Technology-Policy Tradeoff in Doubling Farmers' Income: A Case Study on Pulses

Balaji, S.J.[a], Kishore, P.[a], Raka Saxena[a], Naveen P. Singh[a] and Franco, D.[b]

[a]ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi-110 012
[b]Division of Agricultural Economics, ICAR-Indian Agricultural Research Institute, New Delhi-110 012

Abstract

The paper has studied technology-policy tradeoff in doubling the income of farmers by selecting pulses, arhar and gram. The study has revealed that making available the existing technologies and factors at further scale to farmers through bridging yield gaps would greatly help in increasing the output at farm level. The study has shown that a slight increase in MSP and FHP can *double the real income* of the gram and arhar growing farmers *by 2022*. The scenario analysis has indicated that the real 'gross' income in arhar can be doubled just by achieving yield levels of 24 q/ha in Maharashtra and 14 q/ha in Madhya Pradesh and Karnataka by the year 2022, and letting the MSP and FHPs to increase by 10 per cent a year. An increase in FHPs by ₹ 420/q, ₹ 646/q and ₹ 211/q, respectively in Madhya Pradesh, Maharashtra and Rajasthan above the presumed 10 per cent increase a year for the given yield levels of 12-14 q/ha would double the real 'gross' income by 2022. Further, estimates have indicated that levels of cost increase that would allow doubling both 'gross' and 'net' real income levels are 28 per cent, 29 per cent and 34 per cent in Madhya Pradesh, Maharashtra and Rajasthan for gram, and 21 per cent, 27 per cent and 23 per cent in Maharashtra, Madhya Pradesh and Karnataka for arhar, respectively.

Key words: Doubling farmers' income, pulses, technology, price policy

JEL Classification: Q18

Introduction

In India, the strategies usually followed to increase farmers' income include encouraging production of crops for which demand remains open within the domestic market, and meanwhile achieving import substitution as well (Reddy, 2004; 2009; Srivastava *et al*., 2010). The import substitution not only helps in meeting the domestic demand but also saves foreign reserves. Pulses and oilseeds are the typical examples. Every year, the country imports over 5 million tonnes of pulses and about 14.5 million tonnes of vegetable oils. The gram and tur imports for the year 2016-17 alone are valued ₹ 10,198 crore. The government's priority to increase domestic production, especially of pulses, can be observed through its constant area expansion and yield increasing attempts. Almost all the districts in the country have been covered under The National Food Security Mission (NFSM)[1], which provides on-farm demonstration, financial assistance to procure quality seeds and machineries to augment pulses production (Lingareddy, 2015; Joshi *et al*., 2017).

Technology vs Policy — Any strategy that attempt to increase income, lays its foundations on two major factors, viz. technology and price. Technology helps to shifts the production function up, enabling higher quantity and better quality of output from a given set

---

* Author for correspondence
  Email: balajiniap@gmail.com

[1] As per recent report, 622 out of 642 districts have been iden-
    tified under NFSM-Pulses.

of inputs. At the prevailing prices, it turns into higher income. Or it helps to reap a given level of output with less and less inputs, resulting in cost savings and higher net income. Provided large variations in crop production practices across different climatic regions, and bridging yield gap itself would greatly increase crop output without exerting pressure for more land. The resulting increase in land productivity provides higher income at the prevailing costs and prices so as to gain high net income.

The technology is primarily concerned with output increments; it is the policy choice that turns the benefits of technology to increased income gains. The policies that adequately addressed expansion in irrigation network, making available quality seeds and fertilizers, and better access to extension services proved successful in the past and helped to turn the technology spillovers as positive income gains. Price support through public procurement and expansion in storage facilities are the other major policy drives that have sustained farming till date (Subramanian, 2016; NITI Aayog, 2016). We believe that price policies will have a major say in addressing higher income in the future. As the present agriculture is filled with crisis than prosperities, a look into the role of technology and policy that could deliver effective safeguard against increased risk in cultivation assumes high importance. The present study is an attempt in this direction.

Approach — For doubling farmers' income, two major strategies have been considered. One considers different sources the farmers rely upon for income and devise strategies to double the income as a whole. The second looks into the possibilities of different crops and activities individually and examines the scope of increasing income from each source. We have followed the later as it allows for detailed enquiry. Focusing on individual income choices, like cropping and livestock-rearing, helps us to understand the conditions which generate income, and to create scenarios in which income can be increased. We have focused on crops, particularly on pulses and have considered gram and arhar in their major production regions. We have looked into the trends in yield gaps, farm harvest prices in different states, and support prices of the government over time. Using the past trends, we have created scenarios for the year 2022 in yield levels, reduction in yield gaps, harvest and support prices at which income of the gram and tur growers can be doubled after accounting for inflation in the future.

Data and Methodology

Data

We have used plot-level data provided by the Ministry of Agriculture and Farmers Welfare (MoAFW) to study gaps in yield across farms. While constructing yield gaps, we relied upon yield records of farms rather than the performances in front line demonstrations as the former allowed us to construct a more realistic yield estimates for the future. The Ministry also provides information on prices at which the producer disposed-off his produce to the trader at village site during a given marketing season after harvest. It also provides support prices at which different crops were procured by the government. The yield, input quantities and costs and revenues are also provided for states for each crop. We have used state-level price information to study the trends, costs and revenue and net income in gram and arhar cultivation.

We considered Madhya Pradesh, Maharashtra and Rajasthan for gram, and Maharashtra, Madhya Pradesh and Karnataka for arhar. During the year 2015-16[2], Madhya Pradesh, Maharashtra and Rajasthan occupied 36 per cent, 17 per cent and 11 per cent of total gram area and contributed 46 per cent, 10 per cent and 11 per cent of total production in country. Maharashtra, Madhya Pradesh and Karnataka together accounted 60 per cent of total arhar area and 55 per cent of arhar production. The harvest prices, support prices and future scenarios at which income can be doubled are examined for these states only. While comparing domestic prices with import prices, we derive estimates based on the data provided by the Ministry of Commerce and Industry. The data period from early-2000s to till date were used in yield gap and price trend studies and in estimation.

Methodology

Simple descriptive statistics were used throughout the study. To study the improvements in technology over the years, we used decomposition procedure proposed by Bisaliah (1977). The approach helps to decompose the share of technology in overall output change observed in a given crop. The procedure assumes a Cobb-Douglas production function as in Equation (1), and decomposes the entire output change

---

[2] Fourth advanced estimates

into neutral and non-neutral technology components and input-use component as in Equation (2).

Equation 1: $Y = aX_i^{bi}$

Equation 2: $\ln(Y_h - Y_t)$

$$= \left\{\ln\left(\frac{b_{h0}}{b_{t0}}\right)\right\}$$

$$+ \{(b_{h1} - b_{t1})\ln X_1 + (b_{h2} - b_{t2})\ln X_2 \cdot$$

$$+ (b_{h3} - b_{t3})\ln X_3 + \cdots + (b_{h9} - b_{t9})\ln X_9\}$$

$$+ \left\{b_{h1}\ln\left(\frac{X_{1h}}{X_{1t}}\right) + b_{h2}\ln\left(\frac{X_{2h}}{X_{2t}}\right) + b_{h3}\ln\left(\frac{X_{3h}}{X_{3t}}\right)\cdots\right.$$

$$+ \left. b_{h9}\ln\left(\frac{X_{9h}}{X_{9t}}\right)\right\} + [U_2 - U_1]$$

The sum of the shares of neutral and non-neutral technologies provides us the estimate of technology share in the overall output differences, and the left portion explains the share of input use. To obtain the yield and price scenarios at the targeted year 2022, we have used linear growth estimates based on the pattern observed over the past decade.

Results and Discussion

(A) Yield across Farms

To understand yield variability in and production potential of gram and arhar, we first estimated yield gaps using yield levels at farmers' plots. The idea behind it was to estimate yield levels that could be improved by using existing technologies and operations practised by the farmers. To put it simply, we narrowed down our focus by ignoring the role of transfer on new technologies. We obtained yield gap estimates for irrigated and unirrigated gram separately. As more than 95 per cent area under arhar is unirrigated, we could estimate yield gaps for arhar only from unirrigated plots.

The estimates indicated a moderate decline in yield gap during the past one decade (Figure 1). Except in Madhya Pradesh in case of irrigated gram and unirrigated arhar, there was no major improvement in other states. The other interesting observation emerge out is that reduction in yield gap is more pronounced in unirrigated than irrigated production regions. The reduction in yield gap between TE 2003-04 and TE 2013-14 is around 4.5 per cent in Madhya Pradesh in irrigated gram; around 60 per cent area under gram is irrigated in this state. Other major producers like
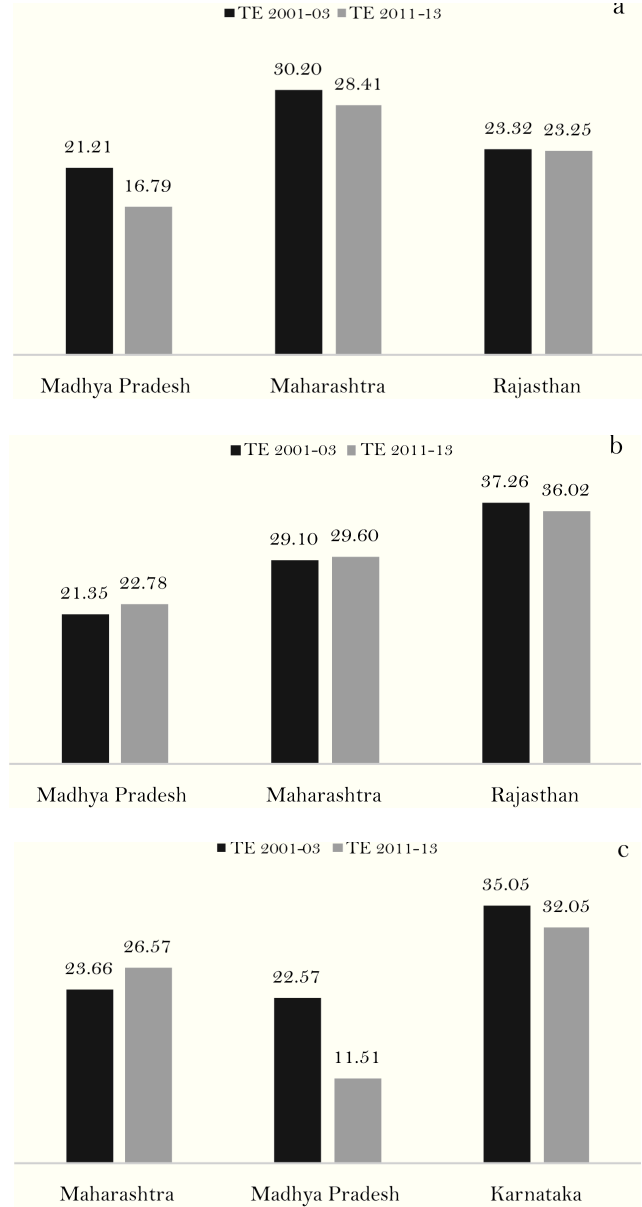

Figure 1. Yield gap in farmers' plots: (a) Irrigated gram, (b) Unirrigated gram and (c) Unirrigated arhar
Source: Authors' estimates based on MoAFW data
Note: Yield gaps were obtained using 80th percentile yield as threshold yield level.

Maharashtra and Rajasthan, where the levels of irrigation are around 25 per cent and 35 per cent respectively, recorded little or no change. The estimated yield gaps in these states are 1.8 per cent and 0.1 per cent, respectively. The performance is still poor in the unirrigated farms. Madhya Pradesh and Maharashtra registered a negative yield gap reduction, viz. -1.4 per cent and -0.5 per cent, respectively. Rajasthan was the
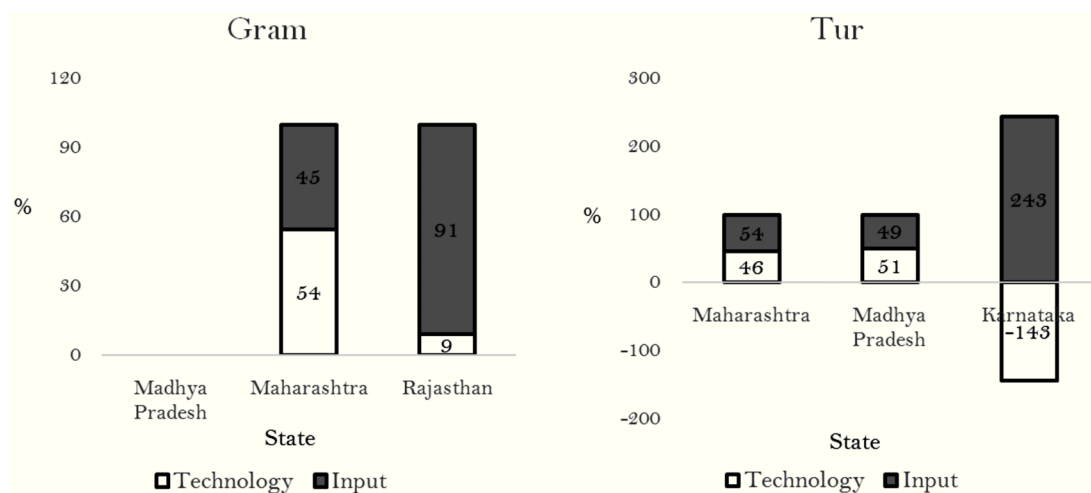
Figure 2. Sources of output change: TE 2013-14

Source: Authors' estimates based on Ministry of Agriculture and Farmers Welfare (MoAFW) data

Notes: (a) Since Madhya Pradesh had no users of local seeds in the MoAFW sample, decomposition was not done.

only state with a reduction in yield gap by 1.2 per cent. To the other side, while almost entire area under arhar is unirrigated, a considerable progress has been observed. The yield gap has halved in arhar in Madhya Pradesh during this period, from 22.6 per cent in TE 2003-04 to 11.5 per cent in TE 2013-14. The reduction in yield gap was by 3 per cent in Karnataka.

(B) Technology and Irrigation

The increase in output emerges through two major factors: (a) technology, and (b) input-use. To ascertain whether technology was a major contributor, we decomposed the total change in output into the contributions of technology and input-use for the years TE 2003-04 and TE 2013-14. The results showed that technology had a major role in output change, but its shares varied across crops and regions (Figure 2). During the year TE 2013-14, technology contributed more than 50 per cent of total output change in gram and arhar. The shares of technology contribution in Maharashtra in gram, and Madhya Pradesh and Maharashtra in arhar were 54 per cent, 51 per cent and 46 per cent, respectively. But the share of technology contribution declined in general with time, as shown by the estimates of TE 2003-04 (Appendix I). While the share of technology in gram increased from 43 per cent to 54 per cent in Maharashtra, it declined from 12 per cent to 9 per cent in Rajasthan. In case of arhar, the shares had declined in all the states considered. Still,

the role of technology remains unaltered, as shown by the statistics for the period TE 2013-14.

Since adoption of improved seed provides higher yield than what local varieties deliver, by making quality seeds available to the farmers, the yield, and thereby income, can be raised appreciably. Providing better access to irrigation could further raise the yield and income levels. Table 1 shows the yield advantages of using quality seeds and irrigation for both the TE 2003-04 and TE 2013-14 for the major producing states of gram and arhar. In doing so, we have assumed the yield levels registered under unirrigated environment as the base category, and reported the combinations of yield increments when irrigation was applied and improved seeds were used.

The role of technology is obvious from that fact that use of improved seeds, even in the irrigated environment, turned yield levels higher. The effect was more pronounced in gram than in arhar. One could observe in column-4 (Table 1) that during TE 2003-04, the marginal yield gains were 2-3 q/ha. It turned to 5.8 q/ha in Maharashtra during the TE 2013-14. Thus, yield gains were 0.2–1.5 q/ha in arhar during the TE 2003-04. At the highest extent, the yield has almost doubled in unirrigated arhar cultivation in Madhya Pradesh, and increased by 2-3 q/ha in Maharashtra and Karnataka.

Under sufficient irrigation, the potential yield could be extremely high. For example, one could see that

Table 1. Yield advantages due to adoption of quality seeds and irrigation

Year	State	Yield (quintals/ha)			
		Unirrigated farms		Irrigated farms	
		Local variety	Improved variety	Local variety	Improved variety
		Gram			
TE 2003-04	Madhya Pradesh	7.50#	+3.19***	+3.34***	+3.64***
	Maharashtra	6.42#	+2.06***	+1.78***	+3.89***
	Rajasthan	4.30#	+3.23***	+5.88***	+5.49***
TE 2013-14	Madhya Pradesh	-	9.66#	-	+4.57***
	Maharashtra	4.82#	+5.71***	+4.57***	+9.54***
	Rajasthan	7.98#	-0.43	+4.05***	+4.70***
		Arhar			
TE 2003-04	Maharashtra	7.68#	+0.23	+4.69*	+7.70***
	Madhya Pradesh	10.12#	+1.48***	-	-
	Karnataka	6.17#	+1.02*	-	-
TE 2013-14	Maharashtra	7.93#	+2.13***	+5.07***	+14.77***
	Madhya Pradesh	11.05#	+11.47***	+6.43***	-
	Karnataka	10.18#	+3.21***	-	-

Source: Authors' calculations based on MoAFW data
Note: (a) '-' indicates 'data not available'; (b) '#' indicates mean yield levels and '+' indicates yield margins over the mean yield levels; (c) ***, ** and * indicate significance at 1 per cent, 5 per cent and 10 per cent, respectively.

the gram yield in Maharashtra almost doubled (TE 2013-14) when the crop was irrigated, even when the seeds were of local varieties. The yield level turned higher by 4.6 q/ha when irrigated. It doubled when the seeds were replaced with improved varieties, turning to yield to be 9.5 q/ha. Similarly, the local varieties of arhar in Maharashtra yield 5 q/ha higher with irrigation. It increased by around 3-times when improved seeds were brought in, registering 14.8 q/ha. This provides us a straightforward direction that making available the quality seeds alone even when irrigation infrastructure is insufficient could raise yield levels by around 50 per cent in gram, and at least by 25 per cent in arhar. When irrigation is complemented with quality seeds, the yield could increase at least by 50 per cent in both gram and arhar, and therefore farmers' income would also increase.

(C) Price Policies and Market Realization

The continuous price support by the government has played a significant role in sustaining pulses production. The floor prices announced in the name of Minimum Support Prices (MSP) have sizably increased in recent times, especially since 2008. Between 2002 and 2008, the average annual rate of increase in MSP was around ₹ 70/q for gram and ₹ 40/q for arhar respectively. It turned up drastically later, more for arhar than gram. Between 2008 and 2015, the annual increase in MSP hiked to more than ₹ 200/q, witnessing a more than 3-times increase than the earlier period. In the case of arhar, the increase was by ₹ 400/q, a 10-times increase than the earlier period. This remarkable shift in protectionist prices in recent times could be the major reason behind increase in pulses production in the country.

On the other hand, the farm harvest prices (FHP) indicate a trend reversal in recent times across states (Figure 3). The support price of gram in Maharashtra was similar to that of the MSP announced. Even in Madhya Pradesh and Rajasthan, the FHPs had been higher just for a short period, between 2006 and 2010. Comparatively, arhar has received better price than gram. Almost all major producers have received harvest prices above MSP, especially since 2008. But the trend has reversed since 2012. Leaving Madhya Pradesh, farm harvest prices have fallen below the MSP in both Maharashtra and Karnataka. This trend reversal in recent times, and uncorrelated movements in MSP and
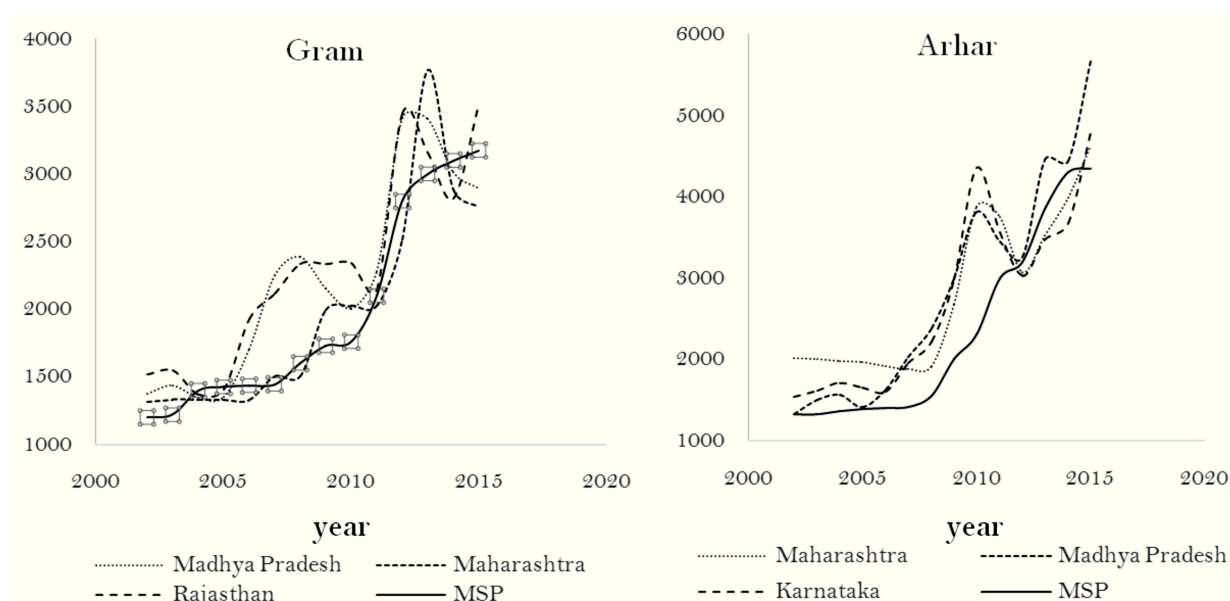
Figure 3. Trends in procurement vs market prices in gram and arhar (₹/q)
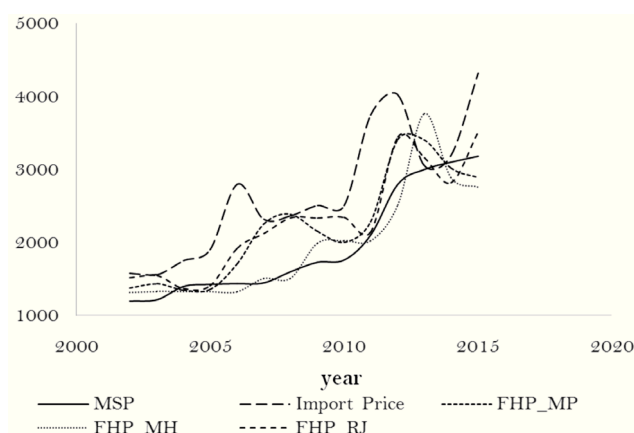Source: MoAFW (various years)

Figure 4. Correlation among different prices of gram (₹/q)
Source: MoAFW & MoCI, various years

FHP indicate us that MSP doesn't clearly act as a signal that determines the price which the farmers receive at market.

The fact that farm harvest prices many a times follow the MSP, remains true even after accounting for imports. The import prices have always been higher than the MSP and FHP. Figure 4 shows the trends in MSP and FHP in major producing states and import prices for gram. The import has always been costlier to the government, justifying the importance of import substitution. Further, farm harvest prices lie between

support and import prices, making one to think in favour of higher support prices in the future which would increase farmers' income on one hand and aggravate domestic production on the other hand.

(D) Scenarios that Could Double Real Farm Income

Having known that a moderate decline in yield gap on one hand and possibilities of increasing yield through quality seeds and irrigation on the other hand, appropriate strategies that would double farmers' income emerge from two major drivers, viz. reduce yield gaps and provide higher harvest and support prices. We have constructed in this section a combination of technological and price scenarios at which income of the farmers could be doubled by 2022. By the term 'doubling', we refer doubling 'real' rather than 'nominal' income. As the call is made in the year 2016, we have assumed the income realized in gram and arhar cultivation during this year as the base to construct future incomes. The approach followed is given below.

The Approach — We estimated yield potential of gram and arhar at farmers' fields in the past using plot level data for the years TE 2003-04 and TE 2013-14. We assumed 80th percentile of entire yield distribution as potential yield at farmers' plots (Ittersum *et al.*, 2013). The yield potentials were calculated separately for the

irrigated and unirrigated plots of gram. As almost entire arhar is grown under unirrigated condition, the estimates of yield potential were restricted to the unirrigated plots by dropping the observations where at least one irrigation was made. The state level estimates were obtained and are presented in Table 2.

The potential yield levels revealed varied performance across states and crops. In case of gram, the yield potential remained stagnant in Madhya Pradesh in both irrigated (14 q/ha) and unirrigated (≈12 q/ha) farms in TE 2003-04 and TE 2013-14. In Maharashtra, it increased from 13 q/ha to 19 q/ha in irrigated farms, and from 10 q/ha to 14 q/ha in unirrigated farms. The change in yield potential in Rajasthan during this period was from 13 q/ha to 16 q/ha in irrigated farms, and from 8 q/ha to 12 q/ha in unirrigated farms. Thus, except Madhya Pradesh, both Maharashtra and Rajasthan registered a notable increase in yield potentials. The yield potential in Madhya Pradesh remained stagnant (10 q/ha) in arhar farms as well during both TE 2003-04 and TE 2013-

14. On the other end, the potential yield level increased by 11 q/ha in Maharashtra, almost double to that of the estimate of 14 q/ha in TE 2003-04 to 26 q/ha in TE 2013-14. The state Karnataka also witnessed doubling of potential in yield level, from 9 q/ha in TE 2003-04 to 16 q/ha in TE 2013-14.

Interestingly, Madhya Pradesh showed a reduction in yield gap in the irrigated gram fields. It declined from 21 per cent in TE 2003-04 to 17 per cent in TE 2013-14. Maharashtra and Rajasthan witnessed a little or no reduction yield gap in the irrigated fields. In unirrigated fields, the yield gap has not undergone any major change, and has remained stagnant. In the case of arhar, while yield gap has halved from 23 per cent to 11 per cent, other states marked no major change. Thus, while yield potential has remained stagnant, whereas yield gap has declined in Madhya Pradesh, other states have roughly shown reverse relations. Presuming that the trends are likely to continue at least in the near future, we set targeted yield potentials and reduction in yield gaps across states for the year 2021-

Table 2. Estimated and projected yield potentials and yield gaps for gram and arhar: TE 2003-04, TE 2013-14 and 2021-22

State	Irrigated farms			Unirrigated farms		
	TE 2003-04	TE 2013-14	2021-22*	TE 2003-04	TE 2013-14	2021-22*
Estimated and projected yield (q/ha)						
Gram						
Madhya Pradesh	14.0	14.0	20.0	12.1	12.5	15.0
Maharashtra	13.3	19.0	25.0	10.0	13.7	15.0
Rajasthan	13.0	16.1	20.0	8.3	12.2	15.0
Arhar						
Maharashtra	-	-	-	14.3	25.6	30.0
Madhya Pradesh	-	-	-	10.0	10.0	15.0
Karnataka	-	-	-	8.6	16.0	20.0
Estimated and projected yield gaps (%)						
Gram						
Madhya Pradesh	21.2	16.8	10.0	21.4	22.8	20.0
Maharashtra	30.2	28.4	25.0	29.1	29.6	25.0
Rajasthan	23.3	23.3	20.0	37.3	36.0	30.0
Arhar						
Maharashtra	-	-	-	23.7	26.6	20.0
Madhya Pradesh	-	-	-	22.6	11.5	5.0
Karnataka	-	-	-	35.1	32.1	30.0

Source: Authors' calculations
Note: * refers projected estimates.

Table 3. Price factors in gram and arhar in doubling real gross income of farmers

State	PMY_22	PFP_22	PTR_22	TTR_22	GAP	FHP*_22	GAP*_22
			Gram				
Madhya Pradesh	14.1	5636	79463	114989	35526	8155	2520
Maharashtra	13.9	5375	74572	128351	53779	9250	3876
Rajasthan	12.4	6840	84987	100689	15702	8104	1264
			Arhar				
Maharashtra	24.0	9030	216729	188777	-27952	7866	-1165
Madhya Pradesh	14.3	11055	157535	110705	-46830	7769	-3286
Karnataka	14.0	9348	130872	123760	-7112	8840	-508

Source: Authors' estimates

Notes: (a) Weights of irrigated and unirrigated areas were used to obtain consolidated yield estimates for Madhya Pradesh; (b) '22' refers to the period 2022, PMY: Potential Mean Yield, PFP: Presumed Farm Harvest Price, PTR: Potential Total Revenue, TTR: Targeted Total Revenue by 2022, GAP: Difference in Potential and Targeted Total Revenue; FHP*: Farm Harvest Price that will double farmers' income by 2022; GAP*: Difference in FHP that should be addressed to double farmers' income by 2022.

22. The targeted estimates are subjective and involved no major statistical forecasts as such exercised would deviate the focus of our study. Despite of a stagnant yield potential in Madhya Pradesh, we set positive figures as targets, on the assumption of higher access to irrigation and quality seeds in future. The presumed estimates of yield potentials and yield gaps are also shown in Table 2.

Using the statistics presumed above, we calculated the average yield levels across farmers' fields for the targeted year. For example, assuming that yield potential in irrigated gram fields by 2022 will be 20 q/ha in Madhya Pradesh, a presumed yield gap of 10 per cent allows us to obtain the average yield of 18 q/ha. Similarly, at a presumed yield potential of 30 q/ha of arhar in Maharashtra, average yield turns to 24 q/ha under 20 per cent yield gap. We obtained similar estimates for all the major states for gram and arhar for the year 2022. The other major factor that determines the income of farmers is the price at which they dispose their produce. The study of past trends in gram showed an increase in FHP and MSP in the range 10-5 per cent a year between 2005 and 2015, and 8-13 per cent between 2002 and 2015. In the case of arhar, the estimates stood at 14 per cent-30 per cent a year between 2005 and 2015, and at 10-25 per cent between 2002 and 2015. Assuming that the trends will continue in future we noted no strong correlation between MSP and FHPs. Following that, we pegged at 10 per cent

increase in FHP in future, at least till 2022, for the corresponding states.

Table 3 presents the scenarios under which gross real income of the gram and arhar growing farmers can be doubled by 2022. The potential mean yield (PMY) that should be realized by the year 2022 is shown in column 1. These estimates were obtained after adjusting for presumed yield gap in the targeted future year. In the second column, we have reported farm harvest prices at an annual growth of 10 per cent a year, as in line with the past trend. The product of these column provides us column-3 showing the potential total nominal revenue that could be obtained during 2022. In column-4, we have reported nominal total revenue that would double the real income of farmers. Note that while the total revenue that are reported to double farmers' income are in nominal terms, the computation procedure involved in obtaining the estimates incorporated the effects of inflation.

We computed the total revenue in gram and arhar cultivation using cost of cultivation data provided by the MoAFW for the selected states for the year 2016. As they are at nominal terms, we constructed a deflator using value of output estimates given by the CSO. Using these deflators, we obtained real income estimates of gram and arhar for the year 2016. Doubling these income figures provides us the real income to be obtained for the year 2022. As these doubled figures will be at real terms, adjusting for inflation for the year

2022 would provide as the nominal income that should be achieved to double the farmers' real income levels. We assumed a 10 per cent growth in inflation for both gram and arhar, which provided us that multiplying the real income figures by 1.77 would turn these to the nominal values. Accordingly, the nominal income estimates for the year 2022 were computed and are reported in column-4 (Table 3).

The difference between columns-3 and 4 shows the 'gap' to be addressed to double the farmers' real income. As figures in column-3 incorporate the possible spread effect of the existing technology in future, the 'gap' must either be addressed through new technological breakthroughs, or through prices. We neglected the former, as it was uncertain in the short future, and proceeded to look into the possibility that FHPs and MSPs could play. Dividing column-4 by column-1 provided us the straightforward price estimates that should prevail, in the presence of which the real income could be doubled. It was wondering to see that the real gross income in arhar can be doubled just by achieving the presumed yield levels and reducing presumed yield gaps, letting the MSP and FHPs to increase by 10 per cent a year. The negative estimates in columns-5 and 7 against arhar dictated us these findings.

Turning our focus on gram, column-7 indicated the difference in FHPs above the presumed increase at which the real income could double. We could obtain that increase in FHP of ₹ 420/q, ₹ 646/q and ₹ 211/q, respectively in Madhya Pradesh, Maharashtra and Rajasthan above the presumed 10 per cent increase a year would double the real income. One could note that these figures remained true for the MSPs as well. A 10 per cent increase in current MSPs in arhar, and an increase in MSPs by ₹ 420/q, ₹ 646/q and ₹ 211/q, respectively in Madhya Pradesh, Maharashtra and Rajasthan above the presumed 10 per cent increase a year would double the real income. The ways and means by which this differential MSPs at states should be implemented are beyond the scope of this study. To note further, the reported figures correspond for doubling real 'gross' income and not real 'net' income. A similar exercise that assumes different levels of increase in costs in future indicate that, allowable levels of cost increase that would permit doubling both gross and net real income levels are 28 per cent, 29 per cent and 34 per cent in Madhya Pradesh, Maharashtra and

Rajasthan for gram, and 21 per cent, 27 per cent and 23 per cent in Maharashtra, Madhya Pradesh and Karnataka for arhar respectively.

Conclusions

The study has revealed that making available the existing technologies and factors at further scale through bridging yield gaps would greatly help in increasing the output at farm level. The study has shown that a moderate improvement in potential future yield levels, and a slight increase in MSP and FHP can double the real income of gram and arhar growing farmers by 2022. The results have shown a moderate decline in yield gap during the past decade. Except in Madhya Pradesh in the case of irrigated gram and unirrigated arhar, no major improvements are observed in other states. Still, technology retains its role in total output change, and their shares vary among crops and regions. During the year TE 2013-14, the technology contributed more than 50 per cent to the total output change in gram and arhar. The shares technology contributed in Maharashtra in gram, and Madhya Pradesh and Maharashtra in arhar were 54 per cent, 51 per cent and 46 per cent respectively. But, the share technology contributed had declined in general with time, as shown by the estimates of TE 2003-04. While the share in gram increased from 43 per cent to 54 per cent in Maharashtra, it declined from 12 per cent to 9 per cent in Rajasthan. Still, the role technology plays remains unaltered, as shown by the statistics for the year TE 2013-14. Moreover, both availability of quality seeds, and access to irrigation can provide significant improvement in farm yields. The impact multiplies further when both quality seeds and irrigation are made available. Hence, acting upon bridging yield gap, providing quality seeds and making available irrigation can help increase farm yield substantially.

The other major driver that could help in doubling farmers' income is the increase in prices. The study has shown that since 2008, the support price trend for gram and arhar has undergone a radical shift. Between 2002 and 2008, the average annual rate of increase in MSP was around ₹ 70/q for gram and ₹ 40/q for arhar. It turned up drastically later, more for arhar than the gram. Between 2008 and 2015, the annual increase in MSP hiked to more than ₹ 200/q, witnessing a more than 3-times increase than in the earlier period. In the case of arhar, the rate of increase was ₹ 400/q, a 10-
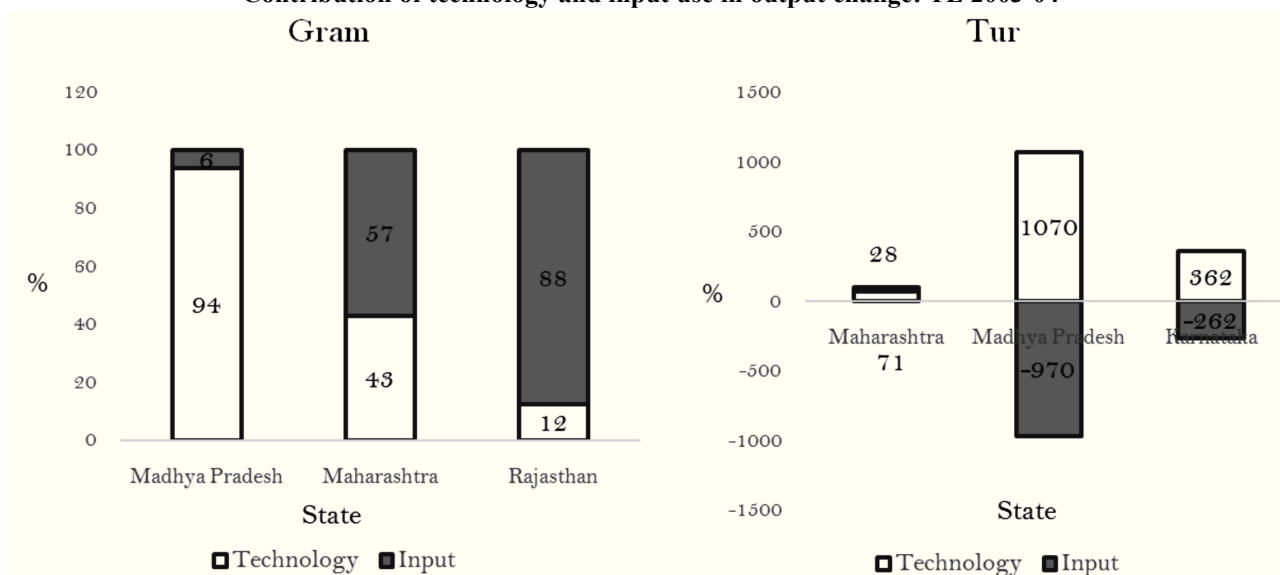
times increase than in the earlier period. The scenario analysis indicated that the real gross income in arhar can be doubled just by achieving the presumed yield levels and reducing presumed yield gaps, letting the MSP and FHPs to increase by 10 per cent a year. A 10 per cent in current MSPs in arhar, and an increase in MSPs by ₹ 420/q, ₹ 646/q and ₹ 211/q, respectively in Madhya Pradesh, Maharashtra and Rajasthan above a presumed 10 per cent increase a year would double the real 'gross' income. Further, estimates have indicated that allowable levels of cost increase that would permit doubling both gross and 'net' real income levels are 28 per cent, 29 per cent and 34 per cent in Madhya Pradesh, Maharashtra and Rajasthan for gram, and 21 per cent, 27 per cent and 23 per cent in Maharashtra, Madhya Pradesh and Karnataka for arhar respectively.

References

Basavaraja, H., Mahajanashetti, S. B. and Sivanagaraju, P. (2008) Technological change in paddy production: A comparative analysis of traditional and SRI methods of cultivation. *Indian Journal of Agricultural Economics,* **63**(4): 629-640.

Bisaliah, S. (1977) Decomposition analysis of output change under new production technology in wheat farming: Some implications to returns on investment. *Indian Journal of Agricultural Economics*, **32**(3): 193-201.

Ittersum, M.K., Cassman, K.G., Grissini, P., Wolf, J., Tittonell, P. and Hochman, Z. (2013) Yield gap analysis with local to global relevance – A review. *Field Crops Research*, **143**: 4–17.

Joshi, P.K., Kishore, A. and Roy, D. (2017) Making pulses affordable again policy options from the farm to retail in India. *Economic and Political Weekly*, **52**(1): 37-44.

Lingareddy, T. (2015) Pulses: Need for production expansion. *Economic and Political Weekly*, **50**(35): 133-136.

NITI Aayog (2016) *Evaluation Study on Efficacy of Minimum Support Prices (MSP) on farmers*. DMEO Report No.231, Development Monitoring and Evaluation Office, Government of India, New Delhi.

Reddy, A.A. (2004) Consumption pattern, trade and production potential of pulses. *Economic and Political Weekly*, **39**(44): 4854-4860.

Reddy, A.A. (2009) Pulses production technology: Status and way forward. *Economic and Political Weekly*, **44**(52): 73-80.

Srivastava, S.K., Sivaramane, N. and Mathur, V.C. (2010) Diagnosis of pulses performance of India. *Agricultural Economics Research Review.* **23**: 137-148.

Subramanian, A. (2016) *Incentivising Pulses Production through Minimum Support Prices (MSP) and related Policies*. Ministry of Finance, Government of India.

Appendix I

Contribution of technology and input use in output change: TE 2003-04

Source: Authors' estimates based on MoAFW data.