CGPRT NO. 5

SOYBEAN DEVELOPMENT IN INDIA

S. Bisaliah

The CGPRT Centre

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UN/ESCAP CGPRT Centre
Regional Co-ordination Centre for
Research and Development of Coarse Grains,
Roots and Tuber crops
in the Humid Tropics of Asia and the Pacific

The UN/ESCAP CGPRT Centre
Jalan Merdeka 99, Bogor 16111
Indonesia

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Printed in Indonesia

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FOREWORD

The regional research project RAS/82/002 is funded by the UNDP, and is implemented by the FAO and the ESCAP/CGPRT Centre.

One of the important objectives is to identify and analyse socio economic constraints to increased production and efficient distribution, and to formulate strategies to exploit economic, employment and nutritional potential of coarse grains and food legumes under varying farming systems.

In line with its mandate, the CGPRT Centre was requested to implement socio-economic studies in selected countries of Asia. Initiated in late 1984, country studies were conducted in 7 countries, namely, Bangladesh, India, Indonesia, Nepal, the Philippines, Sri Lanka and Thailand. Selection of crops was based on their importance to the individual country and on the priority set by the CGPRT Centre, namely, selected pulses for the southern Asia subregion and either maize or soybean for Southeast Asian countries.

The research report "Soybean Development in India" is the first in this series of country reports. It describes the impressive soybean development in several states in India, and analyses contributing factors towards its fast development.

Prof. S. Bisaliah shows clearly in his analyses the relevance of area-specific development. This characteristic is most relevant for development of CGPRT crops in general. The Indian experience will prove to be useful to, among others, planners, researchers and extension workers. The report evaluates the impact of government policy with regard to soybean development. The production increase, based mainly on area expansion, also shows the willingness of farmers to adopt innovation even when it invites risk.

I am pleased to present this report to the reader, and I hope it will stimulate creative planning of research and development of CGPRT crops in the region.

Director,
CGPRT Centre

Shiro Okabe

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Acknowledgements

The author is thankful to Dr. R.D. Ghodake, Dr. Von Oppen, Mr. Parthasarathi and Miss Lalitha, ICRISAT, Hyderabad, India; to Mr. N. Karamathullah, Mr. Lalith Achoth and Mr. T.M. Gajanana, of UAS, Bangalore, and to Mr. Kashive of JNKVV, Jabalpur, for their suggestions, andhelp in the preparation of this report.

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Summary

India activated its development programme for soybean in the 1960s and the expansion seen between 1972 and 1984 was exceptionally rapid. Some 770 thousand hectares of land were brought under soybean from 1972 to 1983, marking a 24-fold increase. In contrast, soybean yields, which in India are a good deal lower than most of the world, had by 1983 decreased 12% from 1972 yields to 716 Kg/ha. . Production increased 21 percent to 583 000mt.

Plausible explanations for this rapid expansion include the development of varieties of soybean well-suited to the Indian agricultural situation, particularly, derivatives of black-seeded indigenous Kalitur, and the advantageous utilization of Kharif fallows for soybean cultivation. In addition, the relatively higher (one-sixth greater) returns of soybean over competing crops, an aggressive support scheme for soybean development launched by the Indian government in 1971 to help offset an- international trade imbalance in edible oils (recalling India's dependence on vegetarian sources of oil--and protein as well), and increased interaction between food processing industries and soybean farmers, contributed to this expension. As well, the improvement of technology for the processing of soybeans and for wider industrial utilization was a factor.

India's unusually rapid development of soybean is based on a highly area-specific expansion. The state of Madhya Pradesh experienced a 38-fold increase- in area (to 615800 ha in 1983) and a similar increase in production (to 440300 mt in 1983) during the period 1972--1983; Uttar Pradesh increased its area and production 10 and 8 times respectively, while Maharestra's soybean crop had become insignificant by 1983. Major factor responsible for concentrated soybean development seem to be the development of irrigation systems to compensate for unfavourable climatic factors, promotion of soybean as an intercrop with sorghum and cotton, and the assured market of newly erected extraction plants in these areas.

The prospects of soybean expanding further into a major crop in India are good. The know-how accumulated on soybean farming in India is already considerable, and industry is becoming increasingly aware of the varied uses of soybean. It appears that the importance of soybean is increasing while the availability of pulses, the nation's cheapest source of protein, is decreasing.

The major constraint to sustained development of soybean remains the low and declining yields. Consumer and farmer education and governmental support can help increase yields; increased industrial utilization of the crop can become more important. High yields are constrained by a complex interaction of genetic, physiologic and climatic factors.

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Glossary

Chapati is a type of flat bread common in India, traditionally made from wheat.

Dal refers to the thick soup or sauce prepared from mature dried seeds of legumes, cooked whole, split, broken or ground in water together with some spices.

JNKVV is the University of Agriculture at Jabalpur (M.P.).

Kharif refers to the Rainy season in India, lasting-from July to October (see Rabi below).

Madhyapradesh (or M.P.), **Uttarpradesh** (or U.P.), **Rajasthan**, **Maharastra** and **Gujarat** are are names of some major Indian states. The major districts of M.P., whose names appear frequently in the text, are listed in Table 16, page 34.

NAFED is an acronym for the National Agricultural Co-operative Marketing Federation of India.

Rabi refers to the winter or dry season in India extending from October to Marchi spring season extends from February to June (see Kharif above).

I. Introduction

1. The use of soybean dates back to the beginning of China's agricultural age. The utilization of this crop has been mentioned in Chinese medical compilations dating back 6000 years. [a] For centuries, soybean has meant meat, milk, cheese, bread and oil to the people of China, Japan, Korea, Manchuria, the Philippines and Indonesia. This explains why this crop has often been mentioned in these countries as the 'Cow of the field', or 'Gold from soil'. The versatility of soybean has of late been recognized in the West. That the West has been a late entry into the area of soybean production could also be illustrated by the fact that even in 1921, China produced about 80 percent of the world's soybean output[b]

Recognizing soybean as the 'golden bean' or the 'miracle bean', the western world provided a massive push to its growth during the early part of the century. The crop, in fact, has revolutionized the agricultural economy of the USA, with its immense potential for food, feed and numerous industrial products. At present, the USA, Brazil and China are the 'Big-3' in soybean production, with the USA enjoying hegemony. The USA now has over 50 percent of total soybean area in the world, producing over 50 percent of the world's soybeans.

Soybean has come to be recognized as one of the premier agricultural crops today for various reasons. In brief, soybean is a major source of vegetable oil, protein and animal feed. Soybean, with over 40 percent protein and 20 percent oil, has now been recognized all over the world as a potential supplementary source of edible oil and nutritious food. The protein of soybean is called a complete protein, because it supplies sufficient amounts of the kinds of amino acids required by the body for building and repair of tissues. Its food value in heart disease and diabetes is well known. It is significant that Chinese infants using soybean milk in place of cow's milk are practically free from rickets.

Soybean is a rich source of edible oil containing no cholesterol and almost none of the saturated fats. Soybean oil surpasses all other oils because it is an ideal food for heart patients and those who wish to avoid heart disease. It also contains a large amount of lecithin and a fair amount of fat-soluble vitamins. Lecithin is an important constituent of all organs of the human body and especially of the nervous tissue, the heart and liver. Soybean is, therefore, a good food.

Besides its nutritive quality, functional properties of soy protein have opened avenues for producing new products and improving the quality of existing standard food products. A chain of soy based industries has emerged in the USA. Oil is extracted for human consumption and industrial uses, and defatted soy meal is converted into various protein rich foods and feed products. In industry, soybean is used in the manufacture of edible lard, margarine, vegetable ghee,

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[a] Horvath (1925), and Krishnamyrthy, K. and K. Shivashankar (1975).
[b] Horvath (1925).

milk, pastries, as well as the manufacture of paints, varnishes, adhesives, etc. Soybean protein concentrate, protein isolate and textured protein have found their way into multifarious commercial food industries. Being a versatile crop with innumerable possibilities, soybean can support many agro-based industries.

Soybeans are looked upon not merely as a means to supply food for humans and animals, but also at the same time to serve as a means for improving the soil through their ability to fix atmospheric nitrogen. As a legume, it is an ideal component of a sound agricultural system. It is in the perspective of all these advantages of soybeans and its adaptability and productivity across tropical, subtropical and temperate environments that significant strides have been made in its innovation. In fact, the expansion of soybean across the world has been characterized as one of the striking developments of recent decades.

India has also entered this soybean development race, although the experience of India as an active participant in this race is not even of two decades. Even so, soybean is not a new crop to India. It was grown in India long before it was introduced to the USA in the early 1800s. Black soybean has been grown for ages in low Himalayan hills as well as in the foothills and some scattered pockets of central India. Soybean was primarily used as a pulse by the local population, and the green and dried vegetative parts were used as forage for cattle. Strangely enough, however, the crop had never become popular on the Indian subcontinent or in other tropical countries until recently.

While the importance of soybean as a commercial crop with immense potential for food and feed has been well recognized by developed countries, developing countries (including India) have delayed the development of this crop.

In India, which is predominantly a vegetarian society, fats and proteins of vegetable origin acquire special significance. Since soybean is both an oilseed and a pulse crop and India has been struggling hard to bridge the oil and protein gap, fresh attempts were initiated in the 1960s to explore the possibility of developing soybean as a commercial crop in the country. It was indicated 55 that production of soybeans would increase farm income and provides a cheap, additional supply of high quality protein suitable for human consumption as well as badly needed edible oil. Many forces were operative in motivating India to be an active participant in the soybean development race since the beginning of the 1970s.

Even though India's share in the world's total area under soybean is about one percent at present, development as well as the expansion of this crop in the country during the last 15 years is rated as one of the striking occurrences in the agricultural development process. Area under soybean in India had increased from about 32 thousand hectares in 1971-72 to about 814 thousand hectares in 1983-84, marking a twenty fivefold increase.

In addition to the rapidity of this expansion, soybean development in India involves another facet: selectivity in its spread. Out of 814 thousand hectares under soybean in the country during 1983-84, about 616 thousand hectares were in the state of Madhya Pradesh in

Central India. In fact, this state increased its area share from 24 percent in 1971-72 to about 77 percent in 1983-84 of total area under soybean in the country. The concentrated selective developmental pattern of this crop is even more evident when we observe that 11 out of 45 districts in the state of Madhya Pradesh had an area share of 80 percent of the total soybean area of the state.

It is against this background of two distinct features of soybean development in India, rapidity and selectivity, that some pertinent issues could be examined. What has been the soybean development performance of India in relation to other important soybean producing countries in the world? What have been the pace and patterns of development in India? What have been the dynamics of expansion and concentration of soybean in India as well as in the state of Madhya Pradesh? What are the possible explanations for both rapid and selective development? What are the technologic and economic potentials for sustaining the innovation of this across the country and on a larger scale? What constraint releasing strategies in terms of research, extension and policy support are required to realize these potentials?

The present study is an attempt to examine these issues. The specific objectives of the study are (1) to assess the soybean development performance of India in terms of its area and production share in world totals and in terms of its yield advantage; (2) to analyse the dynamics of temporal and spatial shifts in soybean development in India; (3) to estimate the growth rate of soybean production, area and yield in the country as a whole as well as in soybean dominant states; (4) to analyse the contribution of different components to production instability; (5) to develop possible explanations for rapid and selective development, and (6) to assess both technologic and economic prospects of the development of soybean in India.

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II. Performance

In a Global Perspective

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2. A brief exposition of the performance of the soybean crop in India in a global perspective is the first objective of the present study. This is attempted in terms of trends in area, production and yield, and shifts in soybean area and production share of India in world totals. This analysis was performed on data for the period 1972-1981. Results on these trends are in Tables 1-3 and Figures 1-5 in the appendix.

2.1 Country wise Analysis

It is evident from Table 1 that the total area under soybean in the world as a whole had increased from 38.54 to 50.24 million hectares during the period under study, recording about a 3 percent increase per annum. With respect to production, the increase was from 52.36 to 87.91 million M.T. with about a 7 percent increase per annum. The 'Big-3' in soybean production are the USA, Brazil and China, claiming over 85 percent of the total soybean area in the world.

Pertaining to trends in relative shares, the USA had increased its area share from 48 to 54 percent, and its production share had marginally declined. On the other hand, China experienced a sharp decline in area share from 37 to 15 percent, and a decline in production share from 21 to 9 percent. The countries which experienced moderate declines in their relative positions in soybean area are Korea (DPR), Korea (REP) Indonesia and the USSR. The highest increase in area share occurred in the case of Brazil (from 6% to 17%), followed by Argentina and India. The area share of India increased from 0.09 to 1.24 percent, and its production share from 0.05 to 0.53 percent. However, the absolute performance of India both in soybean area and production expansion has been considerable. During this period, there was about an eighteen-fold increase in area and a seventeen-fold increase in production. Only Argentina recorded a level of absolute performance, which exceeded that of India.

An analysis of trends in yield and the extent to which India has reduced the yield gap in relation to other countries forms the second dimension of this analysis. Table 2 shows that yield trends in the USA represent only a marginal increase, in China, Indonesia and Brazil, a moderate increase, in Korea (DPR), Korea (REP), The USSR and Argentina, a sharp increase, in Japan a stagnant yield level and in India a marginal decline. Argentina exhibited a large area-production performance. This superior performance has been facilitated by a superior yield performance, whereas India has sustained-area-production expansion, despite a marginal decline in yields. This will be discussed in greater depth in chapters 3 and 7.

The relative yield performance of India could also be assessed by comparing the absolute yield levels (Table 2 and Fig. 5). The yield Levels in the world on the whole, the USA, and Brazil were more than twice the yield levels in India during early the 1980's. In Japan, Korea (DPR), and Korea (REP), soybean yield levels were found to be 1.5 times more than what it was in India during this period.

Table 1 Soybean Area and Production Share of Different Countries: 1972-1981

	Year									
Country	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
World A* (1000 ha)	38535	44308	44710	45901	44707	49461	47690	50814	51864	50241
P* (1000 mt)	52368	62350	56950	69641	63028	77566	76822	88943	80862	87907
USA A (% of world)	48.00	50.96	47.40	47.24	44.68	47.38	54.02	6.20	52.45	53.72
P (% of world)	66.03	67.53	58.05	60.47	55.60	60.22	66.20	69.40	60.32	62.86
Argentina A	0.18	0.35	0.30	0.78	0.97	1.33	2.41	3.15	3.91	3.74
P	0.15	0.44	0.87	0.70	1.10	1.80	3.25	4.16	4.33	4.29
Brazil A	5.90	5.13	11.50	12.69	14.35	14.27	16.32	16.25	18.33	16.89
P	7.00	5.88	13.83	14.20	17.81	15.60	12.42	11.51	18.74	17.04
China A	37.07	32.36	31.63	30.81	31.84	28.78	17.87	14.30	14.49	15.15
P	21.46	18.86	20.84	18.18	19.76	16.70	11.77	8.41	9.78	9.12
India A	0.09	0.11	0.15	0.20	0.28	0.39	0.64	0.98	1.17	1.24
P	0.05	0.06	0.09	0.13	0.20	0.24	0.39	0.32	0.55	0.53
Indonesia A	1.78	1.69	1.68	1.29	1.42	1.34	1.54	1.54	1.40	1.46
P	0.99	0.85	1.03	0.85	0.76	0.68	0.80	0.76	0.79	0.74
Japan A	0.23	0.20	0.21	0.19	0.19	0.17	0.27	0.26	0.27	0.29
P	0.24	0.19	0.23	0.18	0.17	0.14	0.15	0.22	0.22	0.24
Korea (DPR) A	1.05	0.93	0.87	0.86	0.89	0.81	0.63	0.60	0.58	0.60
P	0.45	0.40	0.49	0.42	0.48	0.40	0.42	0.37	0.42	0.40
Korea (REP) A	0.73	0.70	0.64	0.60	0.55	0.57	0.52	0.40	0.36	0.40
P	0.43	0.40	0.56	0.45	0.47	0.46	0.38	0.29	0.27	0.28
USSR A	2.35	1.89	1.86	1.77	1.70	1.59	1.71	1.65	1.65	1.72
P	0.49	0.68	0.63	1.12	0.76	0.64	0.83	0.53	0.65	0.57
Other Countries A	2.62	5.68	3.76	3.57	3.13	3.37	4.07	4.67	4.89	4.79
P	2.71	5.11	3.38	3.30	2.89	3.14	3.39	4.03	3.93	3.93

* A = Area; P= Production

Table 2 Trends in Yield (Kg/Ha) of Soybean in Different Countries (1972-1981)

Country	Year									
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
World	1359	1407	1274	1517	1410	1568	1611	1750	1559	1750
USA	1870	1865	1560	1942	1754	1993	1974	2161	1776	2048
Argentina	1147	1732	1483	1363	1603	2121	2174	2313	1724	2005
Brazil	1612	1612	1531	1699	1750	1714	1226	1240	1551	1765
China	787	820	839	895	875	910	1061	1030	1052	1053
India	816	831	769	981	988	945	975	570	728	750
Indonesia	756	704	778	785	758	795	842	867	885	891
Japan	1425	1341	1430	1445	1321	1337	1495	1471	1223	1458
Korea (DPR)	580	610	718	734	750	775	1067	1100	1133	1167
Korea (REP)	795	808	1113	1134	1192	1214	1186	1240	1148	1251
USSR	285	506	434	962	630	636	778	557	615	579

Table 3 Trends in Yield Gap in Soybean : India vs. Different Countries (1972 - 1981)

	Year									
Country	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
World	166	169	166	155	143	166	165	307	214	233
USA	229	224	203	198	177	211	202	379	244	273
Argentina	141	208	193	139	162	224	223	406	237	267
Brazil	197	194	199	173	177	181	126	217	213	235
China	96	99	109	91	89	96	109	181	144	140
India	100	100	100	100	100	100	100	100	100	100
Indonesia	93	85	101	80	77	84	86	152	122	119
Japan	175	161		147	134	141	153	258	168	194
Korea (DPR)	71	73	93	75	76	82	109	193	156	156
Korea (REP)	97	97	145	116	121	128	121	217	158	167
USSR	35	61	56	98	64	67	80	98	84	77

III. Developmental Performance In India

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3. It is recalled from the previous section that India is not an important soybean growing country in the global perspective. But the rapid progress which the country has experienced during the last 13 years with respect. to this crop is one of the fascinating experiences in the developmental process. The present section focuses on a quantitative assessment of trends in area, production and yield, and shifts in the relative position of different states in soybean development. The focus of this section is also on the relative importance of soybean in total cropped area and in total area under oilseeds in the country. As well, this section is concerned with the analysis of growth function estimates and of the contribution of different factors to production variance. These analyses are performed with the available data for the period 1971-1983.

3.1 Trends in Area, Production and Yield

An analysis of trends in area, production and yield of soybean is meant to provide broad insights into the development of the crop. Data on trends in area and production are presented in Table 6 and Figs. 11-13 in the appendix. Four results are extracted from these: (a) Even though India is not a 'Soybean Country' in the global perspective, soybean area had increased from about 0.03 to 0.80 million hectares within a span of 13 years, recording about a twenty-fivefold increase. Production increased from about 0.01 to 0.58 million MT during the same period, with a record forty-twofold increase; (b) the state of M.P. had experienced about an eightyfold increase in area, and fifty-sevenfold increase in production. The state of uttarpradesh, another important soybean state in the country, increased the area by twenty-seven times and production by thirty-three times; (c) Maharastra State, which had started off well in the early 1970's with an area of 18.16 thousand hectares, experienced a drastic fall in the area within a span of five years and almost to the point of extinction soon afterward; (d) Rajasthan, although a late entry (early 1980's) to the soybean development race, increased the area from about 5 thousand hectares to about 23 thousand hectares within a span of 4 years, and production had increased from about 3 thousand MT to 16 thousand MT during the same period.

Trends in yield provide yet another facet of development of the crop. It is recalled that soybean yields are not merely low in India compared to that of other countries, but also have suffered a decline in yield over the years in comparison with other countries. Table 6 and Fig. 13 present data on yield levels in India as well as in individual states. Soybean yields which were low (about 710 kg/ha on the average) during the early 1970s had increased (about 972 kg/ha on the average) during the late 1970s, and then declined again (about 708 kg/ha on the average) during the early 1980s in India.

The state of Madhyapradesh followed almost the same pattern of trend in yields, whereas yield trends were found to have been quite erratic in nature in Uttarpradesh. One of the interesting observations is that yield levels were far lower in Maharastra than in any other state.

Table 4 Soybean Area and Production Share of Different Economic Systems : 1974-1981

Economic System		Year							
		1974	1975	1976	1977	1978	1979	1980	1981
World	Area a)	44710	45901	44707	49461	47690	50814	51864	50241
	Production	56950	69641	63028	77566	76822	88943	80862	87907
Developed Market	Area b)	48.18	47.95	45.37	48.13	55.14	57.28	53.99	54.84
Economies	Production	59.02	61.38	56.36	61.24	57.38	70.62	61.64	64.09
Developing Market	Area c)	16.70	18.10	19.50	20.00	23.88	25.28	28.27	26.73
Economies	Production	18.35	18.38	22.02	20.50	19.08	19.40	26.74	25.27
Centrally Planned	Area c)	35.12	33.95	35.13	31.87	20.98	17.44	17.74	18.43
Economies	Production c)	22.63	20.24	21.62	18.26	13.54	9.98	11.62	10.64
All Developed	Area c)	-	50.11	47.63	50.25	57.52	59.75	56.56	57.41
Economies	Production c)	-	62.97	57.68	62.34	68.70	71.79	63.02	65.13
All Developing	Area c)	-	49.89	52.36	49.75	42.47	40.25	43.44	42.59
Economies	Production c)	-	37.03	42.32	37.66	31.30	28.21	36.98	34.87

a) 1000 ha units
b) 100 mt units
c) % of world total

Table 5 Trends in Yield (Kg/Ha) of Soybean in Different Economies systems (1974-1981)

Economic System	Year							
	1974	1975	1976	1977	1978	1979	1980	1981
World	1274	1517	1410	1568	1611	1750	1559	1750
Developed Market Economies	1560	1942	1751	1995	1968	2158	1780	2045
Developing Market Economies	1399	1540	1592	1604	1287	1343	1474	1654
Centrally Planned Economies	821	905	868	899	1039	1002	1022	1010
All Developed Economies	-	1907	1707	1946	1924	2103	1737	1985
All Developing Economies	-	1126	1139	1187	1187	1227	1327	1432

Table 6 Soybean area, Yield and Production In Different States of India (1971-1983)

States		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
India	A*	32318	33696	47370	66619	93013	124964	194865	306937	496403	607600	622100	770200	814232
	Y*	426	816	831	769	981	988	945	975	570	728	750	637	716
	P*	13728	27510	39355	51241	91256	123468	184097	299189	283008	442200	466500	491755	582950
Madhya	A	7687	16050	25264	39686	55506	80915	136015	232562	414341	454800	454800	584100	615800
Pradesh	Y	1000	747	870	880	1121	1020	997	997	579	770	772	614	715
	P	7687	12000	22000	34947	62224	89000	135741	232000	240000	350000	350000	358600	440300
Uttar	A	5885	15063	20463	25370	36137	43925	54007	68689	76866	134968	141106	157237	157200
Pradesh	Y	597	1000	825	624	781	782	744	878	470	620	721	746	7473
	P	3515	15063	16897	15856	28250	34369	41822	60326	36121	84020	101764	117369	117400
Rajasthan	A	-	-	-	-	-	-	-	-	-	4800	9800	11700	22620
	Y	-	-	-	-	-	-	-	-	-	521	663	533	688
	P	-	-	-	-	-	-	-	-	-	2500	6500	6300	15565
Maharastra	A	18162	1312	1064	568	353	-	-	-	-	-	-	-	-
	Y	123	266	357	274	297	-	-	-	-	-	-	-	-
	P	2250	350	380	150	105	-	-	-	-	-	-	-	-
All Other	A	584	1271	579	995	1017	124	4843	5686	5196	13032	16394	17163	18612
States	Y	565	76	135	289	666	798	1349	1207	1171	436	502	553	520
	P	330	97	78	288	677	99	6534	6863	6087	5680	8236	89486	9685

A* = area in ha.
Y* = Yield in kg/ha.
P* = Production in MT.

Table 7 soybean Area and Production Share of Different states of India (1971-1983)

(Percentages)

	Year												
States	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Madhyapradesh													
A*	24.00	47.63	53.33	59.57	59.68	64.75	69.80	75.77	83.47	74.85	73.11	75.84	76.86
P*	55.78	43.62	55.90	68.20	68.19	72.08	73.73	77.54	84.80	79.15	75.03	72.92	75.53
Uttarpradesh													
A	18.21	44.70	43.20	38.08	38.85	35.15	27.72	22.38	15.48	22.22	22.68	20.42	19.31
P	25.50	54.76	42.93	30.94	30.96	27.84	22.72	20.16	12.76	19.00	21.81	23.87	20.14
Rajasthan													
A	-	-	-	-	-	-	-	-	-	0.79	1.58	1.52	2.78
P	-	-	-	-	-	-	-	-	-	57.00	1.39	1.28	2.67
Maharastra													
A	56.20	3.89	2.25	0.85	0.38	-	-	-	-	-	-	-	-
P	16.33	1.27	0.97	0.29	0.12	-	-	-	-	-	-	-	-
All Other States													
A	1.59	3.78	1.22	1.50	1.09	1.10	2.48	1.85	1.05	2.14	2.63	2.22	1.05
P	2.39	0.36	0.20	0.57	0.73	0.08	3.55	2.30	2.44	1.28	1.77	1.93	1.66
All India													
A	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
P	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

*) A = Area Share
P = Production Share

3.2 Shifts in Area and Production Share

Analysis of data on shifts in relative share of different states in soybean area and production provide yet another way of examining the development of the crop. The results of this analysis are given in Table 7 and Figs. 14 & 15. During the year 1971, the state of Maharastra had the highest area share (56%) followed by Madhya Pradesh (24%), U.P. (18%), and other states (2%). The importance of Maharastra as a soybean area declined drastically from 1972 onward, to the point of extinction in 1976. Expansion of soybean in the state of M.P. represents' what "rapidity" would mean in the development of a crop. The area share of this state had reached about 77 percent in 1983, with a production share of about 76 percent. The area share of U.P., which was around 40 percent during the middle of the 1970s, had declined to around 20 percent during the early 1980s. Production share had followed almost the same pattern of trend. The state of Rajasthan had increased both its area and production share from about less than one to around three percent during the period 1980-83.

3.3 Trends in Yield Gap

In assessing the relative development in different states, trends presented in yield gap could be a convenient conceptual framework. Results are in Table 8. Compared to Madhya Pradesh, soybean yield levels were lower in U.P., Maharastra and Rajasthan during the period for which data were available. Maharastra obtained hardly 29 percent of the yields obtained in M.P. per unit _rea cultivated during the early 1970s. Rajasthan had obtained 84 percent of the yields obtained in M.P. during the early 1980s. Yields in U.P. were closer to those obtained in M.P. especially during the early 1970s and the early 1980s.

Table 8 Trends in Soybean Yield Gap: Madhya Pradesh vs. Other States

State	Average for the Years			
	1971-73	1974-76	1977-79	1980-83
Madhya Pradesh	100	100	100	100
Uttar Pradesh	93	72	82	99
Rajasthan	-	-	-	84
Maharastra *	29	29	-	-

* In the case of Maharastra, the average for the period 1974-76 pertains to only two years, (1974-75), in view of data availability.

3.4 Dynamics of Expansion and Concentration

Two broad results could be recapitulated from the trends analysis. First, soybean experienced rapid development in terms of area and production expansion within a limited period. Second, coupled with rapidity is selectivity in the development of the crop. The rise of M.P. as a soy state presents a concrete representation of this selective development, while Maharastra presents another contrasting situation wherein a sudden boom was followed by an immediate extinction of the crop. The dynamics of expansion and concentration of this crop is vividly portrayed in Figs. 16-23.

The dynamics of area and production expansion as well as concentration have been analysed by defining three periods: Period I (1971-75), Period II (1976-79), and Period III (1980-82). It needs to be made explicit that Period I includes the relative status of Maharastra in the total soybean area and production, and Period III represents the late entry of Rajasthan into the soybean development race in India. To trace the dynamics of expansion as well as relative position of different states, averages for the three periods concerned were computed to develop pictorial presentation. Further, development status in each year during different periods is represented to depict the extent of acceleration or deceleration in different states.

An aggregative pictorial representation of soybean area expansion in India and the share of different states during these three periods is in Fig. 16. During Period II (1976-79), there was a 268 percent increase in area over the Period I (1971-75), and the percent increase in area during Period III (1980-83) was about 250 over Period II. So, this periodic analysis suggests an almost steady growth in area during these periods, even though the rate of expansion appears to have declined marginally during Period III. This could perhaps be correlated with the yearly data on area expansion, as shown in Figs. 17-19. As evident from Fig. 17, except for the area expansion rate for 1972 over 1971, the rates were around 40 percent over the previous years during Period I. Across different years of Period II the area expansion rates (Fig. 18) were about 60 percent, whereas during Period III the area expansion rates (Fig. 19) were as low as 2 percent for 1981 over 1980. This substantiates the conclusion that the rate of area expansion had declined during Period III.

Both aggregative and non-aggregative pictorial representation of soybean production in India as well as in different states are seen in Figs. 20-23. The average production rate change for Period II over Period I was about 398 percent and 123 percent for Period III over Period II (Fig. 20). It is recalled that the corresponding area expansion rates were 268 and 250 percent respectively. These results lead us to infer that there were some yield gains during Period II, whereas during Period III, 250 percent area expansion could lead only to 123 percent production expansion due to fall in yields.

The non-aggregative pictorial representation (Figs. 21-23) suggests that (a) during Period I, except for the production expansion rate in 1972 over 1971, production expansion rates (over the respective previous years) ranged between 30 percent in 1974 to 78 percent in 1975: (b) during Period II, barring the marginal negative rate change of production expansion in 1979 over 1978, production expansion rates were between 63 percent higher in 1978 .than iri 1977, 35 percent higher in 1976 than in 1975; (c) during Period III, the annual production expansion rates were in the range of 5 to 19 percent. This also substantiates our inference that production expansion rates had slowed down considerably during Period III, whereas area expansion rates had slowed down only marginally.

Yet another important facet of developmental dynamics is that the state of M.P. has gained hegemony in the production of soybean, and in fact, has come to be known as the Soy State. This accelerated dominance of M.P. in soybean area and production is portrayed in the shaded area of Figs. 16 & 20 at the aggregative level, and in Figs. 17-19 & Figs. 21-23 at the level of individual years.

The dynamics of the shifting importance of soybean crops could also be analysed by placing its performance within the agricultural economy of the country. This analysis could be attempted by examining the relative position of soybean in total cropped area of the country, in total edible oilseed production, and in total production of pulses. The reason for considering the performance of soybean in relation to that of both oilseeds and pulses is that in India this crop is treated both as an oilseed crop and a pulse crop.

Results obtained from this analysis are in Table 9, from which we derive the following comments: (a) The increased importance of soybean can be be seen from its share in total cropped area, which had increased from about 0.02 percent in the early 1970s to about 0.5 -percent in the early 1980's; (b) The percentage share of soybean in total production of edible oilseeds had increased from about 0.4 in the early 1970s to about 5% in 1980s.

The increased importance of soybean in total oilseeds could also be appreciated if we examine the results (Table 10) on export of soy meal/cakes. Percent share of soy meal/cake in total oilcake/meal had increased from about 0.22 in 1974-75 to 16.44 in 1981-82. (c) Soybean, which formed less than one percent of pulse production (as defined in this study) during the early 1970s, had increased to about 4 percent during the early 1980s.

Table 9 Shift in Relative Position of Soybean in India's Agricultural Economy.

Year	Percentage share in:		
	Total cropped area	Total Edible oil-seed production	Total Pulse production (including soybean)
1971	0.02	0.17	0.12
1972	0.02	0.42	0.28
1973	0.03	0.47	0.39
1974	0.04	0.67	0.51
1975	0.05	0.95	0.70
1976	0.07	1.63	1.10
1977	0.10	2.14	1.54
1978	0.17	3.35	2.39
1979	0.29	3.55	3.20
1980	0.35	5.53	3.81
1981	0.35	4.13	3.90
1982	0.46	5.30	3.98
1983	0.47	4.87	4.40

Table 10 Export of Soymeal/Cake from India

Year	Quantity (000 tonnes)		Share (%) of soymeal/ Cake in total oil / cake Meal
	Soymeal/cake	Total oilcake Meal	
1974-75	1.85	832.00	0.22
75-76	5.76	985.00	0.58
76-77	37.11	1727.00	2.15
77-78	15.44	854.00	1.81
78-79	52.50	885.00	5.93
79-80	48.81	1034.00	4.72
80-81	104.04	805.00	12.92
81-82	1 35.43	824.00	16.44

3.5 Growth Function Estimates

The rate as' well as the pattern of growth in soybean production, area ,and yield would help in identifying whether the growth pattern experienced in India is one of area led, yield led or area-cum-yield led. Further, this analysis is also intended to provide insights into whether soybean has experienced either a constant, increasing or decreasing growth pattern. The following growth function is the logical choice for estimating growth rates as well as for discerning the patterns of growth:

$x_t = {}_{Be}\, gt + kt^2\, U_t$ $\qquad x_t = {}_{Be}\, gt + kt^2\, U_t$ …..(1)

where,

x_t = Production/area/yield of soybean in year t.

t = year, t = 1, 2, ……….n

U_t = error term

By taking logarithms on both sides of the equation, we get the following transformation:

$\text{In } X_t = \ln B + gt + kt^2 + \text{In } U_t$ ……….. (2)

Growth coefficients g and k are estimated by regressing In Xt on t and t2, using observations on X_t for t = 1, 2, …n. If the coefficient of t^2, viz., k is not statistically significant, we infer that soybean has experienced a pattern of constant growth rate over a period of time, and the average_ growth rate over the relevant period is equal to g. If this coefficient is statistically significant, soybean has experienced either a decreasing (for $k < 0$) or increasing (for $k > 0$) growth over a period of time. Average growth rates under this condition will have to be computed by a simple average of ,(g+2Kt) over the relevant period.

For the purpose of discerning whether the production growth pattern has been either area. led, , yield led, or area-cum-yield led, the following simple partitioning model could be used:

$Q_t.= A_t\, Y_t$ ....(3)

where,

Q_t = total production of soybean during the year t;

A_t = total soybean cropped area;

Y_t = yield of soybean per unit area cropped

Taking the log and differentiating (3) with respect to t:

$\text{In } Q_t = \ln A_t + \text{In } Y_t$

$$\frac{1}{Qt}\frac{dQ_t}{dt} = \frac{1}{At}\frac{dA_t}{dt} + \frac{1}{Y_t}\frac{dY_t}{dt}$$

$GQ = G_A + G_y$ …..(4)

Expression (4) suggests that production growth rate is equal to area growth rate (G_A) and yield grow_h rate (G_y). This follows from the identity that total production is equal to area time's yield, and it would provide a simple measure of production growth accounting. These growth rates are to be estimated from the regressions of Into, $l_{n\ A}t$ and ln Y_t on t and t^2. Based on the relative contribution of G_A and G_y to GQ we can infer from these growth patterns whether the observed pattern of soybean production growth has been area led, yield led or area-cum-yield led. These typologies would determine how to search for possible explanations for the emergence of a particular pattern.

The empirical results obtained with the growth function estimates for India, the state of M.P. and the state of U.P. are presented in Table 11. It is evident from Table 11 that the quadratic function of the exponential form has proved to be a good fit in the case of production and area growth in India overall, as well as in the other two states, even though coefficient k is not statistically significant in some cases, neither at 1% nor 5%. However, k is negative in all cases, implying that growth rates have been increasing at a negative rate. This is much more so regarding soybean area growth in the states of M.P. and U.P. where k is negative and statistically significant. The slope coefficients of yield-growth functions are found to be no significant in the soy-states of M.P. and U.P., even though the coefficients are significant in the all-India yield-growth function due, perhaps, to the trends in other states.

Based on the estimates presented in Table 11, annual growth rates of production, area and yield can be derived. Restating the growth equation (2) and differentiating it with respect to time (t):

$$\ln X_t = \ln B + gt + kt^2 + \ln Ut$$

$$\frac{dX_t}{dt} = \frac{1}{X} = g + 2\,kt \qquad \text{.........(5)}$$

Annual growth rates are derived, using expression (5) and the results are presented in Table 12. The overall growth rates are obtained by computing a simple average of (g+2kt) over the relevant periods, viz., 13 years. These results are in Table 12. Results on annual growth rates suggest that both soybean production and area have experienced the pattern of positive growth rate at a decreasing rate (obviously due to K<O) throughout the period under study in India. Yield growth rates India are found to have experienced positive growth at a decreasing rate up to the eighth year of the study, and beyond that, the yield growth pattern has been one of increasing negativity. As well, in MP, both area and production have recorded positive growth rates throughout the period, but at a decreasing rate. Barring the first three years, yield growth rates have been increasingly negative. Finally, the state of U.P. presents the same pattern of area and production growth. The yield growth rates are found to have been negative throughout the period except for the last two years under study.

The next logical step in the analysis would be to discuss the overall average growth rates of product on, area and yield, and to identify any growth patterns. During the period under study, India as a whole experienced a compound production growth rate of about 31 percent, which has been contributed to by a 30.84% growth rate in area. Soybean yield growth rate was hardly 0.15 percent. The positive production growth rate of about 33 percent in M.P. had been due only to area growth. In fact, positive area growth of 38 percent had more than offset the negative 3 percent yield growth rate to generate a positive production growth rate. The soybean production growth rate was about 24 percent in U.P., and this due only to 25 percent area growth rate, which had more than offset the negative yield growth rate of about 1 percent.

Table 11 Soybean Growth Function Estimates

Country/State		Coefficient			
		B	G	k	R^2
India:	Production	9168.23	0.5086**	-0.0142*	96%
		(36.974)	(6.274)	(2.519)	
	Area	16278.49	0.4148**	-0.0076 NS	98%
		(52.360)	(6.817)	(1.791)	
	Yield	493.19	0.1709*	-0.0121*	30%
		(31.033)	(2.603)	(2.658)	
Madhya Pradesh:	Production	4960.69	0.5208**	-0.0133 NS	87%
		(17.074)	(3.181)	(1.168)	
	Area	4053.75	0.6594**	-0.0203**	99%
		(50.720)	(12.256)	(5.435)	
	Yield	848.52	0.0459 NS	-0.0053 NS	29%
		(39.901)	(0.826)	(1.380)	
Uttar Pradesh:	Production	3991.81	0.4347**	-0.01 36 NS	90%
		(25..770)	(4.112)	(1.846)	
	Area	5081.69	0.4516**	-0.0141**	97%
		(52.189)	(8.4076)	(3.79)	
	Yield	790.76	-0.0211 NS	0.0009 NS	16%
		(32.974)	(0.317)	(0.191)	

Note: The values in parentheses are the t-values.
** Significant at 1%
* Significant at 5%

Table 12 Estimates of Annual and Overall Growth Rates

(Percentages)

Year	India			Madhya Pradesh			Uttar Pradesh		
	P	A	Y	P	A	Y	P	A	Y
1	48.02	39.96	14.67	49.42	61.88	3.53	40.75	42.34	-1 .93
2	45.18	38.44	12.25	46.76	57.82	2.47	38.03	39.52	-1.75
3	42.34	36.92	9.83	44.10	53.76	1. 41	35.31	36.70	-1 .57
4	39.50	35.40	7.41	41.44	49.70	-0.35	32.59	33.88	-1.39
5	36.66	33.88	4.99	38.78	45.64	-0.71	29.87	31 .06	-1 .21
6	33.02	32.36	2.57	36.12	41.50	-1 .77	27.15	2G.24	-1 .03
7	30.98	30.84	0.15	33.46	37.52	-2.03	24.43	25.42	-0.85
8	28.14	29.32	-2.27	30.80	33.46	-3.39	21.71	22.60	-0.67
9	25.30	27.80	-4.69	28.14	29.40	-4.95	18.99	19.78	-0.49
10	22.46	26.28	-7.11	25.48	25.3.4	-6.01	16.27	16.96	-0.31
11	19.62	24.76	-9.53	22.82	21.28	-7.07	13.55	14.14	-0.13
12	16.78	23.24	-11.95	20.16	17.22	-8.13	10.83	11 .32	-0.05
13	13.94	21 .72	-14.37	17.50	13.16	-9.19	8.11	8.50	0.23
Overall	30.98	30.80	0.15	33.46	37.52	-2.83	24.43	25.42	-0.85

P = Production A = Area Y = Yield

An analysis of data from the growth function estimates suggests that soybean experienced a considerable positive growth in production, but at a declining rate. This positive growth in production has been due only to area expansion. In fact, area expansion was strong enough to offset negative yield growth rate in the two soybean dominant states of M.P and U.P If the production growth pattern has been predominantly area led, as it was in the case of soybean nationwide, this could imply that research strategies and efforts have not been adequate to generate a yield led growth pattern, or extension efforts have not been adequate in providing knowledge on the what, when and how of dimensions of soybean production technology at the farm level.

This also implies that increased production sustained by area increases has been facilitated by incentives provided by government policy in the form of subsidized inputs, price support for output, marketing infrastructure for the operation of effective price support policy, and the relative profitability of soybean vis-a-vis its competing crops. This will be discussed in chapter 5.

3.6 Decomposition of Production Variance

One of the important dimensions of soybean development in India is the considerable variance in production, a measure of instability. This has been amply demonstrated in earlier sections. A study of the components of soybean production variance would provide a measure of the sources of instability. The decomposition methodology of Hazell (1982, 1984) is used in this study to unravel the sources of soybean production instability. For the purpose of partitioning the total production variance, two periods, namely, Period I (1971-1978) and Period II (1979-1983), are considered, keeping in view the special thrust placed on the development of soybean in the country, the justification to divide the total period of 13 years into two periods will be evident after visual inspection of Fig. 12.

Total production of soybean (Q) as product of area (A) and yield (Y) is specified as follows:

$$Q = AY$$

The variance of production, V (Q), can be expressed as;

$$V(Q) = \bar{A}^2 V(Y) + \breve{Y}^2 V(A) + 2\ A\ CoV(A,Y) - CoV(A,Y)^2 + R \qquad \text{......}(6)$$

where:

$\bar{A}$ = mean area under soybean
$\breve{Y}$ = mean yield.

V(Y), V(A) = yield variance and area variance respectively
CoV(A,Y) = area - yield covariance.
R = residual term

From expression (6), production variance is clearly not only a function of the yield and area variance, but also of the mean area and yield and of area-yield covariance. Any change in V(Q) between two periods of time could originate from a change in anyone of these components during the periods.

The change in V (Q) between two periods of time can be expressed as:

$OV(Q) = V(Q)_{II} - V(Q)_{I}$

Similarly, components on the right hand side of the expression (6) are defined. Following Hazell (1984), three broad sources of change in V (Q) are outlined in Table 13.

Table 13 Sources of Change in Production Variance

Description of Sources	Results			
	M.P.	U.P.	Other	India
I. Pure Effects:				
1. Change in mean yield	-124.26	-3.95	4.11	-124.1
2. Change in mean area	157.77	17.87	433.84	609.48
3. Change in yield variance	-1 .44	-0.21	-15.55	-17.2
4. Change in area variance	90.82	18.59	141.11	250.52
5. Change in area-yield Covariance	-23.04	-6.81	-30.95	-60.80
II. Interaction Effects	-544.00	-7.98	-446.8	-998.78
III. Change in Residual	432.94	118.93	-110.99	440.80
Change in production variance	-11.21	136.44	-25.23	100.00

AS shown in Table 13, the decomposition analysis partitions the changes in V (Q) between the two periods into pure effects comprising five components and total interaction effects, which occur because of simultaneous changes in mean yield and mean area, in mean area and yield variance, in mean yield and area variance, and in mean area and yield and area-yield covariance.

The third component in the decomposition process is the change in the residual term. The focus of the analysis in Table 13 is on accounting for changes in V (Q) in India, with an emphasis-on the contribution of important soybean growing states toward changes in these components. The rows correspond to the sources of change defined for production variance and covariance, with four interaction terms combined. All entries in the table are expressed as percent of change in variance of total soybean production in India.

The data suggest that

a) Variance of production in M.P. as well as in other states has contributed to the increase of production stability in the country, while U.P. has contributed substantially to the increase in total variance of soybean production in the country. This is also supported by the trends in Fig. 12.

b) Change in mean area has been an important component responsible for soybean production instability. While mean area change in M.P. has contributed to the extent of about 158 percent, the largest contribution to instability (434%) has been from other states. As discussed earlier, the erratic fluctuation in area in states such as Maharastra and Rajasthan has contributed to this dominant influence on change in mean area and on the variance of total soybean production.

c) Changes in area-yield covariance are found to have been more important than changes in yield variance for reducing production variance. To probe into causes for an area-yield covariance change, the decomposition procedure suggested by Hazell (1984) was employed. Based on this procedure, the contribution to change in area-yield covariance can be partitioned into three fields.

$$\Delta \text{ CoV } (Y,A) = r_1 (Sy_1 \text{ e:. } Sa + Sa_1 \ \Delta Sy + Sy \ \Delta Sa) + \Delta r (S_{y1} \ Sa1) + \Delta r (Sy \ \Delta S_a + Sa_1 \ \Delta S_y + \Delta Sa \ \Delta S_y) \quad \ldots\ldots(7)$$

where: r1 = correlation coefficient between area and yield during the first period

Δr = $r_2 - r_1$ = difference in correlation coefficients between the second and first periods

Sy_1 = standard deviation in yield during first period.

Sa_1 = standard deviation in area during the = second period

ΔSa ΔS_y = defined as in the case of Δ r.

The first term on the right hand side of expression (7) arises from changes in the yield variance; the second term from autonomous changes in yield-area correlation, and the third due to the interactions of these two. Results derived from this methodology have revealed that in all cases, changes in area-yield correlation (second term) has the dominant influence in reducing production instability. This implies that the association between area and yield during the first period was higher was higher (r=O.58) than during the second period (r=O.32). The lower correlation coefficient during the second period is suggestive of a lack of adequate increase in yield to keep step with the rapid increase in area.

Decomposition methodology could also be used to sort out the components of production variance in the different states considered for this analysis. The results are in Table 14.

On examining the components of sources of production variance recorded in individual states (Table 14), three results warrant critical examination:

(i) In Madhya Pradesh, production variance had been reduced during the second period, despite the fact that rapid increase in area and consequently in area variance had a de-stabilizing effect on production. The de-stabilizing effect of changes in mean area and area variance was more than offset by the stabilizing effects of other components of instability such as mean yield, yield variance, area-yield covariance and the interaction effects. It is interesting to note that there are unexplained factors adding to instability in production.

(ii) In Uttar Pradesh, changes in mean area and area-variance, together with some unexplained components, have given rise to production instability which has not been offset by the stabilizing effects of mean yield, yield variance, area-yield covariance and the interaction effects.

Table 14 Sources of Soybean Production Variance in Different States of India

Description of sources	Results			
	India	M.P.	U.P.	Other States
I. Pure Effects:				
1. Change in mean yield	-124.1	1108.47	-2.90	-16.29
2. Change in mean area	609.48	-1407.40	13.11	-1719.54
3. Change in yield variance	-17.2	12.84	-0.15	61.63
4. Change in area variance	250.52	-810.17	13.63	-559.29
5. Change in area-yield Covariance	-60.80	205.53	-4.99	122.67
II. Interaction Effects	-998.78	4852.81	-5.85	1770.91
III. Change in Residual	440.80	-3862.08	87.15	439.72
Change in production Variance	100.00	100.00	100.00	100.00

(iii) In other states, production stability has been achieved largely because of interaction effects, residual effects and area-yield covariance. However, change in mean area and therefore in area variance has contributed to increased production instability. This could be explained by the fact that the state of Maharastra, an important soybean growing state during the first period, switched over to other crops for the reasons stated earlier, whereas Rajasthan began, on a large scale, to grow soybeans during the second period.

IV. Madhya Pradesh-

The Soy state

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4. It is recalled that Madhya Pradesh (M.P.) has come to be known as the Soy State, in view of rapid as well as concentrated developments which the state has experienced. A recapitulation of a few quantitative dimensions of soybean development in M.P. in terms of development of this crop in the country indicates that:

a) The state experienced about an eightyfold increase in area and fifty-sevenfold increase in production. It also increased its area share (of total area under soybean in the country) from 24 percent in 1971 to 77 percent in 1983. The story of soybean development in India is, in fact, a story of how M.P. has gained the status of hegemony in soybean production in the country.

b) Yield levels, which were low (about 870 kgs/ha.) during the early 1970s, increased (to about 1050 kgs/ha) during the late 1970s, and again declined (to about 700 kgs/ha) during the early 1980s. Through all this, the state of M.P. is found to have a relative yield advantage over other soybean dominant states in the country.

c) During the period 1971-1983, M.P. had recorded about a 33 percent annual compound growth rate of production. This has been due only to area expansion and in fact, yields have been declining. A positive area growth rate of 38 percent had more than offset a 3 percent negative yield growth rate.

This section is concerned with the analysis of different facets of the selective development of soybean in the state of M.P.

4.1 Area Share In Cropping Patterns

Data on the share of soybeans in total cropped area as well as in area sown during the Kharif season are in Table 15. The area share of soybean which was about 0.12% of total cropped area in 1973 had increased to over 2% during 1981. Against this, paddy had an area share of 23 percent, wheat 15 percent, sorghum 11 percent, and gram 9 percent during the years 1978/79 - 1981/82.

Soybean is a Kharif crop in M.P. As evident from Table 15, the area share of soybean which was less than one percent even during 1974 had increased to about 11 percent during 1982. It is this rapidity of innovation of the crop' that has drawn the attention of development specialists.

4.2 Soy Districts

Yet another facet of selectivity in the development of soybean in India is its concentration not only in the state of M.P. as whole, but in several districts within the state as well. As can be seen from Table 16, 11 out of 45 districts in the state had an area and production share of over 80 percent of total area under soybean and total production during the years 1981/82-1983/84, and 16 districts had a share of over 90 percent. Out of these 16 districts, the three districts of Hoshangabad, Indore and Betul alone had over 30 percent of area and production. The remaining 29 districts of the state had

Table 15 Percent Share of Soybean in the Total Cropped area of Madhya Pradesh and Total Sown Area during Kharif Madhya Pradesh

Year	Percent share in :	
	Total cropped area	Area Sown during Kharif
1973	0.12	0.55
1974	0.19	0.78
1975	0.26	1.03
1976	0.39	1.57
1977	0.63	2.60
1978	1.07	4.35
1979	1.99	8.22
1980	2.13	9.38
1981	2.08	9.24
1982	-	11.39

Table 16 Area and Production Share of Soybean in Different Districts of Madhya Pradesh (1981/82-1983/84)

District	Percent share of :	
	Area	Production
1. Hoshangabad	11.85	12.40
2. Indore	10.80	11.50
3. Betul	10.28	8.38
4. Ujjain	9.08	9.06
5. Dewas	8.80	8.41
6. Sehore	7.88	7.89
7. Shaljapur	5.96	6.53
8. Dhar	5.68	3.56
9. Chindawara	4.28	5.32
10. Raisen	4.25	4.44
11. Rajgarh	4.01	4.04
12. Vidisha	2.91	2.44
13. Narasingpur	2.20	2.53
14. Guna	1.84	1.59
15. Bhopal	1.80	2.34
16. Tikamgarh	1.15	1.18
Percent share of districts	92.77	91.16
Percent share of remaining 29 districts	7.23	8.84
State of Madhya Pradesh	100.00 (502400 Ha)	100.00 (344667 MT)

hardly 7 percent of the area, with a production share of only about 9 percent. These results suggest selectivity in soybean development: soybean production is concentrated in the western and south central parts of the state. This is in accordance with what Rathod and Motiramani (1974) predicted over a decade ago.

It is appropriate to examine the question of how important soybean has been in relation to the total cropped area of 11 soybean districts, where the area as well as production share has been over 80 percent of state totals.

It can be seen from Table 17 that:

(a) the districts of Dewas and Indore, which had about 3 percent of their total cropped area under soybean during the first period of 1973/74-1975/76, had increased that share to about 12 and 15 percent respectively during the third period of 1979/80-1982/82. During this third period, Dewas had about 40 percent of its total cropped area under sorghum, 17 percent under wheat and 13 percent under cotton. In Indore, about 30 percent was under wheat, 22 percent under sorghum and 22 percent under gram;

(b) the districts of Hoshangabed, Betul, Sehore, Shajapur and Ujjain which had less than one percent of their total cropped area under soybean during first period had increased that to 7.26, 7.07, 6.63, 6.36 and 5.28 percent respectively during the third period. In Hoshangabed, wheat (33%), gram (13%) sorghum (10%) and cotton (9%) are the most important crops in the total" cropped area. Sorghum (20%), wheat (16%), and paddy (10%) are the most important crops in the cropping pattern of Betul district. In the district of Sehore, wheat (43%), Sorghum (21%) and gram (18%) are the most important crops. Sorghum, wheat and gram are the most important crops in the districts of Shajapur and Ujjain, occupying about 70 percent of total cropped area of these districts.

Table 17 Percent Area Under Soybean in Districts of Madhyapradesh State

District	Three year average		
	1973/74-1975/76	1976/77-1978/79	1979/80-1981/82
1. Hoshangabad	0.03	0.56	7.26
2. Indore	2.58	7.46	14.59
3. Betul	0.03	0.95	7.07
4. Ujjain	0.75	2.85	5.28
5. Dewas	3.16	7.32	11.66
6. Sehore	0.16	1.06	6.63
7. Shajapur	0.81	3.20	6.36
8. Dhar	0.27	1 .48	2.44
9. Chindwara	0.05	0.08	-
10. Raisen	-	0.13	0.98
11. Rajgarh	-	1.02	4.14

A brief exposition of the factors which are postulated to have contributed to the concentrated development of the crop is in order:

District:		**Factors**
1. Hoshangabad	**	Huge Kharif fallow (over 0.3 million hectares); More remunerative than Kharif sorghum-Recent development of irrigation (20.4% of total cropped area irrigated as against 11.5% in the state during 1981-82); Short duration crop; Ready market for raw soybean due to the location of a soybean processing plant.
2. Indore	**	Intercropping with sorghum and cotton; Replacing part of sorghum and groundout areas as a sole crop; Demand for raw soybean by processing industries.
3. Betul	**	More popular as a mixed crop; intercropping with sorghum; Planting in rain fed Kharif fallow and irrigated command area; Ready market for raw soybean due to demand by a solvent extraction plant.
4. Ujjain	**	Planting in Kharif fallow; Popular in irrigation command area; An-intercrop with sorghum; Soya extraction plants in the district; Demand by extraction plants at Indore.
5. Dewas	**	Initial demand by solvent extraction plants at Indore; Establishment of plants at Dewas later-Soybean more remunerative than sorghum, and popular as an intercrop with sorghum.
6. Sehore	**	Planting in Kharif fallow, irrigated command area; As an intercrop with sorghum; Existence of soybean solvent extraction plant; Specific efforts by the extension team of the Agricultural College of Sehore.
7. Shajapur	**	Planting as an intercrop with cotton and with sorghum; Planting in Kharif fallow and irrigated command area; Assured market for raw soybean due to demand by processing plants.
8. Dhar	**	Planting in Kharif fallow and command area; Popular as an intercrop with cotton.
9. Rajgarh	**	Popular as an intercrop with sorghum; Replacing sorghum as a substitute sole crop; Increased soybean area in the irrigated command area.
10. Vidisha	**	Planting as an intercrop with sorghum; Replacing low return Rabi crops in Kharif fallow land.
11. Raisen	**	As an intercrop; Planting in Kharif fallow and command area.

From the examination of this list, factors such as the availability of Kharif fallow, development of irrigation (which has promoted double cropping), scope for soybean as an inter crop with sorghum and cotton, scope for soybean as an intercrop with sorghum and cotton, and the assured market for raw soybean due to regular demand by soybean extraction plants stand out _s the major determinants. This will be examined in chapter 5.

4.3 Productivity and Area Share Ranking

One of the important questions which can be examined with the available data is the relationship between soybean productivity ranking of the district and its area share. Theoretically, there are three types of possible relationships. First, ranking in area share approximates the ranking in productivity. Second, ranking in area share is much above the ranking in productivity. Third, area share ranking is far below the productivity ranking. All these possibilities are examined, with results shown in Table 18, on 16 districts occupying about 93 percent .of the total'soybean area in the state of M.P.

The districts of Betul, Sehore, Shajapur, Dhar, Rajgarth, Guna and Bhopal fall into the category of area share ranking approximating productivity ranking. The first four of these districts are in the category of high rank in area share as well as in productivity, whereas the other three districts fall into low area share productivity rank category.

Area share rank exceeds productivity rank considerably in the districts of Hoshangabad, Indore, Ujjain, Dewas, and Vidisha. The district of Hoshangabad, which enjoys first rank in area share, has the ranking of VII in productivity. The districts of Indore, Ujjain and Dewas, which enjoy an area share of 10.80, 9.08, and 8.80 respectively, are rated for X, XIV and XIII in productivity ranking.

With respect to the districts of Chindwara, Raisen, Narasingpur and Tikamgarh, productivity rank exceeds area share rank considerably. Chindwara and Tikamgarh districts, which enjoy ranking I and II in productivity have only 4.28 and 1.15 percent of the total soybean area of the state which, in turn, has placed them in the IX and XVI ranks, in area share. Narasingpur district with rank III in productivity is found to have only rank XIII in area. Out of 29 districts which are not covered in this analysis, at least 7 districts (Raipur, Bastur, Mandala, Sagar, Ratlam, Morena and Gwalior) obtained a soybean yield of over 700 kg/ha during the year 1981/82-1983/84, even though soybean area was insignificant in these districts.

An identification of agro-climatic and any other factors which might have given rise to these typologies of soybean innovation across different districts of the state would be quite valuable. No such attempt is made in this study. However, data on rainfall during the period June to September when soybean is grown, and on irrigation facilities, are examined to gain insights into one possible set of explanations for differential levels of soybean innovation in different districts.

Table 18 Productivity/Area Share Ranking of Dominant Soybean Districts of Madhya Pradesh: 1981/82-1983/84.

(Three year average)

District	Area share (Percent)	Ranking	Prdductivity (Kg/ha)	Ranking
1. Hoshangabad	11 .85	I	738	VII
2. Indore	10.80	II	729	X
3. Betul	10.28	III	789	IV
4. Ujjain	9.08	IV	675	XIV
5. Dewas	8.80	V	676	XIII
6. Sehore	7.88	VI	733	IX
7. Shajapur	5.96	VII	760	V
8. Dhar	5.68	VIII	735	VIII
9. Chindwara	4.28	IX	825	I
10.. Raisen	4.25	X	740	VI
11. Rajgarh	4.01	XI	715	XI
12. Vidisha	2.91	XII	546	XVI
13. Narasingpur	2.20	XIII	799	III
14. Guna	1.84	XIV	664	XV
15. Bhopal	1.80	XV	702	XII
16. Tikamgarh	1 .15	XVI	822	II

It is clear from Table 19 that rainfall during the period at the soybean crop appears to have some bearing on this innovation process. For example, Hoshangabad District, which has the highest level of rainfall during the period of this crop, is the one which has the highest area share (11.855). The high rainfall and high area share association [a)] could also be observed to some extent in the case of Ujjain, Dewas, Sehore, Raisen and Rajgarh Districts.

Table 19 average Rainfall in Different soybean District of Madhyapradesh State (in mm. for the season June-sept.)

District	1971/72-1973/74	1976/77-1978/79
1. Hoshangabad	1664	1372
2. Indore	1032	884
3. Betul	1016	860
4. Ujjain	1104	1088
5. Dewas	1256	1088
6. Sehore	1444	1088
7. Shajapur	1024	880
8. Dhar	948	948
9. Chindwara	1008	976
10.. Raisen	1276	1084
11. Rajgarh	1156	832
12. Vidisha	1208	1004
13. Narasingpur	1228	1288
14. Guna	1040	780
15. Bhopal	-	-
16. Tikamgarh	1068	888

a) It is also reported (Personal Communication, Oct. 26, 1985, from Dr. B. R. Chandrawansi, College of Agriculture, Raichur, M.P.) that under heavy rainfall other dry land crops are not stable in productivity.

It is recalled from Table 17 that the districts of Hoshangabad Ujjain, Dewas and Sehore have relatively large percentages of area under soybean with respect to their total cropped area. Further, it can also be seen from Table 20 that the districts of Hoshangabad, Indore, Betul, Ujjain, Dewas and Dhar, which have relatively high percentages of total cropped area under irrigation, also have relatively high soybean area and production share in the state totals. This is only to indicate the possible association of climatic (and other) factors and the extent of soybean innovation. Obviously, a much more elaborate study is required to identify the powerful discriminators which could explain the concentrated innovation of soybean in some districts.

The question that follows from this analysis is whether the resource endowment vectors of these districts are different from those of other districts which have experienced either only a moderate or a low expansion of this crop. These resource endowment vectors could be defined in terms of agro-economic infrastructure such as soil, rainfall, irrigation infrastructure, use of chemical fertilizers and high yielding varieties (proxies for the innovative nature of farmers), cropping pattern, location of soybean processing industries, and so on. Further, one could identify characteristics which discriminate districts where soybean is important from those where soybean is unimportant. Based on the most powerful discriminators, it would perhaps be possible to postulate which factors would tend to make a particular area a soy district.

Table 20 Comparison of area under irrigation to total cropped area in soybean districts of Madhya Pradesh (by percent)

District	Three year average		
	1971/72-1973/74	1976/77-1978/79	1981-82
1. Hoshangabad	3.77	8.81	20.4
2. Indore	9.70	13.17	16.8
3. Betul	7.78	8.96	10.4
4. Ujjain	4.84	7.35	9.7
5. Dewas	4.86	8.46	11.1
6. Sehore	5.44	7.54	8.3
7. Shajapur	6.76	8.09	8.8
8. Dhar	6.17	8.54	10.7
9. Chindwara	5.58	7.08	-
10.. Raisen	2.57	3.89	5.1
11. Rajgarh	5.79	7.08	6.9
12. Vidisha	0.85	1.54	2.2
13. Narasingpur	5.20	7.12	-
14. Guna	3.70	4.28	-
15. Bhopal	-	-	-
16. Tikamgarh	29.92	30.41	-
Average for the state	-	10.74	11.5

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V. Rapidity and Selectivity

In Innovation-

Some explanations

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5. It is recalled that one of the objectives of the present study is to develop possible explanations for rapid and selective innovation of the soybean crop in India. The development matrix generated for this crop consists of technologic, institutional and economic elements. Developmental support for the crop has come from a technological base created for its production at the farm level, relative profitability of the crop, the provision of input price subsidies as well as output price support, farm-factory interactions, and the technological base provided for product development and utilization. The present section elaborates on these matters.

5.1 Technological Base for Production

The emergence of soybean as one of the leading crops in American agriculture is a classic example of what a 'technological base' means for the development of a crop. There has been no "Bean Revolution" in the USA, but rather a sustained series of inputs from the various scientific disciplines that has extended the adoption and increased the productivity of this crop. It is in this perspective that one could examine the efforts made in India to evaluate the technological base for the promotion of this crop at the farm level.

It is recalled that soybean is not a new crop to India. It is a crop that has been cultivated for ages in the hilly parts of northern India and in some pockets of central India. However, the black seeded varieties grown have generally been of long maturity duration, viny growth habits, and very low yields and with small and freely shattering pods. The crop did not fit well into existing crop rotation. India has passed through several phases in its attempts to introduce high yielding varieties of soybean.

Several attempts at introduction of high yielding commercial varieties from the USA and other countries prior to 1965 failed. 55 As far back as 1822, limited experimental work on soybean was initiated. As a result of soybean research from 1917 to the 1950s, some improvements were made in yields and oil content. However, the results in general were so discouraging that the Agricultural Research Committee of M.P. abandoned soybean research in 1953 because of inability to develop a variety that would yield well, fit into rotation with Rabi or wheat, and survive drought on non-irrigated lands.

Some leads in this regard emerged from the attempts made during the early and middle 1960s through the joint programme of the University of Illinois (Urbana, USA), USAID, the Indian Council of Agricul tural Research (ICAR), the Uni versi ty of Agriculture and Technology at Pantnagar (U.P., India) and the University of Agriculture (JNKVV) at Jabalp'..lr (M.P., India). Collaborative research efforts made at Pant nagar and Jabalpur in 1966 established the feasibility of introducing exotic yellow soybean varieties developed in the USA. The soybean varieties used in these trials were varieties that had been developed for production in the southern United States. They were early maturing types which could be harvested in time to be followed by wheat or other Rabi crops. Some of these varieties appeared initially suitable for production in north central India. Moreover, India's stock of genetic materials was enhanced by the addition of these varieties. Through adaptive research, they were available for use in developing varieties that could be even better suited to Indian conditions.

Encouraged by the initial success of soybean at these centres, ICAR launched the interdisciplinary multilocational All India Coordinated Research Project on Soybean in 1967, with ICAR as the main centre, Pantnagar and Jabalpur as special centres, and another six locations as subcentres distributed throughout the country.

This step to strengthen soybean research in India reflected awareness of the potential, that soybeans have for some of the nation's needs. Among these are augmenting productivity and production capabilities of Indian agriculture, providing a relatively cheap and abundant source of protein-rich foods, and increasing domestic production to reduce the foreign exchange bill on oil imports. Beginning in 1975, the All India Soybean Research Project had by 1985 established 18 centres across the country, with the coordinating unit at Pantnagar.

The project has been working on all major aspects of soybean including production, protection, marketing, utilization and extension. The main objectives of the coordinated research project on soybean have been:

(a) collection; evaluation and maintenance of *germplasm* for direct and indirect use for different agro-climatic zones of the country;

(b) evolution of high yielding varieties with resistance to diseases like yellow mosaic, Rhizoctonia, rust, bacterial pustules and others;

(c) development of early maturing varieties for companion cropping with cotton and maize;

(d) incorporation of good germination and longer storage characteristics from the indigenous black variety and from exotic *germplasm*;

(e) understanding of input demands at different stages of plant growth for standardizing production technology;

(f) agronomical practices for companion cropping with crops like maize, cotton, fingermillets and other millets;

(g) isolation of efficient strains of *Rhizobium* cultural for nitrogen fixation, with long shelf life and wider adaptability;

(h) development of planting, harvesting and threshing machinery;

(i) surveillance of disease and pests to develop effective control measures within economic boundaries;

(j) economic production analyses of soybean vis-a-vis competing crops;

(k) studies of the economic viability of soybean as a pure crop as well as a companion crop, and

(l) product utilization in human food and cattle feed. The present study is not meant to evaluate how far these objectives have been accomplished, but to indicate the thrust that has been launched for evolving a knowledge base for the crop.

Research efforts directed towards the evaluation of the performance of American exotic yellow varieties at Pantnagar and Jabalpur during late sixties led to the recommendation of some of these varieties for general cultivation in India. Initially, varieties such as Bragg, Clark-63, Improved Pelican Hardy and Davis gave an indication of their adaptability to Indian conditions. Soon, the limitations of these varieties in India began to manifest themselves in the form of poor seed viability, susceptibility to yellow mosaic virus, their unsuitability to mixed cropping with cotton, sorghum and maize and to dry sowing in black cotton soils of Gujarat. There was a problem in finding a compatible *rhizobium* culture from the indigenous sources. Further they were hard to cook and could not be directly used by the farmers for domestic consumption.

In fact, lack of adequate knowledge on appropriate varieties and cultural practices impeded the development of the crop' in the intitial stage. This also led to the realization of the need for giving a drastic 'indigenous touch' to research efforts for evolving new varieties. Table 21 provides details on the indigenously evolved and released varieties in India.

Table 21 Indigenously Bred and Released Varieties of Soybean in India.

Name of the variety	Area of adaptability	Duration (days)	Yield (potential) (Qtl/ha)
1. PK-262	North Plains Zone	120-125	30-35
2. PK-327	North Plains Zone & North Hills Zone	.105-110	25-30
3. PK-308	North Plains Zone	110-115	25-30
4. PK-416	North Plain Zone & North Hills Zone	115-120	32-37
5. Ankur	Central Zone	130-135	25-30
6. Alankar	North Plains Zone	115-120	23-30
7. Shilajeet	North Plains Zone	105-110	20-25
	& North Hills Zone	105-110	20-25
8. JS-2	Central Zone	105-110	20-25
9. Punjab-1	Hills & Plains Zones	115-120	20-25
10. Gaurav (JS-72-44)	Central Zone	110-115	20-25
11. Durga (JS-72-280)	Central Zone	110-115	20-25
12. KHSb-2	Southern Zone	115-120	20-25
13. SL-4	Punjab	115-120	20-25
14. Birsa Soy-1	Bihar	120-125	20-25
15. J-231 (G. Soy-1)	Gujarat	110-115	20-25
16. J-202 (G.Soy-2)	Gujarat	110-115	20-25

Source: Annual Workshop Report (1984-1985), All India Coordinated Research Project on Soybean.

It is clear from Table 21 that during the last 15 years, efforts have been made to diversify the availability of soybean varieties for different agro-climatic zones. There are varieties in an early maturing group, a medium maturing group and in a late maturing group. One important result that draws our attention is the yield potentials of these varieties, ranging from 2 thousand to 3 thousand kgs per hectare, as against an average yield of less than 800 kgs per hectare in India on the farm on the average. The actual yields realized by the farmers were found to be less than 40 percent of the potential yield, as shown in data obtained from experimental plots.

Constraint analysis alone indicates the contribution of physical, biological and socio-economic factors for the magnitude of this yield gap. However, the technological base provided through well-focused research on soybeans is considerable for the spread of this crop. Adaptability of the varieties is no longer a severe problem, nor is yellow mosaic virus. Indigenous sources of *rhizobium* culture with better modulating capacity have been found and brought to commercial production lines[27]. Derivatives of Kalitur, the black seeded indigenous variety, have helped eliminate some constraints to consumption of soybeans.

It is appropriate to examine the experience of M.P., the Soy State, in the soybean variety innovation process. Black-seeded soybean (locally called Kaltur) has been under cultivation for ages in parts of M.P. In the early phase of the All India Coordinated Soybean Research Project launched in 1967, black soybean did not figure into the breeding programmes. Research was carried out on the genetic base of imported cream coloured yellow soybeans, so that suitable varieties could be identified for different agro-climatic conditions in the state of M.P. These efforts led to the recommendation of yellow varieties of soybeans, such as Bragg, for large-scale cultivation.

The commercial stage of soybean production was triggered in 1971. The relative importance of black and yellow (Bragg variety) soybeans is shown in Table 22. Out of the total area under soybean in M.P. 65 percent was planted with the yellow variety and 35 percent with the black variety during the agricultural production year 1971-72. The area share of yellow. soybean was reduced to only 6 percent in 1977-78, and the area share of black soybean increased to 94 percent. The cycle of variety adoption then appears to have gone in favour of the yellow variety in the sense that it claimed about 21 percent of the total soybean area by 1979-80. At present, the area share of yellow soybean is said to be about 25 percent, while the black variety claims the remaining 75 percent.

An examination of available evidence on this unusual innovation process, i.e., the spectacular growth of indigenous black soybeans, even though research and development efforts were directed toward promotion of the exotic yellow soybean variety Bragg would be valuable for gaining insights into crop innovation impeding and promoting factors. 30 Even though the yield (12.45 vs . 9.85 QtIs / Ha) was moderately more in the case of the yellow variety than with the black variety, the input/output ratio (1.45 vs 1.60) was more favourable, with respect to black soybean. If cash expenses alone are considered, the cash input/output ratio for the black variety was higher (5.26) than for the ratio of the yellow variety (2.69).

The capital component in cultivation of yellow soybeans is nearly double that of black. This implies that the cultivation of yellow soybean is relatively more capitally intensive and involves higher cash expense compared to that of black. This is part of the reason that the black soybeans are favoured by the farming community, who operate under severe capital constraint in M.P.

The lack of adoption of the yellow variety on any extensive scale is further accentuated by the non-realization of its potential on the farm. The black soybean has also an added advantage of less variability in yield. Furthermore, under rain fed conditions, risk (in the event of failure of rain) is less with black than with yellow soybeans and other competive Kharif crops like maize, sorghum and other pulse crops.

These factors all account for why agricultural production technology does not find easy adoption among farmers, operating under scarce capital resources and low managerial ability. Any knowledge base that is developed ignoring this implication is likely to be rejected by a majority of farmers and confined to an elite farmer group. Farmers obviously favour the genetic attributes in varieties of low seed index and .high viability, low yield variability and low level of management.

Table 22 Relative area Share of Yellow and Black Soybeans In Madhya Pradesh

Year	Percentage Area Share of:		Total
	yellow variety	Black variety	
1971	65.0	35.0	100.0
1972	50.0	50.0	100.0
1973	40.0	60.0	100.0
1974	30.0	70.0	100.0
1975	25.0	75.0	100.0
1976	10.0	90.0	100.0
1977	6.0	94.0	100.0
1978	13.0	87.0	100.0
1979	21.0	79.0	100.0

Sources: 1. Motiramani, et.al (1979).

2. Personal Communication from Prof. Kashive of JNKVV,Jabalpur.

5.2 Zero-opportunity Cost Explanation

Another developmental impetus for the spread of soybean in the states of M.P. and U.P. is said to be the availability of Kharif fallow. In the deep vertisol areas, the practice of fallowing land during Kharif has been prevalent all long. It is commonly believed that fallowing land has been practised to conserve moisture for Rabi season crops, mainly wheat. Behind this practice is the fact that in large areas of M.P. and U.P. where rice is unimportant; farmers traditionally have depended upon Rabi crops as the mainstay for their livelihood.

Three other reasons are advanced for fallowing land:

(a) In the absence of good soaking rains, the deep vertisols are too hard to work. Once substantial rains begin, it is difficult to enter such fields;

(b) If crops are dry sown in these areas prior to rains, crop management (especially of weeds) during the following wet period is extremely difficult;

(c) Lack of profitable Kharif season crops of sufficiently short duration to successfully proceed Rabi crops is said to be another possible reason for fallowing land.

For these reasons, in M.P. alone, about 5 million hectares of lands was left fallow during Kharif in the year 1971-72, as evident from able 23. The practice of fallowing land during Kharif has been more widely practiced in the central and western districts of M.P. where the soybean districts are concentrated. In fact, about 30 percent of net area was left fallow in the state during the year 1971-72. It is clear that this percentage decreased to about 26% during the year 1981-82,due in part to the spread of soybeans.

Table 23 Trends in Percentage Area Under Kharif Fallow in Madhya Pradesh

Year	Net area sown (million ha.)	Area under Kharif crops (million ha.)	Kharif fallow	Percentage of Kharif fallow to net area
1971-72	18.46	12.98	5.48	30
1972-73	18.50	13.49	5.01	27
1973-74	18.56	13.98	4.59	25
1974-75	18.52	13.41	5.10	28
1975-76	18.72	13.34	5.38	29
1976-77	18.53	13.38	5.15	28
1977-78	18.80	13.47	5.23	28
1978-79	18.85	13.50	5.35	28
1979-80	18.40	13.36	5.04	27
1980-81	18.70	13.85	4.85	26
1981 -82	18.84	13.92	4.92	26

This fallow land, the opportunity cost of which is zero during the Kharif season, has been one of the factors promoting the spread of soybean in M.P. It is claimed that if soybean is cultivated in these fallow lands, besides retaining moisture, it will make the land more fertile. Since it is a legume crop, it fixes nitrogen in the soil, and its leaves, which fall off at maturity, help check moisture loss.

Soybean withstands the vagaries of weather, both drought and flood, better than the other crops normally cultivated during Kharif season. In the state of M.P heavy mansoon rainfall sharply reduced yields of sorghum, maize, Kharif pulses and groundnut during 1971-72.
Many fields planted to those crops were ploughed up in failure or near failure. Soybeans proved generally more tolerant of excess water than of those other crops. That fact has also contributed to the continuing interest of farmers in soybeans.

5.3 Relative Profitability

It is understandable that farmers in developing countries give priority to producing crops for household consumption and livestock feed before allocating resources to production for market. Given this constraint, the choice of crops depends upon the farmer's assessment of comparative economies. In making this assessment, farmers consider limitations in their resources and other factors such as risk and uncertainty. With the advancement of commercialization of agriculture, comparative returns would gain ascendancy over the domestic consumption requirements in making decisions on land use for different enterprises.

In this perspective, we could examine the available evidence on relative profitability of soybeans vis-a-vis competing crops from farm level micro studies 22, 24-26, 32, 54 conducted in Madhya Pradesh. In the studies conducted in the early 1970s, net returns after expenses for seed, fertilizer and pesticides are estimated for soybeans and for six crops with which soybeans were expected to compete. The results are presented in Table 24.

Table 24 Relative Profitability of Soybean Vis-à-vis Competing Crops

Crop	Expenditures on Seed, Fertilizer, and Pesticides (Rupees)	Gross returns (Rupees)	Net returns (Rupees)
Soybean	387	1125	740
Maize	175	810	635
Sorghum	30	510	480
Bajra	30	590	560
Upland Paddy	35	530	495
Kharif Pulses	25	475	450
Small Millets	15	260	245

Source: Adopted from Williams, S.W. et al. (1974). were developed from available research on the situation in the states of U.P. and M.P.

It is evident from Table 24 that the net return obtained from growing soybean was approximately one-sixth more than estimated net returns from maize, one-third more than those from Bajra, and one-half or more than those from other crops in he comparison.

Analysis of farm survey data on the cost of soybean and competing crops (maize, sorghum and groundnut considered the strongest competitors for soybeans in M.P.) in M.P. for four years (1970/7 - 1973/74) has shown that net returns to farmers from soybeans were generally higher than those from maize, jowar and groundnut, so that the majority of farmers included in this study considered soybeans to be a superior crop to all the competing Kharif dominant crops.

It is appropriate to examine recent research evidence 22 on the profitability of soybeans vis-a-vis competing crops grown in Sehore, Indore, Hoshangabed and Seoni districts of M.P. during Kharif 1981. In this study, relative profitability of soybeans was also assessed in comparison with dominant Rabi crops such as wheat and gram. Relative profitability of black soybeans in comparison to yellow soybeans, and profitability of soybeans as a sole crop in comparison to soybean as a mixed crop with sorghum were also assessed.

Table 25 provides the results of costs and returns analyses from soybeans (both black and yellow) and competing Kharif crops (groundnut and sorghum).

Table 25 Cost and Returns: Soybeans vs. Competing crops (Kharif 1981)

(per hectare result)

Cost-Return	Black soybean	Yellow soybean	Ground-nut	Sorghum
Total Costs (Rupees)	1100	1450	1300	800
Gross Return (Rupees)	1900	2800	2100	900
Net Return (Rupees)	800	1350	800	100
Per Rupee Return	1.7	1 .9	1.6	1.1

Source: Adapted from Kashive, R.C (1982).

It is evident from Table 25 that yellow soybean were more profitable than the competing crops of groundnut and sorghum. Profitability (net return) of black soybeans, even though less than that of yellow soybeans, was equal to that of groundnut and decidedly more than that of sorghum. Profitability measured suggests that both black and yellow soybeans were more profitable than that of competing crops.

Relative profitability of soybeans could also be gauged in the situation of black soybeans grown as a sole crop and as a mixed crop with sorghum. As evident from Table 26, the 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.

Table 26 Cost-Raturn Analysis : Soybean As Sole Crop vs. Mixed crop (Kharif 1981)

Cost-Return	Black Soybean	
	Sole crop	Mixed crop with Sorghum
Total Costs (Rupees)	1100	1300
Gross Retun (Rupees)	1900	2450
Net Return (Rupees)	800	1150
Per Rupee Return	1.7	1 .9

Source: Adapted from Kashive, R.C (1982).

Yet another profitability analysis which could be undertaken is to compare the return of soybeans with Rabi crops, viz., wheat and gram. This analysis is meaningful in the context of M.P. where Kharif fallow land (with soil moisture conserved) is used for growing crops during Rabi season. As can be seen in Table 27, net returns from Rabi crops were far below that from soybeans. Per hectare net return from wheat was Rs.250 and from gram only Rs.50, whereas soybeans yielded a net return of Rs.800. Further, per rupee return was decidedly in favour of soybean.

Table 27 Cost and Returns of Soybean and Rabi crops (Kharif 1981)

Cost-Return	Black soybean	Wheat	Gram
Total Costs (Rupees)	1100	850	850
Gross Returns (Rupees)	1900	1100	900
Net Returns (Rupees)	800	250	50
Per Rupee Return	1.7	1.3	1 .1

Source: Adapted from Kashive, R.C. (1982)

It would also be worthwhile to examine the relative profitability of black and yellow soybeans under both traditional and improved production technologies. Results derived from farm level studies conducted in M.P. are shown in Table 28, and are indicative of the increased profitability of improved practices i.e., (combination of adequate quantities of material inputs such as seeds, irrigation, plant protection and plant nutrients, and other cultural practices, under both black and yellow varieties. .

Under black soybeans, an incremental cost of Rs.800 for improved practices generated an incremental gross return of Rs.1800, which is turn gave rise to an incremental per rupee return (incremental cost benefit ratio) of 2.3. In the case of yellow soybeans, an incremental cost of Rs.1035/-was 'rewarded' with an incremental gross return of Rs.3700. The estimated incremental cost-benefit ratio was in the order of 3.6.

These results reflect the magnitude of yield gap. On the average, farmers obtained about 8 quintals of black soybean per hectare under traditional practices, whereas the yield potential with improved practices was estimated to be about 18 quintals. In the case of yellow soybeans, farmers had obtained, on the average, about 11 quintals per hectare with traditional practices, whereas adoption of improved practices yielded about 25 quintals per hectare.

Table 28 Profitability Technologies Analysis of Soybeans Produced under Different Technologies

Cost- Return	Black Soybean		Yellow Soybeans	
	Traditional practices	Improved practices	Traditional practices	Improved practices
Total Costs (Rupees)	1160	1900	1920	2955
Gross Returns (Rupees)	1900	3700	2800	6500
Net Returns (Rupees)	800	1800	880	3545
Per Rupee Return	1.7	2.0	1.5	2.2

Source: Adapted from Kashive, R.C. (1982 & 1983)

An examination of data from farm level studies conducted in M.P. during several periods suggests that there have been incentives for farmers to grow soybeans in Kharif fallow which could be released for Rabi crops, incentives to grow soybeans even if land could not be released for Rabi crops, incentives to reduce the area under competing crops such as sorghum and groundnut during Kharif season so that land could be utilised much more profitably by growing soybeans, and incentives to grow soybean as a mixed crop with sorghum. All these incentives appear to have contributed substantially to rapid innovation of this crop.

5.4 Developmental Policy Support

Developmental policy support by the government has been one of the major measures taken sustaining the innovation of soybean in India. The major reason for extending development policy support to this crop has been the widening gap between the availability of edible oils and the country's requirement for them. In fact, India was the world's premier exporter 7 of oilseeds and oil prior to World War II. Now it has become the largest importer of vegetable oils. Againstthe estimated oil requirement of more than 4.4 million tonnes in 1982-83, the production of edible oil in the country was estimated at 2.5 to 3.0 tonnes. Thus, there was a gap of 1 to 1.5 million tonnes.

It can be seen from Table 29 that the total import of edible oils has been increasing in India over a period of time, from about 67 thousand tonnes in 1972-73 to 1628 thousand tonnes in 1983-84, with considerable yearly variations in imports. The total quantity of soybean oil imported had increased from about 43 thousand tonnes in 1968-69 to 750 thousand tonnes in 1983-84. Even during the year 1983-84, the share of soybean oil to total quantity of edible oil imported came to about 46%.

Table 29 Imports of Soybean Oil Into India (1968/69-1983/84)

Year	Total quantity (000 Tonnes)		Share (%) of soybean oil
	Soybean oil	all edible oils	
1968-69	43.37	-	-
1969-70	72 . 50	-	-
1970-71	78.96	-	-
1971-72	101 .51	-	-
1972-73	50.26	66.73	75.32
1973-74	60.39	184.95	32.65
1974-75	14.87	30.10	49.40
1975-76	3.51	27.52	12.75
1976-77	87.95	169.23	51.97
1977-78	345.80	1286.84	26.87
1978-79	350.62	1043.21	33.61
1979-80	267.07	720.60	37.06
1980-81	793.02	1666.21	47.59
1981-82	473.79	1349.77	35.10
1982-83	537.00	1 227.00	43.77
1983-84	750.00	1628.00	46.07

Sources: 1. Bansi1 (1984). .
2. Various issues of Monthly Statistics of Foreign Trade of India

The reason for initiating special developmental assistance to this crop was its major share in India's oil imports. In fact, vegetable oils have been a big drain on the country's foreign exchange resources.37 It is recalled that the chronic shortage of vegetable oil in the country was one of the major reasons for renewed efforts to popularize soybean development in India in the late 1960s. It was in this context that both the Government of India and agricultural scientists appreciated the need for maximizing soybean production within the country. A centrally sponsored scheme for soybean development was sanctioned during 1971-72 for the states of Madhya Pradesh, Uttar Pradesh, Maharastra and Gujarat, with the following development package: 10, 32, and 33 '

(1) Arrangements for the supply of two vital inputs, i.e., seed and inoculum: for seed production, the research institutes, private producers and the National Seed Corporation collaborated. Arrangements were also made for the import of inoculum to meet the needs of the 1971-72 programme, and for 1972-73 domestic production requirements;
(2) Governmental support for seeds: good quality seeds were available from Rs.250 to 300 per quintal. At this price, per hectare cost of seed would have ranged between Rs.190 to 225, at 75 kg of seed per hectare. Since this cost was considered too high, a subsidy of 25 percent of seed cost subject to a maximum of Rs.60 was extended by the government as a part of developmental support to this crop;
(3) Insecticide subsidies of up to 25 percent;
(4) Training of extension staff in cultivation techniques of soybeans;
(5) Staff at field level to ensure timely supply of inputs and provide technical guidance to farmers.

Now, the Government of India has launched a new scheme 50 to promote the development of soybean in the states of M.P., U.P., Rajasthan, Gujarat and Karnataka. Under this programme, incentives to farmers in the form of good quality seed, *Rhizobium* culture and plant protection chemicals are provided. ' ,

As a part of the developmental support package, the Government of India realized the importance of output price support policy, and this policy was made part of the developmental support package launched during 1971/72. The Government announced a support price of Rs.85 per quintal, and a premium of Rs.15 per quintal was added later. The Food Corporation of India was to make the purchases,at the support price. Subsequently in 1977, the operation of price supports of soybean (as well as of groundnut and sunflower) was entrusted to the National Agricultural Cooperative Marketing Federation of India (NAFED), which was to operate this through the state marketing federations and local primary marketing societies in the concerned states. These institutions work as agents of NAFED for procurement, storage, and movement and processing (if necessary) of those stocks at the support price.

Information on support prices for soybean announced during different years in India are in Table 30. The officially announced support price was Rs.85 per quintal of yellow soybean for the year 1971-72. The reaction to this was that it did not provide sufficient incentive to farmers to cultivate soybean 10,16 especially the yellow variety. The support price (for both black and yellow varieties) was increased to Rs.145 during the year 1977-78. The general reaction to this was that this provided reasonably moderate support and guarantees to soybean growers. It considerably facilitated marketing arrangements especially in the areas where the soybeans were in the initial stage of introduction and the markets were less developed.46%

During the year 1978-79, a support price of Rs.175 was announced for both black and yellow soybeans. Subsequently, a price premium of Rs.15 was announced for yellow soybeans during the years 1970/80-1980/81, of Rs.20 during the year 1981-82, and of Rs.25 during the subsequent period. The reason for providing this premium was to promote the spread of high yielding yellow varieties. It is recalled from the earlier discussions that the yellow' soybean varieties started increasing its area share during recent years, and it appears that the price premium on this variety appears to have been one of the factors responsible.

Table 30 Minimum Support Price of Soybean in India: 1971/72-1985/86

Year	Price (in Rupees) per Quintal	
	Black soybean	Yellow soybean
1971-72	-	85
1972-73	-	100
1973-74	-	125
1974-75	-	140
1975-76	-	140
1976-77	-	140
1977-78	145	145
1978-79	175	175
1979-80	175	190
1980-81	183	198
1981-82	210	230
1982-83	220	245
1983-84	230	255
1984-85	240	265
1985-86	250	275

Yet another way to evaluate the output price support policy extended to soybean is to assess whether the support favoured soybeans rather than the most important oilseed crop in India, i.e., groundnut. Table .31 provides analytical results on the support price of soybean vs. groundnut. The support prices for black soybean were the same as for yellow soybean during the years 1977-78 and 1978-79. But during subsequent years, the support price for black soybeans was about 10 percent less than yellow varieties. During the year 1978-79, the support price announced was the same for soybeans (both black and yellow) and groundnut. Subsequently, the support price policy was tilted in. favour of groundnut during the year 1985-86, for black soybean the support price was about 29 percent less than what it was for groundnut. In the case of yellow soybeans, the support price was about 21 percent less than what it was for groundnut. This indicates that the government appears to have 'favoured' groundnut much more than soybeans.

Table 31 Support Price of soybean vs. Groundnut In India (1977/78 – 1985/86)

Year	Price per quintal in Rupees			Price realitivity		
	Black soybean	Yellow soybean	Groundnut (in-share)	$\frac{^{P}BS}{^{P}YS}$	$\frac{^{P}BS}{^{P}G}$	$\frac{^{P}YS}{^{P}G}$
1977-78	145	145	160	1.00	0.91	0.91
1978-79	175	175	175	1.00	1.00	1.00
1979-80	175	190	190	0.92	0.92	1.00
1980-81	183	198	206	0.92	0.89	0.96
1981-82	210	230	270	0.91	0.78	0.85
1982-83	220	245	295	0.90	0.75	0.83
1983-84	230	255	315	0.90	0.73	0.81
1984-85	240	265	340	0.91	0.71	0.78
1985-36	250	275	350	0.91	0.71	0.79

Notes: a. ^{P}BS = Price of Black Soybean, ^{P}YS = Price of Yellow Soybean
^{P}G = Price of Groundnut
b. Support price is for Fair-Average-Quality (F.A.Q.)

This implication does not discount the role which the support price policy has played in accelerating the. innovation process. In this context, the experience of M.P and the state of Karnataka, which has good potential for soybean development, is pertinent. In the state of M.P, the policy of price support has been effective enough .to prevent sales below support prices. During the year 1972-73, the support price announced by the government was Rs.100, but. the market price in M.P. was in the range of Rs.120 to Rs.150 per quintal 16. So there was almost no need for the government agency to procure soybeans at the support price. Even during 1979, hardly 29 percent of total production was purchased by NAFED. About 54 percent was purchased by processors and traders for processing in industry: retention by farmers was 17 percent 16 .Soybean marketing and processing was left to the existing market channels in M.P.

The experience of the state of Karnataka presents a developmental contrast, wherein the price support policy has been inoperative[20]. The cost-return study conducted with 1978-79 data from two soybean dominant districts, i.e., Belgaum and Dharwar of Karnataka State, suggested that at the prevailing cost-price relations, soybean was less profitable than rice, sorghum, maize, cotton, groundnut and chili. However, if the farmers had been paid the Government of India support price of Rs.175 per quintal, soybean could have been more profitable than sorghum, maize and cotton. The policy was totally inoperative in the sense that there was no institutional arrangement made for the procurement of soybeans from the farmers at the support price. In fact, 94 percent of the respondents were not even aware of the policy.

It is appropriate here to outline the developmental support extended to soybean growers by the state government of M.P under a cooperative structure. 14 The state government of M.P commissioned a special organization called the Madhya Pradesh Tilhan Sangh, or, the Oilseed Federation, in 1979. The major task entrusted to this organization was to procure, process and market soybean and soybean products under cooperative forms of business. As of late 1985, there were 480 village level (primary) societies. These societies have been providing soybean growers quality seeds, other key inputs such as fertilizers and pesticides, modern harvesting equipment and marketing facilities. The society and its members are also backed by the experts of the Federation. This represents an arrangement whereby material inputs, credit, technical guidance and marketing form the components of the developmental package, and the links between production at the farm level and processing at the actory level are forged.

It is also appropriate to discuss the developmental support extended by another model of soybean development institution evolved in Uttar Pradesh. The Soybean Production and Research Association of Bareilly, U.P, in collaboration with G.P.Pant University of Agriculture and Technology, Pantnagar, developed a new model of institution to promote the development of this crop.47 The objectives of this soybean extension project were:

(a) To encourage and educate farmers in the cultivation of soybeans;
(b) To help farmers in planning the rotation of crops with soybean;
(c) To educate farmers in uses of soybean and its nutritional value, and
(d) To help farmers in the project area market their produce.

Adoptive research trials (e.g., culture and varietal trials), demonstrations (e.g., package of practices for mixed cropping), thevillage saturation programme (providing all material inputs, mechanical inputs, technical know-how to demonstrate the impact on yield), identification of field level problems (e.g., poor germination, inadequate modulation and Yellow Mosaic), crop competition (to motivate farmers toward higher yields), training meetings, field days (to demonstrate the impact of improved package of practices to farmers), soybean days (to discuss all aspects of soybean production), supply of extension literature and advisory services (to promote soybean cultivation in new and problem areas) are some of the developmental activities through which spread of soybean is being promoted. The focus of this developmental project is on assured markets and the provision of material and technical inputs.

5.5 Farm-Factory Interaction

Another major line of explanation for the development of soybean in India is the emergence of farm-factory interaction. Complementary to the output price support policy of the government has been the role of private processor and traders in promoting the innovation of soybean. The role of market channels in connecting the unrealized potential supply of soybeans with the latent demand for soybean oil and soymeal is obviously crucial.

Soybean is basically an industrial crop. The success of soybean development depends, obviously, on the industry purchasing raw soybeans for commercial exploitation. During the early years of soybean development in India, most production was marketed and sold under some kind of written or oral contractual arrangement. Subsequently, 32.33 factory interactions have emerged to provide greater developmental impetus for this crop. The processors and traders have realized that two products, i.e., soybean oil and soymeal, could be substitutes for groundnut oil and gram flour. They have also realized the multiple uses of soybeans and demand for soymeal in foreign countries. Public support has been mainly limited to promoting the production of raw soybeans, while private industries, for the greater part (especially, pharmaceutical, oil hydrogenation, and soy-based food industries), have provided the support for this crop by absorbing the quantity produced.

The acquaintance of processors and traders with soybeans was reflected in the arrival of soybeans in 'high quantities in major markets of the state of M.P, and in market prices of soybeans which were mostly above support prices. For example, during the year 1972-73, the support price announced by the government was Rs.100 per quintal, whereas the ruling market price was in the range of Rs.120-150 per quintal.16 In fact, the processors paid more for soybeans than the organizations which were buying soybeans for seed purposes [16] For almost the first time, soybeans started to arrive in the markets of the state of M.P. during this year. There are about 90 sub-market yards in the state of M.P. where soybean is one of the major crop arrivals among Kharif crops.

Two important factors have contributed to effective linkages between farms and factories. First, there has been a considerable increase in the number of solvent extraction plants in M.P.; out of 35 plants in the state, [a)] most were in soy districts of Shajapur (6), Dewas (6), Indore (4), Hoshangabed (4), Raisen (3), and two plants each in the districts of Sehore, Betul and Ujjain. The states of Maharastra, Gujarat and V.P.

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a) Personal communication from Dr.R.C.Kashive of JNKVV, Jabalpur, M.P. on October 10, 1985.

are other important states which have experienced the emergence of solvent extraction plants for processing soybeans.

Soybean food processing plants have complemented the emergence of these processing plants about 50 percent of food processing plants are located in the state of Maharastra, and the remaining 50 percent are spread mainly about the states of M.P., U.P., and Gujarat. Second, the processors and traders have sharpened farm-factory interactions by providing technical know-how on soybean cultivation and credit and other key inputs, in addition to assured price of soybeans. This kind of developmental support by processors has already been illustrated by the components of the production contract promoted by the Soybean Production and Research Association of Bareilly, U.P.

Some of the processing units in Maharastra had mainly supplied seed to farmers and paid a price premium for increases in protein above 39 percent. Further, it is recalled that the Madhya Pradesh Tilhan Sangh, i.e., the Oilseed Federation, had started operating procurement, processing, and marketing of soybean and soybean products under a cooperativestructure. This is yet another model of farm-factory interaction that has emerged in M.P.

It is obvious from the preceding discussion that soybean market development has assumed different forms. In this connection, it is reasonable to assume that the support price policy has provided reasonably moderate support and guarantees to soybean growers. But not much of total production needs to be procured by government agencies at the support price. As discussed earlier, during the year 1979, about 29 percent of the total quantity sold in M.P. was purchased by NAFED, whereas 43 percent was purchased and processed by soybean industries in the state, and about 11 percent was purchased by processors and traders from other states, mainly Gujaratand Maharastra, where soy-based food and solvent extraction plants are located.

There are reasons to believe that the share of NAFED in total quantity purchased has been declining due to market prices, exceeding the support prices. It is reported [a] that market prices of soybean in M.P. were between Rs.200 and Rs.290 during the 1980 season, against the support price of Rs.183 for black and Rs.198 for yellow soybeans. This has been mainly due to the growth of processing industries which accelerated in response to increasing demand for soybean oil within the country and for soymeal abroad.

5.6 Technology for Processing, Product Development and Utilization

Technology for soybean production at the farm level, and farmfactory interactions in the soybean market have also been accompanied by the development and modification of technology for processing, product development and utilization. The high price of edible vegetable oils in India has provided a strong incentive for processors to extract oil from soybeans. The oil hydrogenation industry could easily utilize whatever quantity of soybean oil was available in the country. It is in this context that the choice of appropriate technology for soybean processing has assumed importance. 1, 10, 32,35,40,54

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[a] Personal communication from Dr.R.C. Kashive of JNKVV, Jabalpur, M.P. on October 10, 1985.

In India, three oilseed processing technology models are used: first, the Ghanis, a low pressure village operation which is not suitable for soybeans; second, mechanical expellers under which two thirds of the oil can be removed from soybeans by double pressing. This technology provides a means of partial extraction of the oil in comparatively low-cost small-scale processing units. The disadvantage of expeller technology is that in addition to leaving a substantial part (about 7%) of the oil in the cake, it does not permit close regulation of the heat treatment and sanitary quality of the cake. This complicates grinding, increases the cost of flour made from the cake, and yields flour of higher fat content than consumers desire. Third, solvent extraction technology is the most effective means of separating soybeans into oil and cake. The resultant deoiled cake contains less than one percent oil. Some existing solvent oil mills can be adopted to soybean processing with considerably less capital.

Soybean flour is one of the most promising forms by which to add soybean protein to the human diet. Acceptance studies of soybean enriched wheat flour for use in chapatis have shown that most consumers prefer defatted or low-fat soyflour.54 Solvent extraction plants, under large volume operation, provide the most satisfactory means of processing soybeans into oil and high quality flour. However, these plants involve very large investments and high fixed costs for physical facilities. Unwillingness of potential processors to incur the risks (e.g., lack of adequate supply of soybeans) and high costs in the early years of soybean production has been understandable.

Under these conditions of the early years of soybean production in India, mechanical expeller technology was used mainly for processing soybeans. These expeller mills played a usef role in getting soybean production and processing started locally. Attempts have also been made to use modified expeller technology to produce low-fat soybean flour of better quality with limited capital investment. The modified expeller method involves splitting the soybeans into dal, adding measured quantities of water to dal and cake before the first and second pressing; for flour to be consumed with little or no further cooking, a third expelling at slightly higher pressure is performed. This procedure recovers a large portion of the oil and produces soymeal of high quality. It is rational to argue that the modified expeller method is an intermediate between traditional expeller and solvent extraction technology. This technology appears to be suitable for small volume processors with limited capital and to situations in which supply of soybeans. is limited.

However, for processing soybeans into oil and meal for human consumption, the expeller technology does not seem to be a long-term solution. Soybean processing with solvent extraction technology offers the only long-range solution. The concerns of the choice of appropriate technology for processing could be illustrated by the following paragraph from Soybean Marketing Information (No.6, 1972):

> "Both potential processors and purchasers of soy flour or grits may need advice about processing techniques, product specifications and tests, and similar matters. Dr. Eldon R. Rice, Food Formulation Technologist, FAO/USAID, West Building, American Embassy, Chankyapuri, New Delhi-11.Phone 70351, will provide such information upon request. If .you write to him, we will be grateful if you send us a copy of your correspondence for our information"

In addition to the development of processing technology, the need to develop a knowledge base for soybean utilization has also provided impetus for soybean development programmes in India. In fact, research studies on product development and utilization have been part of the All India Coordinated Research Project on soybeans. It is recalled that soybean is basically an industrial crop, but with various other multiple uses. Soybean provides human food, animal feed, and raw material of industrial importance. 2, 3,18,19,28, 40,42,44,50

The pattern of utilization of soybeans in the USA has been mostly industrial, e.g., cooking oil, hydrogenated oils, margarine, salad oil and processed cattle feed. In Japan, various food products of whole soybeans, .e.g., tofu, misa, natto, kori and soy sauce, etc, are popular. In India, research studies have established that both the American and Japanese patterns of soy utilization are feasible. Methods for home-level and commercial utilization of soybean have already begun to be developed.

Home-level processes for utilizing soybean in daily diet have been developed at different soybean research centres. Green beans of Hardee have been used for making popular south Indian dishes. Soybean varieties such as JB-2 have proved to be good for blending with potatoes to make vegetable cutlets. Vegetable soybean varieties like Kim, Prize, and others are used for making curries. At the Delhi Soybean Research Centre, recipes have been developed using water immersion cooking or dry roasting to remove the beany flavour, and to denature ant nutritional factors. These have been dem9nstrated to farming communities through the usual channels of mass communication including the Satellite Instructional Television Experiment (SITE).

The chief end-products of soybean processing are soybean oil (crude and refined), and deoiled cake. Crude oil is purchased by the oil hydrogenation industry, while refined oil is for direct consumption by consumers. The deoiled cake is used for cattle feed a) but it can be further processed to yield edible flour and texturized vegetable proteins. Soybean flour has attracted the attention of manufacturers of weaning foods, bread, biscuits, and other products under nutrition programmes. Commercial processes for making soybean beverages (e.g., soy milk), soy curd, soy ice cream, soy candy, and soy nuts have been developed. Soy beverages is an important and promising area which has attracted the attention of many entrepreneurs in India. Soy milk as traditionally prepared could not be popularized in India because it has a beany taste that is considered undesirable, but new techniques have since een developed. Experiments on fermented foods have revealed that acceptable cheese and cheese spreads can be prepared.

Technical know-how for commercial production of cooked extruded products has been generated. The Soy Production and Research Association, Bareilly (U.P.) has been manufacturing cooked extrusion products on a commercial scale. The textured soy products are gradually getting known on the market. The refined high protein soy foods, soy protein

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[a)] A major portion of soymeal is exported to foreign countries including Thailand, USSR, Zambia, Sri Lanka and Burma.

concentrate and soy protein isolate have also attracted the attention of the food industry. While they have many potential uses, they may prove too costly for widespread use in India. Future progress, however, will depend greatly on the quick dissemination of production technology for making refined soy products 'tailored' for specific uses and making them available at competitive rates on the market. The versatility and effectiveness of improved soy food processing technology, however, would call for availability of much needed equipment, technical know-how in installation and operation, trained personnel as well as considerable capital investment.

However, a technological base generated through research, and technology transfer effected through extension efforts in the area of processing, product development and utilization have provided the development support required for soybean production at the farm level. The growing production of soybeans cannot be attributed only to the shortage of vegetable oil in India. Because soybeans have only less than half the oil content of groundnuts, and there is no preference for soybean oil over groundnut oil. The growing demand is due rather, to an increasing awareness of the qualities of soybean protein and a consequent increase in demand for this product.

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VI. Development Prospects and Constraints

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6. In this chapter we examine two questions: first, what are the developmental prospects both technologic and economic, of soybean in India? and second, what constraints operate on widespread innovation of soybeans and what are the possible constraint-releasing strategies?

6.1 Technologic and Economic Prospects

There are good reasons to believe that soybean could develop into a major crop in India. Development of soybeans in India has already passed through initial disrepair and the attendant inertia. The 'growing pains' in the innovation of a new crop appear to have subsided. As a result of orchestrating developmental support extended to the crop in terms of a knowledge base, the response of the farmers to experimenting with a relatively new crop, the willingness of the government to extend a package of developmental incentives, and the response of the industrial sector to tuning farm-factory interactions, there has been considerable accumulation of knowledge on this crop. Scientists who have generated as well as transferred knowledge on this crop, and the farmers who have chosen to grow it, as well as the industrialists who have opted for using raw soybean as an input in the manufacture of food and other products, and market intermediaries who have seized the opportunity of dealing in raw soybean and soy products, consumers who have 'exhibited' their preference for soybean and soy products and the government that has provided policy support are all participants in this innovation process, and they have considerably broadened as well as deepened the knowledge base.

The potential for growing soybeans throughout the year as well as throughout the country have been identified, even though the crop has been predominantly Kharif grown in the states of M.P. and U.P. The Asian Vegetable Research and Development Centre (AVRDC) has recognised that in the tropics, there is great potential to grow soybeans the year round, unlike in temperate areas. 50 For this reason, AVRDC has included soybean as one of the mandate crops for improvement in the tropics.

India can be divided agro-ecologically into four zones: northern hills, and northern, central and southern plains.42 Soybeans can be grown in all these zones as a rainy season (July to October) crop, as a spring season (February to June) crop in the northern and central zones under irrigation, and as a Rabi season (October to March) crop in parts of central and southern zones either with irrigation or on residual moisture. In the northern hills zone, it has started replacing the poor yielding low income crop of finger millet, and is grown as a mixed crop with maize and finger millet, as well as on the bunds of paddy fields. In the northern plains zone, it is grown on fallow land and competes with maize and sorghum for land. It fits well as a mixed crop with pigeon pea, cotton, sugarcane, sunflower and maize. In central India, it is predominantly grown on Kharif fallow. In the southern zone, it can be a companion crop to cotton, sorghum, sugarcane, and pigeon pea. It is a promising crop on rice fallows.

This indicates several ways in which soybean may enter the cropping systems in different parts of the country and help in reducing oil and protein gaps. It fits in as a short season crop releasing land for the next season, as a mixed crop, and as a substitute crop for low value Kharif season crops. Furthermore, soybeans have proved to be more tolerant to drought as well as to excessive rainfall than most of the competing crops. The recent agronomic trials conducted under the All India Coordinated Agronomic Research Project in the soy districts of Sehore, Indore and Jabalpur in the state of Madhya Pradesh, have identified soybean varieties for sole cropping, for soybean-wheat sequences, and as a companion crop to sorghum.49

It is recalled that soybean development has concentrated mainly in the two states of M.P. and V.P. But soybean crops have also been cultivated in the northeastern regions of the country, particularly in Manipur and Sikkim. The added advantage of promoting the development of soybeans in these regions is that there already exists a demand for soybean consumption as a pulse or as a blend in different recipes., So, development efforts are required in terms of suitable varieties as well as packages of practices for cultivation. The government of India has placed more emphasis during recent years on extending the area under soybean in Himachal Pradesh and Bihar, particularly with a view to ameliorating the economic conditions of tribal people. The vast scope for the spread of soybean in the states of Maharastra and Gujarat as a companion crop to cotton is another possibility, and this would facilitate the supply of soybeans to processing plants located in these states. Crop management techniques as well as varieties suitable for intercultivation with cotton need more refinements than what. has been attempted so far.

Yet another approach to the assessment of prospects for the development of soybean in India is to examine the supply and demand situation of oil seeds and pulses. The agricultural transformation that has taken place in India during the last two decades has come to be known as the Green Revolution. But this transformation, reflected in yield-dominant output growth, has been mainly in the cereal sector. The annual compound growth rate of production of cereals from 1967-68 to 1980-81 was about 2.67 percent, whereas the growth rate was about 1.00 percent in the case of oilseeds, and 0.17 percent in the case of pulses.[17,38]

This explains why the per capita availability of vegetable oil has come to 5 kg per annum as against the requirement of 11 kg. It is also recalled that edible oil imports constitute the largest drain on the country's foreign exchange resources, second only to petroleum. In the case of pulses, the cheapest source of, protein in the Indian diet, the problem has been much more severe. The per capita net availability of pulses decreased from about 61 gros to 39 gms per day. Relative prices have favoured pulses, but yield increases in major cereals have been large enough to outweigh these advantages.[8]

As a result, the production of pulses has been stagnating at around 11 to 13 million tonnes over the last three decades. Related to stagnation in the production of pulses and inadequate increase in the production of oilseeds is the nature of price elasticities in the supply of pulses and oilseeds. It is reported34 that the supply elasticity of groundnut, the dominant oilseed crop, and of pulses are around +0.5.Added to this low price elasticity of the supply of oil seeds and pulses are the relatively high income and price elasticity of demand for these commodities. Income elasticities for both edible oil seeds as well as pulses are around +1 in general, and more than +1 in the case of low income rural and urban groups. In the case of edible oils and pulses, low income groups have large price elasticities for demand, and the price elasticity coefficient decreases as income increases. [34]

The low price elasticity of supply and the high income elasticity of demand alone would create pressure on the prices of these commodities. It will tend to stabilize market prices without creating strong pressure on the supply side. All this would force people in lower income groups to reduce consumption of these commodities considerably, while the higher income groups will continue to consume oils and pulses at slightly reduced rates. The lower income strata is the worst affected by these tendencies. It is projected 7 that India will have 1.54 million tonnes of deficit in vegetable oil by 1990-91, 2.41 million tonnes by 1995-96, and 3.60 million tonnes by 2000-2001.

It is in the perspective of the nature of supply and demand elasticity of oils and pulses that the expansion in soybean production is expected to minimize the crisis of the oil-protein gap in the country. Does India have to emphasize27 the development of this crop to meet the edible oil gap? India is endowed with a large number of edible oilseed crops. One cannot really expect a better oil-yielding crop than sesamum, with 50 percent oil. The oil content of soybean in India is around 18 percent as against 45 to 50 percent in groundnut, and 45 percent in sunflower. Determined efforts are underway to develop sunflower and safflower as oilseed crops in India. As well, India has the rapeseed mustard, with roughly 40 to 45 percent oil.

In spite of these better oil-yielding crops, and the technical handicap of low oil content it suffers from, soybean is the foremost oilseed crop in the world today. It is not because of oil content alone but also because of its rich protein content that soybean has been rated as a premier oilseed crop.

The Orientals had realized the dual significance of this crop much earlier than the advent of science and technology into the realm of food production. This does not mean that its premier position in the world is the justification for its development in India. Both technological and economical merits of the crop have already been discussed. The crop has not disrupted the commodity balance. It has found its way on to Kharif fallows, found an alliance with traditional crops as a companion, and has been a substitute for crops of low profitability. The crop has become endeared to farmers in some areas, because it augments their income.

As discussed earlier, there is one more reason that soybean is likely to be a favourite candidate among oilseed crops.[51] India was in the grip of drought over a very large area during 1979-80. Consequently, production of most of the crops, including oilseeds, was adversely affected. Soybean had come to the rescue of the edible oil economy of the country to a limited extent, in the sense that soybean had been able to withstand drought better than other crops. Propelling developmental support to this crop will be of a great help in meeting the complex problem of perpetual shortage of edible oil in the country, even in years of adverse weather conditions.

Related to this is the growing preference for soybean oil.[37] Unlike in India, in the developed countries of the West there, there is now a definitely more marked preference for polyunsaturated oils like soybean and sunflower in various food uses.

Underlying this development is the growing consumer consciousness of the existence of a close relationship between cardiovascular disease and the type of oil or fat consumed. In India as well, this kind of consciousness is slowly becoming perceptible among high income groups.

Apart from macro-assessment of opportunities for the development of soybean, there is a need to examine the micro level results derived from a whole farm model exercise.[11] Since data from the Soy State, Madhya Pradesh, have been used in performing this whole-farm model exercise, the results from this study are indicative of techno economic prospects of soybeans under existing farming practices and under crop production improving activities. It is reported in this study that even with existing farming technology for paddy-wheat sequences and chickpea-wheat intercropping, sesamum, soybean and linseed dominate the farms. With improved technology, intercrops such as soybean-pigeonpea and sorghum pigeonpea occupy major areas on medium and large farms, and substantial area on smaller farms. The main crop sequence appearing in the whole farm model is soybean followed by lentil. A soybean-chickpea sequence is also suggested on small farms, mainly to meet consumption needs for chickpea. Sequential wheat, sequential chickpea and sequential linseed with any first season crop, particularly soybean, do not have potential for adoption by the farmers when the improved cropping systems such as soybean-pigeonpea intercropping, sorghum pigeonpea intercropping and soybean-lentil sequences are available. This might be due to insufficient soil moisture to cultivate those crops in Rabi after soybean in Kharif. Crops like wheat, chickpea and linseed, which require good seed beds and enough soil moisture, did not perform well when taken after soybean. Even under existing farm practices, sequential wheat is not widely followed due to the moisture constraint, but wheat alone and wheat inter crops are common.

This suggests that research stressing sufficient cropping system options is required to identify potential and feasible cropping systems. Related to this is available evidence on the observed behaviour of farmers in Madhya Pradesh with respect to soybean-wheat sequences. Farmers plant soybeans where either they do not expect to grow any Rabi crop (except perhaps chickpea) or where they know they have water from a well for establishing the Rabi wheat crop. There is about a 70 percent probability that wheat cannot be sown without presowing irrigation. [a)] This is only to indicate that the prospect for widespread innovation of soybean will be enhanced as irrigation is expanded. 55 As additional water for Rabi season crops on tracts now fallow during the Kharif season becomes available, farmers can be expected to commence growing Kharif season crop on most of the fallow tracts. Further, soybean promises to be the major profitable Kharif season crop of any from which farmers may choose.

An examination of the soybean development programmes which Madhya Pradesh has proposed for the period of the Seventh Five Year Plan (1985-1990) also indicates developmental prospects for the crop. The Special Soybean Development Project initiated in the state of M.P. during the current plan period has divided the districts into three groups. [b)] Group A comprises 7 districts in which there is no scope

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[a)] Communication from Mr. Sushil Paridey of the University_of New England, Australia to Dr. Von M. Oppen, ICRISAT, Hyderabad

[b)] Commuriication from Dr.R.C. Kashive of JNKVV, Jabalpur (M.P.), during October, 1985.

for increasing acreage under soybeans, and any increase in total production is to be accomplished through yield increase. In Group B districts (7), the scope for increasing total soybean production through area expansion and yield increase is identified. Group C consists of districts (15) where only the scope for area expansion is considerable. In the remaining 16 districts of the state, soybean development during the Seventh Five Year Plan period remains to be initiated.

Total soybean production in the state of M.P. will have to be increased under the Intensive Oilseed Development Programme, through appropriate strategies for four types of districts identified for this purpose. The major strategies designed include subsidies for seeds, insecticides, sprayers and equipment, and culture (*Rhyzobium*), demonstrations, free distribution of seeds of new varieties through minikits, and free distribution of fertilizer minikits. With the implementation of these strategies, the target for the end of Seventh Plan is to have increased the area under soybean in M.P. to 1.8 million hectares, from 0.62 million hectares in 1983. The production target for the end of this period is placed at 1.44 million tonnes as against the actual production of 0.44 million tonnes in 1983.

6.2 Some Developmental Constraints

Developmental prospects for soybean in India have been outlined in the preceding section. For realizing these prospects in the field, market, processing and utilization levels, an appropriate development support package is obviously important. This development support package may comprise stabilizing high yields of different soybean varieties in various agro-climatic zones during different seasons, extension efforts to popularize these varieties among farmers through providing the technical know-how, adequate subsidies for key inputs, an effective output price support policy with adequate arrangements for procurement of soybeans, establishment of processing and other soybased industries, and promoting consumer education on the nutritive value of soybeans and soy products. Constraints operating on anyone of these facets could impede the accelerated innovation of this crop. This section is concerned with discussing major constraints which could prevent the full exploitation of soybean's developmental prospect in India.

a. Low soybean yield in India is the major constraint to realizing widespread expansion across different regions and different farm groups. To place the problem of low yield in proper perspective, some data examined earlier in this report are recalled. Expansion of soybean production in India has been sustained only by area expansion. In fact, in the Soy State (M.P.), area expansion rates have been high enough to offset negative yield growth rates, so that production expansion could be achieved. In the global perspective, India has suffered yield decline in relation to the yield performance of all other countries. Further yields which were low during the early 1970s in India had increased during the period of the late 1970s, and then again declined during the early 1980s.

M.P. followed similar patterns of trends in yield, whereas yield trends are found to have been quite erratic in the state of U.P., which claims about 20 percent of all the soybean area in the country. This could perhaps be one of the reasons for decline in both area and production expansion rates during the early 1980s compared to that to the early 1970s and the late 1970s. Production expansion had slowed down considerably during the early 1980s due to lower yields, whereas areal expansion had slowed down only marginally. Related to this is the recent report 50 that yields have declined in the fields. On the contrary, with experience, expertise and the buildup of inoculum in soil, yield levels will generally increase.

The spread of soybean in India has brought the farmer to the evaluation stage of the innovation process, though some segments of the farming population in the states of M.P. and U.P. have undergone the trials in adoption. The extensive trials and the final adoption of soybean are constrained by elements of risk and uncertainty in the production process. Although high yields of soybean are obtained on research plots and in demonstrations and maximization trials on the farm, their actual realization by a large segment of the farming population has not occurred. A price support policy is a necessary condition, but is not sufficient to sustain the accelerated expansion of soybean area and production.

Comparative economics, which is in favour of soybeans, is likely to be tilted against the crop if yields continue to decline. Low yields maybe supportive of the argument that research strategies and efforts have not been adequate in generating and sustaining a yield led production growth pattern. On the other hand, extension efforts may not have been adequate in providing knowledge on the what, when and how of the dimensions of production technology on the farm level.

This kind of extension gap has been identified in a study 20 conducted in Karnataka, one of the potential soybean states in the country. The possible high payoffs from extension and demonstration efforts are illustrated in the study by Oppen (December 1974), with the analysis of farm level data from the state of M.P. during a period of four years. It is reported in this study (P.14) that "this learning process [experienced by farmers] undoubtedly contributed to the 40 percent decline in the production cost of protein and calories over four years. On these grounds relatively high payoffs are to be expected from extension and demonstration efforts which aim not only at expansion of acreage, but also at the improvement of yields."

The need for breakthrough in yield is very well recognized. However, it would be crucial to recognize that the genetic and physiologic complexities involved (in all grain legumes) seem to limit its ability to produce higher yields.[34] Dramatic increase in maize yields in the USA is in constrast to a linear soybean yield increase. The biological constitution of soybean enables it, in symbiosis with *rhizobium* bacteria, to draw nitrogen from the air to produce grains of high protein and high fat content, leading to yield trade-off. It is recalled that the black variety, which is widely adopted in the state of M.P., has some desirable properties from the farmer's point of view, such as low seed rate, less fertilizer, and higher resistance to insects and pests. Yet, at the same time, yields are low and the black seed coat of this variety is one of the undesirable attributes from an industrial point of view, which in turn is reflected in price discounts on black soybeans.

To overcome these problems, research efforts are focusing on developing early maturing and high yielding yellow varieties having germination and disease resistance characteristics similar to black varieties. The present strategy is to combine high yield potential and short duration of the American cultivars with the disease resistance of local black seed varieties. Efforts in these. directions would provide technological support for further adoption of soybeans in the country.

b. Lack of adequate marketing for raw soybeans is yet another major constraint in areas where developmental potential exists for soybeans. It is recalled that public support has mainly promoted production at the farm level, and the NAFED has been entrusted with the task of implementing the procurement policy of the government at support prices. The NAFAD has for the most part be8n inactive in M.P., because farm-factory interactions have promoted the role of private initiative in marketing. However, in areas where soybean adoption has yet to gather momentum, the procurement policy at support prices does not appear to have been effective.

Soybean is a commercial crop, and it belongs to the category of 'highly marketable surplus'. In the absence of market outlets, the area production expansion of the crop is obviously constrained. It is reported 20 in farm-microstudies conducted in the state of Karnataka during the years 1978-79 that 94 percent of the farmers responding were not even aware of the policy of price support for soybean, and that 50 percent of soybean production was used as animal feed. It is also reported that the processing units are confronted with the problem of availability of adequate quantities of raw soybeans.[20] This is to imply that the need is for an institutional arrangement to bring the farmers and processors together as partners in developing a soybean economy.

For this purpose, one of the possible institutional arrangements is the system of contract production, as in the case of sugarcane, cotton and tobacco. The major components32.33.55 of contractual arrangements between growers and processors of soybean could be price, quantity, manner of delivery, manner of payment, penalties for not fulfilling the contract, agreement on technical assistance to the growers, and seed and fertilizer supplied on credit. These contractual agreements has yet to take off.

The educational and promotional efforts directed at cultivators by processing firms could provide the impetus required for further spread of soybean crops. All these support the suggestion that processing plants of economical size be strategically located within the supply areas from which soybeans can be assembled at relatively low cost.35 An alternative or complement to this could be an arrangement between the government procurement agency and processing units wherein the agency procures soybeans from farmers and supplies the required quantity to the processing units. Unless these market developments are initiated, soybean development in India will be one of concentrated geographic patterning, and the developmental potential for the crop across the country will not be exploited.

c. Soy-based product development and utilization is the third area which requires concerted efforts. The phenomenal rise in soybean production in the USA is the result of a three pronged effort:

(i) the development of high yielding and protein and oil rich varieties;

(ii) utilization of the produce for food for people and feed for animals;

(iii) utilization of by-products in various industries. In India, area of soybean production expansion has served mainly to meet increasing demand in the soy oil industry. Even though the multiple uses of the crop have been recognized, implementation has yet to be carried out. Soybean has yet to gain importance as a food crop, instead of only as an oilseed.

Farmers have many misgivings about domestic use of soybean, which can be removed only by education and demonstrations of the preparation of simple soybean products.20 In a recent study, 9 retailers of raw soybeans were asked about the efforts required to promote the use of soybeans. They did state that demonstrations regarding the use of soybeans would be very beneficial in improving consumer awareness and ultimately fostering the sale of the product. Soybean and soy-based products are in the introductory stage in terms of consumer use. This conclusion is drawn from the literature available, extensive discussions with producers, manufacturers, suppliers and consumers of soybean and soy products. The current consumer is decidedly from upper socio-economic strata. The results from this study are suggestive of a lack of adequate efforts to promote consumer education on the nutritive value of soybean and soy products, and also suggestive of comparative economics working against the large scale consumption of soy products.

Domestic consumption of defatted soy flour needs to be increased for food and feed. While India is deficient in protein supply, soy flour--rich in protein--is being exported to other countries for cattle feed. This protein drain could be prevented, provided the soy-based food industry is developed well enough to produce low cost soy-based products. Enough attention has not been paid either to the development of low cost soy foods or to the promotion of consumer awareness. This calls for research, based on the premise that the developmental prospects of soybean in India will be enhanced with the development of the soy food industry.

Development of the compound feed industry is yet another propelling force for enhancing the spread of soybeans. Although some far eastern countries, notably Japan and China, do use soybean meal for food, the use of meal for direct consumption is small all over the world. [37] Soymeal protein with higher lysene content has distinctly greater biological value than other meals and is therefore preferred particularly as livestock feed. Furthermore, absence of toxic materials such as aflatoxin, explains the worldwide preference for soymeal. These qualities have encouraged compound feed manufacturers to turn to soybean meal in preference to other oilcakes. However, the Indian compound feed industry, which has not passed early development, did not absorb more than 5 percent of total oilcake supplies in 1979. 37

The dependence of India on international markets for oilcakes in general is quite high. The price on the international markets depends mainly on the US crop. Given the high meal-to-oil ratio in the case of soybean, the expansion of Indian soybean cultivation will be constrained by the comparative advantage of our selling soymeal on the international market. Any failure to compete in the international market will create a soymeal glut in the country which in turn will transmit 'discouraging' signals to soybean growers. It is in this perspective that the development of the compound feed industry needs to be examined.

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VII. Concluding Observations

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7. This report is an attempt to analyse the developmental performance of soybean in India in the global as well as the national perspective. Globally, India is one of the three countries which, along with Brazil and Argentina, have experienced perceptible improvement in soybean are as well as production share. India has experienced this rapid area production expansion, even through it has suffered declines in relative yield. Nationally, soybean development has experienced both rapid growth (about 31% annual compound growth rate in output) and geographically selective development.

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Rapidity in soybean output growth has taken place under a situation of decline in yield. Explanations for rapidity and selectivity have been formulated in terms of development of a technological base for production at the farm level, zero-opportunity cost (of Kharif fallow land), relative profitability, developmental policy support extended by the government, farm-factory interactions, and development of a technological base for processing and utilization.

Developmental prospects, both technologic and economic of soybean in India have been indicated within the framework of soybean innovation across the country as well as across different cropping systems,' supply-demand-elasticities of oilseeds and pulses, techno economic performance of soybeans under improved crop production techniques in Madhya Pradesh and in the framework of the Soybean Development Programme, initiated in the Soy State during the 1985-1990 period of the Seventh Five Year Plan.

In addition, there is a worldwide demand for oilseeds, oils and oilcakes, with resultant population and per capita income growth. Among these, effective demand for oilcakes tends to outstrip that for fats and oils, because of a high income elasticity of the demand for meat and poultry products. Consequently, demand for oilseeds and oil-bearing materials like soybean, with a high meal-to-oil ratio, tends to be higher then demand for oilseeds with a low meal-to-oil ratio.

The prospects for the development of soybean could be realized, if developmental constraints are identified and constraint releasing strategies are implemented. In the present study, low-yield-imposed, market imposed, and product-cum-utilization imposed constraints on the realization of the developmental prospects of soybean in India have been identified, and possible constraint releasing strategies are indicated. The farmer's decision to adopt soybean, to discontinue after initial adoption, or to continue adoption and expansion would obviously depend on the choice of appropriate strategies for the release of constraints. A multifaceted constraint analysis at farm, market, factory, policy and consumption levels would provide insights into developmental interactions. Maximization of positive interactions and the elimination or minimization of negative interactions would provide a viable foundation for the development of the crop. Further, a cross-country soybean developmental performance, prospect and constraint analysis would provide more valuable insights into international agricultural development processes and problems relating to soybean.

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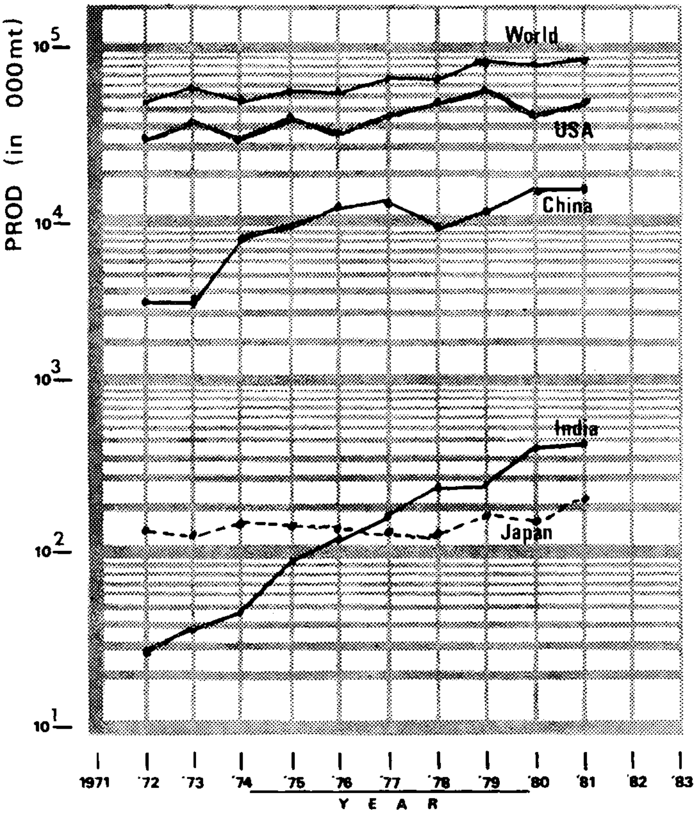
Appendix

Fig.1 Soybean production trends in different countries.



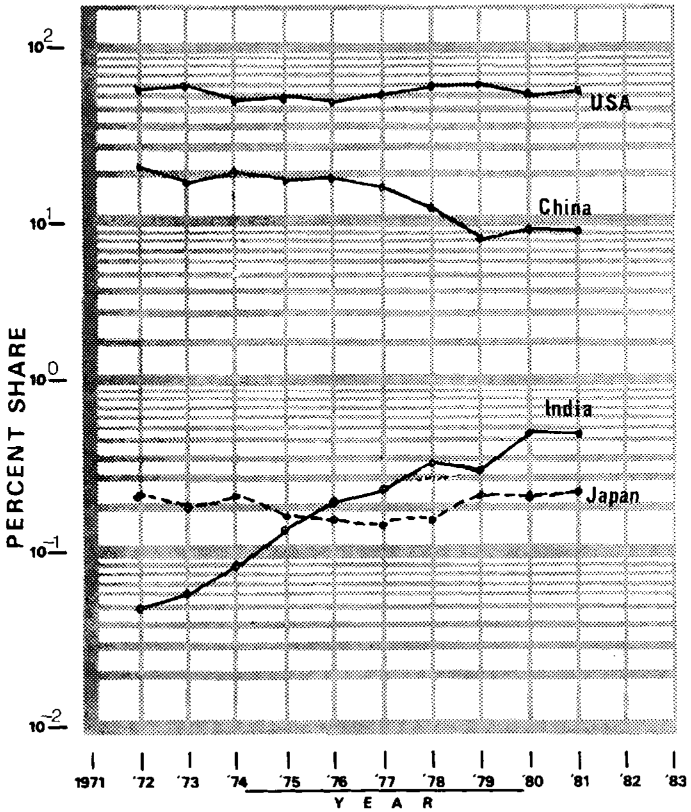
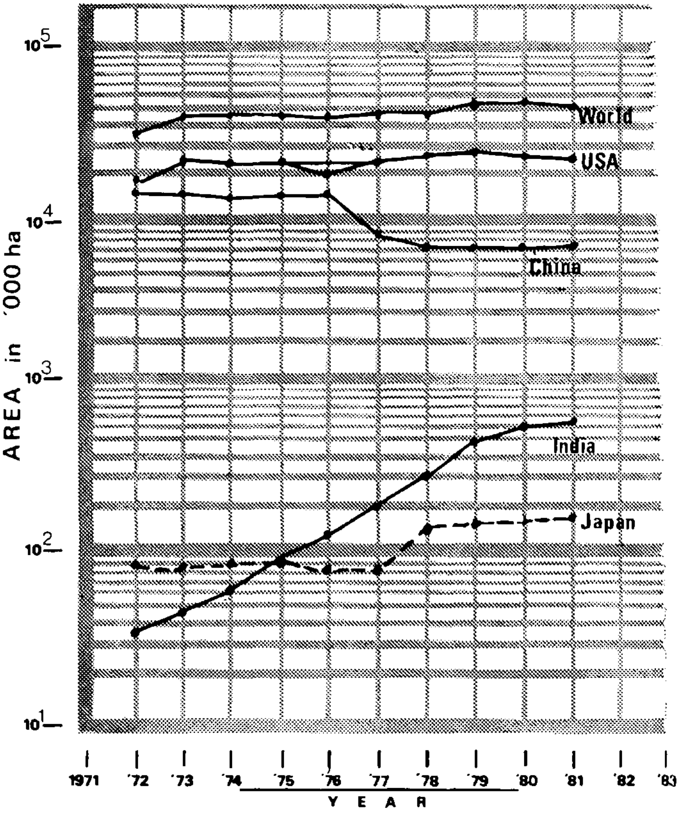


Fig.2 Percentage share of different countries in soybean production.

Fig.3 Soybean area-trends in different countries.



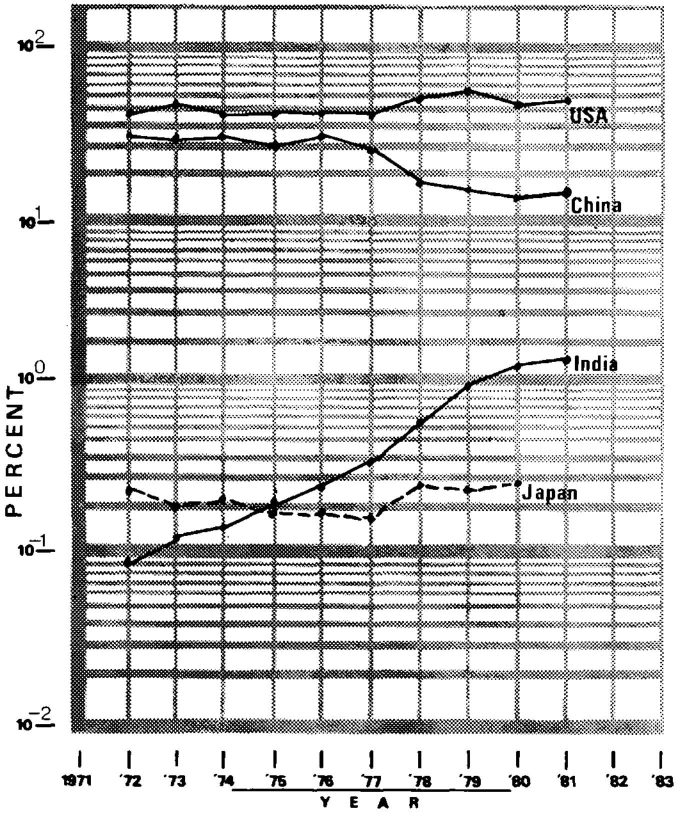
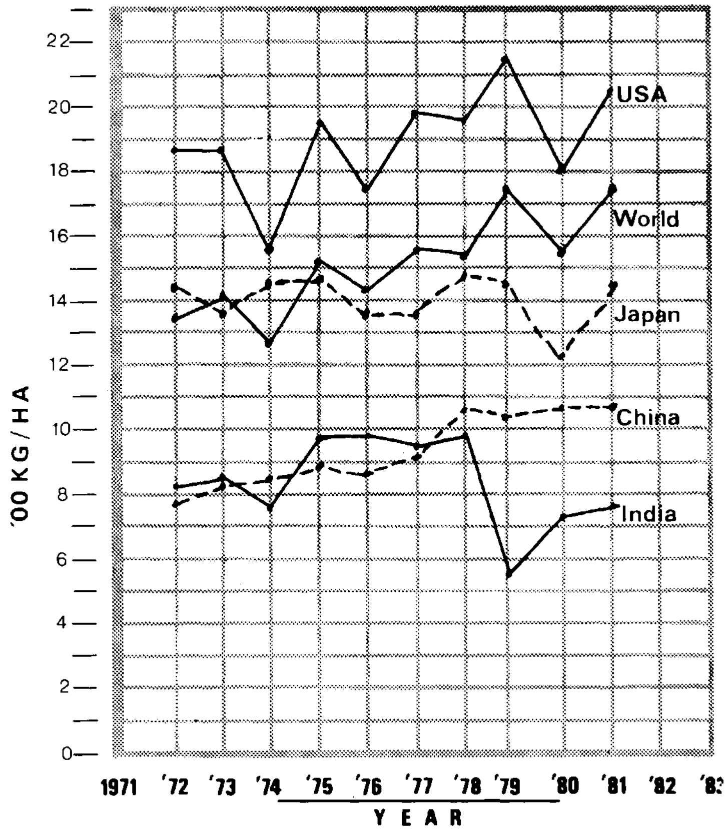


Fig.4 Percentage share of different countries in soybean area.

Fig.5 Soybean yield trends in different countries.



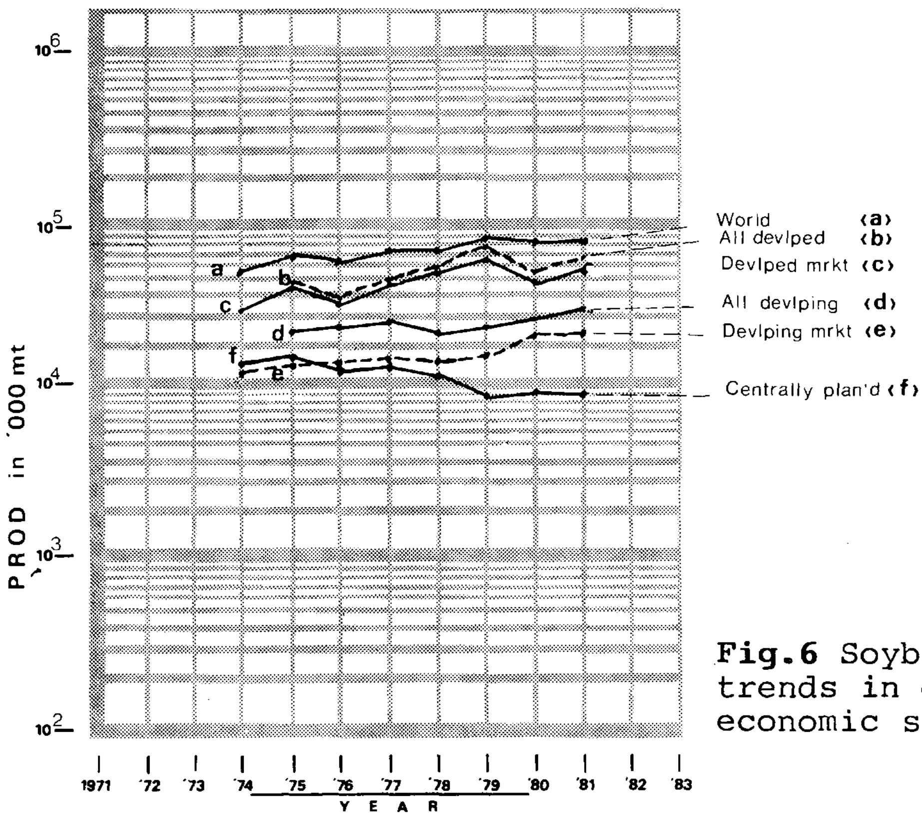
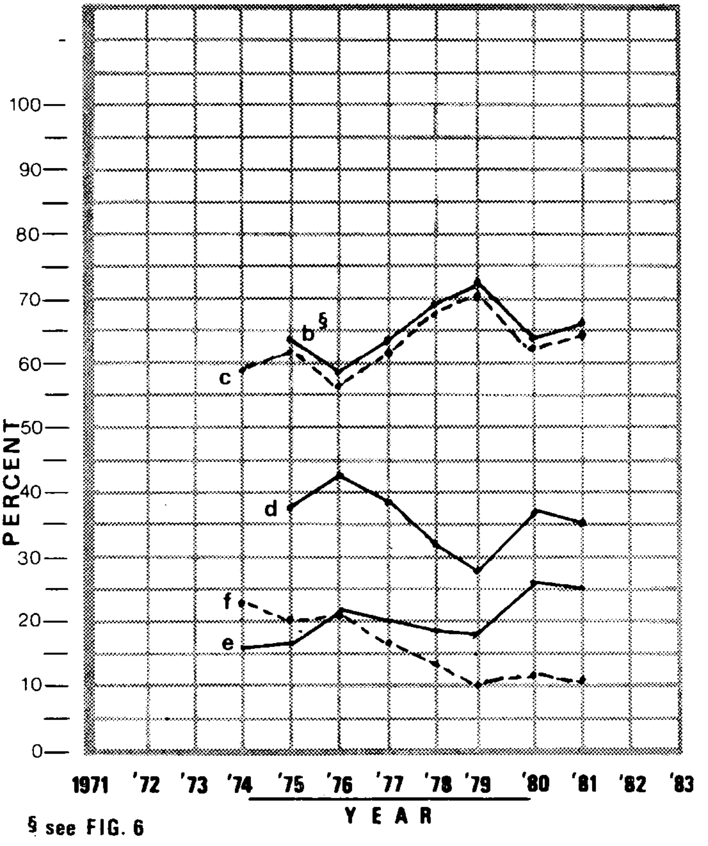


Fig.6 Soybean production trends in different economic systems.

Fig.7 Percentage share of different economic systems in soybean production.



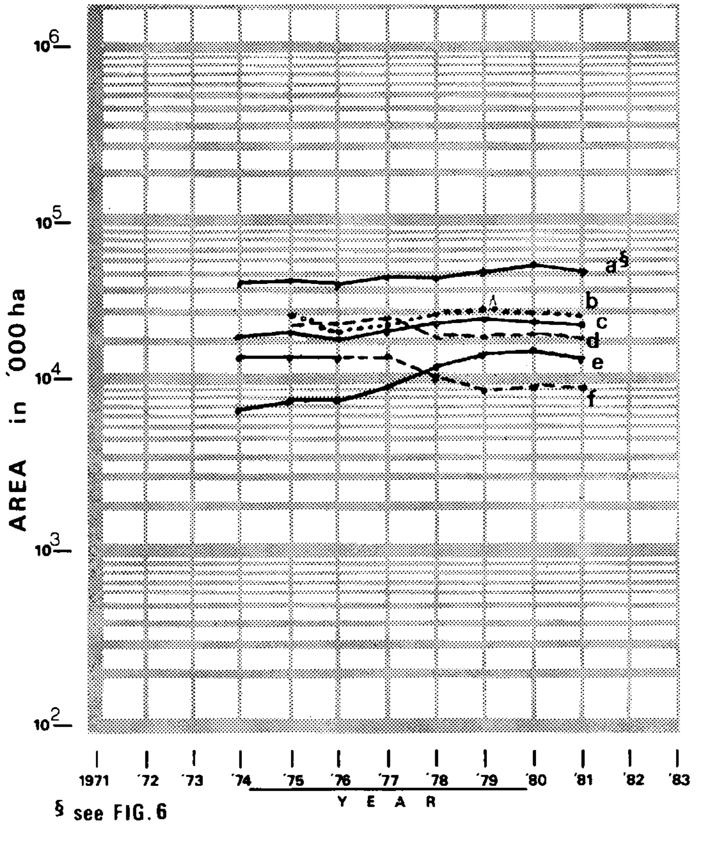
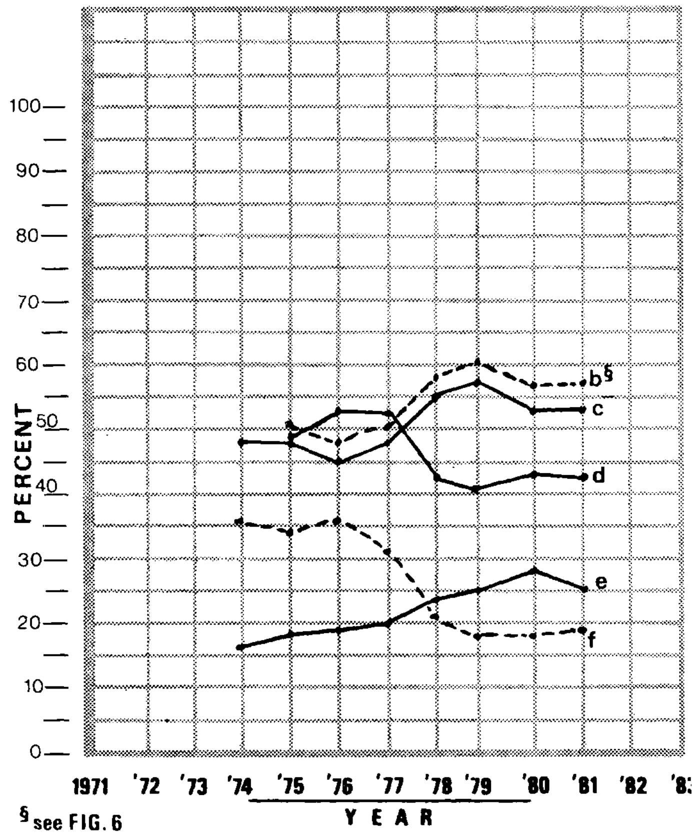


Fig.8 Soybean area-trends in different economic systems.

Fig.9 Percentage share of different economic systems in soybean area.



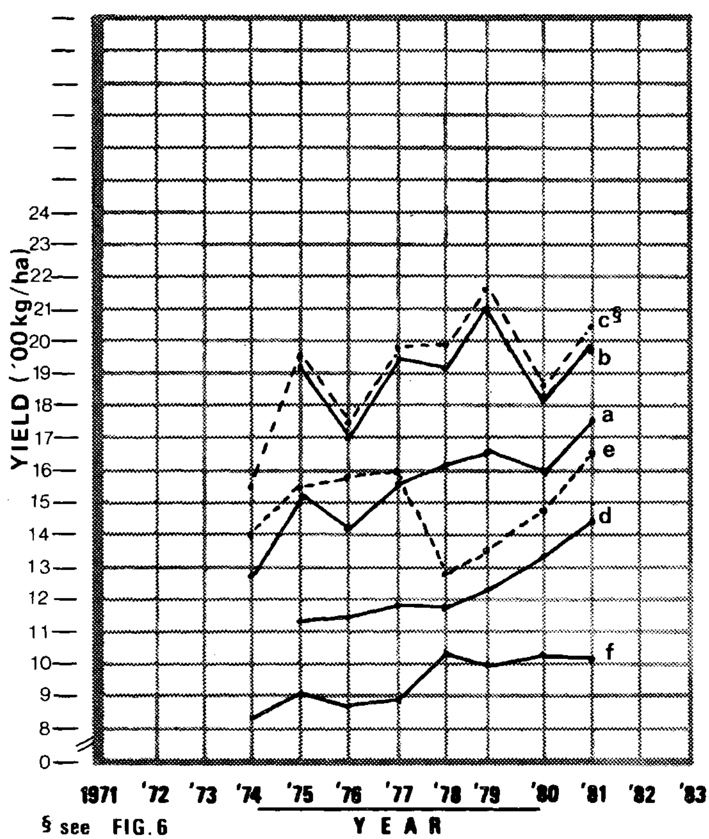
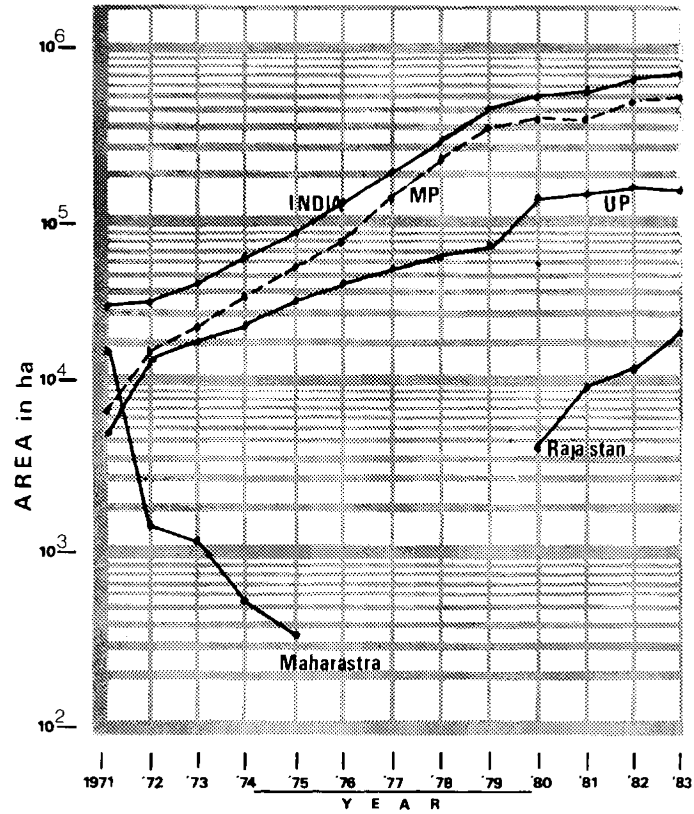


Fig.10 Soybean yield-trends in different economic systems.

Fig.11 Soybean area-trends in different Indian states.



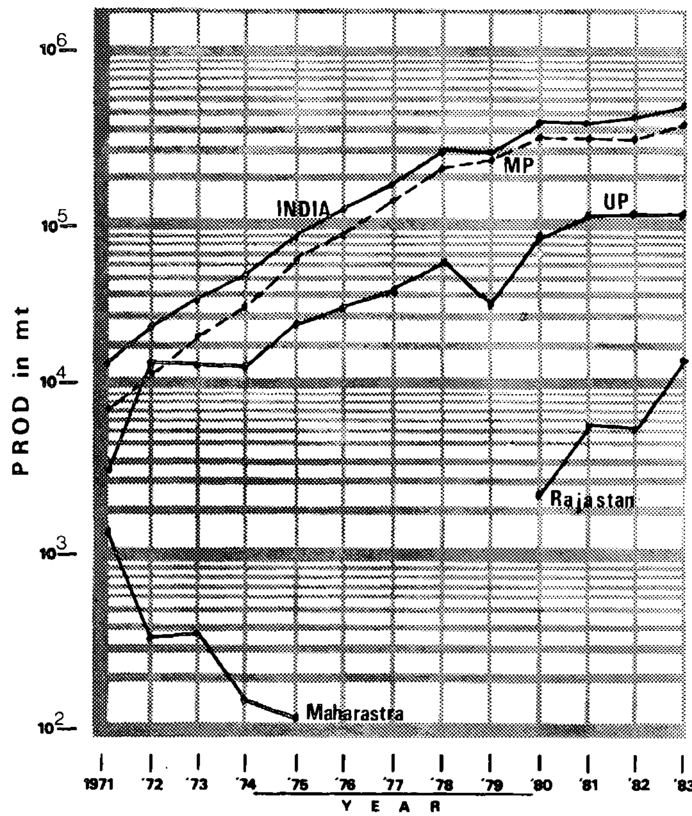
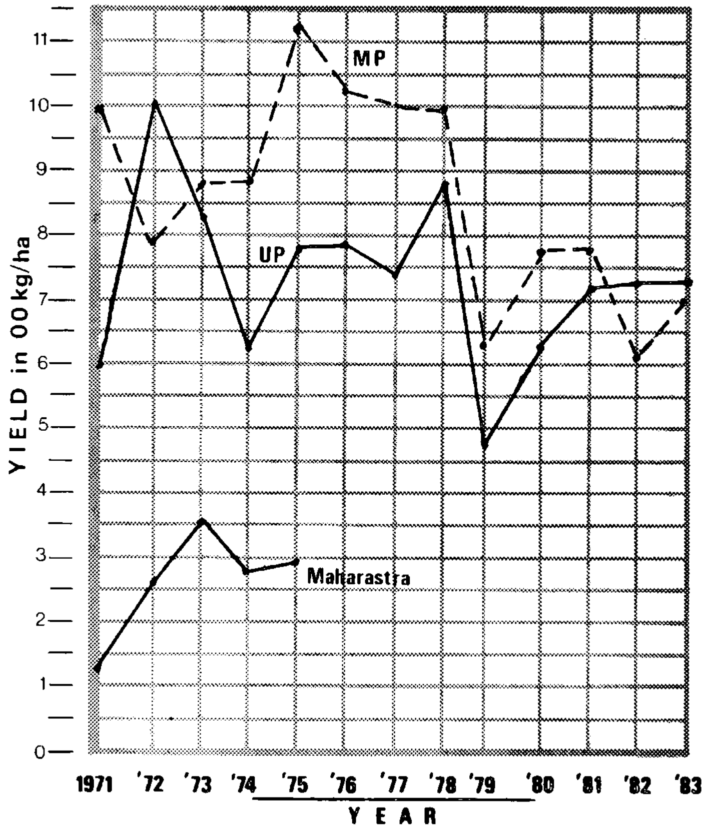


Fig.12 Soybean production trends in different Indian states.

Fig.13 Soybean yield-trends in different Indian states.



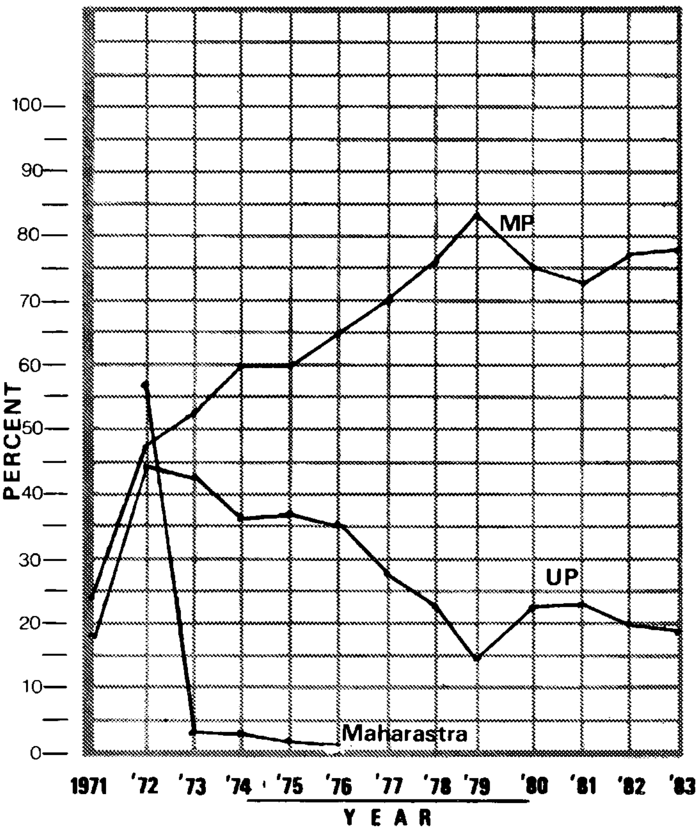
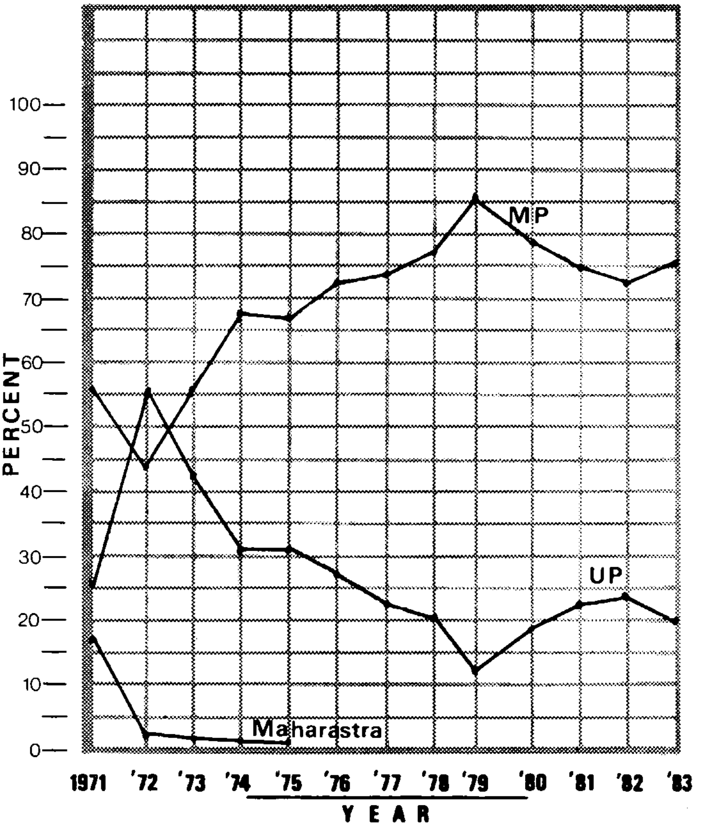
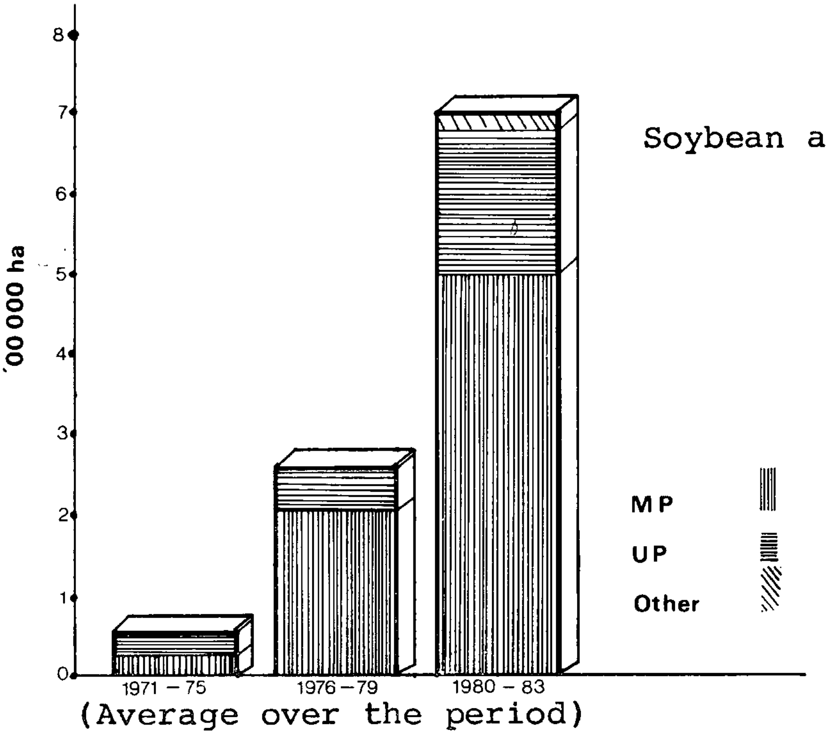


Fig.14 Percentage share of different Indian states (for area under soy).

Fig.15 Percentage share of different Indian states in soybean production.



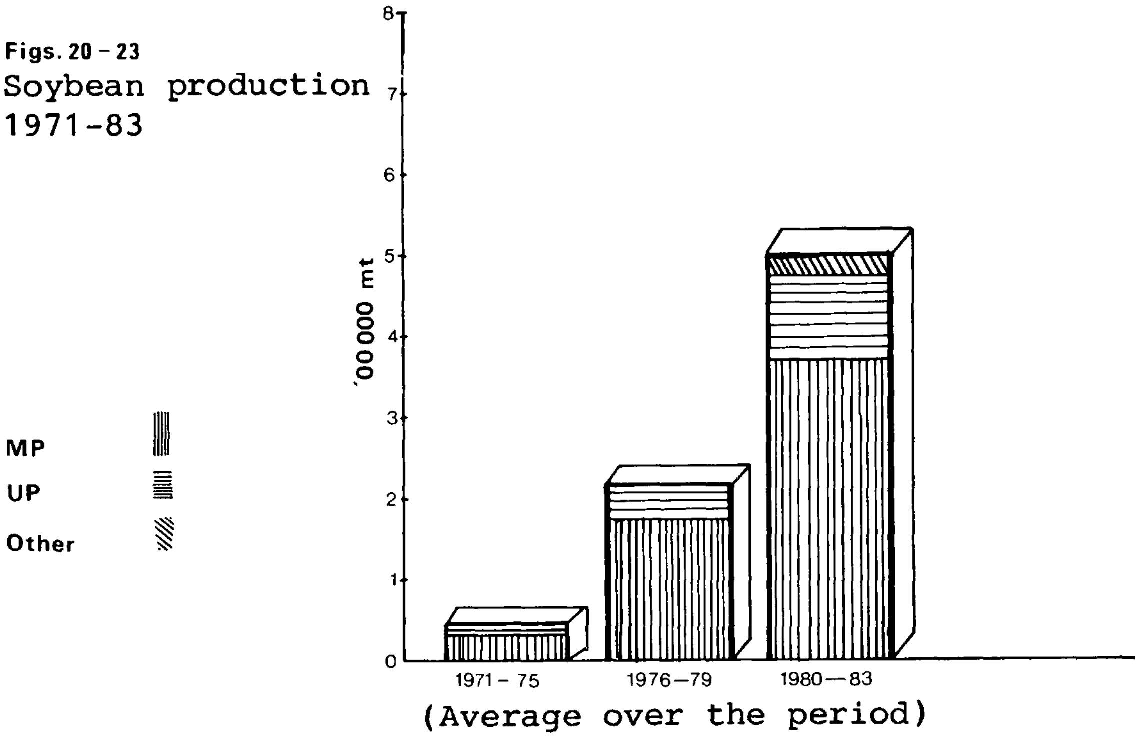


Figs.16 – 19
Soybean area 1971-83

(Average over the period)

Figs. 20 - 23

Soybean production
1971-83



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