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Economics and Technology of Soybean Cultivation in Central India

E. Revathi
B. Suresh Reddy

CENTRE FOR ECONOMIC AND SOCIAL STUDIES
BEGUMPET, HYDERABAD

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Foreword

The Centre for Economic and Social Studies (CESS) was established in 1980 to undertake research in the field of economic and social development in India. The Centre recognizes that a comprehensive study of economic and social development issues requires an interdisciplinary approach and tries to involve researchers from various disciplines. The Centre's focus has been on policy relevant research through empirical investigation with sound methodology. Being a Hyderabad based think tank, it has focused on, among other things, several distinctive features of the development process in the undivided state of Andhra Pradesh earlier and the Telangana state in the present times though its sphere of research activities has expanded beyond the state, covering other states apart from issues at the nation level. In keeping with the interests of the faculty, CESS has developed expertise on themes such as economic growth and equity, rural development and poverty, agriculture and food security, irrigation and water management, public finance, demography, health, environment and other studies. It is important to recognize the need to reorient the priorities of research taking into account the contemporary and emerging problems. Dissemination of research findings to fellow researchers and policy thinkers is an important dimension of policy relevant research which directly or indirectly contributes to policy formulation and evaluation. CESS has published several books, journal articles, working papers and monographs over the years. The monographs are basically research studies and project reports done at the Centre. They provide an opportunity for CESS faculty, visiting scholars and students to disseminate their research findings in an elaborate form.

The present study analyses the trends in growth of area, production and yield (APY) of soybean crop at All India and the selected states of Madhya Pradesh, Rajasthan, Maharashtra and Telangana. This empirical study covering all major soybean growing areas provides a comprehensive understanding of issues at the field level and also the farmers' view point. It focused on assessing adoption and impact of technology in soybean seed varieties. The major findings of the study are: area expansion has been high at the All India and for all selected states till the year 2000; among the four selected states area expansion rate has been high for the emerging states, Maharashtra and Telangana; yield growth rates were negative till 2000 and turned positive after that for the All-India and production trends show positive growth for All India and all selected states. It was found that nearly 96 percent of the sampled households are growing varieties developed by Indian Council for Agricultural Research. The total factor productivity has tapered off in states cultivating soybean crop for a long time like Madhya Pradesh. Technical efficiency does not vary much among the states and districts in each state. But there is much variation in the allocative efficiency and economic efficiency across states. Farms belonging to bottom deciles purchase inputs (fertilizer) at higher price compared to top deciles resulting in variations in economic efficiency. Appropriate policy measure could ensure that inputs are supplied at same price to all farms to improve economic efficiency. I hope the present study will be useful to academicians and policy makers.

S. Galab
Director, CESS

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Executive Summary

Context

Soybean has been traditionally grown on small scale in hills of Uttarakhand, Himachal Pradesh, eastern Bengal, Khasi Hills, Manipur, Naga Hills but soon was able to spread out to the heartland of India of Madhya Pradesh, Gujarat and Rajasthan by seventies and to the dry lands of Maharashtra and parts of undivided Andhra Pradesh (Telangana) and Karnataka by the end of the last century. It could gain the attention of farmers because it was a short duration crop fitting well into the early kharif crop cycle followed by wheat or chick pea; predominantly rain fed crop; yield and price advantage over coarse cereals and pulses; does not require much financial investment; assured markets; and price factors. The crop assumed larger economic significance for the farmers of major soybean growing states as well as government of India, as it is import substituting with regard to edible oil and export earnings through oil cake.

A number of varieties of soybean have been developed by the ICAR's All India Coordinated Research Project (AICRP) and State Agricultural Universities (SAUs) that combined resistance to disease and high yield potential with good seed viability. Along with these varieties complete package of practices have been developed suitable for different agro climatic zones and cropping systems which resulted in spread of soybean crop. Soybean crop is primarily cultivated in three states of Madhya Pradesh, Rajasthan and Maharashtra. The contribution of MP to the total area under soybean is 52 percent and to total production is 45 percent while the contribution of Maharashtra state stands next to MP with 32 percent to area and 40 percent to production. Rajasthan contributes around 9 percent to area and 8 percent to production.

Several studies indicated the stagnation of soybean yields since last couple of decades. Lack of access to quality seed, higher input costs, continuous mono cropping of soybean without proper crop rotation resulting in soil fertility decline, poor extension services, prolonged dry spells and excess rains at times are the major causes for stagnation of soybean productivity in India despite the increase in area.

Need for the Study

There is dearth of major empirical studies covering all major soybean growing areas which can provide a comprehensive understanding of the issues at the field level and also the farmers view point. Similarly not many attempts by earlier studies were made to understand the gap in technology with respect to adoption of each component by farmers in major soya bean growing areas vis-à-vis recommendations of soya bean scientists of Directorate of Soybean Research. Despite the release of several varieties for different agro-climatic zones, studies indicate that only few varieties dominate the fields of farmers. In the light of these issues the present study has been taken up with the following objectives

1. To analyse the trends in growth of area, production and yield (APY) at All India and the selected states and to carry the decomposition analysis of growth of soybean production
2. To contextualize the cultivation of soybean crop in different agro climatic situations across the sample states chosen
3. To assess the adoption of technology (package of practices) by soybean cultivating farmers in the selected states and find its determinants
4. To assess the impact of public sector technology in soybean seed varieties on output, by assessing area, production, and productivity of soybean crop over time at All India and in selected states through the primary data
5. To measure the total factor productivity (TFP) of soybean crop using the cost of cultivation data (collected from secondary sources) and the determinants of TFP growth
6. Estimate the technical efficiency, allocative efficiency and economic efficiency of farmers cultivating soybean crop in the selected states and analyze their determinants
7. To suggest appropriate policy measures.

The study has been conducted in four states viz Madhya Pradesh, Rajasthan, Maharashtra and Telangana, the first three being major soybean growing states and the last a newly cultivating state. Further the length of time of cultivation of the crop also would throw up the differentials in total factor productivity, technical and economic efficiency, and adoption of technology and so on which have implications for policy. Two districts within each of these states were selected based on area under soybean crop cultivation. In Madhya Pradesh, Ujjain district in Ujjain division and Rajgarh district in Bhopal divisions were selected. In Maharashtra, Amaravati district in Amaravati division and Latur district in Latur division are selected. In Rajasthan Kota CAD and Jhalawar were selected from Kota division and in Telangana two districts Adilabad and Nizamabad in North Telangana zone were selected for the study. Two blocks/ mandals (as in Telangana) from each district and two or three villages from each block/ mandal were selected based on criterion such as area under soybean crop. Villages with minimum population size of 1000 were selected which gives scope to cover different communities. All the households were listed to identify farmer households cultivating soybean crop. 48 soybean farmer households were selected from each of the selected village stratified across 4 broad land holdings categories of marginal, small, medium and big. The total households covered by the study are 1692.

Findings of the Study Area, Production and Yield (APY)

Two patterns emerge in the course of area expansion of soybean crop, firstly that traditional crops were replaced by soybean (long term change) in the states of Madhya Pradesh and Rajasthan and secondly crops like maize, pulses and cotton are being replaced due to relatively higher and stable returns, rain fed in nature and short duration of soybean crop. The second pattern is found in the late entry states of Maharashtra and Telangana.

Area production and yield analysis of soybean crop indicates that area expansion has been high at the All India and for all states till the year 2000. The compound growth rate for area has fallen for all states after 2001. Among the four selected states area expansion rate has been high for the emerging states in soybean cultivation (Maharashtra and Telangana) compared to the other two states MP and Rajasthan. Yield growth rates were negative till 2000 for All India and for the states of Rajasthan and Madhya Pradesh but positive for Maharashtra and Telangana. After 2001 yield growth rates have become positive for All India but remained negative for Rajasthan and Maharashtra, and constant for MP and positive for Telangana. Production trends show positive growth for All India and all states, high growth is found for the states of Telangana and Maharashtra respectively.

Growth rate of soybean production are positive but have fallen after 2001 for all the states. A decomposition analysis of change in average production and variance in production has been conducted. Results show area expansion has contributed largely to the extent of 80 percent to change in average production while yield has contributed to an extent of 10 percent only at the All India level. In case of state of Maharashtra 97 percent of change in production is because of change in mean area; while in Telangana along with change in mean area interaction between mean area and yield has contributed majorly for change in average production. Change in area variance has contributed more to variance in production for All India, and for the states of Maharashtra and Rajasthan. While in case of the state of Madhya Pradesh change in yield variance has contributed to variance in production, the interaction effect between mean yield and area variance has contributed to change in variance in production in Telangana state.

Among the selected sample villages' average area under soybean crop is highest in sample villages in Maharashtra followed by sample villages in Madhya Pradesh; while average yield (qtls per acre) is high in sample villages in Madhya Pradesh. Rajasthan villages have the lowest average yields. There is much variation in yield in the sample villages of Telangana, Maharashtra and Rajasthan. Madhya Pradesh villages have less variation in yields/ production.

Public sector research made phenomenal contribution to the development of varieties with respect to soybean crop and thereby increase in its cultivation area. Nearly 96 percent of the sampled households are growing varieties developed by ICAR through its AICRP and which are also recommended varieties. The seed variety of JS 335 was predominant in the states of Madhya Pradesh and Rajasthan in 2005 and 2010 which later shifted to NRC- 7 and JS 9560; however JS 335 is the most preferred variety in Maharashtra and Telangana in the current times. The farm yield (FY) and potential yields (PY) show there is difference between the two in case of varieties like JS 335, JS 9305. In case of 1024 and NRC-7 the FY is on the lower side of the PY. For the seed variety 1024 yield gap is highest in Delchikurd and Lohana in Mehidpur and Badnagar blocks in Ujjain district of MP. For the popular variety of JS 335 except in the villages of Rajgarh (MP) and Latur (Maharashtra) yield gap is high in the rest of the sample villages. In case of 9560 all 4 villages in Kota district had high yield gap. Since the agriculture year 2014-15 was a rainfall deficit year we also collected data for a normal year. The yield gaps between current and normal year were high in all sample villages except those in the state of Madhya Pradesh.

Total Factor Productivity (TFP) Analysis

The TFP analysis of the soybean crop based on secondary data (cost of cultivation data) in the three states of MP, Rajasthan and Maharashtra during the period 1996-97 to 2012-13 reveals the following significant findings: The trend growth rate of TFP in MP is in the band of 1-1.2 while for Rajasthan it ranges from 1.2 to 1.4. In the case of Maharashtra it ranges between 1 to1.4. MP the long standing grower of soybean has not been able to achieve high TFP compared to medium starter and new comer states of Rajasthan and Maharashtra respectively. The increase in input index in MP shows quantities of all inputs used (seed, fertilizer, human and animal labour) have fallen while cost has increased which has pushed the Total Input Index (TII) but has not shown any commensurate rise in the Total Output Index (TOI).

In case of Rajasthan the compound growth rate of price of animal labour is highest and the response to it is seen in the negative compound growth rate of quantity in animal labour use. Human labour might have substituted for animal labour whose price is lower than the latter. Quantity of seed used is showing high growth rate but fertilizer use is showing negative growth rate. In case of state of Maharashtra all input quantities show positive compound growth rate except the seed. Growth rate in fertilizer use (quantity) is highest; this may be due to negative growth rate in fertilizer cost in the state. Animal labour use is high. Machine labour use which is aggregated with animal labour has increased as the rate of growth of machine labour price is low. Crop productivity might be high because of high use of fertilizer quantity and animal and machine use thereby resulting in high TFP growth.

Among the sources of growth of TFP rainfall stands out. The fluctuations in the output are closely related to rainfall in rain-fed conditions. Literacy rate also contributes to productivity as the capacity of the farmers to adopt recommended practices and establish link with markets will be high. While the TFP results apply for an average farmer and not the potential farmer and also do not give variations across land holding size and also because of the benefit of larger data set to pick up more determinant factors in case of primary study we have analyzed the technical efficiency, allocative efficiency and the economic efficiency through the stochastic frontier analysis for all the selected states using the cross section data collected for the agricultural year 2014-15.

Technical Allocative and Economic Efficiency

The maximum likelihood estimation of production frontier function indicates that the observed output significantly differs from frontier output due to factors which are random to a large extent. Only 6 percent of the difference between actual and potential production is primarily due to technically inefficient performance of the farms. The large difference between observed output and frontier output is because of random factors in the current agricultural year (2014-15) or specifically deviation of rainfall from normal as soybean crop is primarily rain fed crop.

On the other hand the maximum likelihood estimation of profit frontier function indicate that observed (restricted) profits significantly differ from frontier profits due to factors which are within the control of famers. 91 percent of the difference between the actual and potential normalized profit are primarily due to economically inefficient performance of the farms.

Technical efficiency does not vary much among the states and districts in each state. But there is much variation in the allocative efficiency and economic efficiency across states. Economic efficiency is least in Rajasthan and highest in Madhya Pradesh. Among the districts Ujjain in Madhya Pradesh, Jhalawar in Rajasthan, Latur in Maharashtra and Adilabad in Telangana have relatively higher levels of economic efficiency within the respective states. A pertinent question arises as to what makes for the difference in economic efficiency across sampled sites. The institutional factors, markets and the state play important role in accessing inputs at differential pricing to the farmers. Farmer's cooperatives (PACs) played positive role in Maharashtra in providing seed and fertilizer and in Rajasthan the Rajasthan State Seed Corporation, ITC, IFFCO also supplied seeds to the farmers. Different factor endowments and different prices may also be influencing the economic efficiency of farmers.

Distribution of technical efficiency across states shows that large percentage of farmers fall in the highest efficiency bracket in the states of MP, Maharashtra, Telangana and Rajasthan in that order. An analysis of determinants of efficiency shows that adoption of package of practices does not significantly impact yield levels or efficiency of production with the adoption of package of practices. This may be due to deficit rainfall in the current agricultural year (2014-15). Younger aged farmers and farmers who practiced crop rotation once in 3-4 years resulted in better efficiency levels. An analysis of variations in use of inputs and level output shows that in order to raise the output of bottom deciles farmers input adjustments like increase in human labour days and reducing machine labour days increase in seed and fertilizer quantities need to be made to reach output level of the top deciles of farmers. Farms classified according to allocative efficiency show that farms belonging to bottom deciles purchase fertilizer at higher price compared to top deciles. Farms classified according to economic efficiency show that top deciles have spent more on human labour; less on machinery but obtained higher output hence returns are higher. Of all the states Madhya Pradesh emerged as best soybean producing state in the current agricultural year with high technical and allocative and hence economic efficiency.

Adoption of Technology

Technology (seed) and adoption of practices are important notwithstanding the indeterminate relation between adoption and efficiency in production of soybean crop in the current year. There are a number of factors that impinge on the performance of crop that range from technical - adoption of right seed variety, adoption of the recommended package of practices, the enabling conditions (institutional) for adoption - support from agricultural institutions, extension support, credit from formal institutions, and farmers living conditions and assets like livestock wealth, farmers awareness and knowledge on farming practices. There are variations in all these factors across the selected sample sites which account for variations in productivity of the crop.

Some practices have been universally followed (deep ploughing, line to line sowing distance, manual/inter cultivation / weedicide practice to control weed, pest and disease management), while seed treatment, fertilizer application, seed germination test, spraying of pesticide before sowing, and have been completely adopted by some and partially adopted by others. The mean score of practices adopted by farmers is high for the state of Rajasthan (12.8) followed by Maharashtra (12.4) and Telangana (12.1). Madhya Pradesh had a low score at 11. The major reasons for non adoption or partial adoption vary across states they are as follows, in Madhya Pradesh and Rajasthan farmers expressed that lack of livestock has constrained adoption; as farmers use their own seed or good quality seed the need for germination test was not felt, based on their experience and perceptions with the seed and the soil type farmers have felt that some of the practices need not be practiced. But in case of crucial practices like treatment of seed either farmer were not aware or not having enough financial resources to conduct it. Surprisingly farmers in Madhya Pradesh too were not aware of different seed treatment procedures but 35 percent have conducted at least one test. In Telangana farmers are not following some general practices like sowing depth and sowing distance but broadcast seeds. Among the determinants of adoption classified into farmer characteristics (land holding, education, experience); farming related (tractor, livestock, extension and training services, credit); and sources of information (weather, seed varieties, soil fertility, quality inputs, pest and disease management, market price) younger aged farmers, farmers owning livestock and received extension and training, who received information have adopted recommended practices. While having access to information is important, source of information too plays crucial role. For example it has been established from data that farmers received information from pesticide dealers in Maharashtra and Telangana but have not adopted the practices for the fear of unreliability. This suggests that reliable sources of information have to be provided to farmers for better adoption of recommended practices.

Farming Conditions, Institutions and Markets

Institutions have a definite role to play in adoption of practices and enhancing productivity of crop. Soil testing has been taken up by 14 to 18 percent of farmers only and those who took up were not adequately satisfied with results. Only 18 percent of all farmers received any extension service. And agriculture department is the dominant provider of extension services followed by private companies. 50 percent of all the sample farmers are not undertaking any crop rotation, while 27 percent are rotating once in two years and 11 percent once in more than five years. Farmers from sample villages in Rajasthan and Madhya Pradesh purchase all inputs from the market while in Telangana 100 percent received soya seed from the agriculture department. Farmers are dependent on borrowed credit from informal sources for the purpose of soybean cultivation in sample villages in Telangana state which increased their cost of cultivation. Only 31 percent of the sample farmers are aware of the minimum support price for the soybean crop. Role of middlemen in supply of inputs and purchase of output is high in sample villages in Adilabad, Nizamabad and Latur districts in that order. Cooperatives are present in Amaravati which provide inputs and also are purchase centers for the soybean crop.

The socio economic conditions of the farming community also matters in connecting to the public institutions, adoption of best practices, new technology, new varieties and thus can be called best farming community. In our field study the Patidar community in Jhalawar, Patels in Badnagar and Mehidpur blocks in Ujjain, Gurati Kapu community in Nizamabad, are found to be better farming communities with relatively bigger sized plots, good quality lands and soil depth and access to tube well irrigation. The other communities also need to be linked to state institutions for adoption of best practices, and achieving better productivity.

Farmers have expressed the limitations in adopting recommended practices which center on lack of awareness, not owning livestock, lack of adequate investment, no proper extension support, belief in existing practices, non availability of instruments/ machinery. The recommended dosage of chemical fertilizers is also not used according to recommendation but use as per their experience. Farmers have expressed problems and constraints in soybean crop cultivation which span from general to particular like deficit rainfall, depleting ground water table, non availability of seed on time, tribal farmers from Telangana state depend more on credit from non formal sources like money lenders, do not have proper documents to avail formal credit. They also perceived that cost of cultivation has been on the rise due to increased disease and pest and application of pesticide. They also face marketing problem due to which they incur high transportation costs. Farming situation for the soybean crop is better in Madhya Pradesh, Rajasthan, and Maharashtra in that order. These differential conditions impact the productivity, cost of cultivation and the economic viability of the farmers.

The suggestions flowing from the farmers across all states are the need to take soil sample collection and to provide the analysis results. Similarly, the respondents also suggested the need to establish soil testing laboratory at the block level for better access to farmers. Large percent of farmers in Madhya Pradesh felt the need to support production of Farm Yard Manure (FYM) in a bigger way. Farmers from Telangana and Rajasthan also felt this need. In line with this suggestion, majority of the farmers in Rajasthan and Maharashtra emphasized the need to provide credit for the purchase of FYM. Substantial number of farmers across all states suggested the need to provide timely access to inputs followed by the need to provide access to latest information related to seeds, fertilizers and pesticides and timely access to credit. Farmers in Telangana and Maharashtra wanted the provision of irrigation facilities for better production and productivity of soya bean. Farmers across all states demanded the need to provide trainings by Krishi Vigyan Kendras (KVK) with respect to soya bean cultivation. In the states of Maharashtra and Telangana, farmers felt that the Agricultural officers should give complete information about soya bean cultivation which is lacking at present. Few farmers in Madhya Pradesh wanted shorter duration varieties than the existing one. The need to support the use of micro nutrients was felt by large number of farmers in Maharashtra and Rajasthan. Nearly 32 per cent of farmers in Telangana wanted crop insurance for soybean.

Policy Implications

Based on the evidence from the field it can be emphasized that there is a strong need to focus on improving the productivity of rain fed soybean crop through development of non-GMO soya bean varieties that can withstand both prolonged drought spells as well as excess rains.

The yield gap between potential yield and farm yield can be bridged if appropriate measures are taken by the state institutions. The dissemination of package of practices needs to be focused on. Right and effective methods of extension have to be adopted so as to work closely with soya bean farmers. Different methods/ modes combining public and private need to be explored keeping in view the diversity of farming situation and farmers conditions for this purpose. Private information sources like the traders and pesticide dealers are not trusted much by farmers therefore knowledge needs to be disseminated through credible sources. A soybean consortia mode may be necessary to translate the research out puts to real out comes, a multi-institutional approach involving the NARS, the state departments of Agriculture, NGO's, KVK's, public sector financial institutions and private industry is required for this.

Appropriate policy measures need to be in place to ensure that inputs are supplied at same cost to all farmers especially bottom deciles farmers to improve their economic efficiency. Linking farmers to appropriate institutions for advice, inputs and markets becomes crucial.

Further Indian soya foods are paid premium price in world market because of cultivation of non-GMO varieties and hence there is a need to retain these markets. To tap the growing organic markets world over and especially in Europe, National Programme for organic production of soya bean crop can also be initiated. Our field survey also revealed pockets of soybean cultivation where chemical fertilizer application is low which could be effectively transformed to organic method of cultivation. This is more so in case of tribal farmers.

CHAPTER I

1. Introduction

Soybean has an important place in world's oilseed cultivation scenario, due to its high productivity, profitability and vital contribution towards maintaining soil fertility. The major soybean producing nations are the United States, Brazil and Argentina. The three countries dominate global production, accounting for 80 percent of the world's soybean supply. Global production of Soybean is 319.37 million metric tons in 2014-15.

In India, 62 percent of the total geographic area or 200 million hectares spanning several agro-ecological regions is under rain fed agriculture. Much of the poverty is concentrated in these dry zones. It accounts for 56 percent of total cropped area, 48 percent under food crops and 68 percent of that under non-food crops. In terms of crop groups 77 percent of pulses, 66 percent of oilseeds and 45 percent of cereals are grown under rain fed conditions. In recent times soybean has become an important crop to farmers in dry land regions as 98 percent of area under soybean cultivation is rain-fed because of its suitability for cultivation in fallow lands, yield and price advantage over coarse cereals and pulses, as well as import substituting with regard to edible oil and export earnings through oil cake (Chand, 2007). Today, India contributes about four per cent of total world soybean production and it stands at fourth position in terms of production.

In India, Soybean has been traditionally grown on small scale in hills of Uttarakhand, Himachal Pradesh, eastern Bengal, Khasi Hills, Manipur, Naga Hills and has spread to parts of central India covering Madhya Pradesh and Maharashtra from 1970s. It is high in protein (40 percent) and oil (20 percent) content and also has beneficial effects on soil fertility. Soybean has been considered as a good source of protein given the perennial protein malnutrition in the country due to stagnant pulse production. Indian Agriculture Research Institute, the GB Pant University of Agriculture and Technology (GBPUAT) in Uttarakhand and Jawaharlal Nehru Krishi Vishwavidyalaya (JNKVV), Jabalpur in Madhya Pradesh in collaboration with University of Illinois, USA have been the pioneers in testing new soybean varieties and taken initiatives to popularize the soybean crop in mid sixties. Then Indian Council of Agricultural Research (ICAR) also initiated an All-

India Project for Coordinated Research (AIPCR) on soybean in 1967. Due to these concerted efforts the area under soybean has expanded from 11,000 hectares in 1961 to 12.20 million hectares in 2013-14.

The USAID (US Agency for International Development) and ICAR have allocated substantial money for research on soybean. Many hurdles on the front of pests like yellow mosaic and rust had to be sorted out subsequently. Soybean breeding programme at Pantnagar with support of United States Department of Agriculture (USAD) could develop varieties resistant to yellow mosaic and rust diseases. A number of varieties have been developed that combined resistance to disease and high yield potential with good seed viability which were tested by the AIPCR across the country and released for general cultivation. Along with these varieties complete package of practices have been developed suitable for different agro climatic zones and cropping systems. All these efforts resulted in spread of soy crop especially in states such as Madhya Pradesh, Rajasthan and Maharashtra. Madhya Pradesh is the largest contributor to soybean crop. It contributes 52 percent to area and 45 percent to production while Maharashtra has emerged second to it and contributes 32 percent to area and 40 percent to production.

Soybean is a major crop grown during the Kharif, or monsoon, season (July-October) in the rain-fed (dry land) areas of central and peninsular India. Soybean yield is low in India as compared to other major soybean-growing countries, and has remained more or less stagnant. The production of soybean and its area of cultivation in India have increased dramatically since its introduction in the 1970's. During this time, however, the yield of soybean in India has remained almost stagnant, at around 1 tonne per hectare which reflects the increasing production of soybean in India has been due to increase in area of cultivation and not an increase in yield. There are geographical variations in the area, and productivity among long time soybean cultivating states like Madhya Pradesh and Rajasthan, and newly cultivating states like the Maharashtra and Telangana. Soybean crop has spread to these states as a competing crop to maize and cotton crops.

Soybean contributes significantly to the Indian edible oil production pool which is 98.6 lakh tonns during 2013-14. Presently soybean contributes 43 percent to the total oilseeds and 25 percent to the total oil production in the country. Currently, India ranks fourth in respect to production of soybean in the world. The crop helps earn valuable foreign exchange (Rs. 62000 millions in 2012-13) by way of soya meal exports.

Soybean has largely been responsible in uplifting farmer's economic status in many pockets of the country. It usually fetches higher income to the farmers owing to the huge export market for soybean de-oiled cake. While on one hand production of Soybean in India has increased at a CAGR of 9.6 per cent from 6.87 million tonns in 2004-05 to 15.68 million tonns in 2012-13. On the other hand Soybean meal consumption has also increased at a CAGR of 10.82 per cent over the last eleven years from 1365 thousand million tonns in 2004-05 to 4225 thousand million tonns in 2014-15 (FICCI, 2015). Therefore to keep pace with the increasing demand it is imperative to increase the productivity level of Soybean in the country.

Marketing was a big constraint for the expansion of soya crop as its use was limited as dhal or flour or animal feed initially. Industrial processing like extraction of edible oil and defatted cake has created demand for soya crop. Further extraction of milk from dried soybean also was done in collaboration with scientists from the USA. Export of defatted oil cake has raised the demand for soy crop removing the marketing constraint. The ICAR has also established in 1987 National Research Center for soybean (NCRS) at Indore in MP. The Central Institute of Agricultural Engineering (CIAE) at Bhopal has contributed to enterprise development and successful diversification by developing various kinds of soy food products to suit local tastes and preferences and also developing apparatus for soybean processing. The institutional intervention by oilseed (soybean) growers' cooperative federation by ensuring inputs and markets had contributed to expansion of soybean crop.

1.1: Need for the Study

In a comparative perspective soybean crop is still less efficiently cultivated in India. For example the productivity level of soybean in India is one half of the average yield in China and one third of that in the United States, Argentina, and Brazil. Soybean yield in India is stagnant around 1000 kg per hectare. Hence the challenge is in terms of promotion of soybean production, improve its economic viability, marketing and processing, consumer acceptability, and to make it competitive. Against this back drop, this study on Economics and Technology of Soybean Cultivation in Central India was carried out with the following objectives.

1.2: Objectives

1. To analyze the trends in growth of area, production and yield (APY) at All India and the selected states and to carry the decomposition analysis of growth of soybean production.

2. To contextualize the cultivation of soybean crop in different agro climatic situations across the sample states chosen.

3. To assess the adoption of technology (package of practices) by soybean cultivating farmers in the selected states and find its determinants.

4. To assess the impact of technology in soybean seed varieties on output, by assessing area, production, and productivity of soybean crop over time at All India and in selected states through the primary data.

5. To measure the total factor productivity (TFP) of soybean crop using the cost of cultivation data (collected from secondary sources) and the determinants of TFP growth.

6. Estimate the technical efficiency, allocative efficiency and economic efficiency of farmers cultivating soybean crop in the selected states and analyze their determinants.

7. To suggest appropriate policy measures.

1.3: Methodology and Study Area

The soybean research in India has developed improved seed varieties and agro ecological zone specific production technologies. Therefore the impact of soybean varieties would be examined in different agro ecological zones in which it is cultivated. Major area under soybean is in the states of Madhya Pradesh, Maharashtra and Rajasthan, but also newer areas under the crop has come in Maharashtra, Madhya Pradesh and Rajasthan in that order. The other states which have contributed to increase in area are Karnataka, undivided Andhra Pradesh and Chhattisgarh (DSR, ICAR). According to the first crop estimate of SOPA (Soybean Oil Processors Association of India) Madhya Pradesh, Maharashtra, Rajasthan and undivided Andhra Pradesh rank first four states in area in 2013 kharif as well as in 2012 kharif. The soybean cultivating area falls in the Telangana region of undivided Andhra Pradesh and by the time study was commenced Telangana state has been formed and hence the selected state is Telangana in place of Andhra Pradesh. Thus, the four states selected for the study are Madhya Pradesh, Rajasthan, Maharashtra and Telangana.

Two Districts within each of these states are selected. The criterion for selection of districts is area under cultivation. In MP Ujjain district in Ujjain division and Rajgarh district in Bhopal divisions are selected. In Maharashtra, Amaravati and Latur districts are selected. In Rajasthan Kota CAD and Jhalawar are selected from Kota division and in Telangana two districts Adilabad and Nizamabad are selected for the study. In all 8 districts are selected from the four major soybean growing states of India. Two Blocks/ mandals (as in Telangana) from each district and two/three villages from each block/

mandal are selected based on criterion such as area under soybean crop. Villages with minimum population size of 1000 are selected which gives scope to cover different communities. 48 soybean farmer households are selected from each of the selected village stratified across 4 broad land holdings categories of marginal, small, medium and big. The total households covered by the study are 1692. The data on cost of cultivation has been collected from secondary sources, Directorate of Economics and Statistics for the years 1996-97 to 2012-13 for the three states of Madhya Pradesh, Rajasthan and Maharashtra.

1.4: Profile of Selected States

Located in central India, Madhya Pradesh (MP) is India's second largest state with an area of 308,252 sq km. called the "heart of India" because of its geographic location; MP borders Uttar Pradesh in the north-east, Chhattisgarh in the south-east, Maharashtra in the south, Gujarat in the west and Rajasthan in the north-west. The state has four agro-climatic zones, and thus, a diverse mix of ethnic groups and tribes, castes and communities, including indigenous tribal groups and relatively more recent migrants from other states. It has a significant tribal population, which constitutes more than one-fifth of its total population and 40 per cent of India's total tribal population. In absolute numbers, Madhya Pradesh is home to the largest number of Scheduled Tribes (STs) in India and is often called "the tribal state of India". There are 43 recognized STs. There are three particularly vulnerable tribal groups in the state - Sahariya, Baiga and Bharia. The tribal population is largely concentrated in and around the forest area of Madhya Pradesh, and is amongst the most marginalized and vulnerable.

Rajasthan with its huge geographical area of 342.7 lakh hectares is the largest state of India constituting 10.4 per cent of total geographical area and 5.67 per cent of total population of India. About 57 per cent of state's geographical area consists of desert which accounts for 61 per cent of the desert of the country. The forest area has hovered around 8 per cent of total reporting area while the net area sown has been largely fluctuating in the state over the years, which has increase during recent past, i.e. from 169.7 lakh hectares in 2009-10 to 180.34 lakh hectares in 2014. The state is divided into 7 divisions, 33 districts, which are further subdivided into 244 tehsils, 249 panchayat sammitees and 9,168 gram panchayats. Physio-graphically, the state can be divided into 4 major regions, namely (i) the western desert with barren hills, rocky plains and sandy plains; (ii) the Aravalli hills running south-west to north-east starting from Gujarat and ending in Delhi; (iii) the eastern plains with rich alluvial soils; and (iv) the south-eastern plateau. Mahi, Chambal and Banas are the three major rivers of the state. The state enjoys a strategic geographical position wherein it is situated between Northern and Western growth hubs in the country and 40 per cent of Delhi Mumbai Industrial Corridor (DMIC) runs through it. The state has well identified 10 agro-climatic zones. The state is endowed with diverse soil and weather conditions comprising of several agro-climatic situations, warm humid in south-eastern parts to dry cool in western parts of the state. About 65 per cent population (i.e. about 56.5 million) of the state is dependent on agriculture and allied activities for their livelihood. The three major canal irrigations, other than the vast area under arid and dry lands offer great help for agricultural development of the state. Agriculture in Rajasthan is primarily rain fed covering country's 13.27 per cent of available land. The diversity in climatic conditions of the state creates potential to develop certain belts of horticultural crops. The arid part of the state which receives not more than annual rainfall of 25 cm thrives on agriculture that is done with irrigation systems and painstaking efforts of the poor farmers of Rajasthan. As a major portion of the state is parched, the risk and instability in agricultural production and productivity are quite high.

Maharashtra is the second largest state in India both in terms of population and geographical area (3.08 lakh sq. km). The state is home to a population of 11.24 crore (Census, 2011) which in other words, is 9.3 per cent of the total population of India. The overall literacy rate is much higher at 82.9 per cent than the national literacy rate of 74 per cent, as per Census 2011. Progress on Human Development Index is often depicted as a benchmark for a state's progress of key development indicators. As per India Human Development Report-2011, Human Development Index of India is 0.467 while the State ranks 5th in the country with a Human Development Index of 0.572 after Kerala, Delhi, Goa and Punjab. The State is also well known for its administrative acumen and innovative ideas besides being the first to have implemented a Women policy and engendering the budget by way of a establishing a separate Woman & Child Development Department. Besides, it was a pioneer in implementing its 'Employment Guarantee Scheme' which subsequently came to be replicated by the Government of India.

In Maharastra, the agriculture & allied activities sector contributes 12.9 per cent to the State's income. For the year 2013-14 the net area sown (173.86 lakh hectares) constitute about 56.59 percent of its total geographical area. Similarly, the state has about 52.1 lakh hectares of forest area. Gross area irrigated in Maharashtra during the year 2013-14 was 40.50 lakh hectares out of which 55 percent is well irrigation and 45 percent by surface irrigation. Numbers of irrigation projects are being implemented to improve irrigation. A watershed mission has been launched to ensure that soil and water conservation measures are implemented speedily in the unirrigated areas. Presently, there are 44185 micro watersheds in Maharashtra, while the area under in-situ moisture conversation and micro-irrigation systems comes to 5.51 lakh hectares.

Telangana is the new born 29th state of India, formed on the 2nd of June 2014. The state has an area of 1, 14, 840 Sq Km and has a population of 3, 52, 86,757. The Telangana region was part of the Hyderabad state from Sept 17th 1948 to Nov 1st 1956, until it was merged with Andhra state to form the Andhra Pradesh state.

Agriculture in Telangana is dependent on rainfall and agricultural production depends upon the distribution of rainfall. Telangana receives a normal rainfall of 906.6 mm in a year. The major Kharif coarse cereals produced in the state are Maize, Jowar, Bajra, and Ragi. During 2013-14 the Gross Area Irrigated by different sources was 31.64 lakh ha and net area irrigated was 22.89 lakh ha and the irrigation intensity was 1.38. The total numbers of operational holdings in the State are 55.54 lakhs covering an area of 61.97 lakh hectares. In Telanagana state marginal farmers are about 61.96 percent operating only 25.28 percent of area, small farmers are 23.9 percent in number operating 30.17 percent of area where as semi medium to large farmers who have 14.14 percent holdings operate 44.55 percent of the area. The average size of holding in Telangana state is 1.12 hectare. Productivity of soybean is 1081 kgs. The agro climatic conditions in Telangana state are suitable for seed production and the policy initiative of the state is in the direction of encouraging seed production. Government is also taking keen interest in rejuvenating tanks which is the lifeline of agriculture in the state. It is proposed to undertake soil sampling, analysis and mapping in 110 mandals of Telangana State during 2015-16 with an estimated amount of Rs 448.00 lakhs.

1.5: Selection of Sample States

The study was carried out in four states i.e. Madhya Pradesh, Rajasthan, Maharashtra and Telangana covering 8 districts and 34 villages (Table 1.1). Madhya Pradesh and Maharashtra are important states in view of area and production of soybean crop. Rajasthan has been a long time cultivating state of soybean crop while Telangana has switched to soybean crop from the early 1990s.

1.6: Selection of the District/ Block/ Village

Based on the highest area under soybean cultivation, two districts were selected and two blocks were selected from each district based on highest area. Selection of study villages from each block was taken up based on following criteria:

Table 1.1: Details of Selected States/Districts/Blocks/Villages and Selected Sample for the Primary Study

Sl. No.	State	District	Blocks/ Mandals*	Area under soybean (in hectares)	Villages	Area under soybean (in hectares)	Number of HH listed	Number of HH selected
1.	Madhya	Ujjain Pradesh	Badnagar	1,02,370	Lohana	607.3 (99)	314	48
					Jandla	127 (99)	470	48
			Mehidpur	85,778	Mundla Parval	201.6 (96)	470	48
					Delchi kurd	295.9 (95)	471	48
		Rajgarh	Biovhra	73,870	Chachakhedi	218.6 (96)	301	48
					Baiheda	278.5 (89)	349	48
			Narsingarh	94,195	Mawasa	184.6 (93)	402	48
					Sarana	145.3 (88)	221	48
2	Rajasthan	Jhalawar	Pidawa	19866	Dhuvliya	170 (78)	359	48
					Dharonia	129.5 (95)	457	48
			Khanpur	38418	Khandi	326.3 (100)	333	48
					Bareda	185.8 (95.03)	277	48
		Kota CAD	Pipalda	41389	Balupa	190.3 (48.5)	183	48
					Durjanpura	215.4 (77)	205	48
			Digodh	54738	Khedlitavhran	189.5 (64)	155	48
					Bislai	263 (60.9)	107	48
3	Maharashtra	Amaravathi	Amaravathi	35,175	Kekatpur	888.67 (71.76)	350	48
					Nayakola	910.93 (67.5)	500	48
			Nandgoan	46,324	Sirpur	182.2 (79.78)	278	48

					Dahigoan	506.1 (83.99)	340	48
		Latur	Latur	62933	Kawa	647.7 (62.06)	356	48
					Bahmni	526.3 (61.03)	272	48
			Ausa	60231	Bahrampur	303.6 (60.63)	224	48
					Vangchi	186.2 (74.19)	245	48
4.	Telangana	Adilabad	Kauthala	8780	Thatipalli	508.1 (79. 63)	132	48
					Pardi	412.9 (77.27)	121	48
					Gangapur	607.3 (55.5)	160	48
			Jainoor	5480	Ashapalle	364.4 (36.1)	172	48
					Patnapur	323.9 (37)	193	48
					Daboli	202.4 (21.8)	227	12
		Nizamabad	Vailpoor	3929	Akloor	301.2 (48.59)	124	48
					Vailpoor	648.2 (43.35)	207	48
					Lakkora	235 (54.14)	150	48
			Tadvai	6102	Kankal	601.2 (48.7)	285	48
					Karadpally	749.8 (55.8)	283	48
					Tadvai	244.1 (57.8)	460	48
All	4	8	16	NA	36	NA		1692

* Mandal is the administrative unit below district in Telangana state.
Note: Figures in brackets are in percentage out of total cultivated area.

- High percentage of Soybean cultivation to the total cropped area of the village and it should not be less than 50 percent
- Minimum number of households in the village should be not less than 200 so as to get enough samples
- A minimum geographical distance of 10-15Kms between villages is ensured to get the wider representation of the block

Based on the above criteria, two villages were selected from each selected block.

1.7: Profile of the Sample Villages

The study is based on thirty six villages belonging to eight districts of Madhya Pradesh, Rajasthan, Maharashtra and Telangana states. Velpoor village in Nizamabad district of Telangana state is the village with the maximum number of households (2532) with a population of 8277, Daboli of Telangana is the village with minimum number of households (91) with a population of 315. All the villages have mixed population with the social categories of general caste, backward caste and scheduled castes, while scheduled tribe population is found to be restricted to few villages. The basic features of the villages related to demography, social structure; land use, land holding pattern, cropping pattern; infrastructure, of sample villages are presented in Appendix tables 2 to 5.

Study villages of Madhya Pradesh and Rajasthan had lesser crop diversity as compared with villages of Maharashtra and Telangana. Crop genetic diversity is an essential dimension of agricultural production in low-input farming systems; a reduction in diversity often leaves small cultivators more vulnerable (Cleveland et.al 1994; Poinetti and Reddy 2002; Reddy 2009). The soils of sample villages have been predominantly black and red gravel/ sandy soils. The predominant source of irrigation in the sample villages has been only tube well irrigation.

The population of cows is maximum in all the study states among the large ruminants followed by Buffaloes. The bullock is drastically reduced in villages of Madhya Pradesh and Rajasthan states as compared with Maharashtra and Telangana. The role of bullocks has been taken over by the tractors to a greater certain extent in Madhya Pradesh and Rajasthan and to a moderate extent in Maharashtra and Telangana and this has significant implications for the fertility of soils. Percentages of farmers using Spiral grading machine was very high in Madhya Pradesh and nil in Telangana state. In Maharashtra a couple villages used this grading machine and it was used by small percentage of farmers in all the villages of Rajasthan (Appendix tables 1 to 5).

1.8: Instruments Used for the Study

Household listing schedule was used for obtaining basic information from all the households to enable sample selection in the selected villages. A household schedule has been used to obtain information from the farmer households. Village schedule has been used to obtain information on farming conditions in general and soybean cultivation in particular administered to the village Panchayat secretary of the selected villages and the Tehsil office of the respective blocks. Strategic Interviews with ICAR, SAU scientists, officials, Officials of DAC (Department of agriculture and cooperation), SOPA and other relevant stakeholders were held.

1.9: Selection of Sample Households

All the households in the selected sample villages were listed and basic information on social category, age, landholding, cropped area, crops cultivated area under soybean crop, and seed variety used currently and in the past for soybean crop was collected for the purpose of sample frame work to enable sample selection.

From each selected village a sample of 48 farmers were selected covering 12 farmers each from category of marginal farmers(0.1 to 2.5 acres), small farmers (2.51 to 5 acres), medium farmers (5.1 to 10 acres) and Big farmers (10.1 and above). Sample of 48 farmers was obtained from the listing schedule which covered all the households in the village. Once the listing of total households is done, households cultivating soybean crop were categorized based on the above mentioned size classes and a separate list is made. Then within each size class farmers are arranged based on their social category. Then a class interval is arrived at by dividing the total number of farmers in each size class with 12. This is done to see that each social category is represented proportionally according to their population in the universe. In case there was no adequate sample in a particular class sample was drawn from the next class. In all a sample of 1692 households cultivating soybean crop were drawn from 36 villages in 16 blocks/ mandals from 8 districts in 4 states of MP, Rajasthan, Maharashtra and Telangana. 384 households were taken for the study each from MP, Rajasthan and Maharashtra while 540 households were taken from Telangana state. In the study districts of Telangana the area under soybean was restricted to few mandals and a few farmers in the villages. Hence to get a comprehensive picture of the soybean cultivation in the study villages of Telangana, more households were taken resulting in more sample than what was proposed in the study. Apart from this, the study analyses the determinants of adoption of technology which is only cause and effect relationship. Moreover we are not providing any estimates for adoption. Data is shown in percentage terms. So, representation of sample does not affect the analysis.

The primary survey conducted pertains to the year 2014-15 which was not a normal year in terms of rainfall. Even though the year was a drought year, as the study has been already initiated, we continued the survey. As the farmers have limited option to adopt production technology during drought year, we tried to collect the data for a normal year in the five year period starting from 2014-15 to 2010-11. In this five year period, good rainfall year is chosen as normal year by the farmer. Thus the normal year may vary based on decision of farmer. Data on cost of cultivation, yield, price, income have been collected for normal year in similar way as for the year 2014-15. Tables pertaining to both current year (drought year) and normal year (Table 6 Appendix) are presented in the report.

The interview schedule was pre-tested in one of the village in an identical village outside the present study. Piloting of household questionnaire was done in Khubgoan village, Nandgoan block, Amaravathi district of Maharashtra and Chickli village, Badnagar block of Ujjain district of Madhya Pradesh. In the light of the experience gained in the pre-testing, suitable modifications were made before finalizing the interview schedule. The questionnaire was translated into Hindi for using in Madhya Pradesh, Rajasthan and Maharashtra.

Information was collected by administering the individual questionnaire to the selected sample households. The questionnaire consists of five sections. The first section is general information about the households family particulars (family members, age, sex, social category, education, role in household activity and occupation), membership in organization, farming experience and sources of income. Second section is about land holding details regarding total operational land, grazing land, fallows, land use in Kharif and Rabi 2014-15, details of soybean cultivation practices. The third section focused on crops grown, livestock details and input used during normal year (any year during 2010-2014) and in the year 2014-15.

The fourth section is about details of inputs used. Section five discusses about the adoption of DSR recommendations by farmers regarding soybean cultivation. Credit sources of farmers, sources of farming information, constraints in soybean cultivation and suggestion for improving the productivity of soybean were the issues on which information was collected.

1.10: Data Analysis

Both quantitative and qualitative information on the details of soybean farming and its determinants were gathered. Descriptive and multivariate analysis was conducted. The analysis was basically done in two ways. One is comparing between the various size classes of large, medium and small farmers and the other analysis was done comparing between different states. The results of the study are discussed at two levels one at the household level and the other is at the plot level. The data gathered was analyzed using different statistical tools. Averages, frequency and percentages were used to analyze the various information related soybean cultivation. Stochastic frontier production function was estimated using the primary data to know the technical efficiency and the distribution of farmers at different levels of technical efficiency. Similarly Profit function was estimated to know the economic efficiency.

Total Factor Productivity is estimated using secondary data on cost of cultivation over a period of time for the states of Madhya Pradesh, Rajasthan and Maharashtra. As cost of cultivation data for Telangana was not available it could not be estimated. Regression analysis was used to analyze the determinants of TFPG, determinants of technical, allocative and economic efficiencies.

1.11: Organisation of Chapters

The monograph is organized into 6 chapters. The present chapter is an introduction to this work. In this chapter, the importance of soybean cultivation is discussed. This is followed by objectives and methodology. The second chapter is a review of the literature on the issues related to soybean. The third chapter is an analysis of APY (area, production and yield) of soybean crop cultivation at All India and in the selected sample sites in the selected states along with crop situation and role of institutions. Fourth chapter deals with adoption of technology by soybean farmers, seed technology and adoption of package of practices, the constraints for adoption. Fifth chapter analyses the total factor productivity of soybean crop and the determinants of its growth in the selected states. Sixth chapter is about the impact of technology, adoption of package of practices on the efficiency of production of soybean crop. The three efficiencies, technical, allocative and economic and their determinants are analyzed in this chapter. The executive summary of the study is presented in the beginning of the report.

CHAPTER II

Review of Literature

Keeping the research objectives in mind, this review aims to span issues relating to the soybean cultivation with an emphasis on various factors hindering the productivity of the crop in major soybean cultivating states. In this chapter an attempt has been made to critically review different views, which have a direct and indirect bearing on the study. The issues covered in the review include a) Production b) Availability of quality seed c) Input costs d) Technology e) Pest and disease incidence f) Declining soil fertility g) Yield potential h) Total factor productivity i) Marketing j) Income k) Extension service l) GMOs vs Non-GMOs m) Impact of climate change and n) Constraints in Soybean cultivation.

2.1: Production/Productivity

From 1985/86 to 98/99, India witnessed highest growth of soybean production and productivity, which, he designated as the 'golden period' of soybean in India. It was, however, followed by a period of decline during 1999/2000 to 2002/03 (Chand, 2014). According to him the crop, again started to recover its growth during 2003/04 to 2012/13, which, he mentioned as 'period of renewed growth'. It is having such a high growth, which is only next to cotton. The maximum area under soybean cultivation in India is covered under only two major varieties JS-335 and JS-93-05 (Wilmot, 2009). Chand predicted that in the next 30-40 years, it will surpass cotton to have the highest growth rate in India. The productivity growth attained during the decades of 1975-95 due to Green revolution technologies (GRTs) could not be sustained during 1995-2005 (Chand et.al. 2012). Also, the benefits from GRTs have not been similar for all crops across different states of India.

Analysis done by Kajale and Shroff (2013) revealed that the growth rates of area and production in soybean crop slowed down after the year 2000 both at district as well as state level. They have also reported that growth rate of productivity is negative/very low in most of the districts in the post 2000 period. As soybean is cultivated under rain-fed conditions, reducing the yield gap may not be possible unless rainfall conservation technologies and cultivars tolerant to drought conditions are developed and adopted (Tiwari, 2014). The major cause of large yield gaps between rainfed yield potential and actual yields harvested by farmers is attributed to non-adoption of improved production technology by the farmers (DSR, 2011).

The area under irrigation, which, currently, is about 0.5percent only, has to be increased so that soybean production can be raised. Vegetable soybean and soy-products meeting Indian tastes are needed to make it popular (Chand, 2014). Despite the efforts of the Central Food Technology Research Institute (CFTRI) of Mysore in popularizing soya foods, not much success has been achieved and even today soybeans are not used as regular food like other pulses, cereals and dairy products (Chand, 2007). Soymeal containing over 50percent protein is exported at meager price leaving large mass population protein hungry (Kulkarni, 2014). Today, the producer of soybean- the farmer-does not retain soybean for food uses for his own family. Kulkarni (2014) feels that domestic scale processing of soybean for food and feed is, thus, a priority in the rural sector.

Srivastava (2014) attributed that major cause of large yield gaps between rainfed yield potential and actual yields harvested by farmers to non-adoption of improved production practices by the farmers. He also stressed the need to have zone wise production technologies for soybean crop so to improve its productivity in different agro-climatic conditions. Chand (2007) reported that the main reasons for the difference in frontline demonstration (FLD) yield and yield at farmer's field are use of quality seed; correct quantity of seed; proper sowing methods; adequate tillage; lack of weed control measures; nutrient management and plant protection measures. Gupta (2014) suggested two pronged strategy for increasing the productivity of Soybean in India. One is to encourage cultivation of soybean in irrigated regions with full technological support to harness the yield potential so that it can complete with the established crops, which are generally high water demanding ones and second is the efficient rain water management to ensure full potential of the genotype being cultivated/recommended.

2.2: Availability of Quality Seed

In a study done by Dupare *et al* (2010) in 11 soybean growing district of Madhya Pradesh with 142 farmers have revealed that non-availability of quality seed of improved varieties of soybean is the major problem experienced by the farmers. Authors further said that, as the seed production chain is not efficient to provide the quality seed of desired varieties to farmers, they are compelled to use farm saved seed by increasing the seed rate to manage required plant population. The study identified the 27 problems encountered by the soybean growers during the cultivation of crop. Among those, insect pest management, nutritional sources and their application, management schedules for weeds and diseases, trait specific preference of varieties, availability of quality seed of preferred variety are the major concerns expressed by majority of the respondents.

According to Tiwari (2014) inadequate availability of quality seeds of improved varieties was one of the major issues identified in soybean cultivation and the others include inadequate and imbalanced use of nutrients; inability of soybean varieties to with stand either drought/excess moisture; repeated adoption of crop-cycle of wheat/chickpea - Soybean; heavy yield loss due pests such as stem fly, griddle beetle and green semi-looper and diseases like yellow mosaic and soybean mosaic; lack of mechanization and lack of support from trade policy and MSP to soybean growers. Based on the empirical evidence of the study, Kajole and Shroff (2013) concluded that most of the farmers have been using HYV seeds and area under such seeds is more than 90 per cent in all size class farmers.

2.3: Input Costs

Wilmot (2009) conducted a study on cost of soybean production to understand changes over time in Ujjain and Ratlam districts of Malwa region, Madhya pradesh state. Contrary to general assumption, study of Wilmot (2009) in Malwa region of MP revealed that soybean requires fewer inputs than alternative kharif crops. According to Wilmot (2009) the reasons for a continued increase in soybean cropped area despite its stagnant and low productivity and increasing cost of production are: suitability for cultivation in fallows; yield and price advantage over other kharif crops; stable price and organized markets; higher net returns as compared to other kharif crops; risk taking ability of farmers and the government scheme - technology mission for oil seeds.

2.4: Technology

The highest soybean yielding areas in MP are Malwa districts and the reasons for this high productivity are the growth overtime of farmers' knowledge and experience of soybean production (Wilmot, 2009). Despite a well established crop in Malwa region, Wilmot (2009) reported that Soybean production in the study sites of Ratlam and Ujjain districts was far from optimum due to - absence of farmers' knowledge regarding IPM/INM; lack of micronutrient utilization and crop rotation adoption; wide spread use of relatively older varieties JS -335and JS-9305; low seed replacement.

2.5: Pest and Disease Incidence

Continuous cropping of soybean, that too mostly mono-cropping has led to increase in disease, insect and weed incidence. Sharma *et al* (2014) pointed out that the pests in soybean which have national significance are stem fly (Melanogromyza sojae); Tobacco caterpillar(Spodoptera litura); green semiloopers (Chrysodeixis acuta, Gesonia gemma and Diachrysia orichalcea); Girdle beetle 9Obereopsis brevis); Pod borer (Helicoverpa armigera) and White fly (Bemisia tabaci). They revealed that yield losses due to these pests range between 20 to 100percent. Farmers in Madhya Pradesh were also quite aware of the importance of Integrated Pest Management (IPM) practices and sought information about the relevance of pesticides of biological origin compared to chemical control measures (Dupare *et al.*, 2010). Diverse non-pesticidal management options are being followed by farmers of Maharashtra and Andhra Pradesh for controlling major pests of cotton and Groundnut respectively (Reddy, 2015). More than eleven percent of the farmers sought information regarding the kind of nutrition for soybean crop i.e organic vs chemical fertilizers. This indicates the farmers concern about the sustainability of the production system. The same study by Dupare *et al* (2010) found that there is high level of awareness among farmers on consequences of the indiscriminate and skewed use of chemical fertilizers. They have also reported that farmers were very much aware on the growing market of organic produce world over and avid to learn on organic production of crops and scope of fetching remunerative price and also availability of domestic market for their produce.

2.6: Declining Soil Fertility

Cultivation of soybeans for several consecutive years results in the extraction and imbalance of soil nutrients, which is one of the reasons for the stagnation in yield in the major soybean growing areas (Chand, 2007). This should be overcome by encouraging the farmers to adopt diverse traditional soil fertility management practices which take care of overall soil health resulting in improvement in productivity (Reddy, 2015). The main plant nutrients recommended for soybeans, phosphorus and sulphur, are not subsidized by the government, whereas there is a large subsidy for nitrogenous fertilizer (Chand, 2007).

2.7: Extension Service

India is in the process of development of second-generation technologies and hence much more intensive efforts are required in extension services to disseminate the improved technologies. The slowing down of emphasis on extension services in agriculture will further widen the gap in the adoption and generation of a technology and will induce movement of cropped area towards negative growth or stagnation in TFP (Chand *et al.*, 2012). Study done by Dupare *et al* (2010) revealed that even after 40 years of successful commercialization of soybean crop, Extension machinery of Madhya pradesh state department of Agriculture has not been able to take the improved package of practices to farmers.

2.8: Yield Potential through Simulations

CROPGRO-Soybean model simulations showed that the average water non-limiting potential of the soybean crop across locations was 3020 Kg/ha, while water limiting potential was 2170 Kgs/hectare indicating a 28percent reduction in yield due to adverse soil moisture conditions (Bhatia *et al.*, 2008). On the other hand the actual yield was just 1000 kgs/ha which was 2020 and 1170 kgs/ha less than the water non-limiting potential and water limiting potential of soybean in India. This simulation study suggested that conservation of rainfall and drought resistant varieties in low rainfall regimes will be the essential components of improved technologies aimed at reducing the yield gaps of soybean. In another study done by Bhatia et al (2006)indicated that sub-optimal water availability and resultant subdued expression of improved management practices are the major factors for lower potential yield in rainfed environments of many locations and regions. These researchers further concluded that development of improved genotypes with better water use efficiency and adoption of improved practices can help in raising the potential productivity and in abridging the large yield gaps of soybean in rainfed environment.

2.9: Total Factor Productivity

Chand *et al* (2012) estimated the total factor productivity for crops and indicates that the aggregate and disaggregate levels to assess the growth in productivity and to quantify the sources of TFP. Farm level data on yield, use of inputs and their prices for major crops grown in different states during the period 1970-71 to 2005-06 were used to estimate crop-wise TFP. The Divisia Tornquist index was used in the study for computing TFP indices for major crops. The researchers have found that the estimates of TFP growth for the major crops at all-India level have shown wide variations across crops. The TFP growth in the edible oilseeds varied in the range of 0.7 - 0.8. The researchers found that the estimated share of TFP growth in output growth ranged between 5 per cent and 74 percent for various crops - the lowest being soybean(below 1 per cent) and the highest for jute. More than 50 percent increase in output of wheat and 24-30 per cent increase in output of rice, sorghum, pearl millet, barley, chickpea and ground nut were possible through technological change or increase in TFP. Similarly these researchers looked at the trends in total factor productivity of various crop in selected states of India. Their findings indicated that for soybean crop total factor productivity growth was positive in Madhya Pradesh and Rajasthan with a low growth range of 0.5 to 1percent and for Uttar Pradesh it TFP growth was moderate with a range of 1-2percent. Contrary to this Maharashtra state has shown growth in TFP. Hence he argues that the priority must be focused on those states which have been observed under negative or stagnant growth.

Chand *et al* (2012) used estimates of regression coefficients which measure the effect of various sources of TFP, were used to compute elasticity of TFP with respect to research stock and to assess the impact of research. The elasticity of TFP with respect to research stock ranged from 0.0185 for groundnut to 0.1933 for red gram. Their study estimates show that to achieve 1 per cent increase in TFP, the investments in research need to be increased by 21.5 per cent for rice, 19.5 per cent for wheat, 19.3 per cent for pearl millet, 13.6 per cent for maize, and 8.7 per cent for sorghum per annum. Among pulses, the research investments will have to be increased by 5.2 per cent for red gram and 10.7 per cent for chickpea per annum. For edible oilseeds, research investments should be increased by 21.4 per cent for rapeseed & mustard and 54 per cent for groundnut to achieve 1 per cent growth in TFP. For cotton, investments on research need to be raised by 12.7 per cent per annum to increase 1 per cent TFP growth. Based on the analysis of their study, authors of the paper concluded that on an average, the investments on research in agriculture need an increase of about 25 per cent annually to achieve 1 per cent growth in TFP. However the study of Chand etal (2012) did not estimate the elasticity of TFP with respect to research stock of Soybean crop to assess the impact of research.

Public funding for agricultural research is an important factor which affects the development of agriculture. Public funding for agricultural R&E increased from ` 37.8 crore in 1971-72 to ` 4308 crore in 2007-08, an increase of 113-times (Chand *et al.*, 2012). There was a steady increase in public funding for agriculture research & education. Another way to assess the funding for research is to compute an intensity ratio such as research expenditure as the percentage of agricultural gross domestic product (AgGDP). Using this method Chand *et al* (2012) reported that the intensity ratio increased significantly from 0.21 per cent to 0.62 per cent during 1971-2008, but remained around 0.6 per cent during 2000s. Researchers felt that this low level of research intensity is a cause of worry given its 1 per cent level globally. Beintema and Stads (2008) noted that for agricultural output of every US$ 100, developed countries spend US$ 2.16 on public agricultural R&D, whereas developing countries hardly spend US$ 0.55.

The analysis of returns to research investment provided justification for the previous findings and also presents a sound basis for future finding, based on the level of returns. Results of the study done by Chand *et al* (2012) showed that rate of returns to research investment was higher during 1995-2005 than during 1985-95 in all crops, except wheat and oil seeds. They revealed that during the period 1975-2005, the overall internal rates of return (IRR) to public investment in agricultural research were highest for red gram (57percent), followed by sorghum and cotton (39percent each), wheat (38percent), chickpea (34percent), pearl millet (31percent), rice (29percent), maize (28percent), and were lowest for groundnut (18percent).

Findings of Chand and *et al* (2012) revealed that about one-fourth growth in output of wheat and cotton, one fifth in the case of pearl millet and nearly 13 per cent in paddy and maize were due investments on research in agriculture. In most of the other crops, about one tenth of output growth was achieved due to public investment on research in agriculture, the lowest being 6.6 per cent in the case of sorghum. The same study also pointed out that despite lot of claims about hybrid sorghum, its TFP growth has shown a decline during 1995-05. In contrast, the TFP growth in pearl millet, which is entirely a rainfed crop, has been highly impressive. Sorghum production and contribution of technology to it have shown deterioration in the selected states, except Maharashtra which has benefited from the technological change in a big way. In soybean, though Madhya Pradesh has experienced an unprecedented growth in output, the role of technology in output growth has been merely 4 per cent.

According to Chand *et al* (2012) the agricultural research carried out during past three decades (1975-05) has improved the self sufficiency status in wheat by 15 per cent and in rice by 7 per cent. The growth in food production induced by research has not only reduced the import dependency but has also added to export capacity, amounting to 17 Mt of cereals. In value terms, it comes to more than four-times the annual investment on agricultural research in the country.

Chand *et al* (2012) concluded that Increase in agricultural investments, especially in agricultural research, is urgently needed to stimulate growth in TFP. To attain 4 per cent agricultural growth, as targeted by the Planning Commission, at least one-third of this growth must come through technological innovations and remaining two-thirds has to be achieved through additional use of agricultural inputs. To meet these targets, investments on agricultural research need to be doubled by 2015 and tripled by 2020 in relation to the investment level of 2002.

2.10: Marketing Policy

A healthy import and marketing policy needs to be put in place for increasing the soybean production (Chand, 2014). Trade policy needs to be revised to increase the tariff on import of crude soybean oil. MSP should be raised to make it relevant to the current market price (Chand, 2014). Deepthi *et al* (2010) carried out a study on intellectual Property Rights, Private investment in Research, and Productivity Growth in Indian Agriculture and concluded that maize and pearl millet yields have grown much more rapidly than yields of wheat and rice in recent decades due to policies that encouraged private investment in the seed industry: public hybrid breeding programs that generated new seeds offering substantial yield gains and biological IPRs conferred by hybridization that conveniently married the private sector's need for suitability with the nation's need for productivity growth. Researchers felt that convergence of policy solutions and technology opportunities can be replicated for other crops that are vital to India's food security. However the study felt that continued public investment in agricultural R&D remains essential, even in the development of hybrids.

Richa (2014) through a study conducted in Malwa region of Madhya pradesh feels that possibilities of empowering farmers in the marketing of their produce must be understood far more broadly than simple technologically-deterministic notions of information provision or disintermediation, which were popularized by projects such as the e-choupal. She argues that power in agrarian markets was shaped by a variety of factors that governed the relationship between farmers and intermediaries who purchased their crop. Richa concludes saying that local geography and ecology, crop characteristics, historic relationships of farmers and intermediaries, and the global and regional economics of the commodity in question become germane questions when considering the possibilities of empowerment.

2.11: Non-GMO vis-a-vis GMOs

According to Vision 2030 document of Directorate of Soybean Research, Indore focus is being done on developing genetically modified soybean to overcome the problems of weeds, defoliators, biotic and abiotic stress and other industrial purposes. Researcher Chand (2014) stressed the need of introducing GM soybean in our country so as to increase production at lower costs of cultivation. However, Matlani (2014) differed with this opinion and he was of the view that the non-GM soy's productivity is not less than that of the GM soy and the reason for low productivity is poor seed replacement as in Madhya Pradesh. There is a strong demand and premium price for Indian soybean due to its non-GMO status (Tiwari, 2014).

2.12: Income

Kajale and Shroff (2013) conducted a study on problems and prospects of soybean cultivation in Maharashtra. Criteria adopted for the selection of the districts was High area-High yield (HH), High area and Low yield (HL), Low area and High yield (LH) and Low area and low yield (LL). Based on the TE 2010-11 data districts were ranked as per area under cultivation and yield and only two districts Kolhapur (LH) and Amaravati (HH) were selected for the study. Based on the probability proportional to size based on distribution at state level, 250 farmers from eight villages of four blocks were selected for the survey in 2011-12. The net income per hectare was positive for all the land size categories (Kajale and Shroff, 2013). The study also clearly revealed that net returns from Soybean cultivation were found to be higher than those of competing crops indicating the relative profitability of the crop. Study done by Bisaliah (1987) reported that profitability of soybean was greater as a mixed crop with sorghum than as a sole crop. The estimated additional net return from mixed cropping was Rs.350, with an additional cost of Rs.200 incurred on growing soybean as a mixed crop.

2.13: Impact of Climate Change

Simulated studies were carried out by Mall *et al* (2004) using CROPGRO model to study the impact of climate change on soybean production in India. Three state-of-theart global climate Models (GCMs) have been used for projecting scenarios for the Indian subcontinent. The findings of the study indicated that there was a decrease (ranging between 10 and 20percent) in soybean yield in all the three future scenarios when the effect of rise in surface air temperatures at the time of the doubling of CO2 concentration was considered. Results of the study indicated that mitigatory option for reducing the negative impacts of temperatures increases indicate that delaying the sowing dates would be favorable for increased yields at all the locations in India. Simulation studies by Bhatia etal (2008) revealed climatic potential to be 3 to 3.5 t/ha while rainfed potential is 2 to 2.5 t/ha.

2.14: Constraints in Soybean Cultivation

Bisaliah (1987) found that high yields in soybean crop are constrained by a complex interaction of genetic, physiologic and climatic factors. Based on the farmer's response Kajole and Shroff (2013) concluded that economic factors such as high input costs, shortage of human labour and price related risks as important constraints. For more than 60 per cent of farmers in all size classes, marketing of soybean crop was an important problem. To make Soybean the most important crop in the cropping pattern of Maharashtra, researchers have suggested that there is a need to increase productivity of soybean through provision of irrigation, quality seeds and extension regarding correct mix of quality inputs. The average yield of Soybean in India is about 1 tonn/ha, compared with 2.3 to 2.8 tonns/ha. Therefore, the greatest challenge for Indian scientists and development programmes is to increase the average yield of soybean (Singh, undated).

2.15: Conclusions

Literature review clearly indicates the economic significance of the crop for the farmers of major soybean growing states as well as government of India through earnings of foreign exchange. However several studies have clearly indicated the stagnation of soybean yields since last couple of decades. Review also indicates that there has not been any in depth analysis regarding the performance of prominent soya bean varieties that are being cultivated by farmers of major soya bean growing states in the last two decades since 2005. What literature indicates is that until now there are no major empirical studies covering all major soybean growing areas at a time which can provide a comprehensive understanding of the issues at the field level and also the farmers view point. There are no detailed studies which analyzed the adoption/non-adoption of each component of soya bean technology and the specific reasons for that. Similarly there were not many attempts by earlier studies to understand the gap in technology with respect to adoption of each component by farmers in major soybean growing areas vis-à-vis recommendations of soybean scientists of Directorate of Soybean Research. Similarly, despite the release of several varieties for different agro-climatic zones, studies indicate that only handful of varieties dominate the fields of farmers. Based on the evidence from review it can be emphasized that there is a strong need to focus on improving the productivity of rainfed soybean crop through development of non-GMO soybean varieties that can withstand both prolonged drought spells as well as excess rains. Level playing field should be provided to diverse soil fertility management methods which not only contribute macro and micro nutrients but also help in addition of organic matter in to the soil. This helps in a major way for improving the productivity of soybean crop in rainfed conditions. To give fillip to production of oil seed crop such as soybean a consortia mode is necessary to translate the research out puts to real out comes, a multi-institutional approach involving the NARS, the state departments of Agriculture, NGO's, KVK's, public sector financial institutions and private industry is required (Arvind, 2015).

CHAPTER III

Geographical Variations in Soybean Crop Cultivation across Selected States

3.1: Context

Soybean crop cultivation has experienced phenomenal rise in India. It is cultivated predominantly in the states of MP, Rajasthan, and Maharashtra and in the southern states like Telangana, Andhra Pradesh, and Karnataka. The present chapter attempts to show the trend in area, production and yield of soybean crop at the country level, and the variations in the major soybean producing states (which are also selected for the study) and the districts and blocks and villages selected for the study. These variations may enable to explain the variations in the productivity in the crop.
The specific research questions the present chapter addresses are

1. To contextualize the cultivation of soybean crop across various geographical locations in the selected sample sites.
2. To carry trend analysis of APY (Area, Prduction, Yield) and decomposition analysis to know the causes of change in average production and variance of production.
3. To analyze the implication of variations in farming conditions, agronomic practices, institutional conditions to area, production and yield of soybean crop

3.2: Area, Production and Yield of Soybean Crop in India

Area under soybean in India has steadily increased over the years starting from 3000 hectares in 1969 to 1220 million hectares by 2014. Soybean crop has shown spectacular growth in area, production and productivity. The compound growth rates show that during the decade of 1971-1981 the compound annual growth rates for area yield and productivity was 0.7, 6.2 and 0.3percent which reached peak by the decade 1991-2001 to 6.5, 11.5 and 7.72 percent respectively in the decade and growth rate of area has fallen to 5.7, but yield growth rate remained almost constant in the 2001-2011 decade. There was high variation in the area under soybean crop and also productivity in the first decade but in the later decades the variation has fallen at a faster rate (Table 3.1).

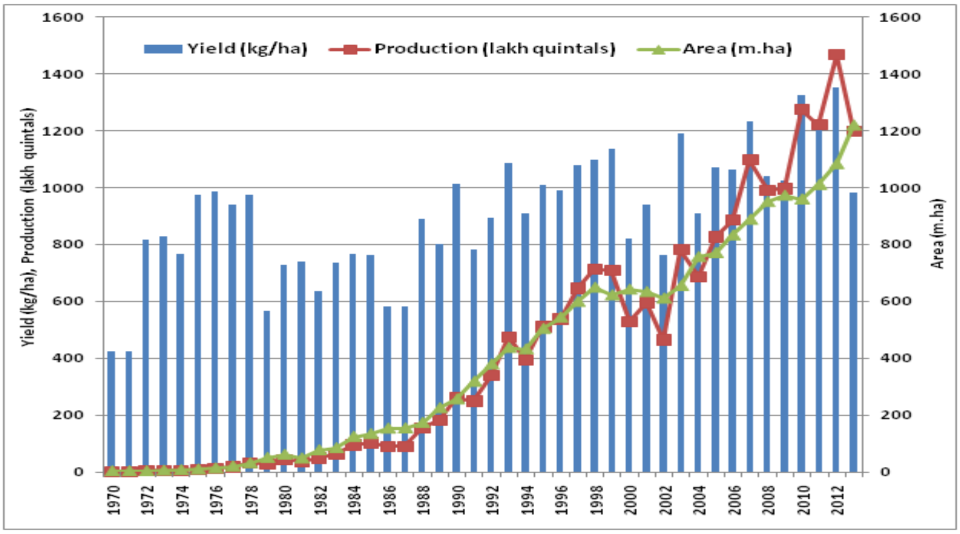
The trend in area shows an increase till 1998 which was stagnant till 2002 and thereupon has risen from 2002 onwards. Total production was in tandem with the area but faced more fluctuations after 1998. It fell due to fall in yield as well as stagnation in area for some time then again increased more sharply from 2004 onwards (Figure 3.1).

Table 3.1 Mean, CAGR, CV of Area, Production and Yield of Soybean Crop in India

Period	Area (000.ha)			Production (000.tonns)			Yield(qtl/ha)		
	Mean	CAGR	CV	Mean	CAGR	CV	Mean	CAGR	CV
1971-1980	14.4	0.07	107	0.1	0.03	97.4	7.71	0.62	28.8
1981-1990	123.3	0.22	45.2	0.9	0.17	52.8	7.23	0.75	13.5
1991-2000	474	0.53	28	4.8	0.51	35.7	10.01	0.96	11
2001-2010	771.5	0.69	17.6	7.9	0.51	27.2	10.06	0.73	15
2011-2013	1068.8	0.84	10.6	12.9	1.02	9.5	12.18	1.20	13.9

Note: The yield rates given above have been worked out on the basis of production & area figures taken in '000 units.
Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation.

Fig 3.1 Trends in Area, Production and Productivity of Soybean Crop in India (1970-2012)

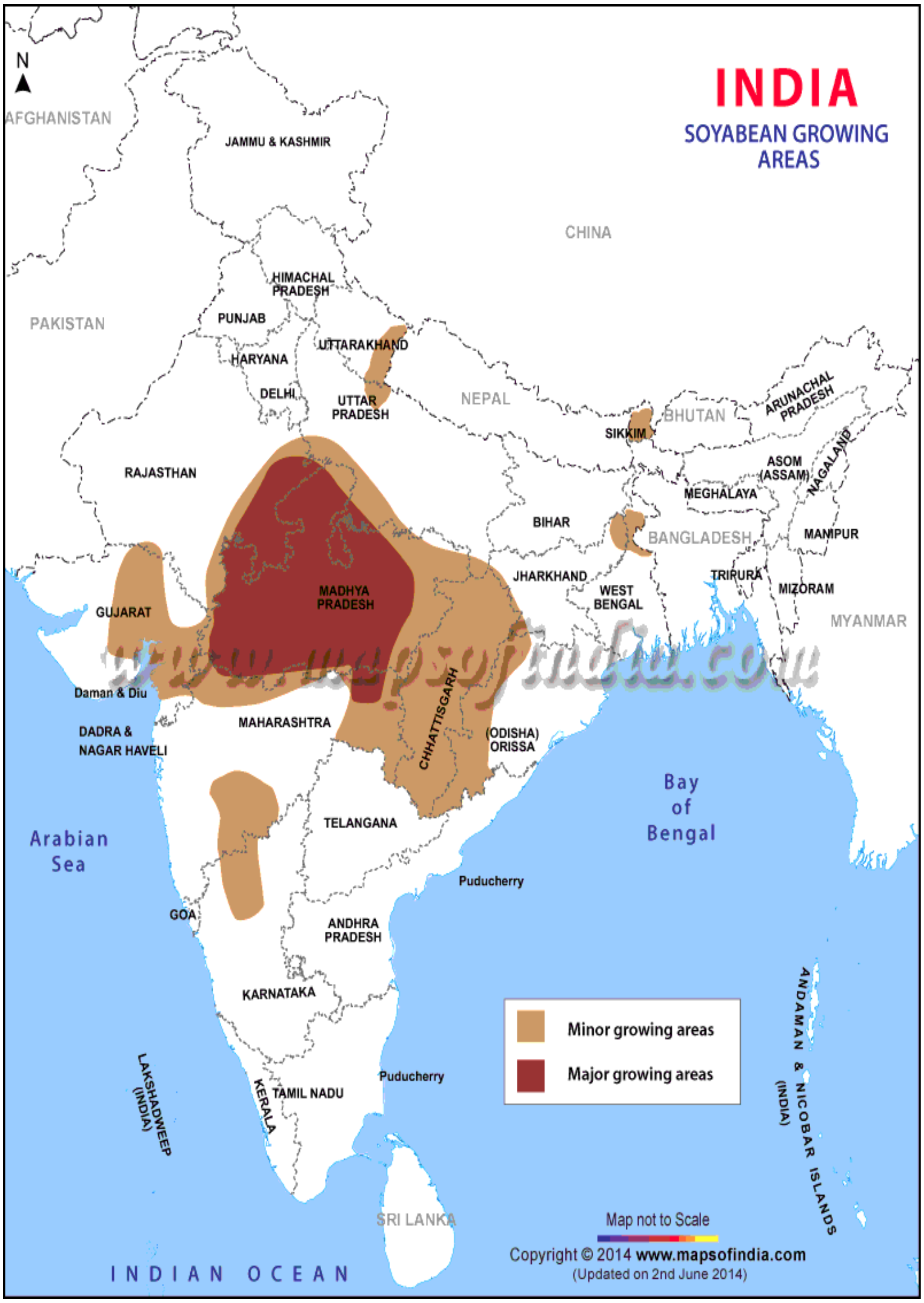


Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation.

3.3: Soybean Crop Production Zones

Soybean is majorly grown in around 150 districts across India. However area is concentrated in 11 districts which contribute around 50 percent of total area (primary zone) and 17 districts contribute another 35 percent of area (secondary zone) while 120 districts contribute only 15 percent of total area (tertiary zone) under soybean crop. The average productivity levels vary across these zones but the coefficient of variation is the lowest in the primary zone and increased thereafter in the secondary and tertiary zones. The initial spread of soybean in the early eighties was mainly in the districts falling under the primary zone (Bhatnagar and Joshi 2004). The major and minor soybean production area is shown in the map below. The area is contiguous with a core (primary zone) and a periphery (minor zone) (Figure 3.2).

Fig 3.2 Soybean Growing Areas in India



Source: Maps of India, Last updated January 2014

3.4: Area, Production and Yield of Soybean Crop in Selected States

Soybean crop is primarily cultivated in three states of MP, Rajasthan and Maharashtra. The contribution of MP to the total area under soybean is 52 percent and to total production is 45 percent. The contribution of Maharashtra state stands next to MP with 32 percent to area and 40 percent to production. Rajasthan contributes around 9 percent to area and 8 percent to production while Telangana contributes 2 percent to area and 3 percent to total production respectively. MP stands the highest soybean producer in the country with highest compound growth in area and yield and also with lowest variation in both area and yield compared to other states. However, the variation in area is less compared to variation in yield in the state of MP witnessing large fluctuations in yield in recent time periods (Table 3.2). In the other three states of Rajasthan, Maharashtra and Telangana the variation in area is more compared to variation in yield. The highest variation in yield is in the decade of 2001-02 to 2011-12 in Rajasthan followed by Telangana and Maharashtra while in the case of variation in area it is in the reverse order with Telangana, Maharashtra and Rajasthan ranking in that order. In view of these variations it is important to analyze the crop situation, adoption of technology (package of practices) and other agronomic practices (improvement in soil quality, enhance water use, improve better fertilizer management), institutions supporting farmers (extension, training, supply of inputs by government, cooperatives, marketing) socio-economic conditions of farmers in the four selected states to explain the variation in yields, and area under the crop. Firstly, variations are explained by using the trend method and decomposition analysis for the All India and the selected states and then the variations are analyzed in terms of the field data collected from the sample sites.

Table 3.2: Area, Production and Productivity of Soybean in Different States of India (compound growth rate)

Period	Area (000.ha)			Production (000.tonns)			Yield(qtl/ha)		
	Mean	CAGR	CV	Mean	CAGR	CV	Mean	CAGR	CV
Madhya Pradesh									
1971-1980	0.1	0.03	1.3	0.1	0.05	1.1	929.7	1.63	0.2
1981-1990	1.2	0.25	0.5	0.9	0.20	0.6	749.7	0.78	0.2
1991-2000	3.8	0.63	0.2	3.7	0.64	0.3	953.7	1.03	0.1
2001-2010	4.8	0.82	0.1	4.9	0.60	0.3	1011.2	0.73	0.2
2011-2013	6.1	0.94	0.1	6.5	1.15	0.2	1081	1.28	0.2
Rajasthan									
1971-1980	NA	NA	NA	NA	NA	NA	NA	NA	NA
1981-1990	0.1	0.09	1	0	0.05	1.1	745.5	0.63	0.2
1991-2000	0.4	0.30	0.4	0.4	0.33	0.5	1101.2	1.08	0.2
2001-2010	0.7	0.87	0.2	0.7	0.67	0.3	1095	0.77	0.3
2011-2013	1	0.79	0.2	1.2	1.37	0.2	1311.5	1.74	0.2
Maharashtra									
1971-1980	NA	NA	NA	NA	NA	NA	NA	NA	NA
1981-1990	NA	NA	NA	NA	NA	NA	NA	NA	NA
1991-2000	0.6	0.28	0.5	0.7	0.19	0.7	1110.5	0.66	0.2
2001-2010	2	0.45	0.4	2.3	0.36	0.4	1125.8	0.81	0.2
2011-2013	3.2	0.79	0.2	4.4	0.85	0.1	1393.5	1.07	0.1
Telangana									
1971-1980	NA	NA	NA	NA	NA	NA	NA	NA	NA
1981-1990	NA	NA	NA	NA	NA	NA	NA	NA	NA
1991-2000	0.01	0.05	0.7	0.01	0.06	0.7	990.4	1.21	0.1
2001-2010	0.09	0.19	0.5	0.14	0.12	0.5	1449.2	0.63	0.3
2011-2013	0.18	0.57	0.3	0.3	0.57	0.3	1680.3	1.00	0.1

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

3.5: Trend Analysis

Time series data on area, production and productivity of soybean crop for the period of 22 years from 1992-93 to 2013-14 was collected for the All India and four selected states of Madhya Pradesh, Rajasthan and Maharashtra and Telangana.

The period of the analysis was divided into two sub-periods, one period of nine years from 1991-92 to 2000-01 and the second from 2001-02 to 2013-14. To measure and compare the level of growth in soybean crop production in the two sub periods two trend lines were fitted to the time series data, the straight line and the exponential function. The linear or straight line trend equation is of the form

$Y= a+bt$

Where,

Y= dependent variable

a and b are constants

t= time variable

b represents the linear absolute rate of growth

The exponential function is of the form

$Y=ab^t$

Where

Y= dependent variable

a= constant

b= regression coefficient

t= time variable

The parameters a and b were estimated using the least square method after transforming the function to the following semi-log linear form.

$\log y = \log a + t \log b$

(Significance of the 'b' values was done through 't-test' where the formula is t=b/SE of b)

3.6: Trend Analysis for Finding Convergence/Divergence and Coefficient of Variation in Production and Variance Ratios as a Measure of Instability

A Linear function was fitted to i) observed values which are higher than the corresponding trend value for the overall observations (peak) and ii) observed values which are lower than corresponding trend value for the overall observations (trough) for area, yield and production to study the convergence/divergence of the data.

Two trend lines one for the peak and one for the trough were obtained as follows

$Y= a^{11}+b^{11}t$ for peak

$Y= a^{1}+ b^{1} t$ for trough

't' was obtained at the point of intersection of peak and trough trend lines, using the formula:

$$t = \frac{a^{11} - a^{1}}{b^{1} - b^{11}}$$

If t>0, then the trend lines are convergent indicating decreasing year to year fluctuations or less instability and if t<0 , then the trend lines are divergent indicating year to year fluctuations or greater instability. In order to measure the instability in soybean production, CV in production was calculated for the two periods for the All India and the selected states. The percentage change in the CV between the two time periods was estimated. And to test the variability of area, yield and production between the two periods, F-ratios were calculated using variances in the two time periods.

Table 3.3: Growth of Area, Production, Yield in All India & Selected States (CAGR)

	Period I			Period II			Overall period		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
All India	0.7	0.6	-0.1	0.6	0.6	0.1	0.6	0.7	0.1
Rajasthan	1.7	0.6	-1.0	0.7	0.4	-0.3	1.1	0.8	-0.3
Madhya Pradesh	0.5	0.4	-0.2	0.3	0.3	0.0	0.4	0.4	0.0
Maharashtra	2.0	2.2	0.2	1.3	1.2	-0.03	1.5	1.7	0.1
Telangana	15.1	12.8	0.2	4.9	5.5	0.5	9.9	9.4	0.4

Note 1: Period I: 1992-93 to 2000-01; Period II: 2002-03 to 2013-14;

Note 2: The CAGR value in this table differs with that of the values presented in Tables 3.1 and 3.2 due to the different periods for which it is calculated.

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

3.7: Results and Discussion

Trend analysis was done for a period of 22 years for the All India and the selected four states. The periods were subdivided into two one from 1991-92 to 2000-01 and the second from 2001-02 to 2013-14. Soybean crop occupies an important place in the state of Madhya Pradesh as it has emerged as an early kharif crop fitting into the cycle of soybean-wheat-chick pea. Area expansion has been high in the first period for all states. Compound growth rate of area is higher for the newly catching up states of Maharashtra and Telangana. Yield rates too were positive in case of these states. Area expansion has fallen by the second period in all the states. Growth rate of yield has fallen for the states of Rajasthan and Maharashtra in the second period while for Telangana it has increased compared to the first period. The growth rate of production is highest for Telangana in the two time periods followed by Maharashtra (Table 3.3). However as soybean crop is predominantly a rain fed crop it suffers from instability.

To examine the instability in the crop trend analysis has been carried out as detailed above. Straight line function has been fitted to the overall and peak and trough points and factor't'has been derived which shows the convergence or divergence over period of time for the area, production and yield. While positive values of't' indicate convergence negative values indicate divergence indicating increasing trend towards instability over years. To know the variability coefficient of variation and the percentage change of this variation has been examined as a measure of increasing or decreasing stability of production. Similarly variance ratios for area, production and yield also show their stability.

Table 3.4: Linear Growth Rate for Overall, Peak and Trough Points for Area, Production and Yield of Soybean Crop

All India/State	Linear Growth rate		
	Area	**Production**	**Yield**
Overall	4.85	4.72	0.50
Peak	4.80**	5.67**	2.01**
Trough	4.37**	4.07*	0.74
SI	D(-14.10)	D(-9.76)	D(-7.99)
Madhya Pradesh			
Overall	4.3	4.0	0.1
Peak	3.78**	3.92*	1.23**
Trough	6.59**	4.37	-1.97
SI	D(-22.67)	D(-17.05)	D(-5.79)
Rajasthan			
Overall	6.9	5.2	-1.5
Peak	5.25**	4.35*	1.20
Trough	2.39**	3	-1.72
SI	D(-10.98)	D(-11.01)	D(-4.11)
Maharashtra			
Overall	6.0	6.5	2.0
Peak	6.51**	7.76**	0.38
Trough	10.86**	11.61**	-1.52
SI	D(-18.44)	D(-12.26)	D(-12.77)
Telangana			
Overall	2.3	1.5	0.5
Peak	10.09**	10.28**	0.15
Trough	23.94**	21.28**	-0.01
SI	D(-7.49)	D(-4.51)	D(-267.35)

Note: ** Significant at 1percent level * significant at 5 percent level
SI indicates State of Instability; D= Divergence
Figures in parentheses indicate value of factor't'

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

The state of instability could be found as the trend lines are divergent indicating year to year fluctuations and instability. This is found in all the states with only degree of difference. While instability is found in area in the states of Madhya Pradesh and Rajasthan, instability in yield is found in case of the other two states of Maharashtra and Telangana. The growth rate in the peaks and troughs are significant. The overall analysis clearly indicated instability in area production and productivity in all the states. Thus there is growth with instability which is affected mainly by deviation from normal rainfall, and other factors like lack of extension advice from agriculture department, inadequate following of package of practices recommended for the soybean seed varieties. Table 3.5 gives the peak and trough years for the different states.

3.8: Decomposition Analysis

Agricultural production is a combined result of area and yield. If there is variability in growth of area and growth of yield, there will be changes in output growth as well. The components of change in average production and variance of production are measured. As statistical identities are used to measure components of change in the mean of production and variance of production it does not impose any behavioral assumptions but will be able to reveal the importance of different components of increased instability (Hazell, 1982).

If P, A and Y are production, area and yield respectively then the relationship between these variables is

$$P= AY$$

Expected or average production E (P) is

$$E(P)= AY+Cov\ (A,Y)$$

Where A, Y and Cov (A, Y) are mean yield, mean area and covariance between area and yields respectively.

To differentiate the changes in E (P) between the two periods, let the average production in the period I be

$$E\ (p_1) = A_1\ Y_1 + Cov\ (A_1,Y_1)$$

Similarly the average production in the period II will be

$$E\ (P_2)= A_2\ Y_2\ +Cov\ (A_2, Y_2)$$

Taking the first period as base period, each variable in the second period can be expressed in terms of its counterpart in the first as follows

Table 3.5: Peak and Trough Years in Area, Production and Yield

	All India			Madhya Pradesh			Rajasthan			Maharashtra			Telangana		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Peak years	1992	2005	1993	2006	1997	1993	1998	1998	1992	2004	2003	1993	2004	2003	2003
	1993	2006	1997	2007	1999	1995	2000	2004	1997	2005	2005	1996	2005	2004	2004
	1994	2007	1998	2008	2006	1997	2001	2005	1998	2006	2006	1998	2006	2005	2005
	1995	2008	1999	2009	2007	1998	2005	2006	1999	2007	2007	1999	2007	2006	2006
	1996	2009	2003	2010	2008	1999	2007	2007	2003	2008	2008	2001	2008	2007	2007
	1997	2010	2005	2011	2009	2003	2008	2008	2004	2009	2009	2002	2009	2008	2008
	1998	2011	2006	2012	2010	2005	2009	2009	2006	2010	2010	2003	2010	2009	2010
	1999	2012	2007	2013	2011	2006	2010	2010	2007	2011	2011	2007	2011	2010	2011
	2000	2013	2010		2012	2007	2011	2011	2009	2012	2012	2010	2012	2011	2012
	2001		2011		2013	2008	2012	2012	2010	2013	2013	2011	2013	2012	2013
	2002		2012			2009	2013	2013	2011			2012		2013	
	2003					2010			2012			2013			
						2011									
						2012									
Trough years	2004	1992	1992	1992	1992	1992	1992	1992	1993	1992	1992	1992	1992	1992	1992
	2005	1993	1994	1993	1993	1994	1993	1993	1994	1993	1993	1994	1993	1993	1993
	2006	1994	1995	1994	1994	1996	1994	1994	1995	1994	1994	1995	1994	1994	1994
	2007	1995	1996	1995	1995	2000	1995	1995	1996	1995	1995	1997	1995	1995	1995
	2008	1996	2000	1996	1996	2001	1996	1996	2000	1996	1996	2000	1996	1996	1996
	2009	1997	2001	1997	1998	2002	1997	1997	2001	1997	1997	2004	1997	1997	1997
	2010	1998	2002	1998	2000	2004	1999	1999	2002	1998	1998	2005	1998	1998	1998
	2011	1999	2004	1999	2001	2013	2002	2000	2005	1999	1999	2006	1999	1999	1999
	2012	2000	2008	2000	2002		2003	2001	2008	2000	2000	2008	2000	2000	2000
	2013	2001	2009	2001	2003		2004	2002	2013	2001	2001	2009	2001	2001	2001
		2002	2013	2002	2004		2006	2003		2002	2002		2002	2002	2002
		2003		2003	2005					2003	2004		2003		2009
		2004		2004											
				2005											

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

$A_2 = A_1 + \Delta A$

$Y_2 = Y_1 + \Delta Y$

Where $A = A_2 - A_1$ and $\Delta Y = Y_2 - Y_1$

$E(P_2) = (A_1 + \Delta A) \ (Y_1 + \Delta Y) + Cov(A_1, Y_1) + \Delta Cov(A,Y)$

The change in the average production $\Delta E(P)$, can be obtained as below

$$\Delta E(P) = E(P_2) - E(P_1)$$

$$= A_1 \ \Delta Y + Y_1 \ \Delta A + \Delta A \ \Delta Y + \Delta Cov(A,Y)$$

Then the change in average production has four sources of change. The first two are the changes that arise from mean area and mean yield and the third term occurs due to interaction effect that is simultaneous changes in mean yield and mean area and the last term arises from the changes in the variability of area and yields

$Cov(A,Y) = r[V(A) \ V(Y)]^{1/2}$

Where r, V(A) and V(Y) are correlation coefficient, variance of area and variance of yield respectively.

The change in the variance of production, V(P), can be decomposed in the same way. The variance of production is expressed as

$V(P) = A^2 V(Y) + Y^2 V(A) + 2 AY Cov(A,Y) - Cov(A,Y)^2 + R$

Where R is a residual term

3.9: Results and Discussion

Change in average production arises because of change in area and change in yield. This change occurs through four processes one change in mean area, change in mean yield, interaction between change in mean area and mean yield and covariance of mean area and mean yield. The percentage figures for all the four components of change are given in table 3.6.

Variance of production is a function of variance in yield and variance in area and the change in mean area and mean yield. The change in variance occurs due to the following factors , change in mean yield, change in mean area, change in variance of area, change in variance of yield, interaction between change in mean area and mean yield, change in area yield covariance, interaction between change in mean area and variance of yield, changes in mean area and mean yield and change in area-yield covariance and change in the residual variable. The percentage values for all the ten components of change are given in table 3.6.

In case of All India change in mean area has contributed to maximum extent to the average of production to the extent of 81 percent and change in yield has contributed to the extent of 10 percent. Interaction effect contributed to only 7 percent and the rest is due to the positive covariance between change in area and yield. The same pattern can be observed for the states of Madhya Pradesh and Rajasthan where major contributor to change in average production is change in mean area followed by change in mean yield, interaction effect between the two and lastly covariance between the area and yield. However for the state of Maharashtra 97 percent of change in average production is due only to area change and yield change and interaction have contributed to the extent of one and three percent respectively. Further the covariance between area and yield is negative indicating that if contribution of area expands contribution of yield to production falls. For Telangana change in mean area is the largest contributor to change in average production but the interaction effect has contributed nearly 34 percent and change in mean yield is very small (3 percent) and covariance between area and yield also contributed only to the extent of 3 percent (Table 3.6). Thus to analyze the changes in production the states of Madhya Pradesh and Maharashtra have the similar pattern largely influencing the All India pattern as these two states are major soybean producing states and the area expansion has driven average production in Maharashtra while in case of Telangana it is area expansion as well as the interaction between area and yield that had influenced the average production.

Table 3.6: Components of Change in Average Production of Soybean between Periods I and II for All India and Selected States (percentage)

Components of change	India	Rajasthan	Madhya Pradesh	Maharashtra	Telangana
Change in mean Yield	10.37	11.61	15.42	1.35	2.99
Change in mean Area	80.64	78.57	77.55	97.32	60.73
Interaction between mean area and mean yield	6.58	7.20	4.42	2.92	33.60
Change in Area Yield covariance	2.41	2.63	2.60	-1.59	2.68

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

Variance of production in case of All India is more determined by variance in area to the extent of 36 percent and area, yield covariance to the extent of 16 percent and the three way interaction among change in mean area and yield and covariance of area and yield to the extent of 13 percent. Change in mean area is also contributing to variance of production (11.4 percent).

In the state of Madhya Pradesh change in yield variance (25 percent) contributing to production variance, area yield covariance is also high (22 percent) and effect of interaction between mean area and yield variance is positive and contributing to variance of production. Change in mean area is also contributing to production variance.

In Rajasthan highest contributor is area variance (26 percent). The interaction between change in mean area and yield variance contributed 17 percent to variance in production, yield variance contributed 11 percent and change in mean area contributed 12 percent to variance in production. Interaction between mean area and mean yield was negative contributing to stability in production but in a very small way.

In Maharashtra change in area variance contributed 75 percent to variance in production and change in mean area contributed 24 percent and interaction between mean area and yield variance to the extent of 15 percent. Covariance between area and yield and interaction between change in mean area yield and area- yield covariance was negative contributing to stabilization of fluctuations in variance of production.

In Telangana the interaction between change in mean yield and area variance contributed 96 percent to variance in production and change in area variance to the extent of 2 percent (Table 3.7).

Table 3.7: Components of Change in Variance of Production of Soybean Crop between Periods I and II for All India and the Selected States (percentage)

Components of change	India	Rajasthan	Madhya Pradesh	Maharashtra	Telangana
Change in mean Yield	3.02	3.80	3.66	0.76	0.02
Change in mean Area	11.40	11.68	14.49	23.62	0.07
Change in yield variance	7.65	10.50	24.74	1.70	0.01
Change in Area Variance	35.99	26.26	11.13	75.49	1.94
Interaction between mean area and mean yield	0.25	-0.31	0.19	0.22	0.00
Change in Area Yield covariance	16.22	11.33	21.56	-5.29	0.04
Interaction between changes in mean area and yield variance	12.78	17.06	16.22	15.23	0.90
Interaction between changes in mean yield and area variance	0.05	10.85	0.17	0.24	96.08
Interaction between changes in mean area and yield and change in area- yield covariance	12.63	8.71	7.84	-11.97	0.86
Changes in Residuals	0.02	0.12	0.01	0.01	0.08

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

On an overall basis while change in area variance has contributed more to variance in production in the states of Maharashtra, Rajasthan and All India, change in yield variance contributed in Madhya Pradesh and interaction effect between change in mean yield and area variance has contributed to variance in production in Telangana state. Area-yield covariance also contributed to variance in production in Madhya Pradesh.

3.10: Area Production and Yield in Sample Sites

Among all selected districts Ujjain tops in all the three parameters of APY followed by Rajgarh in yield and Latur in area. The lowest area and yield are in Kota CAD (Table 3.8).

Table 3.8: Area, Production and Yield of Sample Districts in Selected Study States of India during the Year 2014 Kharif

Sl. No	State	District	Area (Lakh Hectare)	Production (Lakh MT)	Yield (Qtls/Hectare)
1	Madhya Pradesh	Ujjain	4.657	6.450	13.85
		Rajgarh	2.878	2.950	10.25
2	Rajasthan	Kota CAD	0.853	0.482	5.65
		Jhalawar	1.928	1.629	8.45
3	Maharashtra	Amaravathi	3.200	2.576	8.05
		Latur	3.800	3.363	8.85
4	Telangana	Adilabad	1.1136	1.55*	14.00*
		Nizamabad	0.9743	1.35	13.88

Source: SOPA, 2014 and Mandal Development Office, Telangana
*Data pertains to agriculture year 2013-14

Average area under soybean crop is highest in sample villages in Maharashtra (Nayakola, Bamani) but average yield (qtls/acre) is high in sample villages in Madhya Pradesh. Rajasthan has the lowest average yields. There is much variation in yield in the sample villages of Telangana, Maharashtra and Rajasthan. Madhya Pradesh villages have less variation in yields/ production (Table 3.9).

3.11: Yield Gap

Yield gap is defined as the difference in farm yields (FY) and potential yield (PY) which is the yield linked to the seed variety. PY is the yield to be expected with the best-adapted variety (usually the most recent release), with the best management of agronomic and other inputs, and in the absence of manageable abiotic and biotic stresses (Evans and Fischer 1999). PY is the key yardstick to understand the yield changes. FY is the figure generally reported in surveys or district, regional national statistics. It is the yield given the harvested area. Attainable yield (AY) is generally defined as the yield attained by a farmer from average natural resources when economically optimal practices and

Table 3.9: Area, Production and Yield in Sample Villages in 2014-15

State	District /Block	Village	Number of HHs	Average acreage per HH	Average Production (Qtls)	Yield (Qtls/ acre)	Std Dev	CV
Rajasthan	Jhalawar	Dhuvliya	48	5.1	18.9	3.7	2.8	0.8
		Dharonia	48	4.1	13.4	3.3	2.2	0.7
		Bareda	48	2.2	6.4	2.9	5.0	1.8
		Khandi	48	3.0	7.1	2.4	1.6	0.7
	Kota	Balupa	48	2.1	1.8	0.9	0.7	0.8
		Durjanpura	48	3.0	2.5	0.8	0.9	1.0
		Khediltavran	48	3.5	2.6	0.8	0.8	1.1
		Bislai	48	3.6	1.7	0.5	0.3	0.7
Madhya Pradesh	Ujjain	Lohana	48	7.9	25.1	10.3	11.2	1.1
		Jandla	48	7.5	22.7	11.1	5.5	0.5
		Mundla Parval	48	5.1	27.6	10.5	4.6	0.4
		Delchi kurd	48	4.6	10.8	7.2	4.9	0.7
	Rajgarh	Chanchakhedi	48	4.8	11.7	7.9	4.3	0.5
		Bayheda	48	5.3	14.3	9.7	5.7	0.6
		Mavasa	48	7.1	13.9	6.5	3.9	0.6
		Sarana	48	4.6	10.4	7.2	4.5	0.6
Maharashtra	Amaravathi	Kekatpur	48	7.1	48.7	6.8	5.1	0.8
		Nayakola	48	8.1	47.4	5.8	4.0	0.7
		Shirapur	48	6.1	33.4	5.5	3.7	0.7
		Dahigaon	48	4.8	18.3	3.8	3.9	1.0
	Latur	Kahva	48	7.0	63.1	9.0	7.6	0.8
		Bamani	48	8.9	91.2	10.2	13.7	1.3
		Barhanpur	48	5.6	54.0	9.7	12.2	1.3
		Vangaji	48	5.4	35.4	6.6	4.8	0.7
Telangana	Adilabad	Thatipalli	48	6.1	23.1	3.8	2.2	0.6
		Pardi	48	5.8	28.7	4.9	8.9	1.8
		Gangapur	48	4.9	6.8	1.4	1.5	1.1
		Ashapally	48	4.6	5.9	1.3	2.0	1.5
		Patnapur	48	5.4	8.6	1.6	1.7	1.1
		Daboli	12	4.6	7.3	1.6	1.6	1.0
	Nizamabad	Akloor	48	3.3	8.3	2.5	4.0	1.6
		Velpoor	48	2.9	9.2	3.1	2.2	0.7
		Lakkora	48	2.6	6.4	2.5	6.2	2.5
		Kankal	48	4.2	33.7	8.0	17.7	2.2
		Karadpally	48	5.9	20.6	3.5	3.7	1.1
		Tadwai	48	4.1	24.1	5.9	14.0	2.4

Source: Primary Survey

levels of inputs have been adopted while facing the vagaries of weather. Although it is not easy to establish an appropriate attainable yield, general experience suggests that it will be 20-30 percent below PY in general cases or even below where infrastructure and institutions are weak as in case of developing countries. The farm yield and potential yields show there is difference between the two in case of varieties like JS 335, JS 9305. In case of 1024 and NRC-7 the FY is on the lower side of the PY (Table 3.10).

Table 3.10: Farm Yield and Potential Yield according to Major Seed Varieties Cultivated in the Sample Districts (Qtl per acre)

Seed Variety	District	1042 (Pant Soybean)	DS-228 (Phule Kalyani)	JS-335	JS-9305	JS-9560	NRC-7	Total
Potential Yield (qtls/acre)		10 to 12	10.4	10 to 12	8 to 10	7.2 to 8	10 to 14	10-12*
Rajasthan	Jhalawar			6	6.5 (1)	6.1 (4)	6.1 (187)	(192)
	Kota			1.34 (37)	1.5 (38)	1.4 (120)		1.4 (195)
Madhya Pradesh	Ujjain	10.7 (55)		6.3 (7)		8.9 (84)	10.6 (46)	9.8 (193)
	Rajgarh			8.7 (105)	16 (1)	7.5 (98)		8.2 (204)
Maharashtra	Amaravathi		5.25 (182)	12 (1)			5.3 (183)	
	Latur		9.1 (76)	8.88 (106)				9.1 (182)
Telangana	Adilabad			1.59 (246)				1.59 (246)
	Nizamabad			2.73 (286)				2.73 (286)
All States		10.7 (55)	9.1 (76)	4.2 (970)	2.5 (44)	5.7 (369)	10.6 (46)	5.2 (1681)

Note: Figures in brackets indicate number of farmer HH cultivating that seed variety
* Average of all varieties given as a hypothetical indication of PY
PY is according to the release notifications

Source: Primary Survey

Table 3.11: Percentage gap between Potential Yield and Farm Yield according to Major Seed Varieties Cultivated in the Sample Villages (Qtl per acre)

State	District	Mandal	Village	N	1042 (Pant Soybean)	DS-228 (Phule Kalyani)	JS-335	JS-9305	JS-9560	NRC-7	Total
Potential Yield (qtls/acre)					10 to 12	10.4	10 to 12	8 to 10	7.2 to 8	10 to 14	10-12*
Rajasthan	Jhalawar	Pidawa	Dhuvliya	48					-3		-30
			Dharonia	48			-40		-3		-30
		Khanpur	Bareda	48				-12.5	-17		-40
			Khandi	48				-25	-31		-50
	Kota	Pipalda	Balupa	48			-80	-75	-72		-80
			Durjanpura	48			-90	-75	-72		-90
		Digodh	Khediltavran	48					-72		-80
			Bislai	48			-90	-87.5	-86		-90
MP	Ujjain	Badnagar	Lohana	48	-50		-30			8	0
			Jandla	48	10		-30			-30	10
		Mehidpur	Mundla Parval	48	20		-20		39		10
			Delchi kurd	48	-50		-80		-3		-30
	Rajgadh	Biaora	Chanchakhedi	48			-20		-31		-20
			Bayheda	48			10		39		0
		Narsinggadh	Mavasa	48			-10	100	-17		-30
			Sarana	48			-20		-3		-20
MH	Amaravathi	Amaravathi	Kekatpur	48			-40				-40
			Nayakola	48			-40	50			-40
		Nandgaon	Shirapur	48			-50				-50
			Dahigaon	48			-60				-60
	Latur	Latur	Kahva	48		6	-10				0
			Bamani	48		-23	30				0
		Ausa	Barhanpur	48		-23	10				0
			Vangaji	48		-4	-50				-40
TG	Adilabad	Kautala	Thatipalli	48			-80				-80
			Pardi	48			-80				-80

Contd....

Table 3.11: Contd...

State	District	Mandal	Village	N	1042 (Pant Soybean)	DS-228 (Phule Kalyani)	JS-335	JS-9305	JS-9560	NRC-7	Total
			Gangapur	48			-90				-90
		Jainoor	Ashapally	48			-90				-90
			Patnapur	48			-90				-90
			Daboli	12			-90				-90
	Nizamabad	Velpoor	Akloor	48			-80				-80
			Velpoor	48			-70				-70
			Lakkora	48			-90				-90
		Tadwai	Kankal	48			-50				-50
			Karadpally	48			-80				-80
			Tadwai	48			-60				-60

* Average of all varieties given as a hypothetical indication of PY. PY is according to the release notifications

Source: Primary Survey

Table 3.12: Yield Differences between Normal Year and Current Year (average output in qtls/acre) and Percentage Deviation from Normal Year

State/ Districts	Rajasthan		Total	Madhya Pradesh		Total	Maharshtra		Total	Telangana		Total
	Jhalawar	Kota		Ujjain	Rajgadh		Amaravathi	Latur		Adilabad	Nizamabad	
N	192	192	384	192	192	384	192	192	384	252	288	540
Normal year	10.5	9.7	9.9	8	6	7	6.8	10	8.4	5.6	8.7	7.2
current year	6.08	1.45	3.8	9.8	7.8	8.8	5.5	8.9	7.2	2.5	4.3	3.5
Percent deviation	-42	-85	-62	23	30	26	-19	-11	-14	-55	-51	-51

Normal Year: A good year during 2010-14 as reported by the farmers

Source: Primary Survey

The most popular variety in Rajasthan and Madhya Pradesh is JS 9560 and JS 335 in Madhya Pradesh (Rajgarh) and Maharashtra and Telangana. In case of JS 335 the average farm yield for all the sample villages is 4.2 quintals per acre. The yield gap is given as percentage difference between potential yield and actual farm yield at village level in Table 3.11. For the seed variety 1024 yield gap is highest in Delchikurd and Lohana in Mehidpur and Badnagar blocks Ujjain district. For the popular variety of JS 335 except in the villages of Rajgarh and Latur yield gap is high in the rest of the sample villages. In case of 9560 all 4 villages in Kota district had higher yield gap (Table 3.11).

As the agricultural year 2014-15 for which data had to be collected was a deficit rainfall year we also collected data on inputs and output for a normal year during 2010-14 according to the perception of the farmers. By and large the perception coincided at the block level[1]. The percentage deviation (fall) from normal year is the highest in sample villages in Kota district and in all the sample villages in Telangana. However in Madhya Pradesh rainfall deficit was not as severe as in the other three states in 2014-15 hence not much gap is there between normal year yield and current year yield (Table 3.12).

3.12: Situation of Soybean Farming in the Sample Districts

Soybean crop is usually cultivated by owner farmers in the states of Madhya Pradesh and Rajasthan but also on leased in lands in Telangana and Maharashtra to some extent. It can be observed that in the case of tribal areas in Adilabad land is leased in for the crop generally by non-tribal farmers. Lease payment is an additional burden for the farmers which usually range between Rs. 3000 to Rs 5000[2].

Table 3.13: Percentage of Leased in Area for Soybean Crop Cultivation in Maharashtra and Telangana

States	District	Block/Mandal	Percent Leased in Area
Maharashtra	Amaravati	Amaravati	2.83
		Nandgoan	00
	Latur	Latur	3.00
		Ausa	2.73
Telangana	Adilabad	Kautala	35.73
		Jainoor	35.59
	Nizamabad	Velpoor	3.91
		Tadwai	7.95

Source: Primary Survey

[1] Normal years for Adilabad and Nizamabad is 2010-11; Ujjain and Rajgarh 2012-13; Amaravati and Latur 2012-13; Jhalawar and Kota Cad 2012-13

[2] Usually rent is fixed for one year it is higher if there is irrigation facility

3.12.1: Inter cropping/Mixed cropping

Adopting inter cropping/mixed cropping has been a significant practice from the farmers' perspective in maintaining soil fertility management and managing crop pest. Another added benefit is that Intercropping/mixed cropping will safeguard against total failure of the crops during unfavourable climatic conditions and can increase production and income on dry lands (Singh 1979 and Reddy 2015). In mono cropping system the incidence of pest or spread of disease is easy as there is single crop. Whereas the inter/ mixed cropping system itself acts like a barrier to the establishment of pests and thereby reducing the damage. More over it becomes difficult for the pest to locate its food in the mixed cropping system. Interestingly some of the crops in the mixed cropping system simultaneously will be source of food for natural enemies of crop pest. The more the variety of crops in a field, high is the population of beneficial organisms which takes care of pest. This helps in avoiding use of any pesticide.

In is evident from table 3.14 on the whole in soybean fields it was mono-cropping which was predominant in 72 per cent of the sample farmer's plots followed by intercropping (24 percent). Whereas state wise analysis revealed that intercropping was predominant (46 percent) in sample farmers fields in Maharashtra and Telangana states. Farmers value such diversity since it provides greater protection against the risk of crop failure (Scoones, 2001). Mixed cropping was seen to some extent in Maharashtra.

Table 3.14: Distribution of Selected Farmer's Plots according to Cropping System in 2014-15 (Percent)

Cropping Method	Rajasthan	Madhya Pradesh	Maharashtra	Telangana	All States
Mono Cropping	94 (665)	99 (576)	35 (184)	54 (412)	72 (1837)
Inter Cropping	5 (35)	0.2 (1)	46 (238)	46 (351)	24 (625)
Mixed Cropping	1 (6)	0.3 (2)	19 (98)	0.1 (1)	4 (107)
Total	100 (706)	100 (579)	100 (520)	100 (764)	100 (2569)

Source: Primary Survey

Notes: Figures in the parenthesis shows the actual number of plots in that respective category

43 percent of farmers in the sample villages of Telangana have gone for more than 2 crops and this is because sample villages in Tadvai mandal of Nizamabad district are irrigated by Nizamsagar project. They grow paddy, sugarcane, turmeric, cotton, red gram, maize besides soybean (Table 3.15).

[2] Usually rent is fixed for one year it is higher if there is irrigation facility

Table 3.15: Distribution of Sample Households according to their Crop Diversity (Percent)

Number of crops	Rajasthan	Madhya Pradesh	Maharashtra	Telangana	All States
1 to 2 crops	99 (381)	98 (377)	100 (383)	57 (306)	86 (1447)
3 to 4 crops	1 (3)	2 (7)	0 (1)	37 (202)	13 (213)
5 to 6 crops	0 (0)	0 (0)	0 (0)	6.2 (32)	3 (31)
Total	100 (384)	100 (384)	100 (384)	100 (384)	100 (1692)

Source: Primary Survey
Notes: Figures in the parenthesis shows the actual number of household in that respective category.

3.12.2: Soil Depth and Soil Quality

Table 3.16 indicates that majority (33.22 per cent) of sampled plots are having a depth of 1.1 to 2 feet soil depth followed by 2.1 to 3 feet depth. More than 23 per cent of the sampled plots are having a soil depth more than 3 feet. However, interestingly majority are having good (45.70) and average (39.27) soil quality as perceived by farmers (see table 3.17). Twenty five percent of the sampled plots are of good quality. This has implication for soybean cultivation as soil fertility will directly affect crop yield.

Table 3.16: Distribution of Sample HHs Land according to their Soil Depth (Percent)

Soil Depth	Rajasthan	Madhya Pradesh	Maharashtra	Telangana	All States
Upto 1 feet	31.71 (745)	2.08 (107)	6.46 (194)	14.85 (501)	14.97 (1547)
1.1 to 2 feet	35.60 (1035)	27.38 (654)	39.17 (994)	31.87 (1302)	33.22 (3985)
2.1 to 3 feet	25.60 (636)	50.44 (1394)	22.05 (544)	22.08 (834)	28.62 (3408)
3.1 to 4 feet	2.64 (127)	9.88 (247)	17.30 (430)	13.90 (675)	10.92 (1479)
4.1 feet & above	4.45 (91)	10.22 (332)	15.02 (499)	17.30 (184)	12.27 (1621)
Total	100 (2633)	100 (2734)	100 (2660)	100 (4013)	100 (12040)

Source: Primary Survey
Notes: Figures in the parenthesis shows the actual number of acres in that respective category.

Table 3.17: Distribution of Sample Households Land according to their Soil Quality (Percent)

Soil Quality	Rajasthan	Madhya Pradesh	Maharashtra	Telangana	All States
Very Bad	3.20 (51)	0.35 (12)	2.67 (86)	0.66 (25)	1.59 (174)
Bad	2.37 (54)	1.04 (46)	6.46 (195)	12.50 (493)	6.58 (788)
Average	47.84 (1333)	22.36 (480)	42.63 (1014)	41.07 (1512)	39.27 (4338)
Good	44.23 (1127)	68.98 (2003)	40.87 (148)	36.47 (1533)	45.70 (5811)
Very Good	2.36 (69)	7.27 (194)	7.60 (217)	9.30 (451)	6.86 (931)
Total	100 (2633)	100 (2734)	100 (2660)	100 (4013)	100 (12040)

Source: Primary Survey
Notes: Figures in the parenthesis shows the actual number of acres in that respective category.

3.12.3: Crop Replacement

The study looked at the crops that were being replaced due to cultivation of soybean. As it has been long time (see table 3.18) since the sample farmers started cultivating soybean in their farms responses of only those plots for which farmers could remember the crop sown prior to soybean were taken into consideration for calculation. Table 3.18 indicates that among all study states, soybean occupied area of Traditional jowar (29.60 percent), Maize (22.18 percent), Black gram (9.88 percent), Cotton (8.74 percent) and Hybrid jowar (8.07 percent). State wise analysis reveals variations in the crops replaced due to spread of soybean. In Rajasthan state, traditional jowar (57.73percent), Black gram (17.43 percent) and Maize (13.51 percent) were the crops that were replaced by soybean. Crop replaced in Madhya Pradesh include hybrid jowar (41.64 percent), Maize (33.46 percent) and Redgram (10.40 percent). This is inline with the findings of Reddy *et al.* (2015). Similary, in Maharashtra black gram, cotton, green gram and traditional jowar have lost major area among all crops. Maize (30.81 percent), Traditional jowar (28.96 percent) and sesame (8.84 percent) cotton (8 percent) have been replaced by soybean in Telangana state. Two patterns emerge from the crop replacement one that traditional crops were replaced by soybean and two crops like maize, pulses and cotton are being replaced due to relatively low returns and unstable returns for these crops, soybean being short duration crop and also being rain fed crop. The second pattern could be observed in the late entry states of Maharashtra and Telangana.

50 percent of all the sample farmers are not undertaking any crop rotation, while 27 percent are rotating once in two years and 11 percent once in more than five years.

Table 3.18: Details of Crops Cultivated in the Present Soybean Growing Plots Prior to It (%)

Crops	Rajasthan	Madhya Pradesh	Maharashtra	Telangana	All States
Traditional Jowar	57.73 (265)	0.37 (1)	9.56 (22)	28.96 (203)	29.60 (491)
Fodder Jowar	0.44 (2)	2.60 (7)	2.60 (6)	0.86 (6)	1.26 (21)
Hybrid Jowar	0.22 (1)	41.64 (112)	1.74 (4)	2.43 (17)	8.07 (134)
Traditional Bajra	0.43 (2)	5.58 (15)	1.30 (3)	0.14 (1)	1.26 (21)
Hybrid Bajra	0.43 (2)	2.23 (6)	0.43 (1)	0.28 (2)	0.66 (11)
Green gram	0.22 (1)	0.37 (1)	22.61 (52)	6.56 (46)	6.03 (100)
Black gram	17.43 (80)	0.37 (1)	30.87 (71)	1.71 (12)	9.88 (164)
Redgram	0.0 (0)	10.40 (28)	1.74 (4)	2.42 (17)	2.95 (49)
Maize	13.51 (62)	33.46 (90)	0.0 (0)	30.81 (216)	22.18 (368)
Groundnut	0.65 (3)	1.12 (3)	0.43 (1)	0.43 0.43(3)	0.60 (10)
Sunflower	0.0 (0)	0.0 (0)	0.43 (1)	0.14 (1)	0.12 (2)
Cotton	5.01 (23)	1.12 (3)	26.96 (62)	8.13 (57)	8.74 (145)
Jute/Mesta	0.0 (0)	0.0 (0)	0.87 (2)	0.0 (0)	0.12 (2)
Potato	0.0 (0)	0.0 (0)	0 (0)	0.14 (1)	0.06 (1)
Garlic	0.22 (1)	0.0 (0)	0 (0)	0.0 (0)	0.06 (1)
Turmeric	0.0 (0)	0.0 (0)	0 (0)	3.85 (27)	1.63 (27)
Sesame	3.27 (15)	0.0 (0)	0.43 (1)	8.84 (62)	4.70 (78)
Paddy	0.0 (0)	0.0 (0)	0 (0)	2.85 (20)	1.20 (20)
Others	0.43 (2)	0.74 (2)	0 (0)	1.43 (10)	0.84 (14)
Total	100.0 (459)	100.0 (269)	100.0 (230)	100.0 (701)	100.0 (1659)

Source: Primary Survey

Notes: Figures in the parenthesis shows the actual number of acres in that respective category.

Majority farmers in the sample villages in Madhya Pradesh are cultivating soybean continuously without any crop change (73 percent) followed by Maharashtra (61 percent). On the other extreme majority farmers in villages of Nizamabad district are changing the crop every two years. The villages of Kankal, Karadpally and Tadwai in Tadwai mandal are irrigated under the Nizamsagar project and farmers cultivate number of crops. The yield (qtls/acre) is also high in these villages on par with villages in Madhya Pradesh (table 3.19). Despite no crop rotation sample villages in Madhya Pradesh have recorded high productivity. This may be because of good adoption practices and the experience of soybean crop cultivation from a very long time.

3.13: Institutions and Their Role in Soybean Crop Cultivation

Institutional support is very crucial for agriculture in general and soybean crop in particular because of its rapid geographical spread from traditional to new states. The role of Agriculture department, KVK and agriculture research station is important in disseminating knowledge, practices and also in supply of inputs and so on. Soil testing is crucial for crop productivity but only 14 to 18 percent farmers have completed soil testing in the sample villages[3] (Appendix Table 1). The percentage of farmers who had their soil tested is abysmally low in Madhya Pradesh and better in sample villages in Maharashtra and Telangana. At the overall level 56 percent got it tested once in mostly dry lands and in majority cases the sample was collected by the agriculture department people. 51 percent of farmers whose soil was tested was done in district soil testing labs but again majority farmers (84 percent) have not received any results of the soil tested. 84 percent of farmers who got the results were not satisfied with the result and those satisfy the level of satisfaction was less (Table 1 Appendix). The story of soil testing thus ends with inadequate coverage of farmers and poor institutional response towards a crucial element like soil testing.

Farmers from sample villages in Rajasthan and Madhya Pradesh purchase all inputs from the market while in Telangana 100 percent received soya seed from the Agriculture department. This can be observed to some extent in Maharashtra too (Table 3.20). Farmers are dependent on borrowed credit for the purpose of soybean cultivation in sample villages in Telangana but not in other states. While 76 percent are borrowing for soybean crop cultivation only 37 percent borrowed from formal sources. The interest burden is more on farmers borrowing from private sources which add to the cost of cultivation and cuts into the returns from crop of the farmers.

[3] Detailed data on soil testing practices and the role of institutions is given in Appendix Table 1

Table 3.19: Percentage of Farmers Adopting Crop Rotation in Sample Villages

State	District	Mandal	Village	Once in 2 years	Once in 3 years	Once in 5 years	Once in more than 5 years	No change
Rajasthan	Jhalawar	Pidawa	Dhuvliya	29	0	2	50	19
			Dharonia	21	4	2	23	50
		Khanpur	Bareda	8	2	0	40	50
			Khandi	17	4	0	17	63
	Kota	Pipalda	Balupa	19	6	0	58	17
			Durjanpura	2	0	2	58	38
		Digodh	Khediltavran	0	0	0	40	60
			Bislai	0	0	0	31	69
M P	Ujjain	Badnagar	Lohana	4	8	13	0	75
			Jandla	2	21	35	2	40
		Mehidpur	Mundla Parval	17	13	10	4	56
			Delchi kurd	2	15	10	8	65
	Rajgadh	Biaora	Chanchakhedi	6	2	10	4	77
			Bayheda	0	2	4	4	90
		Narsinggadh	Mavasa	0	0	0	10	90
			Sarana	0	4	0	0	96
Maharashtra	Amaravathi	Amaravathi	Kekatpur	17	25	0	4	54
			Nayakola	21	4	4	2	69
		Nandgaon	Shirapur	10	19	0	6	65
			Dahigaon	13	4	0	0	83
	Latur	Latur	Kahva	8	31	2	2	56
			Bamani	2	29	4	0	65
		Ausa	Barhanpur	4	38	4	4	50
			Vangaji	8	40	6	4	42
Telangana	Adilabad	Kautala	Thatipalli	13	2	2	6	77
			Pardi	0	0	2	6	92
			Gangapur	63	19	0	0	19
		Jainoor	Ashapally	69	15	2	2	13
			Patnapur	88	4	2	0	6
			Daboli	92	0	0	0	8
	Nizamabad	Velpoor	Akloor	73	6	0	0	21
			Velpoor	94	0	0	0	6
			Lakkora	67	2	0	0	31
		Tadwai	Kankal	85	6	0	0	8
			Karadpally	75	4	0	0	21
			Tadwai	81	2	0	0	17
			All States	27	9	3	11	50

Source: Primary Survey

Table 3.20: Percentage of Farmers Done Soil Testing

State	District	Percent
Rajasthan	Jhalawar	15
	Kota	13
State Total		14
Madhya Pradesh	Ujjain	4
	Rajgadh	2
State Total		3
Maharashtra	Amaravathi	21
	Latur	13
State Total		17
Telangana	Adilabad	18
	Nizamabad	17
State Total		18

Source: Primary Survey

Table 3.21: Distribution of Sample HHs according to their access to Government Outlet on Agricultural Inputs and Credit (percent farmers)

Particulars	Rajasthan	Madhya Pradesh	Maharashtra	Telangana
Seeds	0 (0)	0 (0)	16 (61)	100 (540)
Chemical fertilizers	5 (20)	1 (4)	14 (55)	6.5 (35)
Credit from formal sources	Nil	Nil	Nil	76 (459)

Note: Figures in brackets are number of farmers
Source: Primary Survey

Farmers in all states received extension services mostly from Agricultural department followed by private companies (Table 3.22). The frequency of visit by farmers to service providers is mostly once or twice. Farmers preferred mostly agricultural department and private companies as service providers (Table 3.22).

3.13.1: Marketing of Soybean Crop

Price is an important variable in deciding the area to be cultivated under soybean. Only 31 percent of the sample farmers are aware of the minimum support price for the soybean crop. 62 percent of farmers in the sample villages in Maharashtra are aware of minimum support price of soybean crop.

Table 3.22: Number of Farmers Received Extension Services, Frequency of Visit and Quality of Service

Extension Service	Received Service		Frequency of Visit				Rate the Service				
	Yes	No	Once	Twice	Thrice	Four times	First	Second	Third	Fourth	Fifth
Rajasthan											
Agriculture Dept	41	343	33	8	1	0	7	31	0	0	NA
KVK	3	381	2	0	0	1	2	1	0	0	NA
Private Company	13	371	9	3	0	1	6	7	0	0	NA
Farmers Cooperative	10	374	8	1	2	0	3	7	0	0	NA
Madhya Pradesh											
Agriculture Dept	20	364	12	2	1	0	2	9	1	1	NA
KVK	6	378	3	2	0	1	3	3	0	0	NA
Private Company	18	366	8	3	4	0	6	8	1	0	NA
Farmers Cooperative	4	380	3	1	0	0	1	0	2	1	NA
Maharashtra											
Agriculture Dept	81	303	20	41	22	8	13	56	10	11	0
KVK	8	376	2	5	2	0	3	3	1	1	1
Agriculture Univ.	4	380	2	1	1	0	1	3	0	0	0
Private Company	25	359	8	7	6	4	4	16	5	0	0
NGOs	9	375	6	2	2	0	1	8	0	0	0
Farmers Cooperative	2	382	2	0	0	0	0	2	0	0	0
Telangana											
Agriculture Dept	16	524	16	0	0	0	NA	NA	10	5	NA
Private Company	17	523	14	2	1	0	NA	NA	5	12	NA

Source: Primary Survey

Table 3.23: Awareness of MSP of Soybean Crop (percent farmers)

Aware of MSP	Jhalawar	Kota	Rajasthan	Ujjain	Rajgadh	Madhya Pradesh	Amaravathi	Latur	Maharashtra	Adilabad	Nizamabad	Telangana	All
Yes	15	3	18	11	4	15	148	89	237	110	145	255	525
Percent	8	2	5	6	2	4	77	46	62	44	50	47	31
Total	192	192	384	192	192	384	192	192	384	252	288	540	1691

Source: Primary Survey

Soybean crop is sold mostly in the regulated market yards. 61 percent sold in market yards and 29 percent sold to private traders and middlemen. Role of middlemen and traders in supply of seed, fertilizer and pesticide and purchase of output is prevalent in sample villages in Adilabad, Nizamabad and Latur in that order. Cooperatives are present in Amaravati which provide inputs and also are purchase centers.

Table 3.24: Percentage Farmers Marketing Soybean Produce according to different avenues

Place of Marketing of Soya produce	Rajasthan		Madhya Pradesh		Maharashtra		Telangana	
	Jhalawar	Kota	Ujjain	Rajgadh	Amaravathi	Latur	Adilabad	Nizamabad
Market Yard	87	97	81	89	64	43	15	33
Private traders	9.6	1.7	5.6	0	4.7	30.1	79	55
Co-operatives	0	0	0	0	31	2	0	0
Other Places	3.4	1.3	13.4	11	0.3	24.9	6	12

Source: Primary Survey

Sample villages in Madhya Pradesh and Maharashtra have high area under soybean crop while productivity is high in Madhya Pradesh villages. Yield gap for popular varieties is positive in MP villages and the current year yields have been close to the normal year in MP due to relatively favourable monsoon. Overall soybean cultivation is better in MP compared to other states. This better performance is despite the not so better agricultural practices in case of soil testing practices, agricultural extension. On the other hand inputs are supplied by government outlets in Telangana and cooperatives have strong presence in Maharashtra. Agricultural extension services are also better in Maharashtra. All these may have reduced cost of production if not contributed to yield enhancement.

Table 3.25: Pattern of Expenditure by households from earnings from Soybean crop (Percentage)

Sl. No.	Expenditure	Rajasthan	Madhya Pradesh	Maharashtra	Telangana	All States
1	**Pattern of Expenditure**					
1.1	Purchase of Land	65 (250)	67 (259)	67 (259)	70 (380)	68 (1148)
1.2	Capital expenditure in agriculture	57 (219)	60 (232)	54 (208)	64 (345)	59 (1004)
1.3	Current expenditure in agriculture	24 (93)	32 (122)	32 (122)	34 (183)	31 (520)
1.4	Food	50 (194)	55 (210)	60 (229)	56 (305)	55 (938)
1.5	Education	39 (150)	45 (174)	42 (162)	40 (219)	42 (705)
1.6	Health	69 (267)	74 (284)	76 (291)	75 (403)	74 (1245)
1.7	Clothing	42 (162)	43 (167)	42 (162)	37 (203)	41 (694)
1.8	Purchase of vehicles/vehicle maintenance	64 (247)	65 (250)	65 (251)	69 (374)	66 (1122)
1.9	Purchase and maintenance of luxury goods	5 (18)	5 (21)	7 (29)	7 (40)	6 (108)
1.10	Dowry, marriage	21 (82)	24 (91)	25 (98)	26 (139)	24 (410)
1.11	Liquor consumption	8 (32)	11 (41)	6 (25)	5 (29)	7 (127)
1.12	Recreation	13 (51)	17 (65)	11 (43)	11 (59)	13 (218)
2	**Average expenditure (Percentage)**	**Rajasthan**	**Madhya Pradesh**	**Mahara-shtra**	**Telan-gana**	**All States**
2.1	Purchase of Land	17	17	17	18	17
2.2	Capital expenditure in agriculture	8	8	7	8	8
2.3	Current expenditure in agriculture	4	6	6	6	6
2.4	Food	5	6	7	6	6
2.5	Education	5	5	6	5	5
2.6	Health	9	9	11	9	9
2.7	Clothing	3	4	3	3	3
2.8	Purchase of vehicles/vehicle maintenance	7	7	7	7	7
2.9	Purchase and maintenance of luxury goods	1	1	1	1	1
2.10	Dowry, marriage	4	4	4	6	4
2.11	Liquor consumption	1	1	0	0	1
2.12	Recreation	4	4	2	2	3

Note: Figures in parenthesis indicate number of households for Sl.No. 1.1 to 1.12.
Source: Primary survey

3.14: Welfare gains due to soybean crop cultivation

The pattern of expenditure of farmers from the income received from cultivating soybean crop over year's shows that they have spent on purchasing land, investing in land for creating infrastructure, for current expenditure in agriculture. High percentage of farmers has utilized the income for health needs. They have also utilized for purchase of vehicles. Farmers have also used the income for giving dowry to daughters and in performing marriages. There are some variations across states in the expenditure pattern (Table 3.25).

3.15: Concluding Observations

1. Area production and yield analysis of Soybean crop indicates that area expansion has been high at the All India and for all states till the year 2000. The compound growth rate for area has fallen for all states after 2001.

2. Among the four selected states area expansion rate has been high for Maharshtra and Telangana states compared to Madhya Pradesh and Rajasthan.

3. Growth rates of yield have improved after 2001 for All India. Similar trend is seen in Telangana while there have been lower yields in Rajasthan and Madhya Pradesh and constant yields in Maharashtra after 2001.

4. Production trends show increased growth rate for All India and all states. For the states of Telangana and Maharashtra CAGR of production is high compared to other states. Growth rate of soybean production has decreased after 2001 for all the states.

5. Area expansion has contributed to the extent of 80 percent to change in average production and yield has contributed to an extent of 10 percent.

6. In case of state of Maharashtra 97 percent of change in production is because of change in mean area; while in Telangana along with change in mean area interaction between mean area and yield has contributed majorly for change in average production.

7. Change in area variance has contributed more to variance in production for All India, and the states of Maharashtra and Rajasthan.

8. Change in yield variance has contributed for the state of Madhya Pradesh and the interaction effect between mean yield and area variance has contributed to change in variance in production in Telangana.

9. Average area per household under soybean crop is highest in sample villages in Maharashtra (Nayakola, Bamani) followed by sample villages in Madhya Pradesh.

10. Average yield (qtls per acre) is high in sample villages in Madhya Pradesh. Rajasthan villages have the lowest average yields.

11. Variation in yield is high in the sample villages of Telangana, Maharashtra and Rajasthan. Madhya Pradesh villages have less variation in yields/ production.

12. For the seed variety 1024 yield gap is highest in Delchikurd and Lohana in Mehidpur and Badnagar blocks Ujjain district. For the popular variety of JS 335 except in the villages of Rajgarh and Latur yield gap (negative) is high in the rest of the sample villages. In case of 9560 all 4 villages in Kota district had negative yield gap.

13. The percentage deviation of current year yields from normal year is negative (short fall) in all sample villages except those in Madhya Pradesh.

14. Two patterns emerge in case of crop replacement. Firstly, traditional crops were replaced by which soybean is a long term change and secondly crops like maize, pulses and cotton are being replaced due to relatively higher returns, rain fed in nature and short duration of soybean crop. The second pattern is found in the late entry states of Maharashtra and Telangana.

15. Fifty percent of all the sample farmers are not undertaking any crop rotation, while 27 percent are rotating once in two years and 11 percent once in more than five years.

16. Only 14 to 18 percent farmers have completed soil testing in the sample villages, this is more in the sample villages in Maharashtra and Telangana.

17. Farmers from sample villages in Rajasthan and Madhya Pradesh purchase all inputs from the market while in Telangana 100 percent received soya seed from the Agriculture department.

18. Farmers are dependent on borrowed credit for the purpose of soybean cultivation in sample villages in Telangana state but not in other three states.

19. The percentage of farmers that received any extension services are 18 percent in Rajasthan, 14 percent in Madhya Pradesh, 37 percent in Maharashtra and 6 percent in Telangana.

20. By far agriculture department is the dominant provider of extension services followed by private companies.

21. Only 31 percent of the sample farmers are aware of the Minimum Support Price for the soybean crop.

22. Role of middlemen and traders in supply of seed, fertilizer and pesticide and purchase of output is prevalent in sample villages in Adilabad, Nizamabad and Latur in that order. Cooperatives are present in Amaravati which provide inputs and also are purchase centers.

CHAPTER IV

Adoption of Technology in Soybean Crop and Its Determinants: A Cross Section Analysis

4.1: Seed Technology in Soybean

Non-availability of quality seed of improved varieties of soybean is the major problem experienced by the farmers (Dupare et.al., 2010). As the seed production chain is not efficient to provide the quality seed of desired varieties to farmers, they are compelled to use farm saved seed by increasing the seed rate to manage required plant population. Study done by Pionetti (2007) on seed autonomy in Deccan plateau revealed that farmers seed saving practices have two distinct and complementary goals: to reproduce the distinctive characters of each local crop variety and to increase the variability and adaptability of plant genetic resources. Trait specific preference of varieties, and availability of quality seed of preferred variety are the major concerns expressed by soybean farmers. Another related problem is the inadequate availability of quality seeds of improved varieties and also inability of existing soybean varieties to with stand either drought/excess moisture (Tiwari 2014). Most of the farmers have been using HYV seeds and area under such seeds is more than 90 per cent in all size class farmers (Kajale and Shroff, 2013).

The most popular seed varieties in soybean crop are JS-335 which is a variety under Jawahar Seed Varieties released by JNKVV. It had many problems like poor productivity due to moisture stress at pod filling stage and non adoption of technology. JS-335 was later replaced by a new variety i.e. JS 95-60 suitable to the area and best fitted to soybean-potato-onion/ garlic cropping system. JS 95-60 (introduced by the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya and KVK of Ujjain) is a short duration variety giving better productivity than JS 335. Our field data also reveals that JS 95-60 has been extensively used by farmers in the states of Rajasthan and MP (Table 4.1).

The frontline demonstrations show the effectiveness of the seed variety however there is gap in the lab to land transfer of technologies.

4.2: Varieties Cultivated by all Soybean Farmers in the Study Villages

The present study tried to understand the scenario related to diverse seed varieties being used by farmers since 2005. Using recall method, data was collected for the years 2005, 2010 and 2014 from all the soybean growing farmers of the study villages in four study states. Those farmers who did not cultivate the crop during that period or those who could not remember the variety name could not respond and were placed under the head not answered in the table 4.1. The following section discusses the predominance of different varieties at different points of time.

Table 4.1 Varieties Cultivated by Soybean Households (listed) in Sampled Districts of Rajasthan State during 2005, 2010 and 2014

Variety Cultivated	Rajasthan					
	Jhalawar			Kota		
	2014	2010	2005	2014	2010	2005
1024 (Pant Soybean)	12.04 (93)	5.38 (43)	7.82 (61)	1.72 (11)	-	-
JS-335	16.1 (124)	56.76 (453)	35.38 (276)	57.99 (370)	70.66 (460)	58.03 (372)
JS-95-60	29.79 (230)	8.27 (66)	5.7 (45)	26.95 (172)	23.50 (153)	6.24 (40)
NRC-7 (Ahilya-3)	41.97 (324)	18.17 (145)	9.37 (73)	-	-	-
Punjab-1	-	4.38 (35)	33.46 (261)	-	0.92 (6)	10.14 (65)
JS 71-05	-	5.88 (47)	5.89 (46)	-	-	-
1042 (Pant Soybean)	0.12 (1)	-	0.77 (6)	-	-	-
JS-9041	-	0.12 (1)	-	-	-	-
JS 20-29	-	-	0.12 (1)	-	0.47 (3)	-
JS-93-05	-	-	-	11.28 (72)	3.07 (20)	3.12 (20)
Kali Tur	-	-	-	0.17 (1)	- (127)	19.81
Punjab-1	-	-	-	0.31 (2)	-	-
Not Answered	-	1.0 (8)	1.15 (9)	0.47 (3)	0.51 (4)	1.09 (7)
Others	-	-	0.25 (2)	2.7 (17)	0.77 (5)	1.57 (10)
Grand Total	100 (772)	100 (798)	100 (780)	100 (638)	100 (651)	100 (641)

Source: Primary Survey

Table 4.1 reveals that JS 335 is predominant during the years 2005, 2010 and 2014 followed by JS 95-60 except during the year 2005 Kalitur was predominant after JS-335 in Kota district of Rajasthan. In Jhalawar district JS-335 was predominant during the years 2005 and 2010 but not in 2014. NRC-7 was being cultivated by 41.97 percent of the soybean farmers in the study villages followed by 29.79 per cent farmers cultivating JS-95-60. It was interesting to see that (see table 4.1) NRC-7 slowly picked up with farmers since 2005 and has increased substantially from the year 2005 to 2014 dominating all the other varieties in Jhalawar district. Like NRC-7, Pant Soybean (1024) variety was prevalent in 2005, 2010 and 2014.

Table 4.2: Varieties Cultivated by Soybean Households (listed) in Sampled Districts of Madhya Pradesh State during 2005, 2010 and 2014

Variety Cultivated	Madhya Pradesh					
	Ujjain			Rajgarh		
	2014	2010	2005	2014	2010	2005
JS-71-05	0.5 (6)	1.9 (23)	-	0.1 (1)	-	-
JS-335	0.17 (2)	23.30 (288)	67.78 (814)	24.81 (229)	49.36 (542)	42.0 (512)
JS-95-60	85.02 (1028)	23.54 (291)	-	55.36 (511)	6.46 (71)	-
JS-90-41	0.74 (9)	27.58 (341)	1.74 (21)	0.54 (5)	4.73 (52)	3.69 (45)
JS-93-05	0.17 (2)	6.14 (79)	1.08 (13)	18.85 (174)	20.03 (220)	0.65 (8)
PK472	-	2.83 (35)	5.41 (65)	-	-	27.8 (339)
Punjab1	0.17 (2)	-	-	0.32 (3)	-	-
Maratha13	-	0.48 (6)	2.58 (31)	-	-	-
Pusa -16	-	-	0.24 (3)	-	-	-
1042 (Pant Soybean)	6.95 (84)	-	-	-	-	-
NRC-7(Ahilya 3)	6.2 (75)	-	-	-	-	-
Others	0.08 (1)	1.21 (15)	7.66 (92)	-	-	-
Not Answered	-	12.78 (158)	13.48 (162)	-	19.39 (213)	25.84 (315)
Grand Total	100 (1209)	100 (1236)	100 (1201)	100 (923)	100 (1098)	100 (1219)

Source: Primary Survey

Table 4.2 indicates that in Ujjain district of Madhya Pradesh different soybean varieties dominated during 2005 (JS-335), 2010 (JS-90-41 and 2014 (JS-95-60). More than 85 percent of farmers in study villages are cultivating JS-95-60 in their fields during the year 2014 Kharif. Where as in 2010 JS-335 (23.30 per cent farmers), JS-95-60 (23.54 per cent farmers) and JS-90-41 (27.58 per cent farmers) were popular with farming community. In study villages of Rajgarh district of Madhya Pradesh, JS-335 was predominant during the years 2005 and 2010. In 2014 JS-95-60 has become popular like in Ujjain district. In Rajgarh, as compared with the year 2005, JS-93-05 has become popular during the years 2010 (23.03 per cent farmers) and 2014 (18.85 per cent farmers). On the contrary PK-472 which was cultivated by 27.80 percent of farmers during the year 2005 has totally lost the farmers confidence during the years 2010 and 2014.

Table 4.3: Varieties Cultivated Soybean Households (listed) in Sampled Districts of Maharashtra State during 2005, 2010 and 2014

Variety Cultivated	Maharashtra					
	Amaravathi			Latur		
	2014	2010	2005	2014	2010	2005
JS-71-05	-	-	-	3.25 (36)	3.01 (33)	1.18 (13)
JS-335	98.72 (543)	89.29 (484)	68.76 (383)	60.16 (666)	58.57 (642)	65.72 (721)
DS-228 (Phule Kalyani)	-	-	-	34.95 (387)	37.50 (411)	6.38 (70)
MAUS-162	-	-	-	0.27 (3)	-	-
JS-9305	-	-	2.79 (15)	-	-	-
MAUS-71 (Samrudhi)	-	-	-	0.37 (4)	-	-
Not Answered	1.27 (7)	10.7 (58)	12.74 (71)	0.99 (11)	0.91 (10)	26.7 (293)
SARAS	-	-	15.79 (88)	-	-	-
Grand Total	100 (550)	100 (542)	100 (557)	100 (1107)	100 (1096)	100 (1097)

Source: Primary Survey

It is evident from table 4.3 that in the study villages of Maharashtra JS-335 was very popular with all the soybean growing farmers during 2005, 2010 and 2014. Similarly Phule Kalyani has been in cultivation since 2005 in Latur district of Maharashtra. However, in the recent times from the year 2010, Phule Kalyani (DS-228) is being grown by nearly 35 percent of farmers. Similarly a very small percent of farmers (table 4.3) were cultivating JS-71-05 during the years 2005, 2010 and 2014. In Maharashtra and Telangana, as the soybean crop has been a recent entry, farmers could not respond to the question of varieties cultivated during the years 2005 and 2010. In Telangana, soybean is a very recent entry into the farmer's fields. The data from study villages (see table 4.4) of Adilabad and Nizamabad district of Telangan state indicate that more than 95 per cent of soybean farmers are using only JS-335 variety due to its suitability to them.

The study also tried to look at the details of soybean varieties being used by sampled households in the study states during the Kharif 2014-15. Contrary to the all the listed soybean farmers data (see table 4.4) in Jhalwar district of Rajasthan, empirical data reveals that majority (54.91 per cent) of the sampled households were cultivating JS-95-60 followed by NRC-7 (41.25). In Kota also the same JS-95-60 was predominant (57.73 per cent) followed by JS-9305. In Madhya state in Ujjain district JS-95-60 was predominant followed by Pant Soybean and NRC-7. This differs from the findings of research study of Wilmat (2009) which reported that JS-335 is predominant variety in Ujjain district. However, JS-335 was predominant with sampled households of Rajgarh (see table 4.5). When we look at state level aggregate data of sampled households, JS-95-60 is the leading variety with farmers in the states of Madhya Pradesh (46.31 percent) and Rajsthan (77.57 percent) followed by NRC-7 (21.29percent) in Rajasthan and JS-335 (24.56percent). In Maharashtra and Telangana states JS-335 was predominantly cultivated by sampled households.

Table 4.4: Varieties Cultivated by Soybean Households (listed) in Sampled Districts of Telangana State during 2005, 2010 and 2014

Variety Cultivated	Telangana					
	Adilabad			Nizamabad		
	2014	2010	2005	2014	2010	2005
JS-335	95.68 (355)	-	-	97.96 (386)	-	-
Not aware	1.34 (5)	-	-	0.0 (0)	-	-
Others	(12)	-	-	2.03 (8)	-	-
Grand Total	100 (371)			100 (394)		

Source: Primary Survey

Table 4.5: Soybean Seed Varieties Used by the Sample Farmers in the Total Plots Cultivated by them during the Year 2014-15.

Variety Used	Rajasthan		Total	Madhya Pradesh		Total	Maharashtra		Total	Telangana		Total	All States
	Jhalawar	Kota		Ujjain	Rajgarh		Amaravathi	Latur		Adilabad	Nizamabad		
Punjab 1	0.82 (3)	0.0 (0)	0.42 (3)	0.65 (2)	1.14 (3)	0.88 (5)	0.41 (1)	0.81 (2)	0.62 (3)	0.0 (0)	0.0 (0)	0.0 (0)	0.43 (11)
J.S-71-05	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.37 (1)	0.17 (1)	0.0 (0)	0.40 (1)	0.20 (1)	0.0 (0)	0.0 (0)	0.0 (0)	0.08 (2)
J.S-90-41	1.37 (5)	0.0 (0)	0.70 (5)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.19 (5)
Phule Kalyani	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	13.82 (34)	6.99 (34)	0.0 (0)	0.0 (0)	0.0 (0)	1.32 (34)
1042(Pant Soybean)	0.0 (0)	0.0 (0)	0.0 (0)	27.45 (84)	0.0 (0)	14.74 (84)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	3.27 (84)
1050	0.27 (1)	0.0 (0)	0.14 (1)	0.65 (2)	0.0 (0)	0.35 (2)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.12 (3)
P.K-1029	0.0 (0)	0.0 (0)	0.0 (0)	0.32 (1)	0.0 (0)	0.17 (1)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.04 (1)
JS-71-05	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.81 (2)	0.41 (2)	0.0 (0)	0.0 (0)	0.0 (0)	0.08 (2)
JS- 95-60	54.91 (201)	57.73 (198)	77.57 (399)	47.71 (146)	44.69 (118)	46.31 (264)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	25.81 (663)
JS-97-52	0.55 (2)	0.0 (0)	0.28 (2)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.08 (2)
JS 93-05	0.82 (3)	20.99 (72)	10.57 (75)	0.0 (0)	(1)	0.57 (1)	0.41 (1)	0.0 (0)	0.20 (1)	0.0 (0)	0.0 (0)	0.0 (0)	3.00 (77)

contd...

Table 4.5: contd..

Variety Used	Rajasthan		Total	Madhya Pradesh		Total	Maharashtra		Total	Telangana		Total	All States
	Jhalawar	Kota		Ujjain	Rajgarh		Amaravathi	Latur		Adilabad	Nizamabad		
JS-90-05	0.0 (0)	0.29 (1)	0.14 (1)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.04 (1)
JS-335	0.0 (0)	19.24 (66)	9.30 (66)	0.65 (2)	52.27 (138)	24.56 (140)	92.08 (221)	78.04 (192)	84.77 (412)	93.02 (360)	95.22 (398)	96.73 (740)	53.56 (1376)
NRC-7	41.25 (151)	0.0 (0)	21.29 (151)	21.89 (67)	0.0 (0)	11.75 (67)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	8.49 (218)
PK-472	0.0 (0)	0.58 (2)	0.28 (2)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.08 (2)
Not aware	0.0 (0)	0.87 (3)	0.42 (3)	0.0 (0)	0.0 (0)	0.0 (0)	2.91 (7)	4.47 (11)	3.70 (18)	2.58 (10)	0.0 (0)	0.65 (5)	1.21 (31)
Others	0.0 (0)	0.29 (1)	0.14 (1)	0.65 (2)	1.13 (3)	0.87 (5)	4.17 (10)	1.62 (4)	2.88 (14)	4.39 (17)	4.78 (20)	2.61 (20)	2.22 (57)
Grand Total	100.0 (366)	100.0 (343)	100.0 (709)	100.0 (306)	100.0 (264)	100.0 (570)	100.0 (240)	100.0 (246)	100.0 (486)	100.0 (387)	100.0 (418)	100.0 (765)	100.0 (2569)

Source: Primary survey

4.3: Potential Yields vis-à-vis Actual Farm Yields

The study tried to assess the yields of major varieties in the sampled districts against the potential yields of these varieties. Those varieties which are grown by substantial number of farmers in the district are being discussed here. Some of them are growing more than one variety in their farms. In Ujjain district of Madhya Pradesh, variety Pant Soybean (1042) was giving average yield of 1071Kgs/acre which is within the range of potential yield. In Maharashtra state, Phule Kalyani (DS-228) variety was yielding (914Kgs/acre) slightly lesser in Latur district than the potential yield (1040Kgs/acre). But this was marginally higher than the JS-335, which was the predominant variety of Latur district with sampled households (see table 4.5). Yield performance of JS-335 which was the popular variety with predominant households in Rajgarh distirct of Madhya Pradesh and study districts of Maharashtra and Telangana states, was lesser than the potential yield. However, the yields were better in Latur and Rajgarh, where substantial number of households is growing this variety. But when it comes to Kota (Rajasthan), Amaravathi (Maharashtra), Adilabad and Nizamabad districts (Telangana), JS-335 yields are very poor. This is due to prolonged dry spells in these regions during the crop growth period. Excepting Rajgarh district, JS-95-60 has been the most popular variety with sampled households in Rajasthan and Madhya Pradesh states during 2014-15. This was bold seeded early maturing variety. In Ujjain district of M.P, average yield performance of the variety was 90kgs higher than the recommended by the Jawaharlal Nehru Krishi Vishwa Vidyalay, Jabalpur. In Rajgarh district the actual yield in the farmer's field was in the range of potential yield (table 3.10 in Chapter III) and in Jhalwar district it was below the potential yield (609Kgs/acre).

JS-95-60 has performed very poor (137Kgs/acre) along with JS-9305 (148Kgs/acre) and JS-335(134 Kgs/acre) in Kota district of Rajasthan due to multiple reasons. These include heavy continuous rainfall after 25 days after sowing days. The black soils study sites of Kota districts have poor water infiltration capacity resulting in water stagnation in the soybean fields. As a result of this farmers could not take up inter-cultivation for controlling weeds. Hence, only weedicide could be sprayed which was not so effective. Again after 45-50 days there was a continuous rainfall resulting in water stagnation and heavy weed infestation in fields. Though weedicide were sprayed, it did not give the desired result. In the later stages of crop growth there was heavy infestation of Girdle beetle in soybean crop. Though control measures were taken up they could not effectively control the pest from causing economic damage. All these factors contributed to poor performance of all the varieties in Kota district of Rajasthan during 2014-15. Though similar kind of rain was prevalent in Jhalawar district of Rajasthan, good drainage in the soils of study sites did not cause much economic damage as compared to Kota. Another reason is the prevalence of Patidar Community in the study region of Jhalawar district who adopt latest and progressive methods in soybean cultivation. Farmers cultivating NRC-7 (Ahilya-3) in Ujjain district of Madhya Pradesh were achieving potential yields. It is very clear from table 4.6 that during 2014-15 all the soybean varieties grown by majority of sampled households are doing extremely well in Ujjain district of Madhya Pradesh giving the potential yields.

4.4: Market Seed vis-à-vis Farm Saved Seeds

Soybean being the major crop of the study districts, the present study tried to analyse the seed autonomy farmers were having in the study villages. It is evident from table 4.6 that per each acre of land, nearly 60 percent of the seed used in Ujjain district of Madhya Pradesh and 50 percent of seed in Jhalawar district of Rajasthan, is the seed saved by farmers from their own previous crop. This helps farmers in taking up timely sowing due to the control he had over seed resources. However, majority of farmers from Kota (Rajasthan) and Rajgarh (Madhya Pradesh) are depending on market seed for soybean cultivation. The average kilograms of own seed used is very less in Maharashtra and negligible in Telangana state. In Maharashtra, farmers are depending mostly on private companies and whereas in Telangana state farmers are getting seed on subsidy from the state department of agriculture for the improvement of area under soybean cultivation. Smaller quantities of seed is borrowed for exchange from peer group and also purchased on credit from market. Highest seed rate (68kgs/acre) is being used in Madhya Pradesh state. Sowing spacing adopted and more use of own saved seed could be one of the reasons for higher seed rate. In certain cases due to poor germination/failure of germination farmers have taken up re-sowing as a result of which seed quantity might have increased. In majority of the study districts (see table 4.6) the value of seed used per each acre is ranging between Rs2000-2500. Only in Madhya Pradesh state farmers are spending more than 3000 rupees/acre for seed and around Rs.1600 in Adilabad district of Telangana state.

4.5: ICAR and SAU Varieties vis-à-vis Private Sector Varieties

Public sector research made phenomenal contribution to the development of varieties with respect to soybean crop and thereby increase in its cultivation area. Private sector contribution was barely minimal in the development of varieties as such. This is due to the fact that development of variety needs long gestation period, huge investments and takes at least 10 years to release one variety which private companies cannot afford. Moreover, the private sector has not been enthusiastic about entering into seed production of high volume low margin crops such as Soybean. Only from past 4-5 years private players started playing role in the development of varieties in soybean crop. There are companies such as Ankur, Eagle etc that are working on it, but have not yet released any variety. The empirical data from household listing of all the soybean farmers in the

Table 4.6: Details of Seed Used By Sampled Households in Rajasthan, Madhya Pradesh, Maharashtra and Telangana during 2014-15 (per acre)

Particulars	Rajasthan		Total	Madhya Pradesh		Total	Maharashtra		Total	Telangana		Total
	Jhalawar (N=192)	Kota (N=192)	(N=534)	Ujjain (N=192)	Rajgarh (N=192)	(N=384)	Amaravathi (N=192)	Latur (N=192)	(N=384)	Adilabad (N=287)	Nizamabad (N=287)	(N=534)
Home Produced Seed (in Kgs)	21	3	12	41	19	30	4	8	6	1	2	2
Value of Home Produced Seed(in Rs)	1107	140	623	1902	890	1396	232	528	380	64	82	72
Seed borrowed as exchanged Seed (in Kg)	0	0	0	0	0	0	0.01	0.3	0.2	0.03	0	0.02
Value of exchanged Seed (in Rs)	0	0	0	0	0	0	0.3	21.7	11.0	1.3	0	0.8
Quantity of Purchased Seed (in Kg)	21	38	29	28	46	37	30	24	27	31	47	38
Value of Purchased Seed (in Rs)	1089	1963	1526	1294	2136	1715	2011	1610	1811	1331	2037	1637
Quantity of Seeds bought on Credit (in Kgs)	0	0	0	0	0	0	1	0	0.5	4	0.003	2
Value of Seed bought Credit (in Rs)	0	0	0	0	0	0	67	0	33	164	0.14	93
Average Price spent by sampled												
House holds/ kg seed(in Rs)	52	52	52	46	46	46	66	66	66	43	43	43
Average quantity of seed used by households (in Kgs)	42	40	41	69	66	68	35	33	34	36	49	42
Average Value of seed used by sampled HHs (in Rs)	2197	2103	2150	3196	3026	3111	2310	2160	2235	1561	2119	1803

Source: Primary Survey

study villages (see table 4.1, 4.2, 4.3 and 4.4) and sampled households (see table 4.5) clearly reveals that it was only those varieties which were produced by public sector institutions that were ruling soybean area in the country during the year 2014-15. These include JS 71-05, JS-335, JS-95-60, JS-90-41, JS-93-05, Pant Soybean, NRC-7, Phule Kalyani (DS-228), Punjab-1, JS-97-52, MAU-71 and MAUS-162.

4.6: Recommended Package of Practices Vs Farmers' Practices

Adoption of technology (package of practices) theoretically has positive correlation with yield levels. Yield gap exists due to lack of adoption of right package of practices and techniques. The Directorate of Soybean Research (DSR) has recommended package of practices to be followed by the soybean cultivating farmers. The study looked critically at each of the practice recommended by DSR and how farmers of research sites have adopted/partially adopted/non-adopted the practice and also looked into the major reasons for this. As only major reasons are presented the number of households in the table showing constraints (see tables 4.8, 4.9, 4.10 and 4.11) will be than less than the cumulative total of all sampled households under partial adoption and non-adoption. The package of practices for which the farmers responses were elicited include deep ploughing; use of farm yard manure; recommended seed variety; germination test; seed treatment; fertilization application; use of ferticum seed drill; sowing distance; spraying of weedicides immediately after seed sowing; intercropping; weed control; pest and disease management through the use of pesticides and non-pesticidal management methods and timely harvesting of crop.

Table 4.7 shows the percentage of farmers who followed these practices. Some practices have been followed by almost all farmers while there is variation across sample farmers in following some other practices. The practices such as deep ploughing after rabi crop farmers and use of the recommended seed variety is being adopted by nearly 98 percent of the sampled households across all states. It is evident from table 4.7 that the percent of sampled households adopting per acre recommended dosages of FYM in Rajasthan, Maharashtra and Telangana state are 44.53 percent, 55.98 percent and 43.33 percent respectively. Use of farm yard manure(FYM) to the optimum extent is least in MP and most in Maharashtra, however percentage farmers who have not at all used any FYM is highest in M.P (80.07percent) and least in Rajasthan(15.62percent). Lack of livestock, reduction in livestock population and high cost of FYM are major reason for this (see table 4.10 and 4.12). Seed germination test has been taken up by most farmers in Rajasthan (91.67percent) followed by Maharashtra (43.59percent) and Telangana (32.41). However, in the predominant soybean growing state of India only 16.41 percent of the sampled households conducted seed germination test before sowing (see table 4.7).

Table 4.7: Soybean Recommended Package of Practices by Directorate of Soybean Research vis-à-vis Adoption by Farmer

Sl. No	Package of Practice	Rajasthan			Total	Madhya Pradesh			Total	Maharashtra			Total	Telangana			Total
		A	PA	NA		A	PA	NA		A	PA	NA		A	PA	NA	
1	Deep ploughing of Land after rabi for exposing to hot sun (540)	98.18	1.56 (377)	0.26 (6)	100 (1)	100 (384)	0.0 (384)	0.0 (0)	100 (0)	99.48 (384)	0.52 (382)	0.0 (2)	100 (0)	97.41 (384)	0.37 (526)	2.22 (2)	100 (12)
2	Use of Farm Yard Manure (@2-4 tonns/acre)	44.53 (171)	39.84 (153)	15.62 (60)	100.0 (384)	13.54 (52)	78.38 (301)	80.07 (31)	100.0 (384)	55.98 (215)	20.31 (78)	23.70 (91)	100.0 (384)	43.33 (234)	11.85 (64)	44.81 (242)	100.0 (540)
3	Recommended Seed Variety	100.0 (384)	0.0 (0)	0.0 (0)	100.0 (384)	99.48 (382)	0.0 (0)	0.52 (2)	100.0 (384)	97.66 (375)	0.0 (0)	2.34 (9)	100.0 (384)	99.63 (538)	0.0	0.37 (2)	100.0 (540)
4	Conducting of Germination test	91.67 (352)	6.25 (8)	6.25 (24)	100.0 (384)	16.41 (63)	3.38 (13)	80.21 (308)	100.0 (384)	43.49 (167)	4.69 (18)	51.82 (199)	100.0 (384)	32.41 (175)	0.0	67.59 (365)	100.0 (540)
5	**Seed Treatment**																
5.1	Chemical Treatment (Carboxin+Thiram)	83.59 (321)	4.69 (18)	11.72 (45)	100.0 (384)	13.80 (53)	5.73 (22)	80.47 (309)	100.0 (384)	54.43 (209)	13.54 (41)	32.03 (123)	100.0 (384)	74.26 (401)	0.18 (1)	25.55 (138)	100.0 (540)
5.2	Biological Treatment with Trichoderma virdi (5-10 gms/kg seed)	2.86 (11)	1.30 (5)	95.83 (368)	100.0 (384)	1.56 (6)	8.07 (31)	90.36 (347)	100.0 (384)	26.30 (101)	11.72 (45)	61.98 (238)	100.0 (384)	1.04 (4)	1.04 (4)	98.51 (532)	100.0 (540)
5.3	Phosphorous Solubulizing Bacteria (PSB) - 5 gms/Kg seed	0.52 (2)	1.32 (5)	98.17 (377)	100.0 (384)	1.56 (6)	7.29 (28)	91.15 (350)	100.0 (384)	23.43 (90)	12.23 (47)	64.32 (247)	100.0 (384)	0.55 (3)	0.55 (4)	98.70 (533)	100.0 (540)
5.4	BradiRhizobium culture: 5gms/kg seed	0.52 (2)	1.04 (4)	98.44 (378)	100.0 (384)	1.04 (4)	5.20 (20)	93.75 (360)	100.0 (384)	21.35 (82)	11.45 (44)	67.18 (258)	100.0 (384)	0.92 (5)	0.74 (4)	98.33 (531)	100.0 (540)
5.5	Cow urine + Ash + Soil under the Banyan tree	0.26 (1)	1.56 (6)	98.17 (377)	100.0 (384)	6.25 (24)	19.01 (73)	74.73 (287)	100.0 (384)	18.48 (71)	6.51 (25)	75.0 (288)	100.0 (384)	0.18 (1)	0.55 (3)	99.26 (536)	100.0 (540)
6	Fertilizer Application																

Sl. No	Package of Practice	Rajasthan			Total	Madhya Pradesh			Total	Maharashtra			Total	Telangana			Total
		A	PA	NA		A	PA	NA		A	PA	NA		A	PA	NA	
6.1	Nitrogen - 8 Kgs	32.55	67.45	0.0	100.0	25.0	75.0	0.0	100.0	43.22	56.78	0.0	100.0	87.96	12.03	0.0	100.0
		(125)	(259)	(0)	(384)	(96)	(288)	(0)	(384)	(166)	(218)	(0)	(384)	(475)	(65)	(0)	(540)
6.2	Phosphorus - 24 to32 kgs	28.12 (108)	71.87 (276)	0.0 (0)	100.0 (384)	24.22 (93)	75.78 (291)	0.0 (0)	100.0 (384)	22.40 (86)	77.60 (298)	0.0 (0)	100.0 (384)	1.67 (9)	93.14 (503)	5.18 (28)	100.0 (540)
6.3	Potassium - 16 to 20Kgs	25.52 (98)	26.30 (101)	48.18 (185)	100.0 (384)	21.87 (84)	53.12 (204)	25.0 (96)	100.0 (384)	23.95 (92)	48.18 (185)	27.86 (107)	100.0 (384)	6.67 (36)	85.92 (464)	7.40 (40)	100.0 (540)
6.4	Sulphur - 8 Kgs	1.56 (6)	2.34 (9)	96.09 (369)	100.0 (384)	17.70 (68)	34.37 (132)	47.92 (184)	100.0 (384)	29.95 (115)	41.40 (159)	28.65 (110)	100.0 (384)	13.52 (73)	60.92 (329)	25.55 (138)	100.0 (540)
7	Use of ferticum seed drill for sowing	99.74 (383)	0.0 (0)	0.26 (1)	100.0 (384)	98.18 (377)	0.0 (0)	1.82 (7)	100.0 (384)	66.15 (254)	0.0 (0)	33.85 (130)	100.0 (384)	22.59 (122)	0.0 (0)	77.41 (418)	100.0 (540)
8	Spraying of weedicide before sowing	1.56 (6)	1.30 (5)	97.14 (373)	100.0 384	11.19 (43)	14.84 (57)	73.95 (284)	100.0 (384)	17.70 (68)	2.08 (8)	80.28 (308)	100.0 (384)	4.07 (22)	0.74 (4)	95.18 (514)	100.0 (540)
9	**Sowing distance**																
9.1	Line to line: 45 cms	82.29 (316)	17.70 (68)	0.0 (0)	100.0 (384)	74.48 (286)	25.52 (98)	0.0 (0)	100.0 (384)	40.10 (154)	59.89 (230)	0.0 (0)	100.0 (384)	76.04 (292)	64.58 (248)	0.0 (0)	100.0 (540)
9.2	Plant to plant: 4-5 cms	100.0 (384)	0.0 (0	0.0 (0	100.0 (384)	51.04 (196)	48.95 (188)	0.0 (0)	100.0 (384)	29.68 (114)	70.32 (270)	0.0 (0)	100.0 (384)	67.22 (363)	6.29 (34)	26.48 (143)	100.0 (540)
9.3	Sowing depth: 2.5 to 3 cms	100.0 (384)	0.0 (0	0.0 (0	100.0 (384)	76.04 (292)	23.95 (92)	0.0 (0)	100.0 (384)	43.22 (166)	56.77 (218)	0.0 (0)	100.0 (384)	74.25 (401)	36.19 (139)	0.0 (0)	100.0 (540)
10	Spraying of weedicide immediately after sowing	7.29 (28)	0.0 (0)	92.70 (356)	100.0 (384)	7.03 (27)	0.0 (0)	92.96 (357)	100.0 (384)	30.72 (118)	0.0 (0)	69.28 (266)	100.0 (384)	14.25 (77)	0.0 (0)	85.74 (463)	100.0 540

Sl. No	Package of Practice	Rajasthan			Total	Madhya Pradesh			Total	Maharashtra			Total	Telangana			Total
		A	PA	NA		A	PA	NA		A	PA	NA		A	PA	NA	
11	Intercropping (either with	9.63	0.0	90.37	100.0	8.07	0.0	91.93	100.0	55.98	0.0	44.02	100.0	52.22	0.0	47.78	100.0
	redgram, Maize, Cotton and Jowar)	(37)	(0)	(347)	(384)	(31)	(0)	(353)	(384)	(215)	(0)	(169)	(384)	(282)	(0)	(258)	(540)
12	Weed control (either manually, through intercultivation/with weedicide spray in 3rd and	97.66 (375)	2.34 (9)	0.0 (0)	100.0 (384)	98.96 (380)	1.04 (4)	0.0 (0)	100.0 (384)	92.97 (357)	7.03 (27)	0.0 (0)	100.0 (384)	97.40 (540)	0.0 (0)	0.0 (0)	100.0 (540)
13	Pest management through use of pesticide	100.0 (384)	0.0 (0)	0.0 (0)	100.0 (384)	99.48 (382)	0.0 (0)	0.52 (2)	100.0 (384)	95.83 (368)	0.0 (0)	4.17 (16)	100.0 (384)	97.40 (526)	0.0 (0)	2.60 (14)	100.0 (540)
14	Pest management through use of NPM method	(0) 0.0	0.0 (0)	100.0 (384)	100.0 (384)	11.98 (46)	0.0 (0)	88.02 (338	100.0 (384)	38.54 (148	0.0 (0)	61.45 (236)	100.0 (384)	1.67 (9)	0.0 (0)	98.33 (531)	100.0 (540)
15	Disease management through use of pesticide	99.73 (383)	0.0 (0)	0.27 (1)	100.0 (384)	100.0 (384)	0.0 (0)	0.0 (0)	100.0 (384)	92.71 (356)	0.0 (0)	7.29 (28)	100.0 (384)	97.41 (526)	0.0 (0)	2.59 (14)	100.0 (540)
16	Disease management through use of NPM method	0.0 (0)	0.0 (0)	100.0 (384)	100.0 (384)	12.5 (48)	0.0 (0)	87.50 (336)	100.0 (384)	30.47 (117)	0.0 (0)	69.53 (267)	100.0 (384)	0.93 (5)	0.0 (0)	99.07 (535)	100.0 (540)
17	Timely harvesting at crop maturity	100.0 (384)	0.0 (0)	0.0 (0)	100.0 (384)	100.0 (384)	0.0 (0)	0.0 (0)	100.0 (384)	98.18 (377)	1.82 (7)	0.0 (0)	100.0 (384)	99.26 (536)	0.74 (4)	0.0 (0)	100.0 (540)

Source: Primary survey

Note: A=Adopted, PA= Partial Adoption and NA= Not Adopted

The major reasons cited by farmers (see table 4.9) are that the seed purchased by them from market are of good quality and do not require germination test and some of them are not aware of it. Another reason could be the use of highest amount of home produced seed (@ 30Kgs/acre) in Madhya Pradesh state (see table 4.6). Seed treatment is crucial for preventing any damage to seed and thereby proper germination is seen. Treatment of seed with Bradi Rhizobium culture and PSB also helps in improving the yield. Seed treatment is generally done with chemicals such as thiram and Carboxin and at times biological treatment with Trichoderma virdi is also done. Along with recommendations of DSR with respect of seed treatment, farmers' traditional method of using cow urine along with ash and soil from beneath the banyan tree is also assessed for adoption across study states. Except in Madhya Pradesh, more than fifty percent of farmers are using chemical treatment. Other methods of seed treatment are used being used by very less percentage of farmers (table 4.7) across all states except in Maharashtra where in these methods are adopted by substantial number of farmers. The major reasons expressed by farmers across different states for not adopting some of these seed treatment methods are lack of money, lack of knowledge, not much improvement in crop yield, very slow results, failure to control pests and no necessity to treat the seed purchased from market (see tables 4.8, 4.9, 4.10 and 4.11).

Fertiliser application plays a key role in improving the crop yields. Use of fertilizers containing nutrients such as nitrogen, phosphorus, potassium and sulphur are recommended for application. The empirical data from table 4.7 clearly reveals that with respect to nitrogen nutrient, majority farmers across all states except Telangana, partially adopted the recommended dosages of nitrogen followed by partial adoption and phosphorus nutrients. In Telangana, majority of sampled households (87.96percent) were adopting application of nitrogen. With respect to Phosphorus, majority of them across all four states were partially adopting Phosphorus nutrient. Excepting Telangana state, potassium is not being adopted by farmers ranging between 25 to 48percent in the remaining three states. Sulphur application helps in improving soybean yields. Adoption of sulphur nutrient by sampled households is more in Maharashtra (29.95percent) followed by Madhya Pradesh (17.70percent), Telangana (13,52percent) and Rajasthan (1.56percent). Partial adoption was done by considerable percent of farmers in Madhya Pradesh, Maharashtra and Telangana states. Some of the major reasons for partial and non-adoption of all the above nutrients by sampled households

Table 4.8: Major Reasons for Partial and Non-adoption of DSR Recommended Soybean Package of Practices in the State of Rajasthan.

Reasons expressed by farmers	Partial Adoption	Non-Adoption	Total
Package of practice : Use of Farm Yard Manure			
Lack of Livestock	97 (148)	95 (57)	96 (205)
Could not maintain live stock due to poverty	3 (5)	5 (3)	4 (8)
Total	100 (153)	100 (60)	100 (213)
Package of practice ; Conducting Seed germination test			
Not aware of seed germination test	100 (8)	71 (17)	78 (25)
To clean up the seed with need grading machine	- (-)	8 (2)	6 (2)
Lack of spiral machine	- (-)	21 (5)	16 (5)
Total	100 (8)	100 (24)	100 (32)
Seed Treatment : Chemical Treatment			
Due to lack of money	50 (9)	76 (34)	75 (42)
No seed treatment for purchased seed from market	50 (9)	24 (11)	21 (12)
Total	100 (18)	100 (45)	100 (56)
Seed Treatment: Biological			
Not aware of Biological seed treatment	80 (4)	64 (236)	64 (240)
Seed treatment is done with only thiram	0 (0)	32 (118)	32 (118)
Results are very slow	20 (1)	4 (14)	4 (15)
Total	100 (5)	100 (368)	100 (373)

Table 4.8: contd..

Seed Treatment : With Phosphorus Solubilizing Bacteria			
Not aware of it	100 (5)	69 (262)	70 (267)
Not much use of it	- (-)	31 (115)	30 (115)
Total	100 (5)	100 (377)	100 (382)
Seed Treatment: With Bradi Rhizobium Culture			
Not aware of it	100 (4)	69 (260)	65 (247)
Not much use of it	- (-)	31 (118)	31 (118)
Total	100 (4)	100 (378)	100 (382)
Seed Treatment : With cow urine +Ash +Soil under the Banyan tree.			
We do seed treatment with only thiram	100 (6)	67 (251)	68 (230)
Results are slow	- (-)	33 (126)	32 (107)
Total	100 (6)	100 (377)	100 (337)
Fertiliser Application : Nitrogen			
To maintain soil productivity we do not used more fertilizers	25 (66)	- (-)	25 (66)
Soils gets spoiled due to higher use of chemical fertilizers	57 (147)	- (-)	57 (147)
Not much aware of these chemical fertilizers	18 (46)	- (-)	18 (46)
Total	100 (259)	- (-)	100 (259)
Fertilizer Application : Phosphorus			
To maintain soil productivity we do not used more fertilizers	21 (58)	- (-)	21 (58)
Soils gets spoiled due to higher use of chemical fertilizers	59 (164)	- (-)	59 (164)
Not much aware of these chemical fertilizers	20 (54)	- (-)	20 (54)

Table 4.8: contd..

Total	100 (276)	- (-)	100 (276)
Fertilizer Application :Potassium			
To maintain soil productivity we do not used more fertilizers	13 (13)	27 (50)	22 (63)
Soils gets spoiled due to higher use of chemical fertilizers	66 (67)	57 (105)	60 (172)
Not much aware of these chemical fertilizers	21 (21)	16 (30)	18 (51)
Total	100 (101)	100 (185)	100 (286)
Fertilizer : Sulphur			
To maintain soil productivity we do not used more fertilizers	22 (2)	17 (63)	17 (65)
Soils gets spoiled due to higher use of chemical fertilizers	44 (4)	29 (107)	29 (109)
Do not use Sulphur	11 (1)	39 (145)	39 (146)
Not much aware of these chemical fertilizers	22 (2)	15 (54)	15 (56)
Total	100 (9)	100 (369)	100 (378)
Spraying of weedicide before sowing			
The seed may get damaged	100 (5)	79 (293)	79 (298)
Seed will not germinate	- (-)	9 (32)	8 (32)
It is safer to spray weedicide after crop grows to a certain height.	- (-)	13 (48)	11 (40)
Total	100 (5)	100 (373)	100 (378)
Sowing distance : Line to Line			
We maintain spacing according to land available with us	63 (43)	- (-)	63 (43)
We maintain as per our requirement	22 (15)	--	22 (15)

Table 4.8: contd..

Due to higher seed rate we keep the distance closer	15 (10)	--	15 (10)
Total	100 (68)	--	100 (68)
Spraying of weedicide immediately after seed sowing			
It may affect germination of seed.	- (-)	100 (356)	100 (356)
Total	- (-)	100 (356)	100 (356)
Intercropping			
Due to fear of livestock we do not cultivate intercrops	17 (1)	72 (250)	71 (251)
Intercrops get affected when weedicide is sprayed.	33 (2)	12 (40)	12 (42)
Not used to growing intercrops	50 (3)	16 (57)	17 (60)
Total	100 (6)	100 (347)	100 (353)
Pest Management through NPM			
Non-pesticidal management methods are not effective	- (-)	9 (34)	9 (34)
Not aware of Non-pesticidal management methods	- (-)	85 (327)	85 (327)
Pest is not controlled effectively due to biological methods	- (-)	6 (23)	6 (23)
Total	- (-)	100 (384)	100 (384)

Source: Primary Survey

Include fear of soil getting spoiled, as FYM is added lesser dosage of chemical fertilizers is used, to reduce input costs, lack of access to money, lack of awareness regarding correct dosages, high cost of fertilizers, excess use results in plant lodging and lack of awareness regarding sulphur use in Soybean crop (see tables 4.8, 4.9, 4.10 and 4.11). Use of ferticum seed drill is important for achieving proper sowing depth for seeds and correct placement of fertilizer for the effective utilization by the germinating seed. Table 4.7 clearly indicates that there is very high adoption rate of this technology in the states of Rajasthan (99.74 percent) and Madhya Pradesh (98.18 percent) followed by (66.15 percent) and Telangana (22.59 percent).

Table 4.9: Major Reasons Expressed by Farmers for Partial and Non-adoption of DSR Recommended Soybean Package of Practices in the State of Madhya Pradesh

Package of practice : Use of Farm Yard Manure			
Reasons Expressed by Farmers	**Partial Adoption**	**Non-Adoption**	**Total**
Due to reduced livestock population, FYM availability has decreased.	86 (260)	13 (4)	80 (264)
Do not have livestock	10 (31)	87 (27)	17 (58)
FYM is costly to purchase	4 (10)	- (-)	3 (10)
Total	100 (301)	100 (31)	100 (332)
Package of practice ; Conducting of Seed germination test			
Purchased seed from market is of good Quality	46 (6)	83 (255)	81 (261)
Not aware of seed germination test.	54 (7)	17 (53)	19 (60)
Total	100 (13)	100 (308)	100 (321)
Seed Treatment : Chemical Treatment			
Not aware of seed treatment method	64 (14)	75 (232)	76 (253)
The chemical used for seed treatment is costly	9 (2)	10 (32)	10 (34)
Despite seed treatment pests do infest the crop.	27 (6)	15 (45)	15 (51)
Total	100 (22)	100 (309)	100 (331)
Seed Treatment: Biological			
Not aware	61 (19)	63 (219)	63 (238)
Ash is available in plenty	6 (2)	18 (61)	17 (63)

Only one method of seed treatment is adopted	32 (10)	17 (60)	19 (70)
Total	100 (31)	100 (347)	100 (378)
Seed Treatment : With Phosphorus Solubilizing Bacteria			
Not aware	54 (15)	66 (230)	65 (245)
Only one method of seed treatment is adopted	46 (13)	34 (120)	35 (133)
Total	100 (28)	100 (350)	100 (378)
Seed Treatment: With Bradi Rhizobium Culture			
Not aware	65 (13)	75 (270)	74 (283)
we use only one method of seed treatment	35 (7)	25 (90)	26 (97)
Total	100 (20)	100 (360)	100 (380)
Seed Treatment : With cow urine +Ash +Soil under the Banyan tree			
Not aware	81 (59)	41 (246)	85 (305)
Only one method of seed treatment is adopted	19 (14)	14 (41)	15 (55)
Total	100 (73)	100 (287)	100 (360)
Fertilizer Application : Nitrogen			
Used lesser quantity of chemical fertilizer	60 (173)	- (-)	60 (173)
Do not have knowledge of exact dosage of fertilizer to be applied	23 (67)	- (-)	23 (67)
The cost of fertilizer is high in the market	8 (22)	- (-)	8 (22)
If higher dosage is used the land gets spoiled	9 (26)	- (-)	9 (26)

Total	100 (288)	- (-)	100 288)
Fertilizer Application : Phosphorus			
Do not have knowledge of exact dosage of fertilizer to be applied	52 (151)	- (-)	52 (151)
Used lesser quantity of chemical fertilizer	37 (108)	- (-)	37 (108)
The cost of fertilizer is high in the market	11 (32)	- (-)	11 (32)
Total	100 (291)	- (-)	100 (291)
Fertilizer Application :Potassium			
Do not have knowledge of exact dosage of fertilizer to be applied	34 (69)	43 (41)	37 (110)
We used lesser quantity of chemical fertilizer	58 (119)	39 (37)	52 (156)
Fertilizer is costly	8 (16)	19 (18)	11 (34)
Total	100 (204)	100 (96)	100 (300)
Fertilizer : Sulphur			
Used lesser quantity of chemical fertilizer	84 (111)	38 (70)	57 (181)
Not aware of use of sulphur in soybean crop	9 (12)	43 (80)	29 (92)
To reduce input costs, we use less fertilizer.	7 (9)	18 (34)	14 (43)
Total	100 (132)	100 (184)	100 (316)
Spraying of weedicide before spraying			
Land gets spoilt	13 (7)	39 (92)	34 (99)
seed will not germinate	83 (45)	36 (85)	45 (130)

we are not aware of its utility	4 (2)	19 (46)	16 (48)
Total	100 (54)	100 (237)	100 (291)
Sowing distance : Line to Line			
Not aware of exact spacing to be maintained	60 (59)	- (-)	60 (59)
Use more seed and hence no problem	21 (21)	- (-)	21 (21)
If you sow wide the crop yield will be less.	18 (18)	- (-)	18 (18)
Total	100 (98)	- (-)	100 (98)
Sowing distance: Plant to Plant			
depending upon soil type and soil depth we take up sowing	60 (112)	- (-)	60 (112)
Used more seed and hence no problem	21 (39)	- (-)	21 (39)
With more seed rate crop yield will be more.	20 (37)	- (-)	20 (37)
Total	100 (188)	- (-)	100 (188)
Sowing Depth			
Not aware of exact depth to be sowed	59 (54)	- (-)	59 (54)
with more seed rate crop yield will be more	23 (21)	- (-)	23 (21)
Used more seed and hence no problem	18 (17)	- (-)	18 (17)
Total	100 (92)	- (-)	100 (92)
Spraying of weedicides immediately after seed sowing			
Herbicide will be effective only when the weed grows a bit.	- (-)	43 (130)	43 (130)

seed will not germinate	- (-)	37 (112)	37 (112)
Not aware of practice	- (-)	20 (59)	20 (59)
Total	- (-)	100 (301)	100 (301)
Intercropping			
There is problem while spraying weedicide/pesticide	- (-)	27 (94)	27 (94)
due to intercrops livestock gets attracted and soya gets damaged	- (-)	29 (101)	29 (101)
we have difficulty in sowing more than one crop	- (-)	21 (75)	21 (75)
Sole crop of soybean gives more profits	- (-)	24 (83)	24 (83)
Total	- (-)	100 (353)	100 (353)
Pest Management through NPM			
Not aware of non-pesticidal management methods	- (-)	71 (241)	71 (241)
These methods cannot control the pests	- (-)	12 (40)	12 (40)
Products are not available in the market.	- (-)	10 (34)	10 (34)
preparation of these products involves lot of labour.	- (-)	7 (23)	7 (23)
Total	- (-)	100 (338)	100 (338)

Source: Primary Survey

The reasons cited by farmers for the low adoption of this technology in state of Rajasthan are lack of awareness and money (see table 4.8) whereas in Telangana the reasons were non-availability of equipment, habit of taking up sowing using bullocks and apprehensions that seed may not fall at proper depth due to ferti-cum seed drill (see table 4.11). For controlling weeds, very few farmers are taking up spraying of pesticide before sowing, that too only in the states of Maharashtra and Madhya Pradesh. The reasons expressed by farmers across states include-farmers habit of taking up spraying only after 19 DAS; fear of seed getting damaged; it is safer to spray weedicide only after crop reaches a certain height and lack of awareness about the utility of adopting this practice. The adoption of sowing distance is crucial for proper crop stand which in turn impacts the crop yield. Table 4.7 clearly indicates that line to line sowing distance is adopted by majority of the sampled households across all states. Plant to plant distance is followed 100 percent in Rajasthan, followed by Telangana (67.22percent), Madhya Pradesh (51.04percent) and Rajasthan (29.68percent). The reasons cited by farmers for lesser adoption are: due to adoption of higher seed rate lesser distance is maintained; farmers feel what they adopt is appropriate; with more seed and closer distance, the crop yield will be more; depends on soil type and soil depth, not aware of proper plant to plant spacing and as neighboring farmers broadcast we also broadcast the seed (see table 4.9, 4.10 and 4.11). Similar scenario exists across all states with reference to adoption of soil depth. The reasons expressed by farmers for partial adoption include - their existing practice suits them, as herbicide is sprayed immediately after sowing it is sown deeper to prevent damage to seed, as higher seed rate is used not much problem is seen with deeper sowing and lack of awareness about proper sowing depth. Except in Maharashtra (30.72 per cent farmers), in other states very small percentage of farmers are spraying weedicide immediately after sowing. The practice of weed control either through manual weeding, inter-cultivation with bullocks and weedicide spray between 3rd to 6th weeks is adopted by 100 per cent sampled households in Telangana state followed by Madhya Pradesh (98.96percent), Rajasthan (97.66percent) and Maharashtra (92.97percent). More than 95 per cent of farmers across all states are adopting recommended technology with respect to pest and disease management through pesticide application. However, pest management through non-pesticidal management methods is negligible in the states of Rajasthan and Telangana. But in Maharashtra 38.54 percent of farmers are also using environment friendly pest management methods and in Madhya Pradesh 11.98percent are adopting it. The reasons for non-adoption by other farmers across all states include: lack of awareness about these methods, ineffectiveness of NPM methods, lack of availability of readymade products and preparation of these bio-pesticides is laborious and time consuming. Addressing the issues brought out by farmers with respect to adoption of recommended package of practices of Directorate of Soybean research, Indore will help in improving the soybean production and productivity in major soybean growing states of India.

Table 4.10: Major Reasons for Partial and Non-adoption of DSR Recommended Soybean Package of Practices in the State of Maharashtra

Package of practice : Use of Farm Yard Manure			
Reasons Expressed by Farmers	**Partial Adoption**	**Non-Adoption**	**Total**
Lack of Livestock	51 (40)	70 (64)	60 (104)
Could not maintain live stock due to poverty	28 (22)	4 (4)	15 (26)
Livestock numbers are maintained as per land holding of HH	12 (9)	3 (3)	7 (12)
Lack of money to buy Farm yard manure	4 (3)	(12)	(15)
Total	100 (78)	100 (91)	100 (173)
Package of practice : Conducting of Seed germination test			
Not aware of seed germination test.	44 (8)	25 (49)	26 (57)
To clean up the seed we need grading machine	6 (1)	6 (12)	6 (13)
Lack of spiral machine	- (13)	7 (13)	6
As we buy the seed from market, we don't go for germination test	50 (9)	63 (125)	62 (134)
Total	100 (18)	100 (199)	100 (217)
Seed Treatment : Chemical Treatment			
Due to lack of money	29 (12)	55 (68)	49 (80)
Do not do seed treatment for purchased seed	17 (7)	20 (25)	20 (32)
Not aware of it	12 (5)	11 (13)	11 (18)
Not much improvement in the crop yield	41 (17)	14 (17)	21 (34)

Total	100 (41)	100 (123)	100 (164)
Seed Treatment: Biological			
Not aware of Biological seed treatment	49 (22)	66 (158)	64 (181)
Seed treatment is done with only thiram	29 (13)	23 (55)	24 (68)
Not much effect on crop yield	22 (10)	11 (25)	12 (35)
Total	100 (45)	100 (238)	100 (283)
Seed Treatment : With Phosphorus Solubilizing Bacteria			
Not aware of it	-	79 (161)	72 (161)
Not much use of it	100 (21)	21 (43)	28 (64)
Total	100 (2)	100 (204)	100 (225)
Seed Treatment: With Bradi Rhizobium Culture			
Not aware of it	70 (23)	67 (143)	67 (166)
Not much use of it	30 (10)	33 (71)	33 (81)
Total	100 (33)	100 (214)	100 (247)
Seed Treatment : With cow urine +Ash +Soil under the Banyan tree			
Seed treatment with only thiram is done	-	65 (136)	63 (136)
Results are slow	100 (7)	35 (72)	37 (79)
Total	100 (7)	100 (208)	100 (215)
Fertiliser Application : Nitrogen			
we fear that soil may get damaged	31 (65)	-	31 (65)

Use lesser dosages as we use certain amount of FYM	23 (50)	-	23 (50)
Lack of access to money	35 (74)	-	35 (74)
To reduce our input costs	7 (15)	-	7 (15)
Not aware of exact recommended dosages for the crop.	4 (9)	-	4 (9)
Total	100 (213)	-	100 (213)
Fertiliser Application : Phosphorus			
Use lesser quantities due to its higher cost	34 (98)	-	34 (98)
Use complex fertilizers	28 (79)	-	28 (79)
To reduce our input costs	22 (64)	-	22 (64)
Use FYM and hence lesser quantities.	16 (45)	-	16 (45)
Total	100 (287)	-	100 (287)
Fertiliser Application :Potassium			
To reduce our input costs	57 (92)	72 (75)	64 (173)
We use complex fertilizers	30 (48)	13 (13)	22 (61)
We use lesser dosages as we use certain amount of FYM	13 (22)	15 (16)	14 (38)
Total	100 (162)	100 (104)	100 (272)
Fertiliser : Sulphur			
Use lesser quantities due to its higher cost	50 (78)	55 (56)	53 (134)
Use complex fertilizers	34 (52)	33 (33)	33 (85)

We use lesser dosages as we use certain amount of FYM	16 (25)	12 (12)	14 (37)
Total	100 (155)	100 (1 01)	100 (256)
Use of Ferticum seed drill			
Not aware of it	- (111)	93 (111)	93
Lack of money	-	7 (8)	7 (8)
Total	- (119)	100 (119)	100 (119)
Spraying of weedicide before sowing			
we spray weedicide only after 19 days of Sowing	62 (5)	69 (210)	68 (215)
We grow crop after it reaches certain height	13 (1)	14 (42)	14 (43)
The seed may get damaged	-	10 (30)	10 (30)
We spray weedicide only after a week.	25 (2)	7 (22)	8 (24)
Total	100 (8)	100 (304)	100 (312)
Sowing distance : Line to Line			
We maintain spacing according to land available with us	71 (160)	-	71 (160)
we need to maintain this much only	19 (42)	-	19 (42)
We maintain as per our requirement	10 (22)	-	10 (22)
Total	100 (224)	-	100 (224)
Sowing distance: Plant to Plant			
As we are using higher seed rate we maintain lesser distance between plants.	65 (142)	-	65 (142)
we need to maintain this much only	35 (77)	-	35 (77)

Total	100 (219)	-	100 (219)
Sowing Depth			
What we adopt suits us	65 (98)	-	65 (98)
As we spray weedicide immediately after sowing	35 (52)	-	35 (52)
Total	100 (150)	-	100 (150)
Spraying of weedicides immediately after seed sowing			
It may affect germination of seed.	-	55 (129)	55 (129)
employed manual labour to remove weeds	- (109)	45 (109)	45
Total	- (241)	100 (241)	100
Intercropping			
The livestock may eat the crops cultivated as intercrop	- (71)	53 (71)	53
Intercrops get damaged due to weedicide sprayings	- (41)	30 (41)	30
Need to spend more amount in harvesting these crops	- (23)	17 (23)	17
Total	- (135)	100 (135)	100
Pest Management through NPM			
Non-pesticidal management methods are not effective	- (23)	11 (23)	11
Not aware of Non-pesticidal management methods	- (135)	66 (135)	66
Ready made products are not available	- (47)	23 (47)	23
Total	**-** **(205)**	**100** **(205)**	**100**

Source: Primary Survey

Table 4.11: Major Reasons for Partial and Non-adoption of DSR Recommended Soybean Package of Practices in the State of Telangana

Reasons Expressed by Farmers	Partial Adoption	Non-Adoption	Total
Package of Practice : Use of Farm Yard Manure			
Due to lack of enough livestock we apply only once in 3 years	89 (57)	66 (138)	71 (195)
Lack of money	2 (1)	13 (28)	11 (29)
Lack of availability	6 (4)	11 (23)	10 (27)
If FYM is applied weed growth will be high	3 (2)	10 (21)	8 (23)
Total	100 (64)	100 (210)	100 (274)
Package of practice ; Conducting of Seed germination test			
We use govt, supplied seed and germination is assured	- (-)	72 (260)	72 (260)
Till now we have not done and no one told us about this	(-)	20 (73)	20 (73)
Due to lack of time	- (-)	8 (29)	8 (29)
Total	- (-)	100 (362)	100 (362)
Seed Treatment : Chemical Treatment			
Not aware of it	- (-)	79 (104)	78 (104)
Women doing seed treatment gets fever and eyes burn when this powder falls in eyes.	100 (1)	21 (28)	22 (29)
Total	100 (1)	100 (132)	100 (133)
Seed Treatment: Biological			
These methods are cumbersome processes	75 (3)	95 (494)	95 (497)
we get Seed which is already treated	25 (1)	5 (26)	5 (27)
Total	100 (4)	100 (520)	100 (524)

Seed Treatment : With Phosphorus Solubilizing Bacteria			
Not aware	100 (4)	100 (522)	100 (526)
Total	100 (4)	100 (522)	100 (526)
Seed Treatment: With Bradi Rhizobium Culture			
Not aware	100 (4)	100 (518)	100 (522)
Total	100 (4)	100 (518)	100 (522)
Seed Treatment : With cow urine +Ash +Soil under the Banyan tree			
Not aware	100 (3)	100 (523)	100 (526)
Total	100 (3)	100 (523)	100 (526)
Fertilizer Application : Nitrogen			
Use according to their own knowledge	67 (35)	- (-)	67 (35)
Not aware about the exact quantities to be applied	33 (17)	- (-)	33 (17)
Total	100 (52)	- (-)	100 (52)
Fertilizer Application : Phosphorus			
If excess is applied, plant lodges	14 (70)	31 (5)	15 (75)
Use according to their own knowledge	86 (422)	69 (11)	85 (433)
Total	100 (492)	100 (16)	100 (508)
Fertilizer Application :Potassium			
Not aware of it	12 (56)	20 (5)	13 (61)
If this fertilizer is used the leaves gets burnt	88 (397)	80 (20)	87 (417)
Total	100 (453)	100 (25)	100 (478)
Fertilizer : Sulphur			
Not aware of sulphur application for soybean	100 (314)	100 (116)	100 (430)

Total	100 (314)	100 (116)	100 (430)
Use of Ferticum seed drill			
Equipment is not available	- (-)	42 (158)	42 (158)
Sowing is done using bullocks	- (-)	38 (141)	38 (141)
Seeds may not fall properly due to seed drill	- (-)	20 (73)	20 (73)
Total	- (-)	100 (372)	100 (372)
Spraying of weedicide before sowing			
As weeds wont be there no weedicide is used	34 (1)	49 (236)	49 (237)
Not aware of using weedicide	- (-)	28 (136)	28 (136)
As others are not doing , we are not doing	33 (1)	13 (63)	13 (64)
We use it only after 21 days after sowing	33 (1)	10 (49)	10 (50)
Total	100 (3)	100 (484)	100 (487)
Sowing distance : Line to Line			
As others are broad casting, we are also do the sme	30 (69)	- (-)	30 (69)
The yield will be reduced	30 (68)	- (-)	30 (68)
No body informs us about the proper spacing	23 (53)	- (-)	23 (53)
we need more labour	17 (40)	- (-)	17 (40)
Total	100 (230)	- (-)	100 (230)
Sowing distance: Plant to Plant			
As others are broad casting, we also do the same.	- (-)	82 (108)	67 (108)
No body informs us about the proper spacing	61 (19)	12 (16)	21 (35)
The yield will be reduced	39 (12)	6 (8)	12 (20)

Total	100 (31)	100 (132)	100 (163)
Sowing Depth			
As others are broad casting, we also do the seed	89 (109)	- (-)	89 (109)
No body informs us about the proper sowing depth	11 (13)	- (-)	11 (13)
Total	100 (122)	- (-)	100 (122)
Spraying of weedicides immediately after seed sowing			
There is no need to spray immediately after sowing	- (-)	32 (145)	32 (145)
Not aware of it.	- (-)	25 (112)	25 (112)
Weedicides spoils the fertility of soil	- (-)	23 (103)	23 (103)
we spray only three weeks	- (-)	20 (94)	20 (94)
Total	- (-)	100 (454)	100 (454)
Intercropping			
If intercropping is adopted we cannot take rabi crop	- (-)	51 (112)	51 (112)
Other crops do not come well	- (-)	23 (51)	23 (51)
Lack of irrigation	- (-)	15 (32)	15 (32)
The shade of intercrops reduces soybean yield	- (-)	11 (25)	11 (25)
Total	- (-)	100 (220)	100 (220)
Pest Management through NPM			
Not aware of NPM methods	- (-)	92 (486)	92 (486)
Only chemical control methods give good yield	- (-)	5 (27)	5 (27)
Preparation of biopesticdes takes much time.	- (-)	3 (18)	3 (17)
Total	- (-)	**100** **(531)**	**100** **(531)**

4.7: Determinants of Adoption

Yield levels are dependent on the adoption of package of practices recommended by the scientific community for the crop. But there is variation in adoption of package of practices across different locations (selected sample sites), category of farmers. Adoption also depends on individual characteristics of farmers like age, level of education, and experience in cultivation of soybean crop possession of agricultural assets; farming characteristics like whether farmers received extension, or received training and so on. Adoption of package of practices which is indexed as a score (giving a rank of 0, 1 and 2 to non adopters, partially adopters and full adopters respectively) is regressed on the above mentioned variables and the results are discussed below.

Adoption of package of practices=

f (a+ b1x1+ b2x2+b3x3+b4x4+b5x5+b6x6+b7x7+……+u)

Where X1= land holding in acres

X2= number of years of education

X3= tractor if used tractor=1 otherwise=0

X4= livestock if owning livestock =1 otherwise=0

X5= extension and training services if received =1 otherwise =0

X6= whether taken loan for soybean cultivation 1= yes otherwise = 0

Source of information

X7 = Radio

X8 = Television

X 9 = Neighbouring farmers

X 10 = Agricultural department

X 11 = NGOs

X 12 = Fertiliser and pesticide dealers

X 13 = Agricultural University

X 14 = Private Companies

Dummy variables

Age of Farmers category

Farmers below 25 yrs age (reference category)

Farmers between 26 to 35 yrs age

Farmers between 36 to 45 yrs age

Farmers above 45 yrs age

Land holding category

Marginal farmers (reference category)

Small farmers= 2

Medium farmers = 3

Big farmers = 4

States

Rajasthan (reference state)

Madhya Pradesh = 2

Maharashtra = 3

Telangana = 4

Table 4.12: Determinants of Adoption of Technology (package of practices): Regression Results

Notation	Variables	Coefficient	Standard error	P > | t |
X1	Land holding	-0.0057103	0.0074968	0.446
X2	Years of education	-0.0083047	0.0095887	0.387
X3	Tractor	0.1196695	0.1447762	0.409
X4	Livestock	0.7752628	0.1075335	0.000***
X5	Extension and Training score	0.1108516	0.045642	0.015**
X6	Credit	0.437786	0.1887784	0.021**
X7	Radio	0.3249791	0.1312699	0.013***
X8	TV	0.3901939	0.0978724	0.000***
X9	Neighboring farmers	0.6497448	0.14766751	0.000***
X10	Agriculture Department	0.4344036	0.0989973	0.000***
X11	NGOS	0.2669374	0.153599	0.082*
X12	Fertilizer and pesticide dealers	-0.1045364	0.0975821	0.284
X13	Agriculture University	0.2812773	0.3336291	0.399
X14	Private Companies	-0.0255521	0.117295	0.828
Dummy Variables				
Headagecat2	26-35 Yrs	-0.3635835	0.2855855	0.203
Headagecat3	36-45 Yrs	-0.4128248	0.2794423	0.140
Headagecat4	Above 45 Yrs	-0.4046487	0.2782186	0.146
Category 2	Small	0.1754127	0.1413587	0.215
Category 3	Medium	0.4919371	0.1408448	0.000***
Category 4	Big	0.7502069	0.181761	0.000***
State 2	Madhya Pradesh	-1.645341	0.1413383	0.000***
State 3	Maharashtra	-0.5159646	0.1359426	0.000***
State 4	Telangana	-0.7630483	0.1956076	0.000***
	Constant	11.0734	0.3823736	0.000***

Note: *** P =0.01 ** P0.05 * P=0.10. R-Square=0.24, F-value=21.31

Table 4.13: Distribution of Respondents according to their usage of Soybean produced by them in study states during 2014-15 (percent)

Particulars	Rajasthan		Total (N=384)	Madhya Pradesh		Total (N=384)	Maharashtra		Total (N=384)	Telangana		Total (N=540)	All States
	Jhalawar (N=192)	Kota (N=192)		Ujjain (N=192)	Rajgadh (N=192)		Amaravathi (N=192)	Latur (N=192)		Adilabad (N=252)	Nizamabad (N=288)		
Use of Soybean produces													
Yes	33	26	30	2	5	3	51	43	47	2	1	2	19
No	67	74	70	98	95	97	49	57	53	98	99	98	81
Total	100	100	100	100	100	100	100	100	100	100	100	100	100
Purpose of Use													
Pulse	0	8	4	25	22	23	4	7	6	0	0	0	5
Papad	13	2	8	50	78	69	15	93	51	20	25	22	35
Mixing with wheat flour	0	0	0	0	0	0	81	0	44	40	75	56	27
Soya wadi	0	0	0	25	0	8	0	0	0	0	0	0	0
Others	88	90	89	0	0	0	0	0	0	40	0	22	33
Total	100	100	100	100	100	100	100	100	100	100	100	100	100
Do you buy soybean related products from market													
Yes	97	99	98	75	97	86	96	96	96	52	30	40	77
No	3	1	2	25	3	14	4	4	4	48	70	60	23
Total	100	100	100	100	100	100	100	100	100	100	100	100	100
If yes what are the products that are purchased?													
Soya nuggets	0	1	1	1	0	0	1	4	2	33	42	36	7
Soy milk	0	0	0	4	0	2	1	1	1	0	0	0	1
Soya panner	0	0	0	3	1	2	0	0	0	2	0	1	1
Soya granules	0	0	0	1	0	0	0	0	0	11	0	7	1
Soya flour	0	0	0	1	0	0	4	1	2	0	0	0	1
Soya oil	100	99	99	88	98	93	95	94	94	51	21	39	87
Soya namkeen	0	0	0	1	0	0	0	0	0	2	37	16	3
Soya pakode	0	0	0	1	0	1	0	0	0	2	0	1	0
Others	0	0	0	1	2	1	0	1	0	0	0	0	0
Total	100	100	100	100	100	100	100	100	100	100	100	100	100
Do you use soya feed for your livestock?													
Yes	92	89	90	84	90	87	94	96	95	85	17	47	77
No	8	11	10	16	10	13	6	4	5	15	83	53	23
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: Primary Survey

The earlier section has given the details of the recommended practice packages by the farmers for optimum yield of soybean crop. Some of these practices are followed by all the farmers and some are least followed. Based on our field data the determining factors have been grouped as:

a) Farmers'characteristics (land holding, education, age)

b) Farming related (tractor, livestock, extension & training, credit)

c) Sources of information on crucial inputs which contribute to the adoption of practices (weather, seed, soil fertility, pest & disease, machinery and market price).

As the age of the farmers is increasing adoption of practices declines showing that younger age group farmers are adept at adopting practices. However the adoption practices by older age farmers are not significantly different from the younger age farmers. Farmers who received extension and training, farmers owning livestock, and farmers who took credit for soybean crop cultivation have adopted the technology since some practices are related to use of farm yard manure. Farmers who have received information on various aspects like weather, seed variety, soil testing, disease and pest management, weedicide and herbicide, disease symptoms, pest management, market price and so on have adopted the technology related to soybean crop. The predominant source of information for the farmers is neighbouring farmers, radio, TV, agriculture department, NGOs, in that order. This order changes somewhat in the different states. In the sample villages of Madhya Pradesh highest number of farmers have accessed information from neighboring farmers compared to all other states. In sample villages of Maharashtra and Telangana pesticide dealers are the major source of information. Agriculture department plays better role in giving information in Maharashtra and Telangana. Our regression results show that the sources of radio, TV, neighbouring farmers, agriculture department, and NGOs are significantly determining the adoption of practices while fertilizer and pesticide dealers is negatively (not significant) determining the source of information. This shows that farmers are rational in using the information for the farming practices and that they are using information only received through reliable sources like agriculture department, TV and radio. This suggests policy measures for strengthening of reliable sources of information to farmers.

Adoption of technology is also significantly taken up by medium and big farmers on par with marginal farmers and compared to the reference state of Rajasthan (where adoption is lowest) all other states have significantly higher adoption levels (Table 4.12).

4.8: Uses of Soybean

The study tried to understand the situation with reference to soya produced by them in their own farms. It could be seen from table 4.13 that above 97 per cent of sampled households in Madhya Pradesh and Telangana do not use soya produced by them in their farms. However, 30 percent of sampled households in Rajasthan and 47 percent households in Maharashtra responded positively with respect to the use of soybean produced in their own farms. Those households who are using soya from their farms were analysed regarding the purpose for which it is being used. It could be seen from table 4.13 that in the case of Maharashtra it is primarily being used to mix with wheat flour for chapathi making and also for papad making. In Rajasthan it is being used for papad making and also for other purposes. Table 4.13 indicates that except in Telangana state sampled households of other states have been purchasing soya products from the market and that too primarily soya oil. Majority of these households are also using soya feed for their livestock.

4.9: Concluding Observations

More than 85 percent of farmers in study villages are cultivating JS-95-60 in their fields during the year 2014 Kharif. Adilabad and Nizamabad district of Telangan state indicate that more than 95 per cent of soybean farmers are using only JS-335 variety due to its suitability to them. All these factors contributed to poor performance of all the varieties in Kota district of Rajasthan during 2014-15. Though similar kind of rain was prevalent in Jhalawar district of Rajasthan, good drainage in the soils of study sites did not cause much economic damage as compared to Kota. Another reason is the prevalence of Patidar Community in the study region of Jhalawar district who adopt latest and progressive methods in soybean cultivation. Farmers cultivating NRC-7 (Ahilya-3) in Ujjain district of Madhya Pradesh were achieving recommended yields.

Farmers cultivating NRC-7 (Ahilya-3) in Ujjain district of Madhya Pradesh were achieving recommended yields. It is very clear from table 4.6 that during 2014-15 all the soybean varieties grown by majority of sampled households are doing extremely well in Ujjain district of Madhya Pradesh giving the recommended yields. Nearly 60 percent of the seed used in Ujjain district of Madhya Pradesh and 50 percent of seed in Jhalawar district of Rajasthan, is the seed saved by farmers from their own previous crop.

In Maharashtra, farmers are depending mostly on private companies and whereas in Telangana state farmers are getting seed on subsidy from the state department of agriculture for the improvement of area under soybean cultivation. Public sector research made phenomenal contribution to the development of varieties with respect to soybean crop and thereby increase in its cultivation area. These include JS 71-05, JS-335, JS-95-

60, JS-90-41, JS-93-05, Pant Soybean, NRC-7, Phule Kalyani (DS-228), Punjab-1, JS-97-52, MAU-71 and MAUS-162. Among public sector developed varieties of soybean, Indian Council of Agricultural Research (ICAR) has contributed maximum for the development of soybean varieties through. Nearly 96 percent of the sampled households (see table 4.5) are growing varieties developed by ICAR.

CHAPTER V

Measurement and Analysis of Total Factor Productivity Growth in Soybean Crop in Selected States in India

5.1: Context

Soybean crop is being cultivated from a long period in the states of Madhya Pradesh, since the year 1971 onwards, while it is being cultivated from 1981 onwards in Rajasthan, 1986 onwards in Maharashtra and 1991 onwards in Telangana region in undivided Andhra Pradesh. It is of interest to examine the total factor productivity of the crop for the different states selected for the study as they can be segregated as long term cultivating (MP) and middle term cultivating (Rajasthan and Maharashtra) and newly cultivating states (Telangana) based on their period of cultivation. This raises the issues whether the long term cultivating states have reached stagnation in productivity and the variation in productivity of crop in middle term cultivating and newly cultivating states. Besides the highest growth of soybean production and productivity was in the period during 1985-86 to 1998-99 which is called the 'golden period' of soybean in India followed by a period of decline during 1999-2000 to 2002-03 and then a period of recovery during 2003-04 to 2012-13 which is designated as 'period of renewed growth'. Soybean stood next to cotton crop and it is also predicted that in the next 30-40 years it will surpass cotton crop to have the highest growth rate in the country (Chand 2014). In this context it becomes important to assess the growth in productivity of soybean crop over a long period of time and across the selected states in view of the above raised issues. The earlier chapter has analyzed partial factor productivity in terms of land productivity in all the selected states and the present chapter analyses the total factor productivity of soybean crop.

5.2: Research Questions

The research questions this chapter addresses are

What is the total factor productivity (TFP) of soybean crop in the selected states of Madhya Pradesh, Rajasthan and Maharashtra?

What are the sources of TFP growth which are not included in the estimation of TFP in soybean crop?

5.3: Concept of TFP

The index of TFP may be defined as the ratio of weighted combination of output to a weighted combination of inputs. Estimates of TFP indices are designed to provide an indication of the change in output per unit of total factor input. TFP would be equal to the rate of growth of output minus the rate of growth of input in the case of homogenous output and single homogenous input. But in reality output and inputs are multi factor and multi product cases where calculation of TFP becomes complex and may raise conceptual and empirical problems (Reddy 1997). Various methods are used to compute the TFP index, like the Divisia index, Tornquist and Theil index. Divisia index of all measured outputs divided by divisia index of all measured inputs gives an estimate of the productivity change that occurred apart from the changes in inputs.

For estimating the TFP for the soybean crop the output index is for the single crop but input index is a composite index of all the inputs used in the cultivation of the crop. As there are several inputs these are aggregated by the Divisia index for computing the total input price index and quantity index. The input price index and the input quantity index have been estimated by two methods, the first is fixed base with 1996-97 as the base and second is chain base index. The latter method enables to take into account changes over time especially in case of long periods. When the chain base method is used comparison is not made with fixed base but is made with changing base from year to year.

$$\ln z_t = \sum_{i=1}^{4} \left\{ \frac{w_{it} + w_{it-1}}{2} \right\} \ln \frac{p_{it}}{p_{it-1}}$$

The chain index linked to the base year (I_1) is obtained by It= It-1 * Zt where Zt= aggregate input price indices in period't'.

Four inputs are seed, fertilizer, human labour and animal labour

Wit=share of the i-th input in t-th year and Pit = price of the i-th input in the t-th year.

The computation of the output and input indices was done taking the current prices. Data on four inputs was taken, seed (Rs per kg), fertilizer (Rs per kg), human labour (Rs per hour) and animal labour (Rs per hour) for the input index. Further organic manure (Rs per quintal) has been converted and aggregated to fertilizer and machine labour converted and aggregated to animal labour. All these inputs covered nearly 90 percent of the operational costs. Pesticide is an important input but because of lack of comparable data across states it could not be taken. As soybean is a rain fed crop irrigation charges and power charges are not important and other input expenses like interest on working capital, fixed costs could not be taken due to data constraints. The share of the various inputs (percentage of input cost to total operational cost) is taken as the weight of the respective inputs and the shares of each input is estimated. Growth rate of the inputs used is taken by taking the logarithm of different input quantities. The growth rate of the input aggregate is taken as the weighted average of the growth rate of the components input share multiplied by input quantity and divided by two. The input index is calculated from the aggregated inputs as the exponential of the aggregated weighted inputs. The Divisia index is obtained by aggregating the input index. Total factor productivity index is obtained by dividing total output index by aggregate input index.

Total Output Index (TOI) = $\frac{Qt}{Qo}$ x 100

where Qt = current year's output per hectare, and Qo = base year's output per hectare.

Total Input Index (TII): Tornqvist suggested the approximation for the Divisia index as

$$lnZ_t = \sum_{i=1}^{4} \left\{ \frac{W_{it} + W_{it-1}}{2} \right\} \ln \frac{Y_{it}}{Y_{it-1}}$$

Zt = eInZt, It = It-1. Zt where Zt is the aggregate input measure and yit is the quantity of i-th input in period 't', wit is share of the i-th input in period 't' in operational cost. This is a quantity chain base index linked to base year. So the TFP is given by

$$\text{TFP} = \frac{Q_t \div Q_o}{Z_t \div Z_o} \quad \frac{\textbf{Output Index}}{\textbf{Aggregate Input Index}}$$

5.4: Data and Methodology

Soybean production has started in India from the decade of 1970. Soybean crop cultivation has started in Madhya Pradesh from 1971 while it started from 1980 in Rajasthan and from 1986 in Maharashtra and from 1991 in undivided Andhra Pradesh. The TFP has been measured for the states of MP, Rajasthan and Maharashtra for the period of 17 years from 1996-97 to 2012-13.

This study uses the cost of cultivation data from 1996-97 to 2012-13 collected under the Comprehensive Scheme of Cost of Cultivation of Principal crops, DES Government of India for the three selected states of Madhya Pradesh, Rajasthan and Maharashtra. Cost of cultivation data for soybean crop for the undivided state of Andhra Pradesh is not available and hence TFP was estimated for only three states. Cost of cultivation data for the three states has been collected from the secondary sources, directorate of

Economics and Statistics. The data in MP is collected from an average number of 276 farmers falling in 34 tehsils and in Rajasthan the sample of holdings range from an average of 47 sample holdings in 8 tehsils. In Maharashtra the average number of sample holdings is 163 located in 31 tehsils.

5.5: Trends in Yield and Cost of Production of Soybean Crop

In the entire period of soybean crop cultivation in the country there are two trough periods in terms of yield per hectare, one is 1982-86 period and the second is 2000-03. Average yield fell all time low in MP and Rajasthan in 1980-82 TE and again fell in 2002-03 TE. Average yields have reached peak in 2012-13 TE at the country level and also in all the states. Among all the states MP has lowest average yield from 1992-93 onwards. Telangana in undivided state of AP has highest average yield in 2012-13 (Figure 5.1).

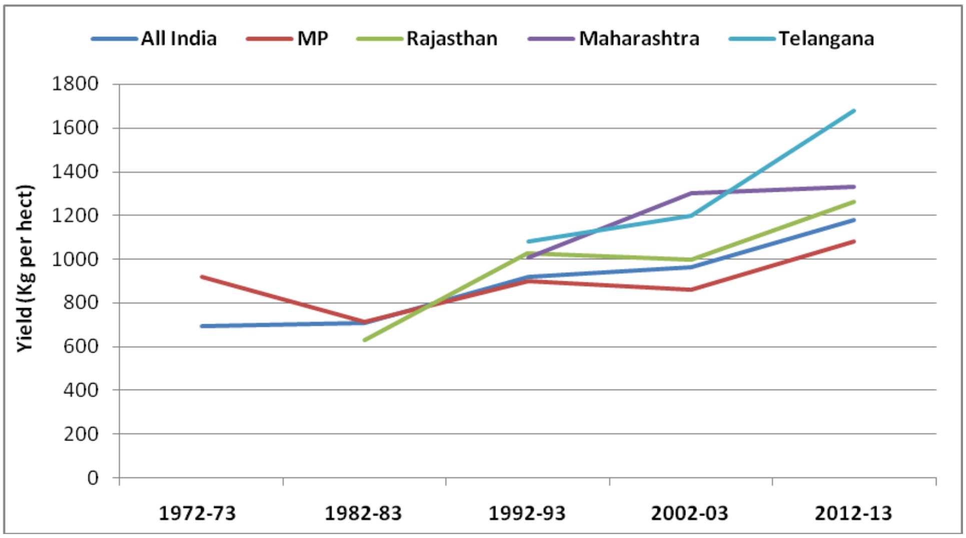


Figure 5.1: Average Yield per Hectare in Different Time Periods (TE)

Source: Directorate of Economics and Statistics

The yield per hectare of soybean crop at the All India has been increasing at 0.32 percent (CAGR) for the entire period of cultivation. Among the selected states MP registered 0.78 growth rate for the entire period. Decade wise growth rate in MP shows it is highest in the first decade (1972-73 to 1982-83) and fell down in the fourth decade (2001-2010). Similar pattern can be seen in all the other states too. Overall growth rate is better for the states of Rajasthan and Maharashtra (Table 5.1).

Table 5.1: Changes in Yields (qtls/ha) Across Selected States (CAGR)

Year (Triennium Ending)	All India	MP	Rajasthan	Maharashtra	Telangana
1972-73	0.07	0.09	NA	1.26	NA
1982-83	0.07	0.07	0.06	NA	NA
1992-93	0.09	0.09	0.10	0.10	0.11
2002-03	0.10	0.09	0.10	0.13	0.12
2012-13	0.12	0.11	0.13	0.13	0.17
1971-1980	0.62	1.63	NA	NA	NA
1981-1990	0.75	0.78	0.63	NA	NA
1991-2000	0.96	1.03	1.08	0.66	1.21
2001-2010	0.73	0.73	0.77	0.81	0.63
2011-2013	1.20	1.28	1.74	1.07	1.00
Entire period	0.32	0.78	0.64	0.54	0.70

Source: Directorate of Economics and Statistics

Table 5.2: Cost of Production per Quintal across Selected States (at 2004-05 prices in Rs)

Year (TE)	MP	Rajasthan	Maharashtra	Telangana
1998-99	2649	2420	2143	NA
2002-03	3748	3850	2495	NA
2012-13	5673	5794	5578	1846
CAGR	5.09	3.89	5.77	NA

Note: Cost per quintal is Cost C2

Source: Directorate of Economics and Statistics

5.6: Cost per Quintal of Soybean

The data on cost of production per quintal at constant prices shows an increasing trend in all states over period of time (Table 5.2). The growth rate of the cost of production is highest for Maharashtra followed by MP and lowest for Rajasthan. It can be observed that average yield per hectare has been rising after 2002-03 and the unit cost of production (quintal) of soybean also is increasing over time in all states.

5.7: Total Factor Productivity

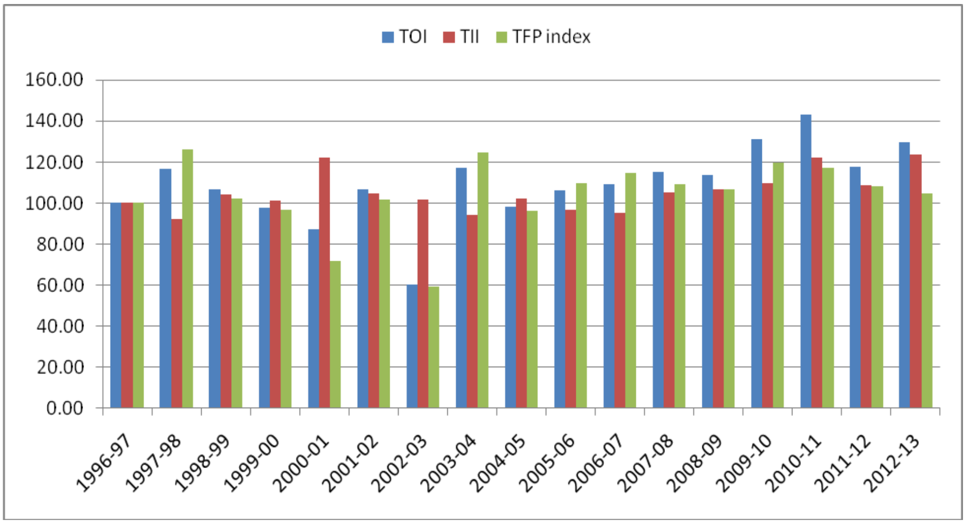
5.7.1: Output and Input Indices

The unit cost of production at constant prices has increased in all the states. Yield improvement has been there in all states after the slump in 2000-03. The output index and the input index over period of time for the selected states gives the relationship between the two. Input index is undergoing lesser fluctuations compared to output index. Then changes in output may not be entirely due to changes in inputs, but also factors other than inputs.

5.7.2: Madhya Pradesh

Input index has exceeded output index in the state of MP in 2000-01 and again in 2002-03. Output index reached the lowest point in 2002-03. In 2002-03 two things happened simultaneously, the input index shot up and also the output index fell drastically and as a result the TFP index was the lowest for the entire period. Output index started to exceed input index from the year 2005-06 onwards (Figure 5.2). TII averaged around 100 and output index between 100 and 120.

Figure 5.2: Total Output Index, Total Input Index and TFP Index for MP



Source: Directorate of Economics and Statistics

5.7.3: Rajasthan

Total input index exceeded the total output index in 2000-01 and 2002-03 and simultaneously output index also fell compared to earlier years. Output index started rising from 2003-04 onwards. In 2008-09 both input and output indices were almost equal but in 2009-10 once again input index exceeded output index , in 2011-12 and 2012-13 output index shot up (Figure 5.3).

5.7.4: Maharashtra

In Maharashtra input index was higher than output index in the beginning years 1996-97 and 1997-98 but later it fell behind output index. The input index has steadily increased; it was more than 100 in almost all the years (Figure 5.4).

Figure 5.3: Total Output Index, Total Input Index and TFP Index for Rajasthan

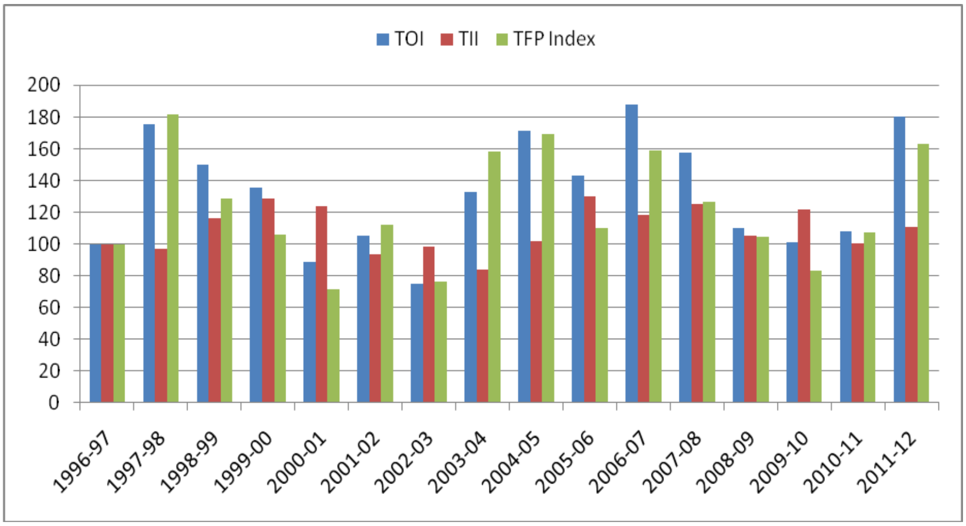
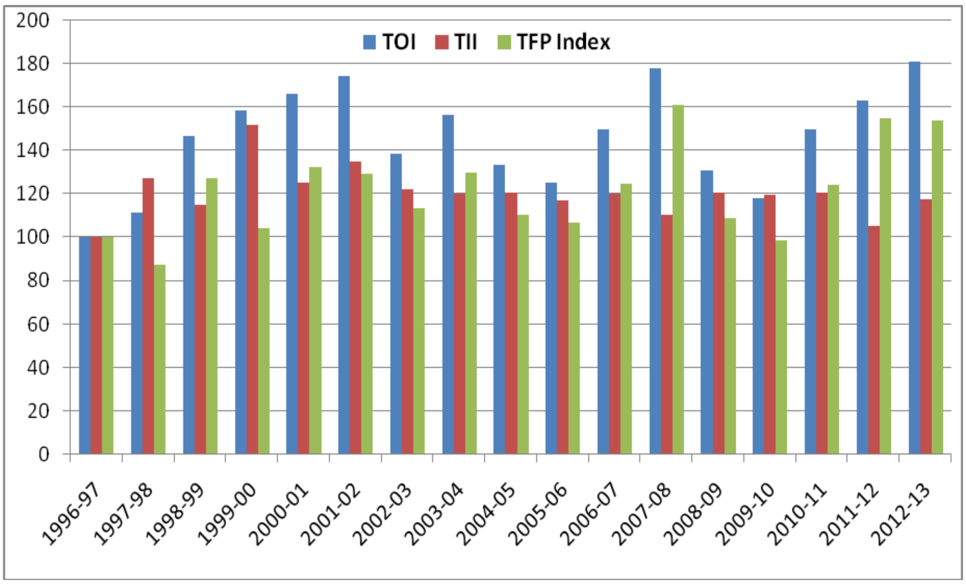


Figure 5.4: Total Output Index, Total Input Index and TFP Index for Maharashtra



Source: Directorate of Economics and Statistics

The contribution of total factor productivity to the output is responsible for increasing the output at the same level of input-use. With the contribution of the TFP the production function can be shifted outwardly to higher level which enables the farmer to get higher output at the same level of input. The TOI and TII and the TFP index for the three states are shown in Table 5.3. Across all the three states the stretch of years 2000-01 to

Table 5.3: Total Factor Productivity Indices (Quantity Chain) of Soybean Crop in Selected States based on Divisia Index

Year	Total output index	Total input index	Total factor productivity index	Triennium averages		
				Total output index	Total input index	TFP index
Madhya Pradesh						
1996-97	100.00	100.00	100.00			
1997-98	116.55	92.45	126.07			
1998-99	106.72	104.31	102.31	107.76	98.9	109.5
1999-00	97.49	101.02	96.51	106.92	99.3	108.3
2000-01	87.35	122.03	71.58	97.19	109.1	90.1
2001-02	106.66	104.89	101.69	97.17	109.3	89.9
2002-03	60.53	101.64	59.56	84.85	109.5	77.6
2003-04	117.37	94.12	124.70	94.85	100.2	95.3
2004-05	98.22	102.18	96.12	92.04	99.3	93.5
2005-06	106.14	96.74	109.72	107.24	97.7	110.2
2006-07	109.32	95.32	114.69	104.56	98.1	106.8
2007-08	115.02	105.32	109.22	110.16	99.1	111.2
2008-09	113.61	106.64	106.53	112.65	102.4	110.1
2009-10	131.00	109.70	119.41	119.88	107.2	111.7
2010-11	142.95	122.19	116.99	129.19	112.8	114.3
2011-12	117.77	108.83	108.22	130.58	113.6	114.9
2012-13	129.52	123.56	104.82	130.08	118.2	110.0
CAGR	1. 35	1.25	0.28			
Rajasthan						
1996-97	100.00	100.00	100			
1997-98	175.43	96.59	181.62			
1998-99	149.77	116.37	128.70	141.73	104.32	136.8
1999-00	135.66	128.48	105.59	153.62	113.81	138.6
2000-01	88.75	123.97	71.59	124.73	122.94	102.0
2001-02	105.25	93.79	112.22	109.89	115.41	96.5
2002-03	74.86	98.04	76.35	89.62	105.27	86.7
2003-04	132.35	83.72	158.09	104.15	91.85	115.6
2004-05	171.26	101.45	168.82	126.16	94.40	134.4
2005-06	143.27	130.09	110.13	148.96	105.09	145.7
2006-07	187.55	118.38	158.43	167.36	116.64	145.8
2007-08	157.58	124.92	126.14	162.80	124.46	131.6

contd...

Year	Total output index	Total input index	Total factor productivity index	Triennium averages		
				Total output index	Total input index	TFP index
2008-09	109.97	105.05	104.68	151.70	116.11	129.8
2009-10	101.22	121.48	83.32	122.92	117.15	104.7
2010-11	107.56	100.20	107.35	106.25	108.91	98.4
2011-12	180.10	110.35	163.21	129.62	110.68	118.0
2012-13	159.24	114.56	139.00	148.97	108.37	136.5
CAGR	2.77	0.80	1.96			
Maharashtra						
1996-97	100.00	100.00	100			
1997-98	111.60	127.61	87.46			
1998-99	146.77	115.27	127.33	119.46	114.29	104.9
1999-00	158.44	152.03	104.21	138.94	131.64	106.3
2000-01	166.47	125.45	132.70	157.23	130.92	121.4
2001-02	174.34	134.88	129.25	166.42	137.46	122.1
2002-03	138.71	122.39	113.33	159.84	127.58	125.1
2003-04	156.68	120.41	130.12	156.58	125.90	124.2
2004-05	133.33	120.55	110.60	142.91	121.12	118.0
2005-06	125.39	117.35	106.85	138.47	119.44	115.9
2006-07	149.75	120.15	124.64	136.16	119.35	114.0
2007-08	177.90	110.59	160.87	151.02	116.03	130.8
2008-09	131.19	120.55	108.83	152.95	117.09	131.4
2009-10	118.07	119.65	98.68	142.39	116.93	122.8
2010-11	149.84	120.77	124.06	133.03	120.32	110.5
2011-12	162.97	105.19	154.93	143.63	115.20	125.9
2012-13	181.12	117.51	154.13	164.64	114.49	144.4
CAGR	3.56	0.95	2.58			

Source: Directorate of Economics and Statistics

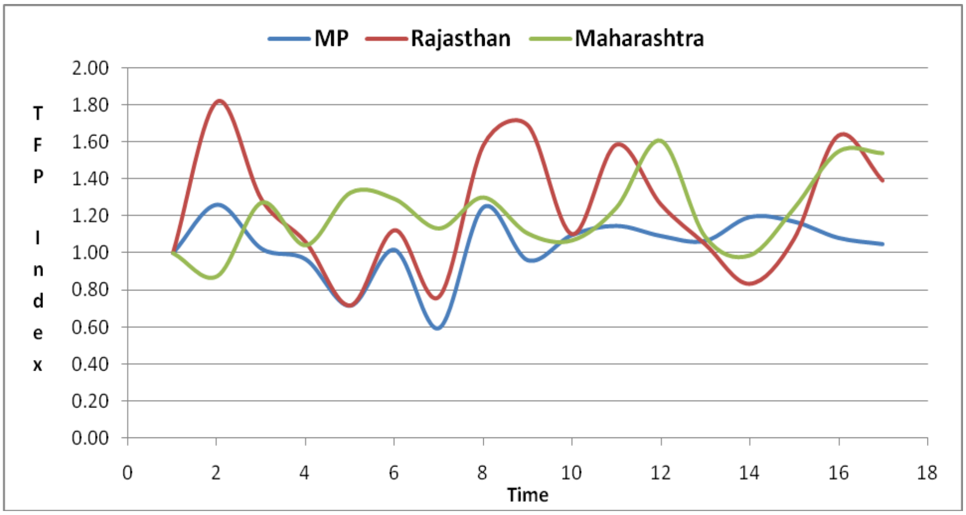
2002-03 have been the slump years where input index has increased abnormally and output index has fallen thus making the TFP below 100. There was a recovery in 2003-04 and 2004-05 and another slump could be observed in 2009-10, to 2011-12 especially in the states of Rajasthan and Maharashtra. 2012-13 is the peak year with highest TFP for Rajasthan and Maharashtra while 2011-12 is the peak year for MP. The compound annual growth rate of output index is higher than that of input index for all the states. The CAGR of input index is the highest for MP and lowest for Rajasthan while CAGR of output index is highest for Maharashtra and lowest for MP. The TFP growth rate (CAGR) is lowest for MP because of high growth rate of input index and low growth of output index; and TFP is medium range in Rajasthan because of low growth rate of input index and relatively better growth rate of output index compared to MP. The TFP is highest for Maharashtra with medium input index growth rate coupled with highest output growth rate (Table 5.4).

Table 5.4: TOI, TII and TFP across Selected States

State	TOI	TII	TFP	Characteristics
MP	Low	High	Low	Long term cultivating state
Rajasthan	Medium	Low	Medium	Medium term
Maharashtra	High	Medium	High	Medium term

Source: Directorate of Economics and Statistics

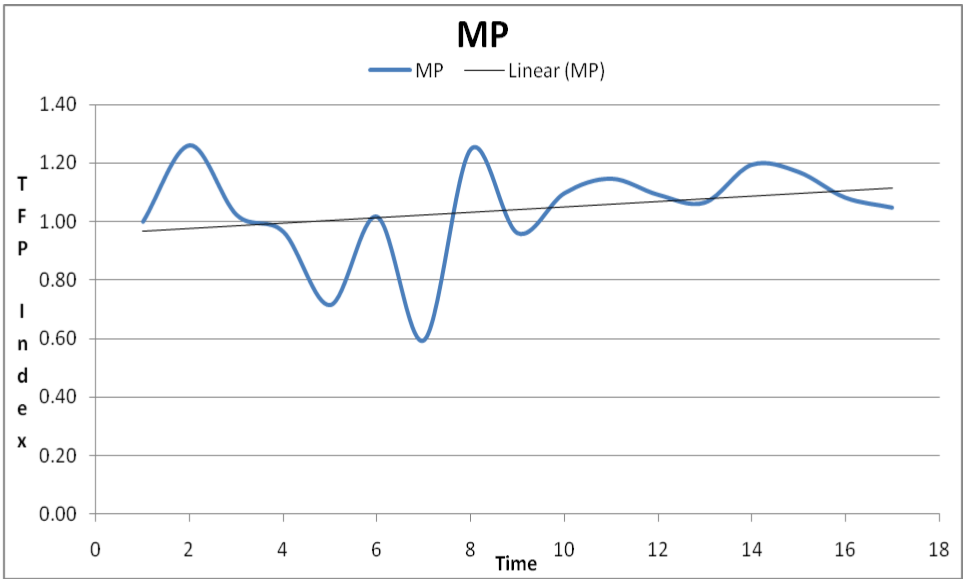
Figure 5.5: TFP Index over Time in MP, Rajasthan and Maharashtra



Source: Directorate of Economics and Statistics

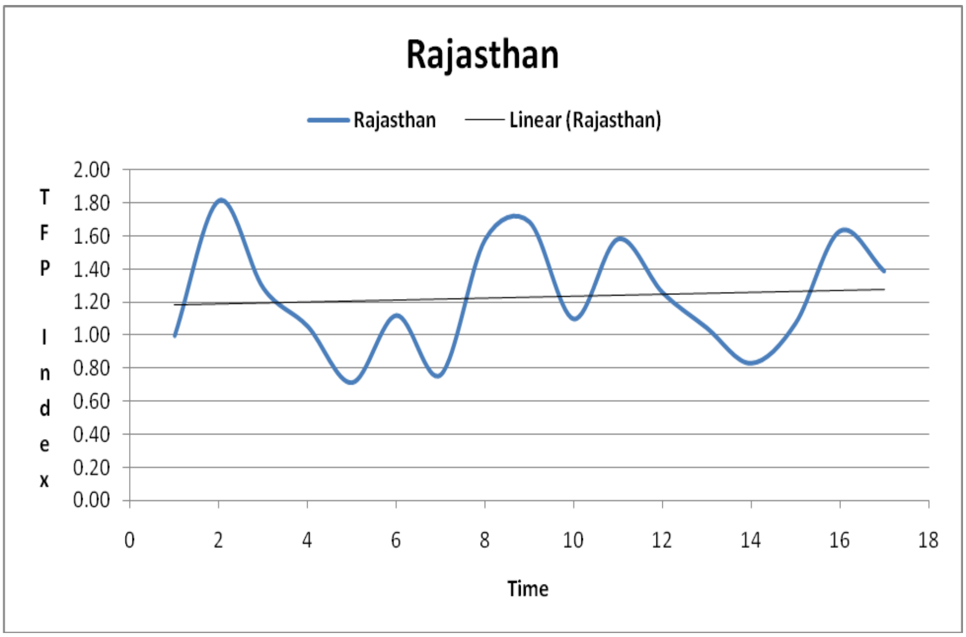
The plotting of TFP overtime in the three states (Figure 5.5) shows high fluctuations in case of Rajasthan while in MP TFP stabilized in years after 2005-06, in Maharashtra it fell in the stretch 2004-05 to 2006-07 and again in 2009-10 and 2010-11. The linear trend shows it is at high path for Maharashtra, medium path in Rajasthan and low path in MP (Figures 5.6, 5.7, 5.8).

Figure 5.6: TFP index and Trend in MP



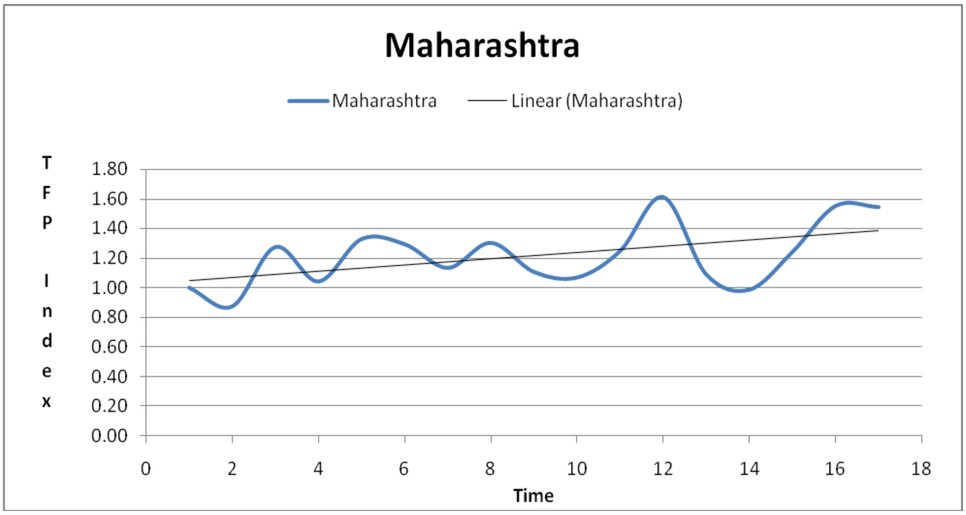
Source: Directorate of Economics and Statistics

Figure 5.7: TFP Index and Trend in Rajasthan



Source: Directorate of Economics and Statistics

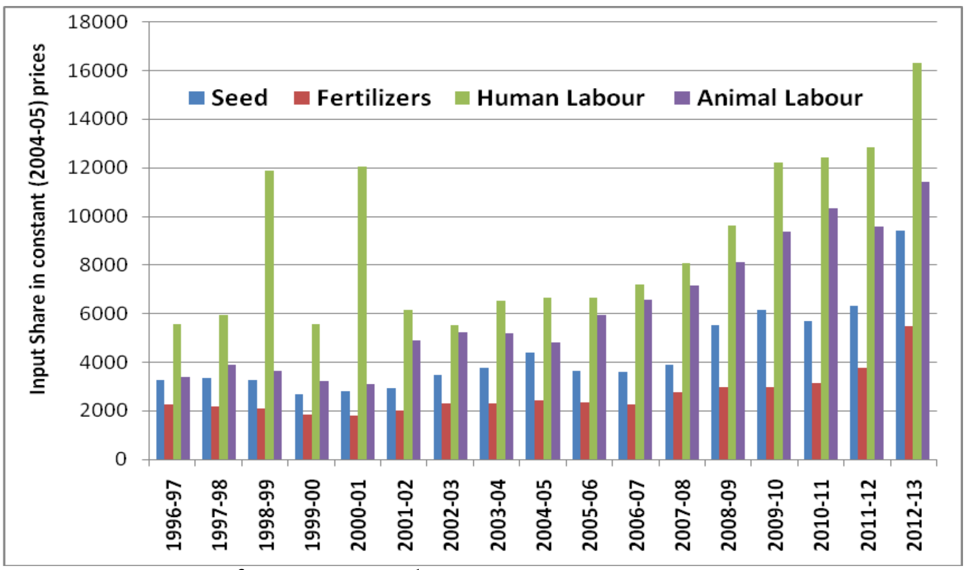
Figure 5.8: TFP Index and Trend in Maharashtra



Source: Directorate of Economics and Statistics

The behavior of the total output index and the total input index in the three states shows that in the states of MP and Rajasthan there was abnormal rise in input index in the years 2000-01 and 2002-03 and output not having increased in proportion to TII has on the other hand declined sharply. Similarly during 2009-10 the TII has risen sharply and TOI has fallen. This simultaneous rise of TII and fall of TOI needs to be analysed by examining the total input index.

Figure 5.9: Share of Inputs in Total Input Value Index at Constant (2004-05) Prices in Madhya Pradesh



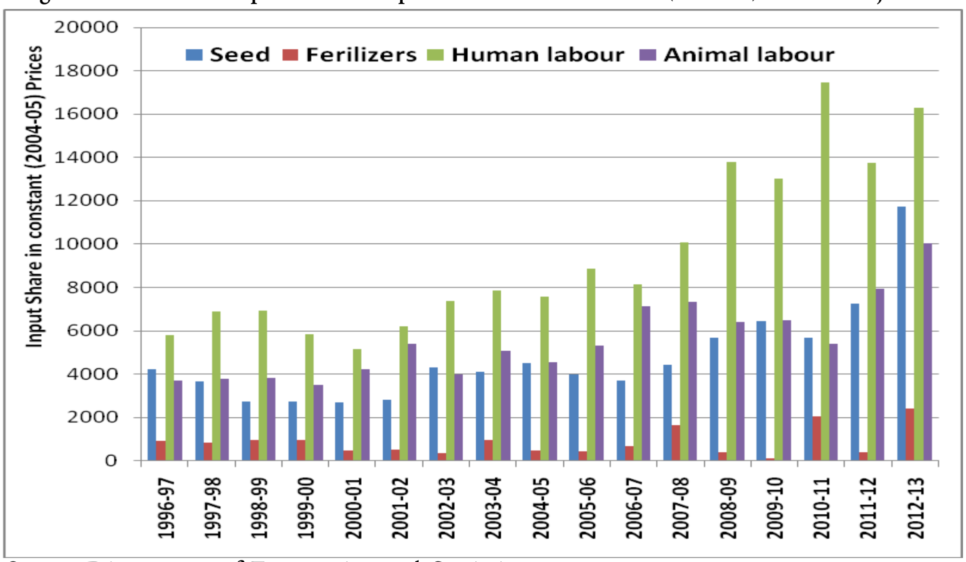
Source: Directorate of Economics and Statistics

5.7.5: Input Indices across States (Figures 5.9, 5.10,5.11)

The input value index[4] in MP shows that share of human labour has been on the rise over time. Share of animal labour which includes machine labour hours has taken second place in the value of inputs. These two inputs are showing rising trend from 2006-07 onwards. The share of fertilizer is almost constant and share of seed also was constant till 2007-08 but thereafter it increased. There is an abnormal increase in human labour in 1998-99 and 2001-02 which has pushed the TII (Figure 5.9). Then the question is whether the rise in human labour value in the above mentioned years is due to increase in number of human labour hours or due to increase in the cost of labour. As the TII is an aggregation of input value it has to be ascertained whether the rise in the input is because of physical quantity of inputs or because of rise in prices.

To examine this aspect we looked into the quantity of human labour used and the price of the human labour separately. The number of human labour hours has not increased but the labour value has increased because of abnormal rise in cost of labour or the wage rate. In constant prices the human labour cost has increased 100 percent in the two years of 1998-99 and 2000-01 which has increased the value of human labour in total input thus pushing the TII abnormally without commensurate rise in output index. Annual (compound) growth rates of physical quantity of all inputs used show a fall while annual growth rates in price show a positive rise (Table 5.7). TOI may have fallen due to exogenous factors.

Figure 5.10: Share of Inputs in Total Input value Index at Constant (2004-05) Prices in Rajasthan

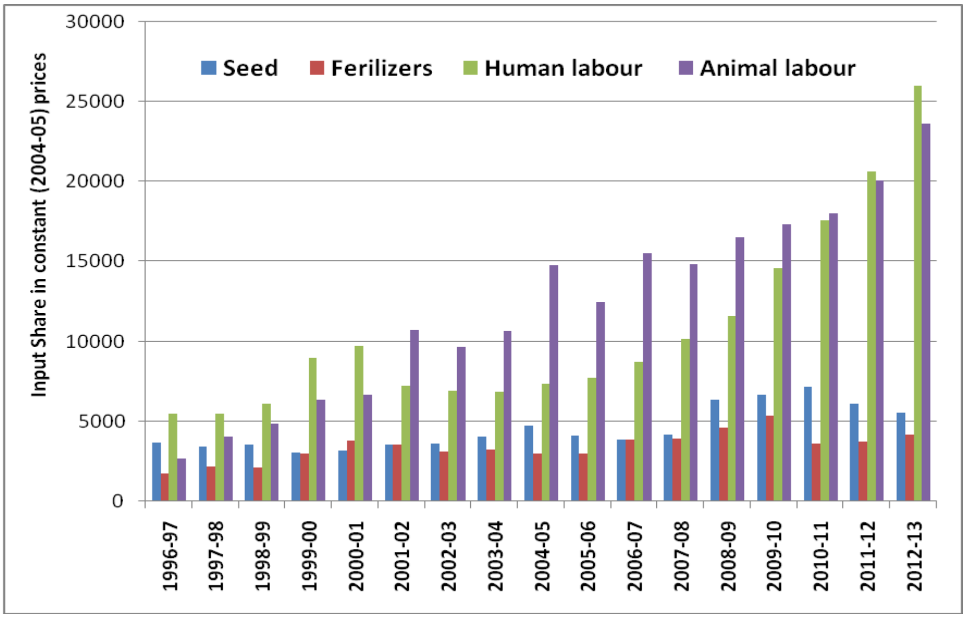


Source: Directorate of Economics and Statistics

[4]Value of Input= quantity * price

In case of Rajasthan state 2001-02 and 2002-03 years have witnessed no rise in TII but steep fall in the TOI. The TII has fallen for the year 2002-03 but the TOI has fallen more than proportionately thus resulting in decline in TFP below hundred. The share of fertilizer is lowest in Rajasthan and it highly correlates with rainfall. When the percentage deviation from normal is more fertilizer use is also lower which may affect productivity (Table 5.5). Human labour has been increasing at faster rate than other inputs. But the quantity of human labour (number of hours) has been declining over period of time which is also reflected in the negative cagr. The price of both animal labour and machine labour has increased enormously in Rajasthan compared to other inputs and also compared to the prices in other states (Tables 5.6 & 5.7).

Figure 5.11: Share of Inputs in Total Input Value Index at Constant (2004-05) prices in Maharshtra



Source: Directorate of Economics and Statistics

In case of Maharashtra in 1997-98 the TII increased but TOI has not increased commensurately thus making the TFP to fall below hundred. The TII has increased due to a spurt in animal labour use in number of hours. Machine labour use which is part of animal labour has increased from 2000 onwards but from 2010 onwards human labour component has increased. Rate of growth of machine price has been lower which explains its increased use. The rate of increase in quantity of inputs used is positive and high especially for fertilizer. Human labour has been substituted by animal (machine) labour (Tables 5.6 and 5.7).

Table 5.5: Fertilizer Use and Rainfall in Rajasthan

Year	Fertilizer use (qtl/ha)	Percent deviation of rainfall
2000-01	0.12	-11.99
2001-02	0.11	-58.99
2002-03	0.1	0.29
2004-05	0.05	-17.16
2005-06	0.042	-14.38
2006-07	0.017	9.95
2008-09	0.089	-2.08
2009-10	0.024	-34.27

Source: Directorate of Economics and Statistics

Table 5.6: Average Quantity of Inputs Used Over Time across States (per hectare)

Triennium	Seed (qtl)	Fertilizer (qtl)	Manure (qtls)	Human labour (hrs)	Animal labour (hrs)	Machine (Rs per hectare) (2004-05 prices)
MP						
1996-98	0.98	0.5	5.30	415.02	57.29	1943
1999-01	0.97	0.4	4.14	347.33	48.12	1826
2002-04	0.92	0.43	5.80	335.94	49.10	2411
2005-07	0.89	0.41	5.39	336.94	45.12	3777
2008-10	0.87	0.41	6.45	312.45	33.63	6480
Rajasthan						
1996-98	0.93	0.24	2.76	407.52	36.3	2256
1999-01	0.89	0.16	0.67	323.70	36.05	2312
2002-04	0.97	0.16	0	386.45	18.88	2968
2005-07	0.98	0.04	5.05	389.83	18.29	5289
2008-10	0.89	0.07	2.21	394.87	7.90	5572
Maharashtra						
1996-98	0.78	0.51	2.79	443.99	90.72	876
1999-01	0.77	0.79	6.94	612.99	81.17	2809
2002-04	0.77	0.64	5.32	489.93	82.91	3688
2005-07	0.78	0.65	6.62	485.41	82.73	4397
2008-10	0.77	0.81	8.32	473.82	77.08	6706

Source: Directorate of Economics and Statistics

Table 5.7: Compound Growth Rate (percentage) of Quantity of Inputs and Price of Inputs during 1996-97 to 2012-13

State	Seed qtl	Fertilizer qtl	Human Labor Price	Animal Labor Price	Seed Price	Fertilizer Price	Human Labor Price	Animal Labor Price	Machine Labor Price
Madhya Pradesh	-0.7	-0.32	-2.61	-1.3	7.17	5.76	9.41	8.81	19.38
Rajasthan	0.67	-0.4	-1.43	-4.82	5.48	6.47	7.84	11.42	24. 47
Maharashtra	-0.42	5.37	0.24	2.38	2.89	-0.05	9.30	10.98	3.73

Note: Animal labour includes machine labour

Source: Directorate of Economics and Statistics

5.8: Sources of Total Factor Productivity Growth (TFPG)

Sources of growth of TFP relevant to the soybean crop have been identified from the literature as well as from the field experience. Infrastructure, human capital (literacy), institutional factors like extension support, research and education are some factors that would determine TFP growth.

We have identified four determinants of TFP for the present study. Since soybean crop is much dependent on rainfall we have taken percentage deviation from normal rainfall as one of the determinant factors. We also found from the primary study the importance of normal rainfall in good crop yields by the difference in yields between normal year and current year. Current year 2013-14 yields have been lesser due to deficit in rainfall. The second variable chosen is the rural adult literacy rate (15 plus years) and the third variable is road length per one lakh population. The fourth variable is the percentage of financial allocation towards extension and training; this is taken as expenditure on extension and training as percentage of agricultural GSDP. However, the budget allocations on extension and training (as given in the budget books under minor head 109) were available for only two states of Madhya Pradesh and Rajasthan.

Secondary data for the above mentioned variables has been collected for the three states of Madhya Pradesh, Maharashtra and Rajasthan during 1996-97 to 2012-13 for a period of 15 years. These time series data have been pooled to get more number of observations.

5.8.1: Model 1

TFPG= a+b1X1+b2 X2+b3X3 +u

Where

TFPG = Quantity chain of TFP

X1= percentage deviation of rainfall

X2= length of road in km per 100 000 population

X3= rural adult (15+) literacy rate

Maharashtra and Rajasthan= Dummy variables

The above analysis makes it clear that even when TII is increasing the TOI need not increase. On the other hand there is a fall in the TOI. This may be because of other than input factors or the autonomous factors. Therefore it is important to examine the sources of Total Factor Productivity Growth. The factors identified are rainfall as soybean crop is predominantly rain fed crop; human capital; infrastructure; and public expenditure on farmer extension and training and on research and education.

Table 5.8a: Estimated Parameters of Sources of TFPG of Soybean during 1996-97 to 2012-13

Sl No	Variable	Coefficient	Standard error	P>{t}
1	Percentage deviation of Rainfall	.0038	.00119	0.009*
2	Road Length per 100000 population	-.00066	.00061	0.283
3	Rural Adult Literacy rate	.0060	.0026	0.029*
4	Rajasthan (dummy variable)	.2002	.0773	0.039*
5	Maharashtra (dummy variable)	.0542	.0890	0.546

Constant= .9893; N=51; Adj R2 = 0.29; F value = 0.0056

Note: * Significant at 1 percent

5.8.2: Model 2

TFPG= a+b1X1+b2 X2+b3X3+b4X4+ u

X1= rainfall measured as the percentage deviation over normal (actual rainfall- normal rainfall/actual rainfall)

X2= rural adult (15+) literacy rate

X3= expenditure on extension and training as percentage of agriculture GSDP

X4= expenditure on agricultural research and education as percentage of agriculture GSDP

Table 5.8b. Estimated Parameters of Sources of TFPG of Soybean during 1996-97 to 2012-13

Sl No	Variable	Coefficient	Standard error	P>{t}
1	Percentage deviation from actual Rainfall	.0067	.0025	0.017*
2	Percentage Expenditure on extension and training	.1793	2.30	0.939
3	Percentage Expenditure on research and education	1.088	.780	0.178
Constant= 1.15; N=24; Adj R20.24; F Value: 0.033				

Note: Data on percentage expenditure on agriculture extension and training and agricultural research and education is available for the states of MP and Rajasthan for few years only, hence less observation are there

Total factor productivity for the period 1996-97 to 2012-13 in the three states of MP, Rajasthan and Maharashtra is regressed on important variables identified and which are not included in the construction of the input index. The results are given in Table 5.8a. The results show that positive deviation over normal rainfall (actual-normal/ normal) and human capitals (rural adult literacy rate) are found to be the important sources of growth in TFP in all the states. Infrastructure variable which is taken as road length in kilo meters standardized for one lakh population has not turned out to be significant variable. To see the variation across states state dummies were incorporated into the analysis. The state of MP which is long time grower of the soybean crop was suppressed and other two states were given dummy values. TFP growth in Rajasthan is better compared to MP which turned out to be significant.

The other important variables considered to have impact on the TFP growth are percentage expenditure on agriculture extension and training (as percentage to agriculture GSDP) and percentage expenditure on research and education (as percentage to agriculture GSDP) have not been found to be significant determinants of TFP. As these variables were available for the states of Rajasthan and Maharashtra we went for a second model taking the three variables of percentage deviation of rainfall and the expenditure on extension and training and research and education. The number of observations for the second model are few i.e. 24 because data was available for limited number of years. It is true that the above may be an underestimation of the expenditure on soybean research but ICAR budget books and annual reports of ICAR-DSR/AICRP have data for all India level and not at state level. As our study is conducted taking state level data, we had to collect figures for expenditure on agricultural research and development, education and training from the respective state budget books. Expenditure on agriculture extension and training and research and education were introduced as mutually exclusive variables along with percentage deviation of rainfall over normal but were found to be insignificant. The reason might be that there is not much variation in the variables across years for the two states. For example the percentage expenditure on agriculture extension and trainings is found to be 0.007 to 0.07 in MP and 0.005 to 0.01 in Rajasthan; while percentage expenditure on agriculture research and education ranges between 0.001 and 0.002 in MP and 0.11 and 0.21 in Maharashtra.

Durbin Watson test was conducted to check auto correlation. The resulting value of the test was 1.8464 which is approximately equal to 2. Hence we concluded that there is no serial correlation and continued with the regression models taking pooled data.

As soybean is dry land crop the yield of the crop is highly correlated with rainfall. To supplement the analysis of sources of growth in TFP, we have also given the correlation coefficient between yield and average annual rainfall in the three states and also the coefficient of variation.

5.9: Concluding Observations

The TFP analysis of the soybean crop in the three states of MP, Rajasthan and Maharashtra during the period 1996-97 to 2012-13 reveals the following significant findings: The trend growth rate of TFP in MP is in the band of 1- 1.20 while for Rajasthan it ranges between 1.20 to 1.40. In the case of Maharashtra it ranges between 1 to 1.4. MP the long standing grower of soybean has not been able to achieve high TFP compared to medium starter and new comer states of Rajasthan and Maharashtra respectively. The increase in input index in MP shows quantities of all inputs used (seed, fertilizer, human and animal labour) have fallen while cost has increased which has pushed the TII but has not shown any commensurate rise in the TOI. The cagr of price of human labour is the highest and the cagr of quantity of human labour is lowest which suggests that human labour might have been replaced by bullock and machine labour. But the cagr of the latter also has been high thereby increasing the input cost. This might be the cause for the TFP to be in low band in MP.

In case of Rajasthan cagr of price of animal labour is highest and the response to it is seen in the negative cagr of quantity in animal labour use. Human labour might have substituted for animal labour whose price is lower than the latter. Quantity of seed used is showing high growth rate but fertilizer use is showing negative growth rate. This is understandable because Rajasthan being semi arid region with low average rainfall the use of fertilizer is highly correlated with rainfall. Farmers might have compensated low use of fertilizer with high use of seed (seed price growth is also the lowest among all the inputs) here which also might have contributed to high yield.

In case of state of Maharashtra all input quantities show positive cagr except the seed. Growth rate in fertilizer use (quantity) is highest; this may be due to negative growth rate in fertilizer cost in the state. Animal labour use is high. Machine labour use which is aggregated with animal labour has increased as the rate of growth of machine labour price is low. Crop productivity might be high because of high use of fertilizer quantity and animal and machine use thereby resulting in high TFP growth.

Among the sources of growth of TFP rainfall stands out. The fluctuations in the output are closely related to rainfall. Extension and training and research and development have not turned significant determinants of TFP may be due to small percentage of expenditure on these. Literacy rate also contributes to productivity as the capacity of the farmers to adopt recommended practices and establish link with markets will be high. Other factors also may determine the TFP growth like the adoption of recommended practices and differences in adoption by different land holding size of farmers. These factors can be analysed with primary data. This analysis has been done in chapter VI on technical, allocative and economic efficiencies using primary data.

CHAPTER VI

Economic Efficiency in Soybean Production and its Determinants: A Cross Section Analysis

6.1: Context

The preceding chapter on 'Measurement and Analysis of TFP growth in soybean crop' in the selected states discussed the total factor productivity using the cost of cultivation data collected from secondary sources. The determinants for the TFP also have been analysed. The TFP results apply for an average farmer and do not give any variation across size of land holding. Due to limited data availability the determinants of TFP also were confined to few variables only. Given these limitations this chapter attempts to analyze the technical efficiency, allocative efficiency and economic efficiency through stochastic frontier analysis of the soybean crop in the selected states using the cross section data collected for the agricultural year 2014-15.

Technical efficiency is defined as a measure of how well or how efficiently inputs are being used towards producing output. It is the capacity and willingness of an economic unit to produce maximum possible output from a given bundle of inputs and a technology.

Allocative efficiency is defined as the efficiency of a farm or production unit which reflects the ability of a farm to use inputs in optimal proportions, given their respective prices. It is the ability and willingness of an economic unit to equate its specific marginal value product with its marginal cost. Economic efficiency is obtained by an interaction between the technical and allocative efficiencies.

Allocative Efficiency= $\frac{Economic\ Efficiency}{Technical\ Efficiency}$

Quantification of these efficiency measures is useful in three ways

To facilitate comparisons across similar economic units which indicate relative efficiency Measurement reveals variations in efficiencies among economic units, further analysis can be undertaken to identify the factors causing such variations

Such analysis has policy implications for improvement of efficiencies (Kalirajan and Shand 1994)

The choice of factors determining technical efficiency is wide in the case of primary data when compared to the secondary data. Adoption of package of practices which are recommended for the cultivation of the soybean crop serves as one of the important determinants. This data has been collected from primary sources and which is not available from secondary sources.

6.2: Objectives of the Chapter

The first objective of this chapter is to estimate the Technical Efficiency (TE), Allocative Efficiency (AE) and Economic Efficiency (EE) to know the relative efficiency of farms; to know the variations in technical and allocative efficiencies among economic units (farms).

The second objective of this chapter is to know the determinants or the factors causing variations in the efficiencies which have policy implications for improvement of efficiencies.

6.3: Methodology

TE is estimated for around 1550 farmers selected in the four states of MP, Rajasthan, Maharashtra and Telangana. The process of selection of the states, districts, blocks and farmer households has been given in detail in the first chapter. The stochastic frontier function methodology is adopted to estimate the TE.

According to the literature, the efficiency of a farm (production unit) can be measured either with respect to its normatively desired performance or with the performance of another farm. Thus, measures of efficiency are essentially computed by comparing observed performance with some specified standard notion of performance. The "production frontier" serves as one such standard in the case of TE. TE can be defined as the ability and willingness of a production unit to obtain the maximum possible output with a specified endowment of inputs (represented by a frontier production function), given the surrounding technology and environmental conditions.

Suppose that a farm has a production plan (Y^o, X^o), where Y^o is the set of outputs and X^o represents the set of inputs. Given a production function f (.), the farm is technically efficient if $Y^o = f(X^o)$ and technically inefficient if $Y^o < f(X^o)$. Therefore, the TE can be measured by the ratio output/ input and its value varies between 0 and 1 or in other words it is the ratio between actual and potential output of a production unit. If a farm is inefficient its actual output is less than the potential output. Its limits are as follows

$$0 \leq Y^o/f(X^o) \leq 1$$

6.4: Stochastic Production Function

This study uses the stochastic (or econometric) frontier production function model for cross sectional data. We define the frontier production function as the maximum feasible or potential output that can be produced by a production unit such as farm, given level of inputs and technology. The actual production function (corresponding to the production unit's actual output) can be written as:

$Qi = f(Xi; \beta) \exp(-ui)$ and $0 < ui < \infty$; $i = 1,2,\ldots,n$. (1)

where Qi represents the actual output for the ith sample (production) unit; Xi is a vector of inputs and β is a vector of parameters that describe the transformation process; f (.) is the frontier production function and ui is a one-sided (non-negative) residual term. If the production unit is inefficient, its actual output is less than the potential output. Therefore, we can treat the ratio of the actual output Qi and the potential output f(.) as a measure of the technical efficiency of the production unit.

Using equation (1) above, we can write this measure as:

TE = Qi / f (Xi; ❑) = exp (-ui) (2)

If the production unit produces the potential output (full TE) ui is zero and it is less than zero when production is below the frontier (less than full TE). A random noise variable vi (independently and identically distributed normal with mean 0 and variance σv^2) can be included in the equation (1) to capture the effect of other omitted variables that can influence the output as:

Qi = f (Xi; ❑) exp (vi-ui), (3)

This new function is known as the individual-specific stochastic production frontier function. In order to estimate equation (3), we consider Battese and Coille model (1998) with exponential distribution.

$$\sigma^2 = \sigma v^2 + \sigma u^2 \text{ and } \gamma = \frac{\sigma u^2}{\sigma^2}$$

A significant σ (and λ) would indicate the significant variations in the output levels. A zero value of γ would indicate that the deviations from the frontier are due entirely to the noise and, value of one would indicate that all deviations are purely due to differences in TE across farms.

6.5: Analysis

An understanding of the average production per acre and response to the changes in the physical inputs per unit is useful before examining the levels of technical efficiency. Among the inputs fertilizer use is more variable or less stable for all states put together. Fertilizer use is more variable in the states of Maharashtra and Rajasthan than in other states. Human labour is variable in Madhya Pradesh and Telangana while machine labour is more dispersed in Telangana compared to other states. Output is less dispersed in Madhya Pradesh and more dispersed in Telangana while in Rajasthan and Maharashtra also it is dispersed (Table 6.1).

Table 6.1: Mean SD and CV of Input use and Output across Selected States (per acre)

State/ variables	Observations	Mean	Std. Dev.	CV
Rajasthan				
Output (qtls)	380	2.72	0.84	30.92
Seed (kgs)	380	39.82	7.40	18.58
Fertiliser (Qtls)	380	3.54	2.27	64.24
Machine labour (Hrs)	380	4.11	1.01	24.67
Human Labour (Man days)	380	9.39	2.95	31.45
Madhya Pradesh				
Output (qtls)	382	7.37	1.30	24.27
Seed (kgs)	382	38.83	10.26	26.42
Fertiliser (Qtls)	382	2.80	1.04	37.01
Machine labour (Hrs)	382	2.57	0.94	36.63
Human Labour (Man days)	382	11.49	6.16	53.59
Maharashtra				
Output (qtls)	357	6.2	1.56	31.74
Seed (kgs)	357	32.48	10.39	31.99
Fertiliser (Qtls)	357	7.01	6.25	89.27
Machine labour (Hrs)	357	3.12	1.21	38.97
Human Labour (Man days)	357	22.73	7.83	34.46
Telangana				
Output (qtls)	407	3.60	1.43	39.69
Seed (kgs)	407	35.81	13.38	37.37
Fertiliser (Qtls)	407	1.22	0.72	59.04
Machine labour (Hrs)	407	3.22	2.23	69.27
Human Labour (Man days)	407	12.41	4.58	36.86
All States				
Output (qtls)	1526	4.15	1.68	40.41
Seed (kgs)	1526	36.82	10.98	29.81
Fertiliser (Qtls)	1526	3.53	3.87	109.49
Machine labour (Hrs)	1526	3.24	1.56	48.04
Human Labour (Man days)	1526	13.80	7.53	54.55

Source: Primary Survey

6.6: Empirical Model

The stochastic production frontier estimated in this study is as follows

$$\text{Ln } Yi=\beta o+\beta 1LnX_{1i} +\beta 2 \text{ Ln } X_{2i} +\beta 3 \text{ Ln } X_{3i} +\beta 4Ln X_{4i} + \beta 5 \text{ Ln } Z_{5i} +V_i -U_i$$

Where

Yi = output per acre in quintals of i^{th} farm

X1i = seed in Kgs of i^{th} farm

X2i = fertilizer in quintals of i^{th} farm[5]

X3i= machine labour in hours of i^{th} farm

X4i = human labour in male days of i^{th} farm [6]

Vi is the random variable assumed to be independent and identically distributed (iid) as N (0, σv^2)

Ui is the firm specific technical efficiency related variable

Some of the farmers have not used machine labour and to avoid statistical problems, bullock labour input (wherever used) has been converted into machine labour by using a conversion factor of one hour tractor use as equivalent to ten hours of bullock labor. This conversion factor has been arrived at on the basis of the sample data for the study and also which is broadly in conformity with other studies. Wage rate was derived by dividing the total machine labour value with total machine labour hours.

6.7: Results and Discussion

The maximum likelihood estimates (MLE) of the parameters of the stochastic frontier production function defined by equation, given the specifications for the efficiency effects defined were obtained. The results have been presented in Table 6.2.

The maximum likelihood estimates of the production frontier indicated all variables are statistically significant except the machine labour. Both σu , σv and are statistically significant at 1 percent level indicating that the observed output significantly differs

[5] Farmers generally use different combinations of N (nitrogen), P (phosphorus) and K (potassium) fertilizers apart from farm yard manure (FYM). Some of the farmers have used either fertilizer or FYM. To avoid statistical problems, FYM was converted into NPK fertilizers in quintals by dividing the total value of FYM with unit price of fertilizer. Price of fertilizer was derived by dividing the total fertilizer value with total fertilizers used in quintals.

[6] Total human labour has been taken in man days and the woman and child days have been converted into man days using the conversion factor man equivalent of female (2/3) and child (1/2) labour hours. Wage rate is derived by dividing the total human labour value with total male days.

from frontier output due to factors which are random to a large extent. γ value is 0.06 indicating that 6 percent of the difference between actual and potential production is primarily due to technically inefficient performance of the farms. The low γ value indicates that farmers faced low or high rainfall compared to normal rainfall. Therefore the large difference between observed output and frontier output is because of random factors or specifically deviation of rainfall from normal as soybean crop is primarily rain fed crop.

Table 6.2: OLS and Maximum Likelihood Estimation of Production Frontier Functions

Variables	OLS Production Function		Frontier Production Function (normal/exponential)	
	Coefficient	**Significance**	**Coefficient**	**Significance**
constant	0.0969 (0.1135)		0.1972 (0.1192)	**
Seed (kg)	0.1127 (0.0275)	***	0.1122 (0.0273)	***
Fertilizer (qtl)	0.0630 (0.0105)	***	0.0635 (0.0105)	***
Machine labour (Hrs)	-0.0259 (0.0211)		-0.027 (0.0210)	
Human Labour (Man Days)	0.3274 (0.0188)	***	0.3241 (0.0190)	***
σ u			0.0899 (0.0302)	***
σv			0.355 (0.0098)	***
			0.06 (0.038)	***
Log Likelihood			-645.1	
R^2	0.21			
Number of observations	1526		1526	
Prob>chi2			0.00	

Source: Primary Survey

Note: 1. Figure in parenthesis indicates Standard Errors

2. *** indicates 1percent ** indicates 5percent and * indicates 10percent levels of significance

The coefficients of the input variables estimated by frontier production function are more or less similar to those estimated by the OLS production function (Table 6.2). The coefficients of inputs are 0.11 for seed, 0.06 for fertilizer, 0.32 for human labour and (negative) -0.02 for machine labour. The response for human labour is high in terms of production and among inputs other than labour, seeds have high response. The implicit assumption may be Hicks neutral technical change where the intercept shifts but slope remains same. In other words Hicks neutral technical change does not affect the relative contribution of each input to the production process. That means the intercept in MLE should be higher than that computed in the OLS.

6.8: The Stochastic Profit Frontier Function

$$\text{Ln } \pi_{it} = \beta ot + \beta 1t \text{ Ln} X_{1it} + \beta 2t \text{ Ln } X_{2it} + \beta 3t \text{ Ln } X_{3it} + \beta 4t \text{Ln } X_{4it} + \beta 5t \text{ Ln } Z_{5it} + V_{it} - U_{it}$$

Where

π_{it} is the restricted profit (current revenue less current variable costs), normalized by the price received per quintal of output of i_{th} farm

X_{1i} is the seed price per kg, normalized by output price of i^{th} farm

X_{2i} is the price of fertilizer per quintal, normalized by the output price of i^{th} farm

X_{3i} is the machine labour wage rate per paired hour, normalized by output price of i^{th} farm

X_{4i} is the human labour male wage rate per day, normalized by output price of i^{th} farm

V^{it} is the random variable assumed to be independent and identically distributed (iid) as $N(0, \sigma\upsilon^2)$ and independent of U_{it} random variable

U_{it} is the farm specific economic efficiency related variable

The restricted profit is the difference between revenue and current variable cost. All the variables are normalized by output price. Only four inputs have been considered- seed, fertilizer, machine labour and human labour. At the aggregate level restricted profit is most inconsistent. Output price seems to be consistent at the aggregate level. Among the inputs fertilizer price/cost is more dispersed followed by machine labour respectively compared to seed and human labour. A comparison of the states shows that restricted profit is highly dispersed in Telangana followed by Rajasthan and Maharashtra. Output price also is relatively more dispersed in Telangana. Surprisingly seed price is high and more dispersed in Madhya Pradesh and Maharashtra (see table 4.7 in Chapter IV on Adoption of Technology). The volume of seed used is high in Madhya Pradesh and farmers are also using their saved seed[7] (reference to chapter IV) because of which there is high dispersion. Fertilizer price and machine labour are more variable in Rajasthan but human labour is more dispersed in Madhya Pradesh and Telangana in that order.

Table 6.3: Mean, SD, CV of Restricted Profit and Prices

State/ Variables	Observations	Mean	Std. Dev	CV
Rajasthan				
Restricted Profit	380	2023.12	2277.34	112.57
Output price	380	3058.16	275.95	9.02
Seed price/ kg	380	47.28	3.43	7.24
Fertilizer price/ Qtls	380	187.37	74.80	39.92
Machine labour price/ Hours	380	320.27	82.96	25.90
Human labour price/ male day price	380	266.18	50.07	18.81
Madhya Pradesh				
Restricted Profit	382	9916.40	4089.81	41.24
Output price	382	3088.11	433.71	14.04
Seed price/ kg	382	48.08	13.15	27.35
Fertilizer price/ Qtls	382	300.60	63.13	21.00
Machine labour price/ Hours	382	504.27	63.19	12.53
Human labour price/ male day price	382	212.12	70.55	33.26
Maharastra				
Restricted Profit	357	3612.56	3497.29	96.81
Output price	357	3191.18	540.32	16.93
Seed price/ kg	357	62.90	17.94	28.52
Fertilizer price/ Qtls	357	213.35	20.93	9.81
Machine labour price/ Hours	357	1160.69	227.44	19.59
Human labour price/ male day price	357	218.07	37.74	17.31
Telangana				
Restricted Profit	407	1200.98	1945.28	161.97
Output price	407	2894.35	704.17	24.33
Seed price/ kg	407	43.09	3.32	7.71
Fertilizer price/ Qtls	407	1089.96	93.71	8.60
Machine labour price/ Hours	407	973.54	81.59	8.38
Human labour price/ male day price	407	241.93	60.92	25.18
All States				
Restricted Profit	1526	4262.74	4660.31	109.33
Output price	1526	3053.76	525.25	17.20
Seed price/kg	1526	49.98	13.36	26.74
Fertilizer price/Qtls	1526	459.40	384.12	83.61
Machine labour price/Hours	1526	732.68	359.08	49.01
Human labour price/male day price	1526	234.48	60.63	25.86

Source: Primary Survey

[7] Use of home produced seed is highest in sample villages Ujjain district in Madhya Pradesh state

Madhya Pradesh emerges as ideal state for soybean crop in the current agricultural year of 2014-15 with high mean restricted profit (Table 6.3). If we extend our analysis beyond restricted profit, also include other inputs like pesticide, and pumping costs; cost of cultivation is high in the states of Maharashtra and Telangana as use of pesticide is high in these states. Pesticide usage is lowest in Rajasthan and pumping costs are high in Madhya Pradesh. Farmers in the two districts (Adilabad and Nizamabad) in Telangana and Kota in Rajasthan have faced negative returns when all the inputs are taken into account. However the net returns in a normal year[8] are positive for all the selected districts. The returns in normal year and current year are not comparable as they are not adjusted to inflation (Table 4.5 Appendix).

6.9: Empirical Model

Table 6.4 OLS and Maximum Likelihood Estimation of Profit Frontier Functions - Results

Variables	OLS Production Function		Frontier Profit Function (normal/exponential)	
	Coefficient	Significance	Coefficient	Significance
Constant	-3.518 (0.742)	***	-2.637 (0.532)	**
Seed (kg)	-0.399 (0.182)	**	-0.074 ((0.112)	***
Fertilizer (qtl)	-0.368 (0.062)	***	-0.346 (0.056)	***
Machine labour (Hrs)	-0.166 ((0.092)	*	-0.359 (0.072)	
Human Labour (Man Days)	-1.356 (0.143)	***	-0.815 (0.123)	***
σu			1.6844 (0.081)	***
σv			0.5362 (0.065)	***
γ			0.908 (0.137)	***
Log Likelihood			-2779	
R^2	0.1161			
Number of observations	1555		1555	
Prob>chi2			0.00	

Note: 1. Figure in parenthesis indicates Standard Errors

2. *** indicates 1percent ** indicates 5percent and * indicates 10percent levels of significance

Source: Primary Survey

[8] Normal Year is an year in which the average rainfall is close to normal rainfall and there is no disease and pest attacks. A normal year is chosen according to the perception of the farmers between 2010-15

6.10: Results and Discussion

The maximum-likelihood estimates (MLE) of the parameters of stochastic profit frontier production function defined by equation, given the specifications for the efficiency effects defined were obtained. The results of the profit frontier function are presented in Table 6.4.

The maximum likelihood estimates of the profit frontier indicated expected signs for all factor inputs. Notably, except the normalized machine labour prices, all are statistically significant at 1 percent level (Table 6.4). σu, σv and γ are statistically significant at 1 percent level, indicating that the observed profits significantly differs from frontier profits due to factors which are within the control of famers. 91 percent of the difference between the actual and potential normalized profit are primarily due to economically inefficient performance of the farms. The likelihood ratio test (χ^2) rejects the null hypothesis that $\gamma = 0$ (Table 6.4). This high ? results indicates that farmers faced different prices for the inputs used. This may be because of the varied institutions like government and private supplying the inputs.

6.11: Estimates of Technical, Allocative and Economic Efficiency

The mean TE across all states is around 92 percent and there is not much variation across states. It is again noted that the technical efficiency ranges from 50 percent to 96 percent and also most of the farmers fall under 90 percent and above efficiency category. Technical efficiency does not vary much among the states and districts in each state (Table 6.5). But there is much variation in the allocative efficiency and economic efficiency across states. Economic efficiency is least in Rajasthan and highest in Madhya Pradesh.

Table 6.5: Technical, Allocative and Economic (Mean) Efficiencies in Soybean Crop across Selected States

State	Technical efficiency	Allocative efficiency	Economic efficiency	Cost of production per quintal (Rs)
Madhya Pradesh	93.30	67.78	63.37	1492
Rajasthan	90.22	20.54	18.84	1501
Maharashtra	91.79	37.44	34.70	2094
Telangana	91.61	26.84	24.79	5107
All States	91.76	38.54	35.79	NA

Source: Primary Survey

Variations in economic efficiency may be due to differential pricing of inputs. Our data from the village schedules of the selected villages show that predominant sources of purchasing seed and fertilizer is from shops in general while it is mostly the Rajasthan state seed corporation (RSSC), ITC, IFFCO, sarkari samithi besides traders in Rajasthan.

In Telangana seed is procured by farmers predominantly from Mandal Agricultural Office (MAO). Similarly hiring charges of machinery especially tractor, harvester and other machinery are different depending on the source and distance. There is also variation in wage rates male wage varied between Rs 200 and 500 and female wage rate between Rs 100 and 300. Due to these factors inefficiency might have been higher in the profit frontier production function. Data from the farmer households on source of purchase of inputs also show the same trend (Table 6.6). Studies also highlight that a production function approach to measure efficiency may not be appropriate when farmers face different prices and have different factor endowments (Ali and Flinn 1989).

Table 6.6: Percentage of Farmers Purchasing Seed and Fertilizer on Credit and from Government Outlets

States	Rajasthan		Madhya Pradesh		Maharashtra		Telangana		All States
Descriptive Variables	Jhalawar	Kota	Ujjain	Rajgadh	Amaravathi	Latur	Adilabad	Nizamabad	
Seed on credit	0.0	0.5	0.0	0.0	4.2	0.0	26.2	4.5	5.2
Seed from Govt outlet	1.0	0.0	0.0	0.0	27.6	1.0	88.1	95.8	32.8
Fertilizer on credit	0.0	0.0	0.0	0.0	1.6	0.0	72.2	25.3	15.2
Fertilizer from Govt outlet	8.9	1.6	0.0	0.5	24.5	0.0	0.8	8.3	5.6

Source: Primary Survey

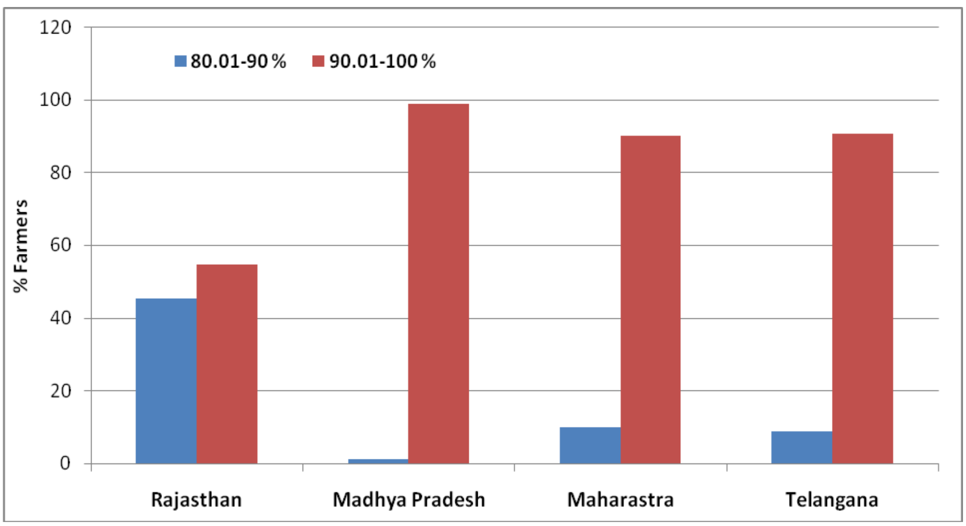
Technical efficiency has not much varied across land holding size in all the states. But allocative efficiency has varied across land holding size at the aggregate for all the states. Perceptible interstate differences are also there in this regard. Allocative efficiency variations across land holding size are more in the states of Madhya Pradesh and Telangana compared to the other two states. Large farms have higher allocative efficiency compared to the marginal. In Rajasthan though there is variation across size class the distance is not very much. In Maharashtra small farms seem to be more efficient in allocating their economic resources (Table 6.7).

Table 6.7: Technical, Allocative and Economic (Mean) Efficiencies in Soybean Crop across Land Holding Size

State	Efficiency type	Land Holding Size				
		Marginal	Small	Medium	Large	Total
Madhya Pradesh	TE	93.10	93.46	93.32	93.28	93.30
	AE	61.38	68.77	68.14	71.38	67.78
	EE	57.38	64.37	63.69	66.68	63.37
Rajasthan	TE	90.04	90.45	90.09	90.30	90.22
	AE	17.95	21.87	18.34	23.52	20.54
	EE	16.47	20.09	16.81	21.56	18.84
Maharashtra	TE	91.63	91.79	91.74	91.96	91.79
	AE	36.66	39.29	35.70	37.03	37.44
	EE	33.93	36.50	33.01	34.30	34.70
Telangana	TE	91.38	91.44	91.56	91.74	91.56
	AE	19.06	25.80	28.81	28.12	26.82
	EE	17.61	23.66	26.62	25.94	24.74
All States	TE	91.53	91.78	91.76	91.86	91.75
	AE	35.02	39.07	38.03	41.06	38.53
	EE	32.54	36.29	35.31	38.11	35.78

Source: Primary Survey

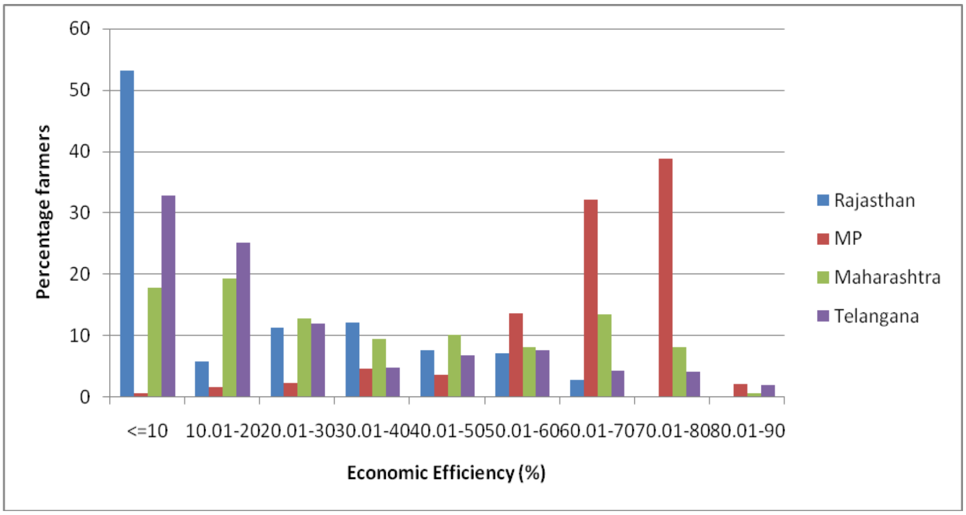
Figure 6.1: Percentage Farmers with Different Levels of TE



Source: Primary Survey

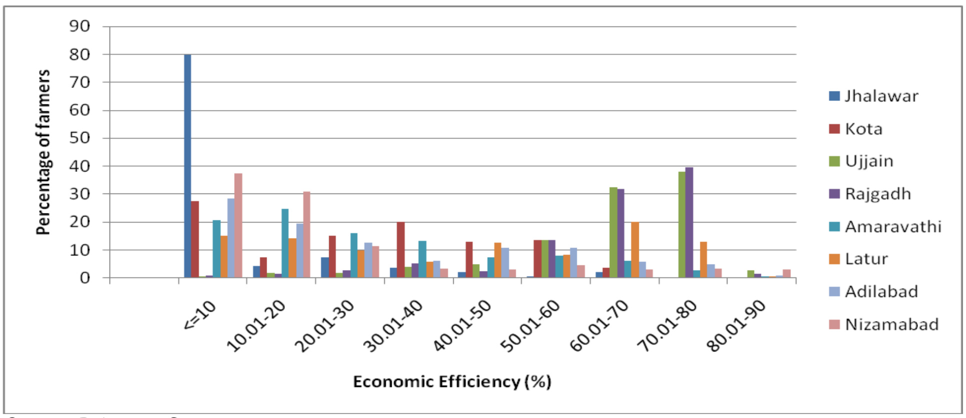
Economic efficiency is an interaction of both technical and allocative efficiencies. Figure 6.1 gives the distribution of farmers according to levels of economic efficiency. In Rajasthan high percentage of farms are placed in low levels of economic efficiency while in MP it is the reverse. Maharashtra and Telangana exhibit more or less similar pattern of distribution. District patterns show that Kota has more even distribution compared to Jhalawar in Rajasthan; Ujjain and Rajgarh are more or less similarly placed in MP; in Maharashtra Latur has more distribution towards higher levels of EE and Amaravathi has more percentage farmers in the lower levels of EE. In Telangana Adilabad has better distribution in the higher levels of economic efficiency (Table 6.8).

Figure 6.2: Distribution of Farms according Economic Efficiency across States (percent)



Source: Primary Survey

Figure 6.3: Distribution of Farms according Economic Efficiency across Districts (percent)



Source: Primary Survey

Table 6.8: Distribution of Economic Efficiency by States and Districts

Particulars	Rajasthan			Madhya Pradesh			Maharashtra			Telangana			Total
	Jhalawar	Kota	All	Ujjain	Rajgadh	All	Amaravathi	Latur	All	Adilabad	Nizamabad	All	
<=10	149 (79.7)	53 (27.5)	202 (53.2)	1 (0.5)	2 (1)	3 (0.7)	36 (20.7)	28 (15.3)	64 (17.9)	59 (28.6)	75 (37.3)	134 (32.9)	403 (25.9)
10.01-20	8 (4.3)	14 (7.3)	22 (5.8)	4 (1.9)	3 (1.5)	7 (1.7)	43 (24.7)	26 (14.2)	69 (19.3)	40 (19.4)	62 (30.9)	102 (25.1)	200 (12.9)
20.01-30	14 (7.5)	29 (15)	43 (11.3)	4 (1.9)	6 (2.9)	10 (2.4)	28 (16.1)	18 (9.8)	46 (12.9)	26 (12.6)	23 (11.4)	49 (12)	148 (9.5)
30.01-40	7 (3.7)	39 (20.2)	46 (12.1)	8 (3.9)	11 (5.4)	19 (4.6)	23 (13.2)	11 (6)	34 (9.5)	13 (6.3)	7 (3.5)	20 (4.9)	119 (7.7)
40.01-50	4 (2.1)	25 (13)	29 (7.6)	10 (4.9)	5 (2.5)	15 (3.7)	13 (7.5)	23 (12.6)	36 (10.1)	22 (10.7)	6 (3)	28 (6.9)	108 (7)
50.01-60	1 (0.5)	26 (13.5)	27 (7.1)	28 (13.6)	28 (13.7)	56 (13.7)	14 (8.1)	15 (8.2)	29 (8.1)	22 (10.7)	9 (4.5)	31 (7.6)	143 (9.2)
60.01-70	4 (2.1)	7 (3.6)	11 (2.9)	67 (32.5)	65 (31.9)	132 (32.2)	11 (6.3)	37 (20.2)	48 (13.5)	12 (5.8)	6 (3)	18 (4.4)	209 (13.5)
70.01-80	0 (0)	0 (0)	0 (0)	78 (37.9)	81 (39.7)	159 (38.8)	5 (2.9)	24 (13.1)	29 (8.1)	10 (4.9)	7 (3.5)	17 (4.2)	205 (13.2)
80.01-90	0 (0)	0 (0)	0 (0)	6 (2.9)	3 (1.5)	9 (2.2)	1 (0.6)	1 (0.6)	2 (0.6)	2 (1)	6 (3)	8 (2)	19 (1.2)
Total	100 (187)	100 (193)	100 (380)	100 (206)	100 (204)	100 (410)	100 (174)	100 (183)	100 (357)	100 (206)	100 (201)	100 (407)	100 (1,554)

Source: Primary Survey
Note: Figures in paranthesis are percentages

6.12: Determinants of Efficiencies

Efficiency scores is bounded by 0 and 1 as per the definition of Efficiencies (E). As a result the OLS regression estimates with efficiencies as the dependent variable are inefficient and the predicted values of efficiencies may fall outside the bounded interval. In addition, non-normality distributed dependent variables results in a non-normal error term and therefore, prevents tests of significance and the making of confidence interval statements. Accordingly, one can use a transformation = Ln (E/(1-E)) which assumes values between $-\infty$ and $+\infty$.

∞

Table 6.9: Determinants of TE, AE and EE

Variable	TE	AE	EE
Adoption of practices	-0.014 (0.27)	-0.397 (1.00)	-0.398 (1.03)
Best practices	-0.056 (1.93)	-0.058 (0.26)	-0.059 (0.27)
Age of farmer	-0.001 (2.61)**	-0.012 (3.87)**	-0.011 (3.87)**
Education (number of years)	-0.000 (0.32)	-0.006 (0.74)	-0.006 (0.69)
Frequency of Crop Rotation			
Once in two years	0.013 (0.62)	0.323 (2.07)	0.298 (1.96)
Once in three years	0.043 (1.48)	0.600 (2.70)**	0.556 (2.56)**
Once in four years	0.067 (3.29)**	0.659 (4.22)**	0.638 (4.19)**
Once in five years	0.008 (0.54)	0.285 (2.55)	0.263 (2.42)
Small farmer	0.046 (3.08)**	0.410 (3.61)**	0.400 (3.61)**
Medium farmer	0.027 (1.84)	0.377 (3.39)**	0.362 (3.34)**
Large farmer	0.039 (2.62)**	0.500 (4.34)**	0.481 (4.28)**
State 2	0.404 (24.80)**	2.795 (22.37)**	2.713 (22.25)**
State 3	0.215 (13.49)**	1.445 (11.80)**	1.430 (11.96)**
State 4	0.191 (11.28)**	0.727 (5.60)**	0.716 (5.65)**
Constant	2.271 (52.58)**	-1.905 (5.75)**	-2.024 (6.26)**
R2	0.39	0.38	0.38
N	1544	1542	1543

Note: *p<0.1; **p<0.05; ***p<0.01

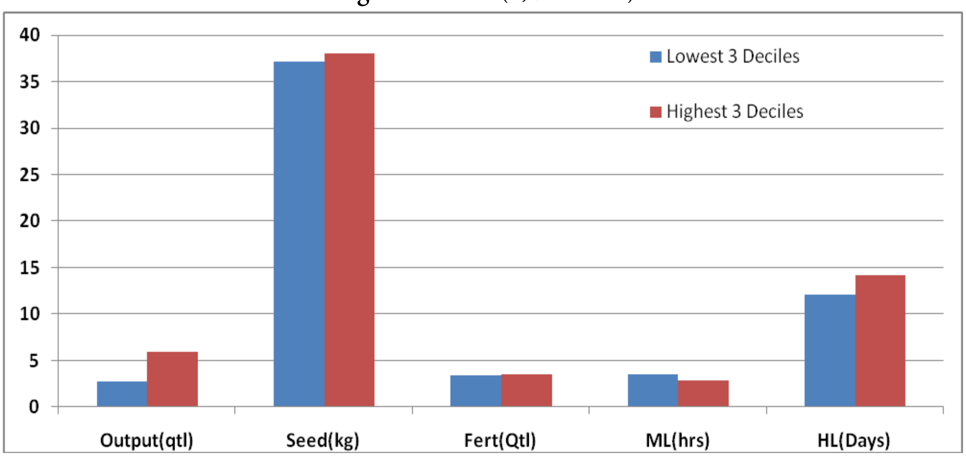
Source: Primary Survey

What are the determinants of the different efficiencies? Some possible determinants have been identified from the data and regressed on the three efficiencies (Table 6.9). Adoption of practices has turned out to be insignificant. Though farmers have adopted some of the package of practices its impact could not be seen on yield level due to deficit rainfall in the current agricultural year. Similarly adoption of best practices also did not have any significant impact on yield. Age of the farmer is a significant variable which is negatively related to efficiency. Younger aged farmers have better efficiency levels. Crop rotation once in three to four years would result in better use of inputs leading to technical efficiency and also economic efficiency. With reference to marginal farmers all other category of farmers (small, medium and large) are better off in achieving all the efficiencies. Similarly with reference to Rajasthan state all other states are better in all three efficiencies (Table 6.9).

6.13: Variations in Inputs and Outputs (Quantity, Prices, Receipts and Expenditure) According to Deciles of Farms

This section analyses the variations in the use of inputs and outputs across different deciles of farmers classified according to technical efficiency, allocative efficiency and economic efficiency levels. Figure 6.4 shows the highest three deciles have used more human labour days, less machine hours, marginally higher fertilizer and seed than the farms falling in the lowest three deciles of technical efficiency. At the same time the output achieved by the top three deciles is higher compared to the bottom three deciles. Therefore in order to raise the output of the bottom three deciles farms input adjustments have to be made by raising human labour days, reducing machine hours, slightly increasing seed and fertilizer in consonance with the top three deciles (Figure 6.4).

Figure 6.4: Variations of Inputs, Output Quantities in Lowest Deciles (1, 2 and 3) to Highest Deciles (8, 9 and 10)

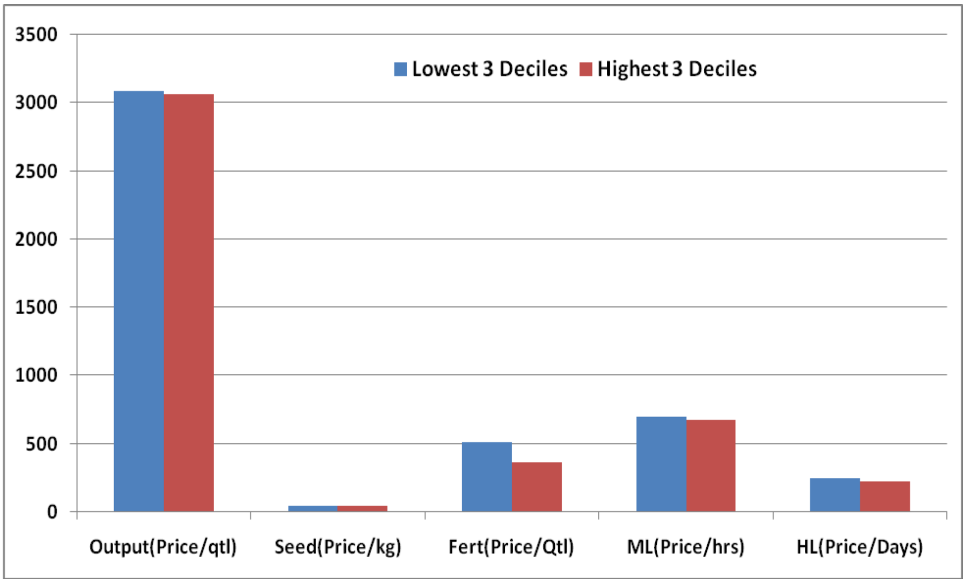


Source: Primary Survey

Note: Fert-Fertilisers, ML-Machine Labour, HL-Human Labour

Farms are classified according to the allocative efficiency into deciles and comparison between top three and bottom three deciles shows that the bottom deciles purchase fertilizer at higher price (per quintal) than the top deciles. There is no difference in the prices of seed and human labour but there is marginally higher price for machine labour in case of bottom deciles. But there is no difference in the output prices received per quintal by both top and bottom deciles (Figure 6.5).

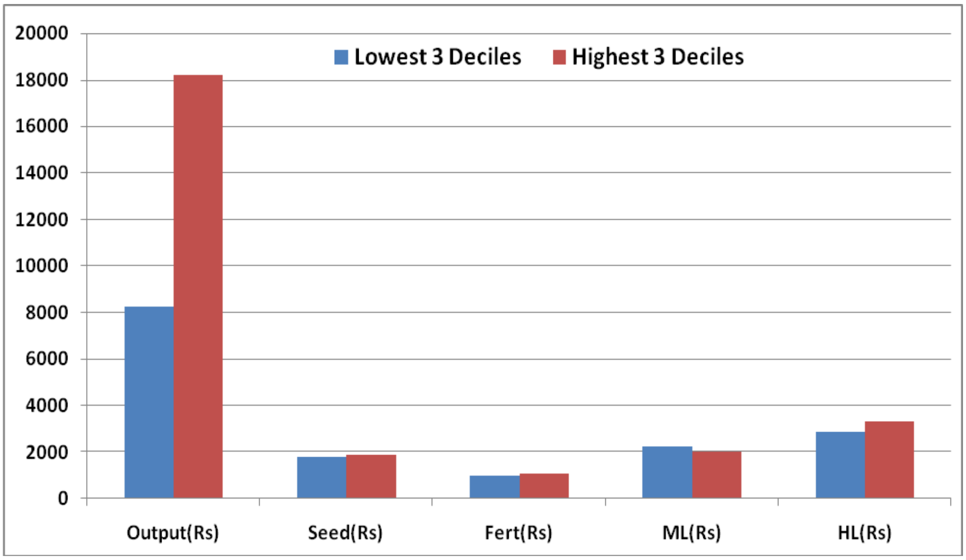
Figure 6.5: Variations of Inputs, Output Prices in Lowest Deciles (1,2 and 3) to Highest Deciles (8, 9 and 10)



Source: Primary Survey
Note: Fert-Fertilisers, ML-Machine Labour, HL-Human Labour

Farms are classified according to the economic efficiency. The top deciles have spent more money on human labour, less on machinery marginally more on fertilizer and seed but the returns on output are far more for the top deciles (Figure 6.6). This is because the physical quantity of output produced by the top three deciles is higher than that produced by the bottom three deciles as shown in figure 6.4. This is the restricted profit per acre (that is profit after the variable cost is subtracted) which takes into account only four variable inputs- seed, fertliser, machine labour and human labour. If other variable costs are taken into account the profit would be even smaller or there may be negative returns too especially for the bottom deciles. If the economic efficiency of the bottom decile farms has to be improved then appropriate policy measures need to be taken towards supplying inputs at the same cost to all farms.

Figure 6.6: Variations of Inputs, Output Spent and Received Rupees in Lowest Deciles (1, 2 and 3) to Highest Deciles (8, 9 and 10)



Source: Primary Survey

Note: Fert-Fertilisers, ML-Machine Labour, HL-Human Labour

6.14: Concluding Observations

The MLE estimates indicate that the observed output significantly differs from frontier output due to factors which are random to a large extent. Only 6 percent of the difference between actual and potential production is primarily due to technically inefficient performance of the farms. The large difference between observed output and frontier output is because of random factors in the current agricultural year (2014-15) or specifically deviation of rainfall from normal as soybean crop is primarily rain fed crop.

The observed profits significantly differ from frontier profits due to factors which are within the control of famers. 91 percent of the difference between the actual and potential normalized profit are primarily due to economically inefficient performance of the farms.

Technical efficiency does not vary much among the states and districts in each state. But there is much variation in the allocative efficiency and economic efficiency across states. Economic efficiency is least in Rajasthan and highest in Madhya Pradesh. Among the districts Ujjain in Madhya Pradesh, Jhalawar in Rajasthan, Latur in Maharashtra and Adilabad in Telangana have relatively higher levels of economic efficiency within the respective states.

Distribution of technical efficiency across states shows that large percentage of farmers fall in the highest efficiency bracket in the states of MP, Maharashtra and Telangana in that order. An analysis of determinants of efficiency show that adoption of package of practices does not significantly impact yield levels may be due to deficit rainfall in the current agricultural year. Younger aged farmers and farmers who practiced crop rotation once in 3-4 years resulted in better efficiency levels. With reference to marginal farmers all other categories are better off and with reference to Rajasthan all other states are better off in achieving efficiency in soybean production.

An analysis of variations in use of inputs and level of outputs show that in order to raise the output of bottom deciles farmers input adjustments like increase human labour days and reduce machine labour days increase in seed and fertilser quantities to reach output level of the top deciles of farmers. Farms classified according to allocative efficiency show that farms belonging to bottom deciles purchase fertilizer at higher price compared to top deciles, however there is no difference in the output price received. Farms classified according to economic efficiency show that top deciles have spent more on human labour; less on machinery but obtained higher output hence returns are higher. Appropriate policy measure could be to ensure inputs are supplied at same cost to bottom decile farms to improve economic efficiency.

REFERENCES

Ali, M. and Flinn, J.C.(1989). "Profit Efficiency among Basmati Rice Producers in Pakistan Punjab". American Journal of Agricultural Economics, 71:303-10.

Arvind Kumar (2015). "Stakeholders Access to Oil seed Technologies towards Self Sufficiency", Dr.M.V.Rao Lecture at Directorate of Rapeseed Mustard Research, Bharatpur, Rajasthan, organized by Indian Society of Oil Seeds research, Rajendra Nagar, Hyderabad.

Beintema, N.M. and Stads, G.J. (2008) *Measuring Agricultural Research Investment: A Revised Global Picture.* ASTI background note. International Food Policy Research Institute, Washington, DC, USA.

Bhatia, V.S., Singh Piara., Wani, S.P., Chauhan, G.S., Kesava Rao, A.V.R., Mishra, A.K and Srinivas, K.(2008), "Analysis of potential yields and yield gaps of rainfed soybean in India using CROPGRO-Soybean model", Agricultural and Forest Meteorology 148: 1252-1265*, Elsevier.*

Bhatia,V.S., Singh,P., Wani,S.P., Rao Keshav, A.V.R and Srinivas, K(2006) "Yeild Gap Analysis of Soybean, Ground nut Pigeon pea and Chickpea in India Using Simulation Modeling", Report of Comprehensive Assessment of Water Management in Agriculture, ICRISAT, India

Bhatnagar and Joshi (2004), "Current Status of Soybean production and Utilization in India in proceeding of world soybean research conference, IV International Soybean Processing and Utilization Conference, Brazilian Soybean Congress, Brazil, pp 26-37.

Bisaliah, S.(1987), "Soy Bean development in India" , ESCAP/CGPRT centre.

Cacek Terry and Langer L. Linda (2009), "The Economic Implications of Organic Farming", American Journal of Alternative Agriculture, pp 1-9.

Chand Ramesh. (2007), "Agro-industries characterization and appraisal: Soybeans in India", Agricultural Management, Marketing and Finance Working Document, FAO, Rome.

Chand Ramesh. (2014), " Policy reorientation for soybean production and Marketing" in Proceedings of Brainstorming workshop on "Soybean for Household Food and Nutrition Security", organized by TAAS, ICAR and NAAS, 21-22 March, New Delhi.

Chand, R., Praduman, K and Kuman, S. (2012), "Total Factor Productivity and Returns to Public Investment on Agricultural Research in India". *Agricultural Economics and Research Review,* Vol. 25(No.2) ,ppn181-194.

Chand, Ramesh and S.S. Raju (2009), "Instability in Indian Agriculture during Different Phases of Technology and Policy", Indian Journal of Agricultural Economics, Vol.64, No 2, April-June, pp.283-288.

Cleveland, D.A., Soleri, D. and Smith, S.E. (1994) "Do Folk Varieties have a Role in Sustainable Agriculture?", BioScience, Vol. 44, pp. 740-51.

Conroy, C., Iyengar, S., Lobo, V., Rao, G.B., and Rani, U. (2001), Livelihood and coping strategies in semi-arid India: A synthesis of macro and micro-level research findings, Natural Resources Institute, Chatam.

Deepthi, K., David, J.S and Anthony, J.C (2010) "Intellectual Property Rights, Private Investment in Research, and Productivity Growth in Indian Agriculture: A Review of Evidence and Options", IFPRI Discussion Paper 01031, Environment and Production Technology Division, International Food Policy Research Institute.

DSR (2011), Vision 2030, Directorate of Soybean Research, Indore, Madhya Pradesh, India.

Dupare,B.U., Billore,S.D and Joshi,O.P.(2010), "Farmers' Problems Associated with Cultivation of Soybean in Madhya Pradesh", *Journal of Agricultural Science and Technology*, ISSN 1939-1250, U.SA, Volume 4, No.6 (Serial no 31).

Evans and Fischer (1999) "Yield potential its definition measurement and significance", crop science society of America.

FICCI (2015) "Evaluation of the PPPIAD project on Soybean", Agriculture division, New Delhi.

G.E.Bettessee & T.J.Coelli (1993). A stochastic frontier production function incorporating a model for technical inefficiency effect, working paper in econometrics and applied statistics No. 69 , University of New England and Armidale

Gopinath Reddy, M., Reddy Suresh, B., and Padakondla, S.R (2015), "Biofuel production through food and fodder crops: is it a viable option for sustainable energy security? Reflections from the fields in the Indian state of Madhya Padesh" Decision, DOI10.1007/s40722-015-0085-1, Springer.

Gupta, H.S (2014) " Prospects of Doubling Soybean Production in India" Lead paper in Proceedings of Brainstorming workshop on "Soybean for Household Food and Nutrition Security", organized by TAAS, ICAR and NAAS, 21-22 March, New Delhi.

Hazell PBR, (1982). Instability in Indian food grain production research report 30 (IFPRI) Washington DC, USA

Jayanti Kajale and Sangeeta Shroff. (2013), report on "Problems and prospects of Soybean Cultivation in Maharashtra", Agro-Economic Research Centre, Gokhale Institute of Politics and Economics, Pune.

Jeyakumar,P. (2014), "Integrated Pest Management Package for Soybean", Ministry of Agriculture and Cooperation, Directorate of Plant Protection, Quarantine and Storage, Government of India, Haryana.

Kalirajan, K.P. and Shand, R.T. (1994). "Modelling and Measuring Economic Efficiency under Risk". Indian Journal of Agricultural Economics, 49(4):579-590.

Kulkarni, S.D.(2014), "Processing Technology for Direct Food Uses", Lead paper in Proceedings of Brainstorming workshop on "Soybean for Household Food and Nutrition Security", organized by TAAS, ICAR and NAAS, 21-22 March, New Delhi.

Mall,R.K., Lal.M., Bhatia,V.S., Rathore,L.S and Singh,R.(2004), "Mitigating Climate Change impact on soybean productivity in India: A Simulation Study", Journal of Agricultural and Forest Meteorology, Elsevier, 121(2004) 113-125.

Matlani, G.(2014), "Role of So Food in Malnutrition Eradication", Lead paper in Proceedings of Brainstorming workshop on "Soybean for Household Food and Nutrition Security", organized by TAAS, ICAR and NAAS, 21-22 March, New Delhi.

Pionetti, C and Suresh Reddy B (2002) "Farmers Perceptions of Crop Diversity in the Deccan Plateau", SEEDLING, Quarterly Newsletter of Genetic Resources Action International (GRAIN), Spain.

Pionetti, C. (2007), "Sowing Autonomy: Gender and Seed Practices in Semi-Ari India", International nstitute for Environment and Development (IIED), London, U.K.

Population Census of India, 2011

Ranjitha, P., Jetska, B. and Christopher, S. (2004) "Sustainable Livestock production in Semi-Arid Watersheds", Economic and Political Weekly, July 31, pp 3477-3483.

Reddy Suresh, B (2009), "Sustenance and enhancement of Agro-biodiversity: Voice of stake holders from Deccan area of southern India". Journal of Social Action, Vol 59, No.1, pp19-30

Reddy Suresh, B. (2011) "Dynamics of Soil Fertility Management Practices in Semi-Arid Regions: A Case study of AP". Economic and Political Weekly, Mumbai, Vol XLVI No 3, pp 56-63

Reddy, P. Prudhvikar (1997) "Economic Analysis of Paddy Cultivation in Andhra Pradesh". PhD Thesis submitted to Dr. B. R. Ambedkar Open University, Hyderabad through Centre for Economic and Social Studies, Hyderabad.

Reddy, Suresh.B (2015) "Non-Pesticidal Management of Pests: An Empirical Analysis", CESS Monograph 38, Centre for Economic and Social studies, Hyderabad, Telangana state.

Reddy, Suresh.B (2015), "Soil Fertility Management in Semiarid Regions: The Sociocultural, Economic and Livelihood Dimensions of Farmers' Practices- A Case of Andhra pradesh", in N.Ghosh *et al* (eds) "Nature, Economy and Society: Understanding the Linkages", Springer, New Delhi.

Richa Kumar (2014) "Elusive Empowerment: Price Information and Disintermediation in Soybean Markets in Malwa, India", Journal of *Development and Change*, 45(6):1332-1360.DOI:10.1111/DECH.12131.

Scoones Ian (2001) "Dynamics and diversity: soil fertility management and farming livelihoods in Africa: case studies from Ethiopia, Mali and Zimbabwe", DFID, London.

Sharma, A.N., Gupta, G.K., Verma, R.K., Sharma, O.P., Someshwar, B., Amaresan, N., Saini, M.R., Chattopadhyay,C., Sushil,S.N., Ram Asre., Kapoor,K.S., Satyagopal, K., and Jayakumar, P. (2014) "Integrated Pest Management for Soybean". PP 41.

Shiro Horiuchi, John R. Wilmoth and Scott D. Pletcher (2008), "A Decomposition Method Based on a Model of Continuous Change", Demography Vol. 45, No. 4 (November 2008), pp. 785-801.

Singh BB, (undated): Success of Soybean in India: The Early Challenges and Pioneer Promoters, International Institute of Tropical Agriculture, Nigeria.

Singh, S.P. (1979), "Intercropping studies in sorghum", In Proceedings of International Workshop on Intercropping held at ICRISAT 10-13 January, 1979 Hyderbad, India, pp. 22-24

Srivastava, S.K.(2014), "Improving Soybean Productivity in Different Agro-climatic Situation" in Proceedings of Brainstorming workshop on "Soybean for Household Food and Nutrition Security", organized by TAAS, ICAR and NAAS, 21-22 March, New Delhi.

Tiwari, S.P (2014) "Raising the Yield Ceilings in Soybean- An Indian Overview" in "Mitigating productivity constraints in Soybean for sustainable agriculture", Proceedings of SOYCON 2014: International Research Conference. Society for Soybean Research and Development, Directorate of Soybean research, Indore, India.

Wilmot, L. (2009), Report on "Assessing the cost of Soybean production in MP, and the Sustainability of a continuing increase in its area of cultivation in MP and in India as a whole", Action for Social Advancement, Bhopal, India.

APPENDIX

Table 1: Distribution of Responses of Sampled HHs with Respect to Soil Testing and Analysis in Study States during 2014-15 (Percent).

Particulars	Rajasthan		Total	Madhya Pradesh		Total	Maharashtra		Total	Telangana		Total
	Jhalawar (N=192)	Kota (N=192)	(N=384)	Ujjain (N=192)	Rajgadh (N=192)	(N=384)	Amaravathi (N=192)	Latur (N=192)	(N=384)	Adilabad (N=252)	Nizamabad (N=288)	(N=540)
Have you done testing of soil												
Yes	15	13	14	4	2	3	21	13	17	18	17	18
No	85	87	86	96	98	97	79	87	83	82	83	82
Total	100	100	100	100	100	100	100	100	100	100	100	100
Number of times soil was tested												
Once	57	75	66	24	75	33	95	52	78	58	54	56
Twice	21	13	17	76	25	67	5	20	11	22	30	26
Thrice	18	8	13	0	0	0	0	24	9	9	8	8
Four Times	4	4	4	0	0	0	0	4	2	2	4	3
Five times	0	0	0	0	0	0	0	0	0	9	4	6
Total	100	100	100	100	100	100	100	100	100	100	100	100
Is it Irrigated land or Dryland												
Irrigated	93	95	88	18	50	24	31	44	36	13	48	32
Dryland	7	5	12	82	50	76	69	56	64	78	44	60
Both	0	0	0	0	0	0	0	0	0	9	8	8
Total	100	100	100	100	100	100	100	100	100	100	100	100
Did you collect sample on your own												
Yes	79	76	73	29	50	33	64	76	69	27	44	36
No	21	24	27	71	50	67	36	24	31	73	56	64
Total	100	100	100	100	100	100	100	100	100	100	100	100
If not collected on own, Agency involved in soil sample collection												
Agril. Department	45	33	42	13	50	21	76	95	83	85	74	80
Agril. Res. Station	5	22	10	80	25	68	15	0	9	15	9	12

Appendix Table 1: contd..

Appendix Table 1: contd..

Particulars	Rajasthan		Total	Madhya Pradesh		Total	Maharashtra		Total	Telangana		Total
	Jhalawar (N=192)	Kota (N=192)	(N=384)	Ujjain (N=192)	Rajgadh (N=192)	(N=384)	Amaravathi (N=192)	Latur (N=192)	(N=384)	Adilabad (N=252)	Nizamabad (N=288)	(N=540)
KVK	23	11	19	0	25	5	6	0	4	0	0	0
NGO	0	0	0	0	0	0	0	5	2	0	3	1
Private Company	0	11	3	0	0	0	3	0	2	0	6	3
Others	27	22	26	7	0	5	0	0	0	0	9	4
Total	100	100	100	100	100	100	100	100	100	100	100	100
The place of soil sample for analysis												
Agril. University	21	8	15	14	0	12	24	40	30	13	5	8
District STL	64	75	69	86	33	76	61	40	52	43	59	51
KVK soil lab	14	4	10	0	67	12	16	20	17	0	0	0
Private organizs.	0	8	4	0	0	0	0	0	0	0	7	4
Others	0	4	2	0	0	0	0	0	0	45	27	36
Don't know	0	0	0	0	0	0	0	0	0	0	2	1
Total	100	100	100	100	100	100	100	100	100	100	100	100
Average time taken for giving the soil analysis result by the agency												
2 Weeks	32	8	21	6	67	15	0	21	8	0	2	1
percent												
1 Month	25	33	29	94	0	80	6	29	15	2	11	7
2 months	0	17	8	0	0	0	11	29	19	0	7	3
3 months	0	4	2	0	0	0	17	0	10	0	0	0
4 to 6 months	0	4	2	0	0	0	3	4	3	0	0	0
6 to 12 months	4	0	2	0	0	0	3	0	2	2	0	1
1 to 2 years	0	0	0	0	0	0	9	4	7	0	0	0
More than 2 years	0	0	0	0	0	0	3	0	2	0	0	0
never gave the result of analysis	29	33	31	0	0	0	49	13	34	88	80	84
others	11	0	6	0	33	5	0	0	0	7	0	3
Total	100	100	100	100	100	100	100	100	100	100	100	100

Appendix Table 1: contd..

Appendix Table 1: contd..

Particulars	Rajasthan		Total	Madhya Pradesh		Total	Maharashtra		Total	Telangana		Total
	Jhalawar (N=192)	Kota (N=192)	(N=384)	Ujjain (N=192)	Rajgadh (N=192)	(N=384)	Amaravathi (N=192)	Latur (N=192)	(N=384)	Adilabad (N=252)	Nizamabad (N=288)	(N=540)
Was the analysis useful												
Yes	100	83	92	86	67	82	71	88	78	5	16	11
No	0	17	8	14	33	18	29	12	22	95	84	89
Total	100	100	100	100	100	100	100	100	100	100	100	100
If yes, how was your satisfaction level?												
Less	14	26	19	8	100	21	26	23	24	100	29	44
Moderate	82	47	68	92	0	79	70	55	63	0	29	22
High	4	16	9	0	0	0	4	14	8	0	29	22
Very High	0	11	4	0	0	0	0	9	4	0	14	11
Total	100	100	100	100	100	100	100	100	100	100	100	100

Source: Primary Survey

Table 2 Details of Village Profile in the Study Sites of Madhya Pradesh State during 2014-15

Particulars	Ujjain District				Rajgarh District			
	Badnagar Block		Mehidpur Block		Biovhra Block		Narsingarh Block	
	Lohana	Jandla	Mundla Parval	Delchikurd	Chachakhedi	Baiheda	Mavasa	Sarana
Total No o f HH	356	191	281	470	301	205	177	106
SCs	32	24	25	24	117	7	26	10
STs	25	6	0	0	0	21	22	0
BPL HHs	293		120		106	221	145	127
Population	2935	1326	1347	2024	1169	1735	1474	956
Literacy (percent)	56.85	64.44	51.59	60.17	53.35	49.34	71.77	69.67
Primary school	1	1	1	1	0	1	1	1
High school	1	1	1	0	0	1	1	1
Anganwadi centres	4	1	0	1	2	2	2	1
Electricity connection (1=yes,2=no)	1	1	1	1	2	1	1	1
Drinking water facility(1=yes,2=no)	1	1	1	1	1	1	1	1
Male Wage Rate	300	250	250	300	300	300	250	250
Female Wage rate	250	250	200	250	300	250	250	250
Small and Marginal farmers	150	50	75	152	140	141	102	63
Number of soybean farmers in the village	356	103	118	198	183	205	155	106
Number of Seed varieties cultivated in the village	2	3	2	2	1	4	4	3
Soybean Acreage(acres)	1500	314	498	731	540	688	456	359
Number of Large Ruminants	424	280	270	265	570	310	366	816
Small Ruminants (Only Goats)	15	60	80	70	50	10	200	100
Farmers using tractor (percent)	99	99	95	90	40	90	95	100
Number of Bullocks in Village	24	30	20	15	120	10	16	16
Percentage of soybean farmers using Grading machine	80	80	20	20	20	40	60	25

Source: Field Survey and Village Records

Table 3 Details of Village Profile in the Study Sites of Rajasthan State during 2014-15

Particulars	Jhalawar District				Kota District			
	Pidawa Block		Khanpur Block		Pipalda Block		Digodh Block	
	Dhuvliya	Dharonia	Bareda	Khandi	Balupa	Durjanpura	Khedlitavran	Bislai
Total No o f HH	359	457	277	333	359	300	210	167
SCs	77	80	10	87	93	65	59	25
STs	83	0	131	51	7	75	4	131
BPL HHs	33	118	44	64	109	29	115	22
Population	1858	2353	1471	1857	1126	2308	1365	1007
Literacy(percent)	70	80	70	60	66	70	60	60
Primary school	1	1						
High school	1	1	1	1	1	1	1	1
Anganwadi centres	1	2	1	1	1	1	1	1
Electricity connection(1=yes,2=no)	1	1	1	1	1	1	1	1
Drinking water facility(1=yes,2=no)	1	1	1	1	1	1	1	1
Male Wage Rate	250	300	250	200	250	300	250	250
Female Wage rate	200	200	200	150	150	200	200	150
Small and Marginal farmers	266	327	143	181	126	199	68	110
Number of soybean farmers in the village	329	402	226	274	190	304	125	166
Number of Seed varieties cultivated in the village	4	4	4	2	3	3	2	2
Soybean Acreage(acres)	420	320	459	806	470	532	468	65
Number of Large Ruminants	585	861	252	635	510	566	369	565
Small Ruminants (Only Goats)	247	417	133	403	730	319	349	157
Farmers using tractor(percent)	90	90	90	90	100	100	90	90
Number of Bullocks in Village	10	33	30	16	20	8	10	16
Percentage of soybean farmers using Grading machine	10	30	10	10	10	10	10	20

Source: Field Survey and Village Records

Table 4 Details of Village Profile in the Study Sites of Maharashtra State during 2014-15

Particulars	Amaravathi District				Latur District			
	Amaravathi Block		Nandgoan Block		Latur Block		Ausa Block	
	Kekatpur	Nayakola	Shirpur	Dahigoan	Kahva	Bamani	Barhanpur	Vangaji
Total No o f HH	429	390	280	500				
SCs	165	105	60	110				
STs	82	100	90	90				
BPL HHs	117	145	42			62	75	
Population	2086	4681	1420	3000		2500	1000	
Literacy(Persons)	120	155	20	50		150	40	
Primary school	1	1	1	1		1	1	
High school	0	1	0	1		1		
Anganwadi centres	1	4	2	1		2	1	
Electricity connection(1=yes,2=no)	1	1	1	1		1	2	
Drinking water facility(1=yes,2=no)	1	1	1	1				
Male Wage Rate	250	200	200	200		300	250	
Female Wage rate	150	150	150	150		150	150	
Small and Marginal farmers	205	170	150	160		60	95	
Number of soybean farmers in the village	400	310	225	250		300	250	
Number of Seed varieties cultivated in the village	3	3	2	2		2	2	
Soybean Acreage(acres)	2195	2250	450	1250			750	
Number of Large Ruminants	210	536	316	237		850	350	
Small Ruminants (Only Goats)	300	200	150	300		50	30	
Farmers using tractor(percent)	75	75	99	90		90	100	
Number of Bullocks in Village	100	166	66	30		200	100	
Percentage of soybean farmers using Grading machine	30	5	2	0			0	

Source: Field Survey and Village Records

Table 5 Details of Village Profile in the Study Sites of Telangana State during 2014-15

Particulars	Adilabad District						Nizamabad District					
	Kautala Mandal			Jainoor Mandal			Velpoor Mandal			Tadwai Block		
	Thatipally	Pardi	Gangapur	Ashapally	Patnapur	Daboli	Akloor	Velpoor	Lakkora	Kankal	Karadpally	Tadwai
Total No. of HH	150	197	250	545	550	91	500	2532	628	559	380	1270
SCs	4	67	83	100	5	28	160	886	60	201	80	284
STs	3	100	0	425	470	44	0	5	40	0	0	32
BPL HHs	135	199	245	325	520	88	500	1836	580	588	560	1052
Population	650	1080	1153	2380	1760	315	1912	8277	2636	2212	1422	5624
Literacy(persons)	300	428	530	476	470	180	1385	4377	1610	1767	1160	4200
Primary school	1	2	1	6	1	1	1	3	3	1	1	3
High school	0	1	1	1	1	0	0	1	1	1	1	1
Anganwadi centres	1	2	2	7	2	1	2	8	3	4	3	6
Electricity connection(1=yes,2=no)	1	1	1	1	1	1	1	1	1	1	1	1
Drinking water facility(1=yes,2=no)	1	1	1	1	1	1	1	1	1	1	1	1
Male Wage Rate	250	200	200	200	200	250	500	500	500	300	200	300
Female Wage rate	150	150	150	100	150	120	300	250	300	150	150	150
Small and Marginal farmers	65		131	130	160	51		1168	325	300	239	349
Soybean farmers in the village	100	150	180	300	150	50		230	370	370		460
Number of Seed varieties cultivated in the village	1	1	1	1	1	1	1	1	1	1	1	1
Soybean Acreage(acres)	400	950	270	900	454	70	900	1601	580	600	na	1042
Number of Large Ruminants	370	3210	510	1400	480	180	320	1988	620	250	640	430
Small Ruminants (OnlyGoats)	100	320	20	1000	300	0	200	1016	100	200	400	200
Farmers using tractor(percent)	100	100	25	25	10	40	100	100	90	100	60	97
Number of Bullocks in Village	300	200	340	400	300	90	10	0	80	200	40	70
Percentage of soybean farmers using Grading machine	0	0	0	0	0	0	0	0	0	0	0	0

Source: Field Survey and Village Record

Note: Mandal is the smallest administrative unit near to the village in Telangana state.

Table 6 Details of Average Cost of Cultivation (in rupees) of Sampled Households for Soyabean Crop in Rajasthan, Madhya Pradesh, Maharashtra and Telangana states during Normal Year in the Last 5 Years (Per acre)

Particulars	Rajasthan		Total (N=384)	Madhya Pradesh		Total (N=384)	Maharashtra		Total (N=384)	Telangana		Total (N=534)
	Jhalawar (N=192)	Kota (N=192)		Ujjain (N=192)	Rajgadh (N=192)		Amaravathi (N=192)	Latur (N=192)		Adilabad (N=247)	Nizamabad (N=287)	
Seed used by households (in Rs.)	2010	1970	1990	2199	1573	1886	1898	1938	1918	1102	1652	1395
Total Fertilizer used (in Rs.).	1043	503	773	1534	1670	1602	1386	1537	1462	506	731	626
Farm Yard Manure used (in Rs.)	994	681	837	941	769	855	569	1117	843	369	441	407
Pesticides used (in Rs.)	1671	1220	1445	1093	1313	1203	1241	1631	1436	527	696	617
Bullock power used (in Rs.)	250	100	123	107	426	266	944	1121	1053	1814	274	1169
Tractor power (in Rs.)	3562	3679	1145	1792	759	1275	1148	2820	1984	1763	2850	2516
Human labour (in Rs.)	5943	4756	5349	3178	2039	2608.50	2934	3754	3583	2940	6539	5251
Pumping (in Rs.)	469	487	478	1809	427	1118	842	456	649	33	35	34
Total Expenditure (in Rs.)	15942	13396	14669	12833	8976	10904.5	10962	14374	12928	9054	13218	12015
Crop Yield (in Qtls.)	10.5	9.7	9.9	10	8.5	9.25	6.8	10	8.4	5.6	8.7	7.2
Price per Quintal												
(in Rs.)	2034	1862	1948	2371	2354	2363	2660	2438	2548	1874	2131	2012
Total income from crop (in Rs.)	21357	18061	19709	23710	20009	21859	18088	24380	21403	10494	18540	14486
Net Income (in Rs.)	5415	4665	5040	10877	11033	10955	7126	10006	8475	1441	5321	2471

Source: Primary Survey

Table 7: Constraints faced by farmers cultivating soybean in selected districts & states (percentage)

Constraints	Rajasthan		Total	Madhya Pradesh		Total	Maharashtra		Total	Telangana		Total	All
	Jhalawar	Kota		Ujjain	Rajgadh		Amaravathi	Latur		Adilabad	Nizamabad		States
N	192	192	384	192	192	384	192	192	384	252	288	540	1692
Absence of soil sample tests and analysis by government	74 (143)	94 (181)	84 (324)	74 (143)	80 (154)	77 (297)	36 (70)	61 (117)	49 (187)	58 (146)	55 (158)	56 (304)	66 (1112)
No Access to latest information related to seeds, fertilizers and pesticides	32 (62)	43 (82)	38 (144)	10 (20)	2 (3)	6 (23)	21 (40)	27 (52)	24 (92)	6 (15)	9 (25)	7 (40)	18 (299)
Dearth of timely access to inputs	32 (62)	72 (139)	52 (201)	13 (25)	1 (1)	7 (26)	64 (123)	16 (31)	40 (154)	9 (22)	15 (43)	12 (65)	26 (446)
Non-availability of FYM and compost Non establishment of	21 (40)	16 (31)	18 (71)	55 (105)	93 (178)	74 (283)	3 (6)	0 (0)	2 (6)	50 (125)	24 (68)	36 (193)	33 (553)
soil testing labs at block level	43 (83)	64 (123)	54 (206)	47 (90)	60 (115)	53 (205)	53 x(45)	17 (33)	20 (78)	13 (33)	31 (89)	23 (122)	36 (611)
Non-availability of Training by KVKs.	6 (12)	17 (32)	11 (44)	7 (14)	64 (122)	35 (136)	4 (7)	2 (4)	3 (11)	17 (43)	2 (5)	9 (48)	14 (239)
No timely access to Credit	2 (3)	3 (5)	2 (8)	2 (3)	4 (8)	3 (11)	34 (65)	16 (30)	25 (95)	50 (126)	27 (79)	38 (205)	18 (309)
Absence of Crop Insurance for Soya crop	11 (21)	5 (9)	8 (30)	2 (3)	1 (1)	1 (4)	2 (4)	5 (9)	3 (13)	12 (29)	50 (144)	32 (173)	13 (220)
Less usage of micro nutrients	13 (24)	24 (47)	18 (71)	9 (18)	10 (19)	10 (37)	33 (63)	32 (62)	33 (125)	0 (1)	0 (0)	0 (1)	14 (234)
Absence of subsidy for seeds, fertilizers and pesticides	13 (24)	10 (20)	11 (44)	5 (9)	1 (2)	3 (11)	6 (12)	23 (44)	15 (56)	54 (135)	50 (144)	52 (279)	23 (390)
No Provision of training on Bio-pesticides & development of short duration varieties	2 (4)	2 (4)	1 (4)	3 (6)	9 (18)	3 (13)	9 (17)	6 (11)	4 (14)	1 (3)	2 (5)	1 (4)	0.5 (8)
Delay in providing complete timely information from Agricultural department	4 (7)	2 (4)	1 (5)	3 (5)	5 (9)	2 (7)	14 (28)	7 (14)	5 (21)	37 (100)	34 (99)	18 (100)	2 (39)

Note: Figures in parenthesis indicate number of households
Source: Primary survey

Authors' Profiles

E. Revathi is Professor of Economics at the Centre for Economic and Social Studies (CESS), Hyderabad with expertise in research and teaching. Her research specialization is in Agriculture, Gender Studies, and Development Studies. She teaches Development Theory and Agricultural Economics for the M Phil and Ph. D students. She is currently Dean of Division for graduate Studies.

She has published research papers on agrarian transformation, agrarian distress and farmers and weavers suicides; women in agriculture, land rights of women and women empowerment; regional exclusion and development; social movements and human development. She co-authored two background chapters for the Andhra Pradesh Human Development Report, 2007, prepared for the state government by CESS. She also contributed to Study Group on Gender and Agriculture in formulating the XI Plan Proposals, Mid Term Appraisal of XI Five Year Plan on 'Agriculture and Water Management'; contributed to Group of Ministers appointed by Government of India on bifurcation of the state of AP on 'Special needs of the backward districts of Telangana' (2013); Millennium Development Goals Report for the two states of Telangana and AP.

She worked individually and with other scholars at CESS in national and state level research projects on MGNREGS, Rural Indebtedness, State Policies, Programmes, Interventions and their Impact on Women's Access to Land, Tenancy and Land Licensed Cultivator Act, Impact of Computerization of Land Records on bank lending, Mid-term evaluation of medium irrigation project in Andhra Pradesh and Telangana, Market Intelligence Study of Handloom Products, Soybean varieties and Package of practices.

She guides M. Phil and Ph.D. students. She is co-editor of the book "Telangana Economy" a forthcoming publication by Telugu Academy. She also edited the special issue on "Economy of Telangana" of The Indian Economic Journal brought out in December 2016.

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