestock during 1980-1989 to 1990-1994 (Fan *et al*., 1999). The major source of the TFP growth has been the public sector investment, notably in research, development and extension (Singh and Pal, 2010).

In an early study on the TFP in India, Kumar and Mruthyunjaya (1992) have reported TFP growth of wheat during 1970-1989 to be 1.9 per cent in Punjab, 2.7 per cent in Haryana and Rajasthan, 2.6 per cent in Uttar Pradesh and 0.4 per cent in Madhya Pradesh. Kumar and Mittal (2006) have reported a positive TFP growth for both rice and wheat during the two-decade period of 1980-2000, but the TFP growth posted a reduction during the second decade compared to the first decade. Chand *et al.* (2011) have noted that during 1975-2005, rice and wheat recorded the TFP growth of 0.67 per cent and 1.92 per cent, respectively. Thus, TFP studies in India have largely focused on major cereals crops, viz. rice and wheat, and that too in the Indo-Gangetic Plains. But for some scattered studies, pulses in general have not received much attention.

Data and Methodology

The analysis of consumption pattern of pulses has been carried out using data from various rounds of consumer surveys conducted by the National Sample Survey Office (NSSO). The data for TFP estimation were collected from the reports of "Comprehensive Scheme for Cost of Cultivation of Principal Crops", published by the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, New Delhi. The analysis has been carried out for four pulse crops, viz. chickpea, pigeon pea, green gram and black gram. All the major states growing these crops were considered for the analysis. The output variable used in the analysis was yield (kg/ha). The six input variables used in the analysis were: chemical fertilizer (NPK, kg/ha), animal labour (pair hours/ha), manure (q/ha), human labour (man-hours/ha), and real costs of machine labour and irrigation[1]. The analysis has been carried for the post-liberalization period of 1994-95 to 2012-13, which was also divided into two sub-periods, viz. 1994-95 to 2003-04 (period I) and 2004-05 to 2012-13 (period II). The first period broadly corresponds to the period of turbulence in the economy characterized by dwindling of public expenditure in agriculture. The second period is characterized by sharp reversal of the public investment and agricultural performance. Triennial ending averages were used to smoothen the data. The analysis has been carried out by using the software DEAP 2.1 (Coelli, 1996).

Analytical framework

Malmquist Productivity Index

The output-oriented Malmquist TFP index measures the maximum level of outputs that can be produced using a given production technology and input vector relative to the observed level of outputs (Coelli *et al.*, 2005). The MPI measures the radial distance of a reference technology relative to the observed output vectors in the period t and t+1. The

Malmquist productivity index for the period t is represented by Equation (1)

$$M^t = \frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \quad \ldots(1)$$

which is defined as the ratio of two output distance functions with respect to reference technology at the period t. It is also possible to construct another productivity index by using period t+1's technology as the reference technology, which can be depicted by Equation (2):

$$M^{t+1} = \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t-1}(x^t, y^t)} \quad \ldots(2)$$

Therefore, there exists an arbitrariness in the choice of the benchmark technology depending on the time period t or t+1. This can be removed by specifying MPI as the geometric mean of the two period indices as defined by Fare *et al.* (1994):

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\left(\frac{D_0^t(x^{t-1}, y^{t+1})}{D_0^t(x^t, y^t)}\right)\left(\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}\right)\right]^{\frac{1}{2}} \quad \ldots(3)$$

where, the notations x and y represent the vector of the inputs as well as outputs, D_0 indicates the distance and M_0 denotes the MPI. Fare *et al* (1994) have shown the MPI as the product of two distinct components, viz. technical change and efficiency change as indicated by Equation (4):

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) =$$

$$\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}\left[\left(\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})}\right)\left(\frac{D_0^t(x^t, y^t)}{D_0^{t-1}(x^t, y^t)}\right)\right]^{\frac{1}{2}} \quad \ldots(4)$$

where,

$$\text{Efficiency change} = \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \quad \ldots(5)$$

and,

$$\text{Technical change} = \left[\left(\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t-1}(x^{t+1}, y^{t+1})}\right)\left(\frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)}\right)\right] \quad \ldots(6)$$

The efficiency change consists of two components — pure efficiency change and scale efficiency change. A detailed account on the MPI can be had from Fare *et al.* (1994), Coelli *et al*. (2005), Bhushan (2005), and Chaudhary (2012).

Case Study of Chickpea in Andhra Pradesh

Chickpea has not traditionally been cultivated in Andhra Pradesh. But, the state has reported the highest growth in area, productivity and production since 1990s (DES, 2015). As on 2013-14, Andhra Pradesh is the state with highest chickpea productivity in India, with 1439 kg/ha. Hence, the factors underlying TFP growth of the chickpea in Andhra Pradesh have been identified to understand the effect of varietal improvement programme in the productivity improvement. The primary data were collected from the state on the spread of improved varieties, net income from the improved varieties, and the relative performance of the improved varieties with respect to the varieties already in vogue in the state. The data were collected purposely from the district of Prakasam in Andhra Pradesh (undivided) using focused group discussions in the year 2012. The relative advantage of chickpea varieties, viz. GJ-11 and KAK 2 over the *desi* varieties has been estimated by using partial budgeting technique.

Results and Discussion

Trend in Pulses Consumption

The data from various rounds of NSS survey indicated that the consumption of pulses in India slid from 22.1 kg/ capita/ year in 1951 to 15.2 kg/capita/ year in 1991, but improved slightly to 15.8 kg/capita/ year in 2013. The analysis has revealed that it is far below the recommended intake of 60 g/ capita/ day and is getting reduced over the years in both rural and urban areas, compared to the peak consumption in 2000 (Figure 1). The decline in consumption of pulses has been noted for all categories of households belonging to low, medium and high income, both in rural and urban areas.

The consumption pattern of pulses has revealed that that there exists a large difference in consumption of pulses between the rich and the poor. The per capita consumption by the poorest decile is about 44 per cent of that of the richest group at all-India level (Table 1). For some states like Rajasthan, the per capita pulse

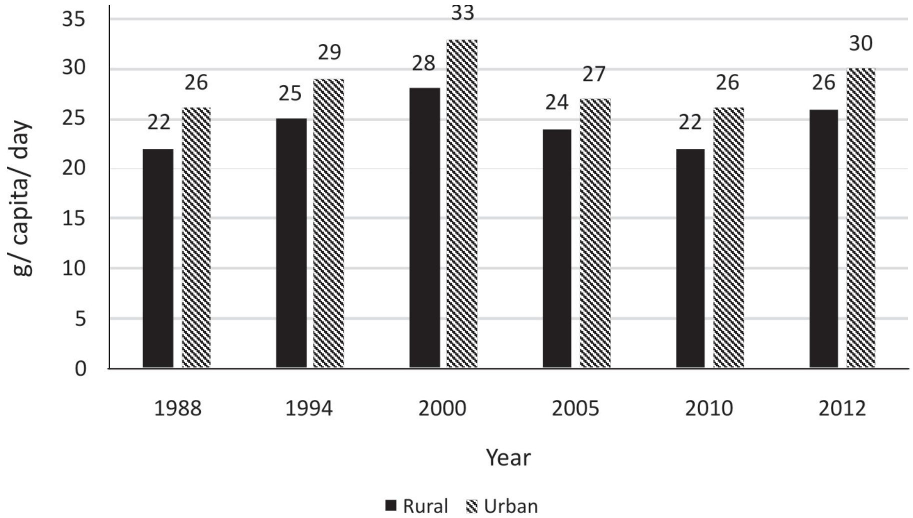

Figure 1. Changes in the per capita pulse consumption in India, 1988-2013
Source: Authors' calculations based on the data from various rounds of NSS surveys

Table 1. Consumption of pulses by poorest and richest groups (decile) of consumers in selected states
(g/ capita/day)

State	Poorest decile	Richest decile
Uttar Pradesh	24	51
Bihar	20	48
Madhya Pradesh	23	61
Rajasthan	11	45
Punjab	21	40
Other states	16	43
All India	19	43

Source: NSS survey, 68th round

consumption is as low as 11 g/day for the poorest group, which is insufficient. The households belonging to landless, poor, illiterate and scheduled caste and scheduled tribe categories consume lower quantity of pulses compared to other households (Reddy, 2004). The price elasticity and income elasticity of demand for pulses at -0.46 and 0.21, respectively are higher compared to that of cereals, and appreciably higher for lower consumption group (Kumar and Joshi, 2016)[2]. This is affecting the food and nutritional security of all the consumers, and more seriously the marginalized sections of society.

The lower consumption of pulses is not compensated by the increased consumption of other protein food commodities, due to their high prices. The pulses, notably peas, lentil and gram constitute the cheapest source of protein compared to other protein sources, mainly of livestock origin (Table 2). Therefore, there is a need to improve the production of the pulses in India through productivity improvement.

Trends in Yields of Pulses in India

The trends in yield growth of pulses in selected states of India, presented in Table 3, have shown that yields of pulses have generally increased over the years.

Table 2. Cost of protein from different food commodities
(₹/kg of protein)

Food commodity	Rural	Urban
Peas	154	192
Lentils/masur	208	223
Gram (chickpea) flour	217	226
Black gram (urad)	235	259
Green gram (moong)	259	284
Pigeon pea/arhar/tur	260	290
Egg	447	437
Chicken	447	463
Beef/buffalo meat	490	478
Milk	613	731
Fish/prawn	611	758
Goat meat/mutton	1094	1220

Source: Government of India (2016), based on NSS survey, 68th round

Table 3. Trend in yield growth of major pulses in India, across major cultivating states, 1994-95 to 2014-15

State	Mean yield (TE average, kg/ha)			Yield growth (% per year)		
	1994-95	2004-05	2014-15	Period I	Period II	Overall
			Chickpea			
Andhra Pradesh*	669.3	1024.7	1152.7	6.2	-0.6	3.5
Madhya Pradesh	836.7	849.2	1100.5	0.2	2.5	1.0
Maharashtra	613.3	551.7	805.4	-0.8	3.9	2.2
Rajasthan	674.7	712.3	865.8	-0.2	3.5	0.5
Uttar Pradesh	908.7	946.0	867.4	1.0	1.1	0.5
			Pigeon pea			
Andhra Pradesh	302.7	407.3	515.3	3.7	-0.8	2.3
Karnataka	339.0	453.2	639.7	0.7	1.2	2.3
Madhya Pradesh	832.3	738.4	786.0	-1.8	-1.4	-1.4
Maharashtra	597.3	667.9	775.0	2.9	1.6	1.5
Uttar Pradesh	1048.7	1012.6	850.5	1.2	-0.7	-1.4
			Green gram			
Andhra Pradesh	396.3	352.3	783.3	-1.8	5.8	2.5
Maharashtra	611.2	465.0	412.7	-3.6	2.6	-0.9
Odisha	349.3	238.0	340.1	-2.7	1.7	1.7
Rajasthan	272.7	318.3	398.4	-2.9	3.6	5.1
			Black gram			
Andhra Pradesh	544.0	534.7	881.1	1.1	3.1	1.7
Madhya Pradesh	452.0	523.0	491.4	-1.0	-2.5	-0.5
Uttar Pradesh	417.0	357.3	552.8	-0.9	5.0	3.2
Maharashtra	581.0	523.0	513.5	-2.4	1.9	1.1
Tamil Nadu	487.7	411.7	745.2	-0.7	4.9	1.0

Note: Period I (1994-95 to 2003-04); Period II (2004-15 to 2014-15) and Overall (1994-95 to 2014-15); *Undivided
Source: Estimated by the authors using DES data

Significant improvement in the yield has been noted in chickpea, particularly in Andhra Pradesh and Madhya Pradesh. In selected states, compared to yield levels in 1994-95, a reduction in the yield was posted only in Uttar Pradesh in 2014-15. During the period 1, the yield has shown stagnation in all selected states, except Andhra Pradesh (undivided). The varieties released during the latter years had changes in important quality parameters, like crop duration. Much focus was provided to development of short-duration varieties that could be cultivated in peninsular India as well, with differing agro-climatic situations. In the case of pigeon pea, production stagnated at all-India level and also in major states. The major producers of pigeon pea are Maharashtra, Madhya Pradesh, Gujarat and Karnataka, and these together contributed to more than two-thirds of total production in 2014-15. The average yield of pigeon pea is quite low, ranging between 500 kg/ha and 850 kg/ ha in major states. Post-1994, most of the states have recorded a yield increase. The yield increase was about 70 per cent in Andhra Pradesh, 90 per cent in Karnataka, and 30 per cent n Maharashtra. However, Uttar Pradesh experienced a sharp decline in productivity of pulses, by about 200 kg/ ha during this period (from 1050 kg/ ha in 1994-95).

For both green gram and black gram, the average productivity has been found much low, and is not showing any significant improvement. In green gram, Andhra Pradesh has shown the highest yield and it has been improving at the rate of 2.5 per cent per year, more sharply during period II. The yield has been quite low in black gram also, but has improved in all the states, notably in Andhra Pradesh, Uttar Pradesh and Tamil Nadu. One significant observation is that yield remained stagnated during the first decade of post-liberalisation, but has improved for most of the crops during the subsequent period. This higher growth rate during the period II has emerged despite pulse-growing getting relegated to marginal areas. Further, research in terms of improving the quality traits and development of varieties suitable for intensive land-use has pushed the cultivation of pulses like chickpea to non-traditional areas as well.

Trend in Total Factor Productivity

Chickpea

Chickpea has witnessed an improvement in TFP for all states, except Uttar Pradesh (Table 4). In period II, the TFP has been observed the highest in Maharashtra (17.5%), followed by Rajasthan (5.8%) and Madhya Pradesh (5.6%). In Uttar Pradesh, farm areas under chickpea are shrinking very fast, along with deceleration of TFP. The seed system of chickpea has undergone changes. One of the quality changes that have been introduced is the development of varieties/hybrids that are suitable for marginal agro-climates and short-duration crops. Chickpea is susceptible to a large number of pests. Reduction in the duration of the crop helps in avoiding pests as well as saving the crop from drought and associated stress conditions. Further, it facilitates inter-cropping and relay cropping. The slowdown of TFP during period I could be due to the slowdown of the technical change, as the efficiency change has been positive for all the states, to the extent of 3.5 per cent in Uttar Pradesh and 1.4 per cent in Madhya Pradesh. The revival of the TFP change has been associated with the improvement of the technical change.

Pigeon pea

In pigeon pea (Table 4), the TFP during period II has shown improvement only for Karnataka, wherein the TFP change of 3.5 per cent is contributed by technical change of 0.7 per cent and efficiency change of 2.8 per cent. The crop has posted positive TFP during period I in Madhya Pradesh (3.6%) and Uttar Pradesh (5.2 %), in which the technical change is about two-thirds in Madhya Pradesh and 100 per cent in Uttar Pradesh. But, this dissipated during period II. The situation is more serious for Maharashtra, the largest producer of pigeon pea, where the TFP decelerated at about -2.3 per cent.

Green Gram and Black Gram

For green gram and black gram, the complete data were available for period II only. Both the crops have exhibited positive TFP growths in all the selected states (Table 5). In green gram, Andhra Pradesh, Maharashtra and Rajasthan have shown the TFP change of 4.4 per cent, 3.4 per cent and 9.6 per cent, respectively. For this crop, TFP change is contributed entirely by the technical change. In black gram, the positive TFP change could be noted for Madhya Pradesh (11.1%) and Maharashtra (3.2%) whereas, Andhra Pradesh, Uttar Pradesh and Tamil Nadu posted negative TFP growths. No state witnessed a positive growth during period II and the efficiency change was the sole factor behind the TFP change. The deceleration in technical change for this crop is a matter of concern, and needs to be addressed.

The analysis has clearly indicated that in general the technical change has been contributing to TFP for chickpea and green gram. On the other hand, pigeon pea and black gram have exhibited deceleration in technical change, which calls for further research on these crops. There is a need to focus on developing varieties suitable for different agro-climates and emerging farming systems.

Another notable feature is the contribution of efficiency in the TFP change. The contribution of efficiency remained unchanged for green gram, improved in most of the states for black gram and pigeon pea, and did not show much improvement in chickpea. The pure efficiency remained unchanged, except for minor changes for all the crops during at all periods.

In the context of discussion whether it is technology fatigue or policy fatigue that is withholding Indian agriculture (Narayanamoorthy, 2007), the study points has observed mixed results with respect to different pulse crops and regions. While chickpea and green gram have shown TFP growths, pigeon pea and black gram have not reported technology changes in most of the states. The present analysis has shown that for most of the crops the TFP growth has improved during period II. This has been reflected in the yield of the crops as well, which has registered an improvement. A critical factor that could affect the productivity is the input intensification.

Table 4. Trends in TFP change for chickpea and pigeon pea in major states, 1994-95 to 2012-13

State	Period I (1994-95 to 2003-04)					Period II (2004-05 to 2012-2013)				
	Efficiency change	Technical change	Pure efficiency change	Scale efficiency change	TFP change	Efficiency change	Technical change	Pure efficiency change	Scale efficiency change	TFP change
Chickpea										
Andhra Pradesh	-	-	-	-	-	0.999	1.003	1.007	0.991	1.002
Madhya Pradesh	1.014	0.966	1.000	1.014	0.979	1.000	1.056	1.000	1.000	1.056
Maharashtra	-	-	-	-	-	0.987	1.191	1.000	0.987	1.175
Rajasthan	1.000	0.922	1.000	1.000	0.922	1.000	1.085	1.000	1.000	1.085
Uttar Pradesh	1.035	0.918	1.000	1.035	0.950	0.997	0.951	1.000	0.997	0.948
Pigeon pea										
Andhra Pradesh	-	-	-	-	-	1.000	0.970	1.000	1.000	0.970
Karnataka	1.000	0.955	1.000	1.000	.955	1.028	1.007	1.000	1.028	1.035
Madhya Pradesh	1.012	1.024	1.000	1.012	1.036	1.000	0.951	1.000	1.000	0.951
Maharashtra	-	-	-	-	-	0.999	0.978	1.000	0.999	0.977
Uttar Pradesh	1.000	1.052	1.000	1.000	0.969	1.000	0.985	1.000	1.000	0.985

Source: Estimated by the authors using DES data
Note: For some states, the data were not fully available for period I.

Table 5. Trends in TFP change for green gram and black gram across major states for the period 2004-2013

State	Efficiency change	Technical change	Pure efficiency change	Scale efficiency change	TFP change
			Green gram		
Andhra Pradesh	1.000	1.044	1.000	1.000	1.044
Maharashtra	1.000	1.034	1.000	1.000	1.034
Rajasthan	1.000	1.096	1.000	1.000	1.096
Odisha	1.000	0.971	1.000	1.000	0.971
			Black gram		
Andhra Pradesh	1.000	0.942	1.000	1.000	0.942
Madhya Pradesh	1.114	0.996	1.109	1.005	1.110
Uttar Pradesh	1.000	0.934	1.000	1.000	0.934
Maharashtra	1.051	0.981	1.000	1.051	1.032
Tamil Nadu	1.035	0.963	1.000	1.035	0.997

Table 6. Trends in certified seed production and distribution of pulses in Andhra Pradesh: 2005-06 to 2012-13

(tonnes)

Crop	2005-06	2006-07	2007-08	2008-09	2009-10	2012-13
Chickpea (KAK-2)	585	0	0	1708	7054	8000
Chickpea (JG-11)	57	61	26555	42845	30155	36000
Improved chickpea varieties (total)	642	61	26555	44553	37209	73000
Green gram	21	0	0	0	0	1700
Red gram	0	164	1132	5604	2177	3400
Black gram	0	0	0	0	791	6900

Source: APSSDC (2012)

The analysis carried out on the trends in input intensification for major crops is presented in Appendix I. The rate of application of fertilizers for all the crops was very low, and ranged between 22-73 kg/ ha in chickpea and 17-123 kg in pigeon pea, and was still lower for green gram and black gram, though marginal improvements have been noted over time. Therefore, the pulse production system depicts a low input intensification regime and needs to be intensified further.

Role of Technology: Enhanced Seed Availability

Andhra Pradesh has witnessed an improvement in area and yield of chickpea from the early-1990s. One major reason for this is the easy availability of certified seeds of certain varieties suitable for the growing areas (Table 6). The varieties of chickpea are classified on the basis seed size, colour and taste. Two of these varieties, namely Kabuli and Desi, are very important in terms of usage and marketing. The Desi varieties of chickpea contribute around 80 per cent and Kabuli around 20 per cent to the total production in India. Having capacity to face drought conditions with deep root system, the Desi variety requires less fertilizer and is considered to be one of the best suited crops for *rabi* season. Being a legume, it is particularly important for the farmers as a rotation crop or second crop after cereals, often maturing early. The availability of heat and disease tolerant varieties suitable for rice fallows and adoption of improved production technologies have helped increase the production of chickpea in central and south India. As a result, cultivation of chickpea is gradually shifting towards the peninsular India.

Chickpea Revolution in Andhra Pradesh: Development of Varieties

This section has examined the factors responsible for higher chickpea production in Andhra Pradesh using both primary and secondary data. The primary data were collected by focused group discussions in the Prakasam district.

There is a large area of fallow lands in the *rabi* season which can expand *rabi*-chickpea area in the state. The major competing crop for chickpea is tobacco, but due to the policy to discourage tobacco production and consumption, the area under tobacco is gradually shifting to other crops, the major being to chickpea. There are many institutional and technological factors that have contributed to this success. The development of new varieties as per the preference of farmers and other market players, has led to the increase in chickpea area. Incidence of low pest and disease, longer storability and higher price attracted many farmers to shift to chickpea. Introduction of short-duration and high-yielding varieties like KAK-2 and JG-11, which are suitable for mechanical harvesting and large scale mechanization are some of the contributing factors for the success. Figure 2 shows the spread of some widely adopted chickpea varieties in the state during the period of 1991-2012.

Table 7 presents variety-wise profitability of chickpea and competing crop tobacco in Andhra Pradesh. A perusal of Table 7 reveals that the *desi* variety JG-11 had less year-to-year fluctuations in price

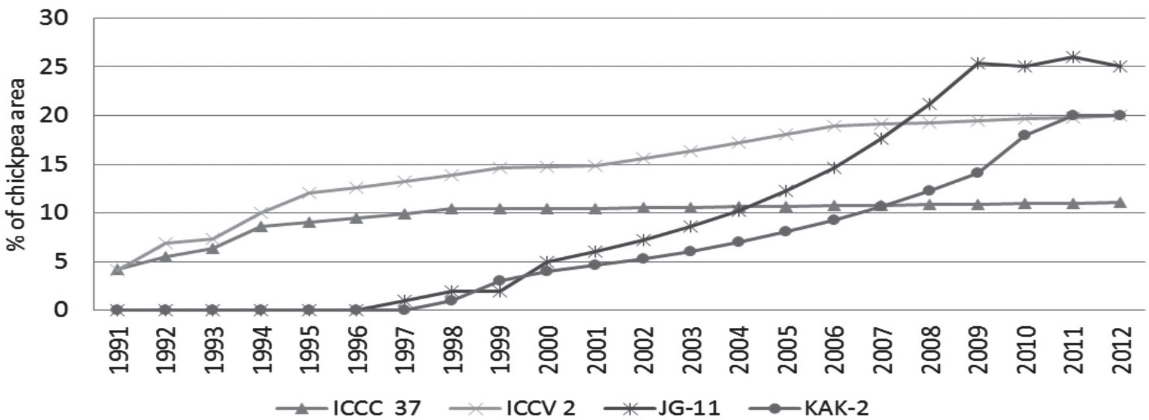

Figure 2. Diffusion of improved varieties of chickpea in Andhra Pradesh:1991-2012
Source: Field survey under Village Dynamics in South Asia, ICRISAT, Hyderabad

Table 7. Variety-wise profitability of chickpea cultivation in AP (average of 2009 and 2010)

Particulars	Chickpea varieties			Tobacco
	JG-11	KAK-2	*Desi* (traditional)	
Grain quantity (kg/ha)	915	1715	670	1688
Output value (₹/ha)	18612	50368	18291	33477
Seed (₹/ha)	1373	6338	1875	1361
Labour (₹/ha)	3900	7869	3410	6676
Bullock power (₹/ha)	477	477	477	302
Pesticide (₹/ha)	969	2354	1869	1468
Fertilizer (₹/ha)	1158	2729	1250	921
Machine power (₹/ha)	2740	6687	2280	3769
Total cost (₹/ha)	10617	26453	11161	14496
Rent value of land (₹/ha)	5333	7500	4000	3687
Net income (₹/ha)	7995	23915	7130	18980
B/C ratio	1.75	1.90	1.64	2.31

Source: Field survey under Village Dynamics in South Asia, ICRISAT, Hyderabad.
Note: Tobacco requires additional working capital in terms of curing which will form up to 40 per cent of working capital

compared to KAK-2 which is *kabuli* type, even though the later fetched higher prices. The cost benefit analysis shows that *desi* (JG-11 variety) and also *kabuli* type (KAK-2) have higher net returns than *desi* (traditional) varieties and also competing crop (tobacco) (Table 7). The net returns on a per hectare basis are higher for KAK-2; but are associated with higher operational cost also, mainly on account of higher seed cost, machine power and human labour charges. This acts as detriment in adoption of the KAK-2 variety, though it performs better in terms of benefit-cost ratio and output value. In that context, the improved *desi* variety JG-11 is popular among the farmers, compared to many unidentifiable desi (traditional) varieties. As on 2012, JG-11 occupied about 25 per cent and KAK-2 another 20 per cent of the chickpea area. The ICCV-2 occupied another 20 per cent.

Conclusions and Policy Implications

The study has revealed that yield of pulses in general has improved marginally over the years, despite being pushed to marginal areas. The present national yield of 750 kg/ha is too low compared to the potential yield as well as compared to yield in other countries. In view of the nutritional importance of pulses as a relatively cheap source of protein, and the difficulties in importing huge quantities of pulses to match the potential demand-supply gap, the domestic production and productivity of pulses needs to be increased. The TFP growth has shown mixed results among different pulse crops and time periods. The chickpea and green gram have exhibited improvement in TFP, but pigeon pea and black gram have not shown any TFP improvement in most of the states considered. It has also been noted that the changes in TFP have been contributed by both technical change and efficiency change. The case study on chickpea in Andhra Pradesh has clearly indicated that the productivity improvement is directly related with the share of improved varieties.

The study has brought out some important implications. The technology fatigue in pulses is not wide-spread, rather technology growth has been noted in chickpea and green gram in most of the selected states. Both technology change and efficiency change are important in accelerating TFP. In view of the development of irrigation facility and shifting of pulse cultivation to marginal areas, the research has to take into consideration the marginal environments. Further, the suitability of pulses as summer crops in certain states needs to be factored in. For example, in states like Bihar and Andhra Pradesh, large areas under rice fallows are available which are suitable for pulse cultivation. The development of varieties that fit well with the prevailing crop pattern is, therefore, significant.

The case study on chickpea in Andhra Pradesh has brought out the importance of technology development suitable to farmers' economic conditions. The emergence of JG-11 as a dominant variety in the state has predominantly been due to its short-duration and low input cost requirement. The additional seed cost alone has contributed to more than a quarter of the additional operational cost in case of the competing variety KAK-2. This clearly point to the need to look into the affordability of the technology while targeting a variety for mass cultivation. In view of the technical efficiency stagnation in pulses, the improvement in the technology needs to be supported with fast spread of information on the associated cultivation practices.

End-notes

[1] The real cost was derived by deflating with price of relevant inputs.

[2] The price elasticity was -0.70 for low income group, -0.53 for middle income group and -0.35 in high income group, constituting a mean price elasticity of 0.46. The corresponding income elasticity was 0.50, 0.27 and 0.10 with a mean income elasticity of 0.21

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Appendix I

Decadal change in fertilizer application in pulses

State	Fertilizer (NPK kg/ha)			Manure (quintal/ ha)		
	1995	2005	2015	1995	2005	2015
			Chickpea			
Andhra Pradesh*		33.79	73.20		0.02	17.68
Madhya Pradesh	13.2	15.3	39.6	22.5	31.3	0.0
Rajasthan	9.3	14.2	22.0	13.3	24.8	18.8
Uttar Pradesh	8.6	14.3	26.5	0.5	12.2	0.0
Maharashtra		34.2	54.6		0.0	1.1
			Pigeon pea			
Andhra Pradesh		49.4	123.8		11.1	3.2
Madhya Pradesh	7.2	13.4	38.1	34.7	47.3	100.0
Karnataka	44.8	69.5	71.1	24.6	16.3	1.9
Maharashtra	11.0	34.3	111.9	1.5	3.1	7.8
Uttar Pradesh	5.7	3.7	17.8	2.9	1.1	0.1
			Green gram			
Andhra Pradesh	9.3	16.6	16.0	1.9	9.9	8.5
Maharashtra	11.3	14.0	51.6	23.6	53.3	27.6
Rajasthan		3.4	13.9		4.7	10.3
Odisha		1.5	10.7		1.2	1.0
			Black gram			
Andhra Pradesh	0.0	6.8	11.7	0.4	3.4	0.0
Madhya Pradesh		8.1	33.7		3.4	2.7
Uttar Pradesh		1.7	4.8		0.0	0.0
Maharashtra	28.1	13.7	60.6	1.8	53.9	5.8
Tamil Nadu		24.8	39.9		1.7	9.7

*Andhra Pradesh (undivided)