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POTENTIAL FOR PRODUCTION AND PROCESSING OF SOYBEANS IN INDIA

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POTENTIAL FOR PRODUCTION AND PROCESSING OF SOYBEANS IN INDIA*

INTRODUCTION

Over the past ten years several countries have experienced large increases in soybean production (see Table 1). Some of these countries, like Argentina, Paraguay, Romania and India, have started their soybean production from virtually zero levels and it is interesting to take a look at their rates of expansion of acreage (see Figure 1).

The countries included in this comparison were selected for their high increases in acreage under soybeans during the last ten years. Experience from these countries shows that the higher the absolute levels of production the more rapid are the increases in area under soybeans until an upper limit is approached. During the early stages, soybean development is restricted by a lack of processing facilities, and processing facilities generally are slow to come up until certain minimum quantities of soybeans are available in sufficient densities for processing in large scale industrial operations.[1/]

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* An earlier version of this paper was given at the Regional Intsoy Conference on Soybeans, Addis Ababa, Oct. 1974. The author is grateful to all who by constructively criticising the earlier paper contributed to the present version.

1/ For instance, when Paraguay reached the point of take off in 1970, it had a production density of 20,000 ha. over its total land area of about 406,000 km.^{2} i.e. .05 t/km^2 of total land area; Romania in 1970 achieved its production increase at a production density of about .3 t/km^2.

Table 1. Production and Trade of Soybeans and Soyproducts in Selected Countries[1/]

(in '000 tonnes)

Country	Year	Soybean Production	Net Exports (+) / Net Imports (-)		
			Soybeans	Soyoil	Soymeal
Brazil	1961-65	353	n.a.	n.a.	n.a.
	1970	1509	+ 290	- 2	+ 525
	1971	1977	+ 200	- 4	+ 901
	1972	3500	+ 1039	+ 48	+ 1432
Argentina	1961-65	12	n.a.	n.a.	n.a.
	1970	27	-	-	-
	1971	59	-	-	-
	1972	78	-	-	-
Paraguay	1961-65	8	n.a.	n.a.	n.a.
	1970	30	+ 1	+ 1	+ 28
	1971	74	+ 12	+ 1	+ 30
	1972	128	+ 42	+ 1	+ 28
Mexico	1961-65	65	n.a.	n.a.	n.a.
	1970	280	- 90	- 3	-
	1971	250	- 50	- 1	-
	1972	360	- 11	- 1	-
Romania	1961-65	3	n.a.	n.a.	n.a.
	1970	91	+ 10	-	-
	1971	165	+ 20	-	-
	1972	170	+ 20	-	-
Thailand	1961-65	27	n.a.	n.a.	n.a.
	1970	70	+ 6	-	+ 4
	1971	74	+ 6	-	+ 1
	1972	70	+ 7	-	+ 1
India	1961-65	- [2/]	-	-	-
	1970	8	-	- 79	-
	1971	18	-	- 177	-
	1972	24	-	- 80	-
	1973	32	-	-	-

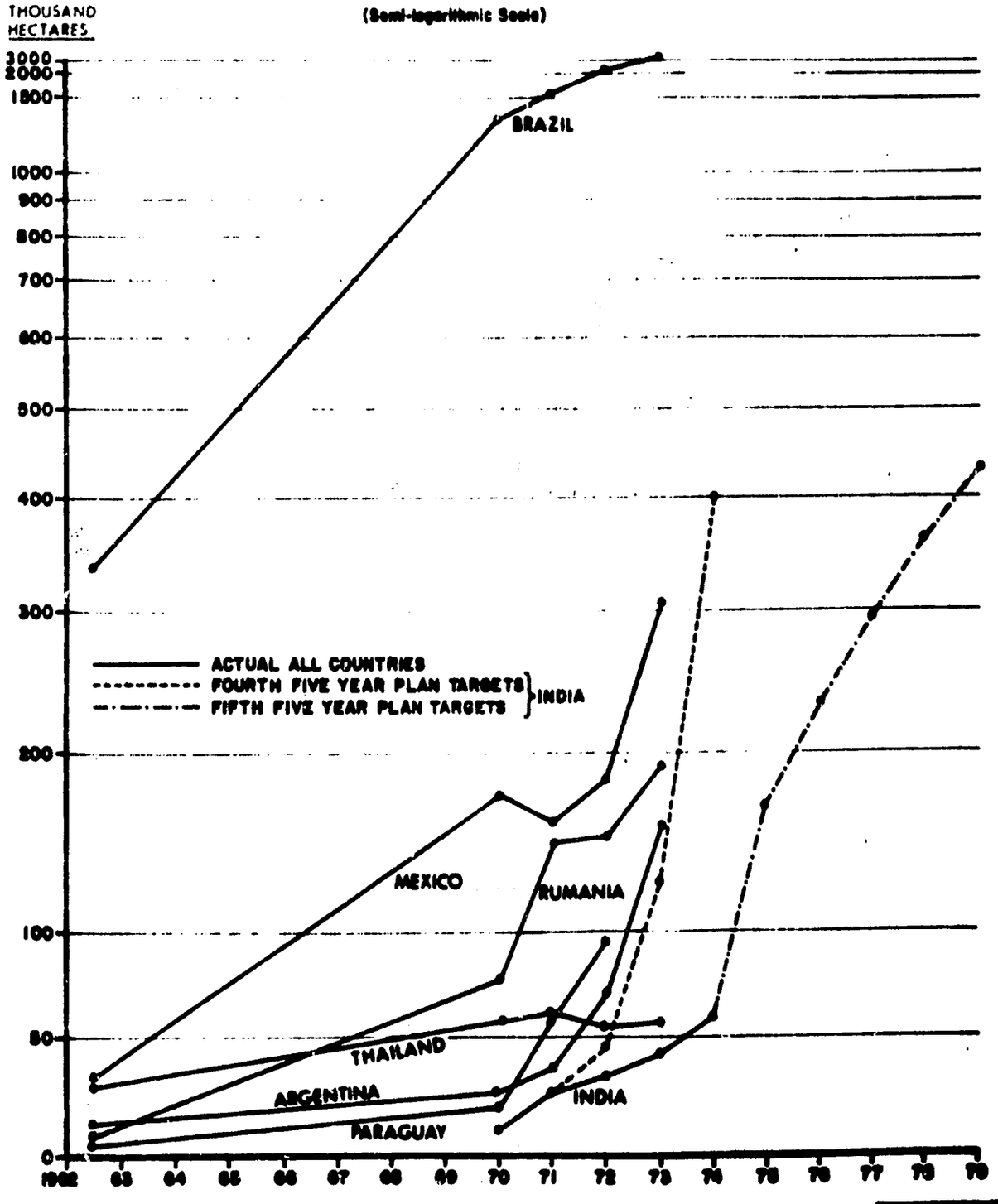
1/ Countries in which area under soybeans increased by at least about 200% or more between 1961-65 and 1972.

2/ Cream coloured varieties only. Production and local consumption of traditional black varieties, mainly in the hilly areas of North India, is about 6000 tonnes per year.

Sources: India : Rathod and Motiramani [10] and the author's estimates of yield of 7.5 t/ha.

Other countries: FAO [2, 3].

FIG. 1: ACTUAL EXPANSION OF THE AREA UNDER SOYBEANS IN SELECTED COUNTRIES AND TARGETS OF INDIA



India is the last country in this group to join the "Soybean-race"and so far its soybean expansion has been somewhat slower than that of most of the countries shown. On the other hand, Figure 1 shows clearly that India pursues an ambitious target of soybean development: 430,000 ha. in 1979. The question one might ask is:

Will India be able to achieve these targets?

Considering India's rates of expansion of soybean acreages during recent years, it would seem that the future expansion in India is likely to remain about behind the targets envisaged, perhaps 200,000 ha. by 1979 would seem a plausible figure.

In fact, India does have a particularly complicated problem to solve. Soybeans will have to find a market within India, because Indian wholesale price levels for food products are generally above world market prices, and the Government of India so far does not financially support the export of soymeal, but rather considers soymeal a human food to be consumed domestically, although it does not support this idea very actively. Consequently, while she is expanding the area under soybeans, India has to simultaneously build up a food industry to process and market soymeal and soyoil for human consumption if she wishes the industry to grow at anywhere near target rates. In order to evaluate the situation in India I want to present some observations. These are based on information

on agricultural production, marketing and processing, and the role of the Government of India with respect to soybean development during the past four to five years. In this way we can obtain clues as to some of the prevailing trends and approaches. From these we can then draw conclusions about the likely direction and speed of future development of soybeans in India.

PRODUCTION OF SOYBEANS

There is evidence from data gathered over the past 4 years on the economics of production and processing of soybeans indicating that its competitive strength over other crops has gradually increased.

Farm survey data on costs of production of soybeans and competing crops in Madhya Pradesh are available for the four years from 1970/71 to 1973/74 (Kashive and Williams [6, 7, 8]). Analysis of the data has shown that the 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 consider soybeans to be a superior crop to all the competing Kharif season crops." (Kashive [8]). In order to compare the basic food values of the different crops irrespective of the market values, agricultural production costs of soybeans and competing crops per unit of protein and per unit of energy were computed from these farm survey data. A comparison on this basis enables us to evaluate the relative agricultural costs at which food from these crops is produced in the farmers' fields over time.

As shown in Figure 2, from the outset of the observations in India in 1970, soybeans have always been the most economic protein crop in terms of agricultural production costs per kilogram of protein. This is due to the high protein content of soybeans and therefore hardly surprising. Also, during the past four years agricultural production cost of protein from soybeans has remained about constant, while for the three major competing crops protein costs have considerably increased.

If we compare the agricultural production costs of energy from soybeans and competing crops (see Figure 3) we notice that at the outset of the farm surveys, calorie production from soybeans was more expensive than that from any of the other crops, but over the subsequent three years the costs of producing energy from competing crops increased to the extent that by 1973/74 soybeans were the cheapest source also of calories for human consumption from among these crops. It is stressed that this includes observations on only three competing kharif crops namely, maize, jowar and groundnuts. But these are generally considered to be the strongest competitors for soybeans in Madhya Pradesh.

These data were collected from farmers who were growing one or the other of the competing crops together with soybeans. Therefore, the skills they have in growing soybeans are also applied to the other crops. Even though only a small fraction of the farmers surveyed were included during all four years of observations, for the aggregate of all farmers observed, a considerable learning process has taken place that has led

FIG. 2: AGRICULTURAL PRODUCTION COSTS PER KILOGRAMME OF PROTIEN FROM DIFFERENT CROPS IN M.P., INDIA

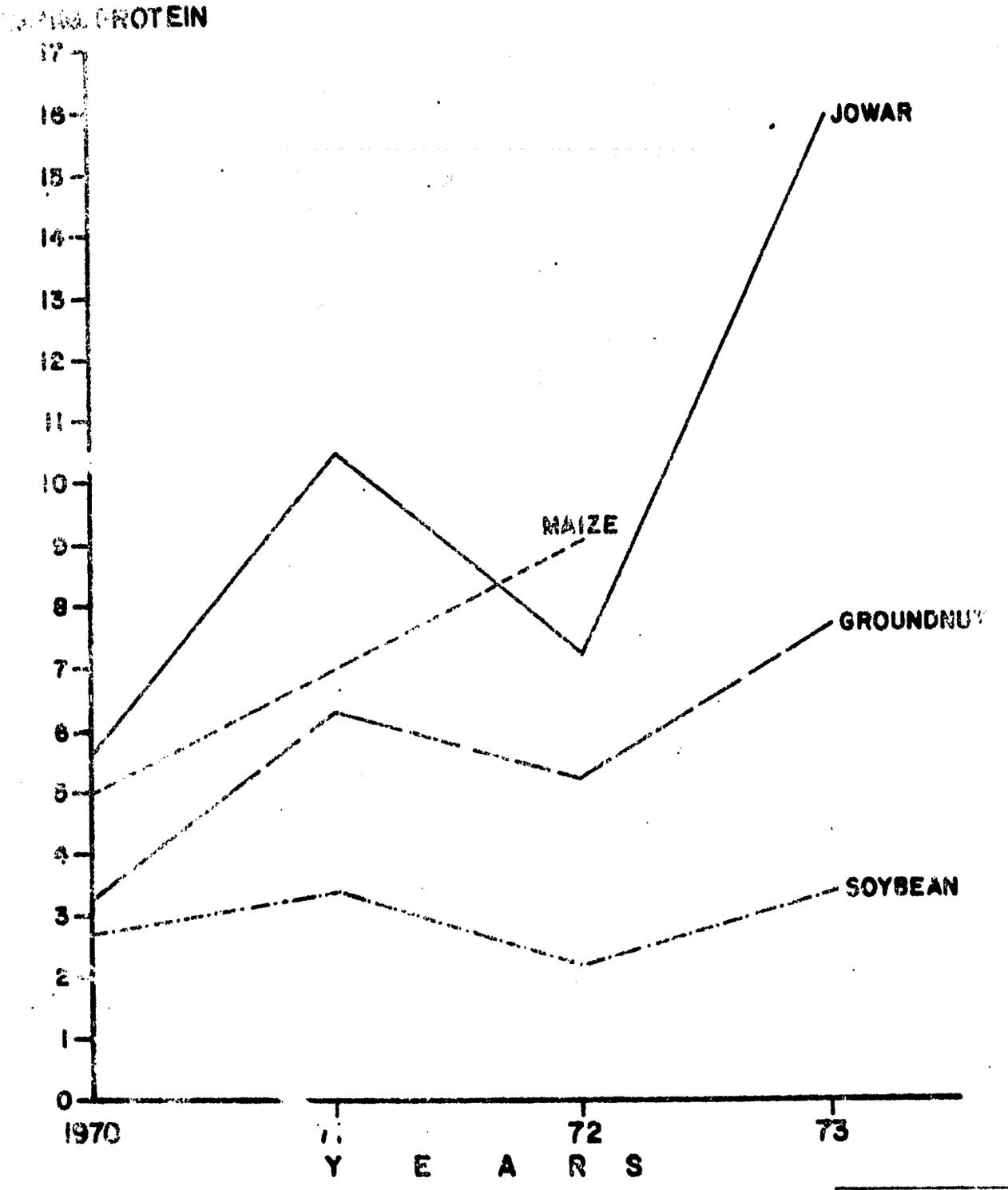


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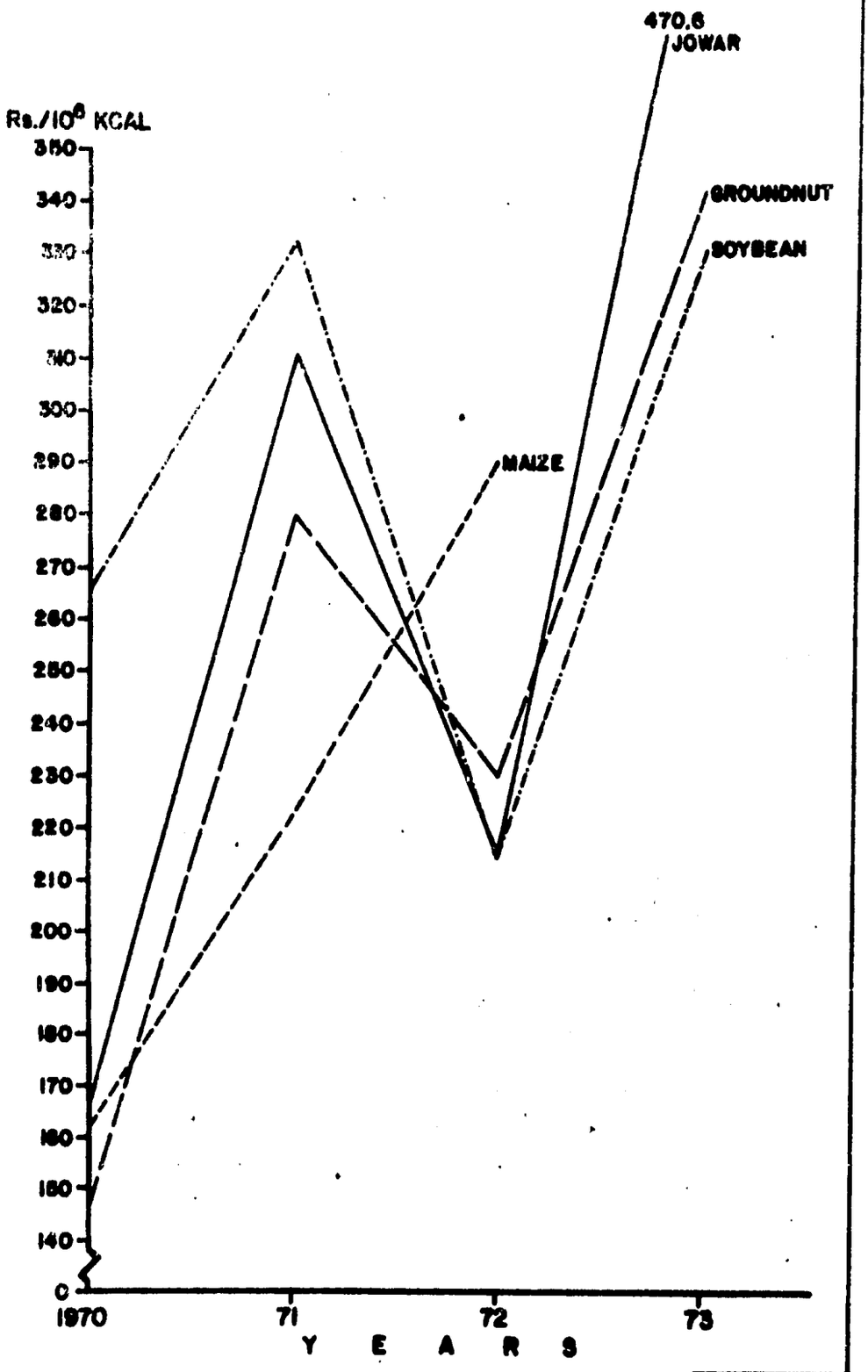
FIG. 3: AGRICULTURAL PRODUCTION COSTS PER 10^6 KCAL FROM DIFFERENT CROPS IN M.P., INDIA



to a consistent relative decrease in costs and/or simultaneous increase in yields as experience in growing soybeans was accumulated and spread.[2/]

This is explained by the fact that in comparison to other crops soybean production requires a relatively sophisticated technology. In order to statistically evaluate the factors affecting yields of soybeans in India, farm survey data consisting of 329 observations in six different districts of Madhya Pradesh for two years 1970/71 and 1971/72, were subjected to multiple regression analysis.[3/] These data contained detailed information on inputs like seed, fertilizer, insecticides and bullock and human labour for different activities, as well as records of date of planting, depth of planting and also observations about exogenous factors like bird damage, dry spells, heavy rains after emergence of the crop, plant population and yields. Furthermore, farmers' experience in growing soybeans is reported in terms of number of years. Since the number of variables that could be included in one equation was restricted by the capacity of the computer, the variables were grouped

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2/ When we are talking about Madhya Pradesh and the spread of experience it must be borne in mind that Madhya Pradesh alone covers an area of about 44 million hectares and soybeans are mainly grown in the western half which has about the same size as the total area of Romania with 24 million hectares.

3/ These data were collected, tabulated and also analyzed using cross tabulation and ranking techniques by R.C. Kashive and S.W. Williams [6]. The author is grateful for being allowed to work on the data. Restrictions in computer capacity made it impossible at this point to explore the given data statistically to the extent that this excellent information deserves.

were grouped into two sets; on the basis of a prior information that plant population and yield are highly correlated (Kashive and Williams [6, p.95] two regressions were run: the *first* regression to evaluate factors that determine the plant population, the *second* regression to evaluate factors (including plant population) that determine yield.

The following two equations were fitted, yielding regression coefficients (t - values in brackets) with significance levels as indicated 4/:

$$
\begin{aligned}
(1)\quad POP = {} & -8.5 - \underset{(.24)}{2.70\ EXP} - \underset{(.071)}{.25\ DPL} + \underset{(.052)}{.0023\ (DPL)^2} \\
& + \underset{(2.17)^{**}}{13.02\ SDR} - \underset{(2.22)^{**}}{.196\ (SDR)^2} - \underset{(2.23)^{**}}{1.54\ DTE} + \underset{(3.30)^{***}}{38.6\ HRN} \\
& - \underset{(1.44)^{*}}{17.9\ DRY} - \underset{(3.95)^{***}}{46.34\ BRD} - \underset{(.185)}{.052\ LPR} \\
& R^2 = .11
\end{aligned}
$$

$$
\begin{aligned}
(2)\quad \log YLD = {} & -2.4 - \underset{(2.14)^{**}}{.0055 \log NS} + \underset{(1.42)^{*}}{.012 \log NR} + \underset{(.49)}{.004 \log PKS} \\
& - \underset{(.19)}{.001 \log PKR} + \underset{(1.14)}{.018 \log SPR} - \underset{(.26)}{.0015 \log LFS} + \underset{(1.64)^{*}}{.012 \log LII} \\
& + \underset{(.087)}{.0064 \log LSW} + \underset{(5.9)^{***}}{.02 \log LHT} + \underset{(3.2)^{***}}{.014 \log LTW} + \underset{(2.4)^{***}}{.506 \log POP} \\
& R^2 = .21
\end{aligned}
$$

4/ *** - significant at 2%
** - significant at 5%
* - significant at 20%

In these equations, the variables are:

POP = Plant population in 1000 plants per ha.

EXP = Number of years grower grew soybeans before.

DPL = Depth of planting in millimeters.

SDR = Seed rate in kilograms per acre.

DTE = Date of planting in number of days before (-) or after (+) June 26.

HRN = Incidence of heavy rains at the time of emergence (Yes=1 or No=0)

DRY = Incidence of hot and dry weather at the time of emergence (Yes=1 or No=0)

BRD = Bird and Insect damage after emergence (none=0, medium=1, heavy=2)

LPR = Labour input in preparing the land in manhours per acre.

YLD = Yield in quintals per acre.

NS = Nitrogen on soybeans in kilograms of the element per acre.

NR = Nitrogen on preceding rabi crop kilograms of the element per acre.

PKS = Phosphorous and Potassium on soybeans in kilograms of the element per acre.

PKR = Phosphorous and Potassium on preceding rabi crop in kilograms of the element per acre.

SPR = Insect spray expenditure in Rupees per acre.

LFS = Man and woman labour hours per acre in fertilizing, seeding.

LII = " " " " " " " " interculture, irrigation.

LSW = " " " " " " " " spraying, weeding.

LHT = " " " " " " " " harvesting, transport.

LTW = " " " " " " " " threshing, winnowing.

It is agreed that this approach has not given best estimates in the pure statistical sense, as the information collected in fact involves a system of simultaneous equations,[5] therefore should be treated accordingly. Also no differentiation among years and between regions could be made because the number of observations per region was too small for the number of variables included to leave sufficient degrees of freedom. Therefore no comparative location-specific information could be derived. Although it is felt that quadratic function might have given a better fit for the second equation, the logarithmic form was chosen because of limits in the computer capacity. From equation (1) we conclude, that plant population is positively associated with heavy rains (a fact which runs contrary to the generally held opinion that heavy rains damage the crops; apparently if the damaging effect of rains is there it is more than offset by positive effects on plant growth - at least this is so for the aggregate of all observations over two years and six different locations, three of which are included in both years). Bird and insect damage naturally have a significant negative effect on plant population: generally, the earlier the planting date is before June 26 the better the plant stand is. Seed rate influences plant population as expressed by one linear and one quadratic term of the variable.

5/ For instance one could postulate the following:

i) POP = f(EXP, DPL, SDR, DTE, HRN, DRY, BRD, LPR, NR, PKR, LSW, LII)
ii) YLD = g(POP, EXP, NS, NR, PKS, PKR, SPR, LFS, LII, LSW, LHT, LTW)
iii) POP = h(EXP, DPL, SDR, DTE, HRN, DRY, BRD, LPR, NR, PKR, LSW, LII, NS, PKS, SPR, LFS, LHT, LTW)

where POP is estimated from equation (iii)

According to our estimates the seed rate was 33 kg./acre for a maximum plant population.[6/] Depth of planting yielded non-significant coefficients as an explanatory variable for plant population. Also the experience of the grower in growing soybeans in earlier years and the amount of labour input for land preparation have a non-significant effect upon plant population.

In equation (2) it is confirmed, that plant population significantly influences yield.[7/] In this equation it is further found that nitrogen fertilizer does have a negative effect upon soybean yields and that phosphorus and potassium applied on soybeans have no effect on yields. Accordingly labour input for fertilizing (and sowing) is non-significantly associated with yield. Surprisingly, spraying expenditures and also labour inputs for spraying and weeding are also not significantly related to yield. All other labour inputs have significant positive effects upon yield.

These data provide some information on the potential for improving soybean yield and/or reducing agricultural production cost by accumulating experience with this crop.

6/ This value is found by taking the first partial derivative with respect to the variable and setting it equal to zero, providing that the second derivative is negative.

7/ In an earlier version of this paper this fact was less obvious. As found out later the data for two districts did not contain appropriate observations on plant population. After excluding the observations from these two districts the analysis yielded the above regressions.

The results indicate the extent to which farmers' activities do or do not contribute to yields. We have arrived at these findings by statistically analyzing the data collected from some 329 farmers about one third of which were observed for two years. However, on an intuitive basis every individual farmer over time also discovers similar relationships, particularly those valid for his own conditions. This learning process undoubtedly contributed to the 40 per cent decline in production costs of protein and calories from soybeans over four years. On these grounds relatively high pay-offs are to be expected from extension and demonstration efforts which aim not only at expansion or acreage but also at the improvement of soybean yields.

MARKETING AND PROCESSING OF SOYBEANS AND SOY-PRODUCTS

During the first years of soybean development in India, most production was probably marketed and sold under some kind of written or oral contractual arrangement (*Soybean Marketing Information* [11]). This is a very reasonable approach for the early stages of soybean marketing, as it reduces several types of risks for both buyers and sellers. However, in the long-run a cash grain crop like soybeans is marketed more efficiently in the open market (von Oppen [13, p.38]). In fact since 1972 and more so in 1973 soybeans have appeared in several market places in Madhya Pradesh where prices of up to Rs.150/qtl. (Indore, December 1972) and Rs.240/qtl. (Ujjain, March 1974) were reported (see Table 2). Despite the increase in soybean production from 1972 to 1973

Table 2. Weekly Prices for Soybeans and Competing Crops in Selected Primary Markets of North India in November and December of 1972 and 1973 in Rupees per Quintal

Year	Month	Week	Soybeans	Groundnuts (in shell)	Jowar (Yellow)	Maize (White)
			INDORE	RAJKOT	UJJAIN	BARAICH
1972	Nov.	1st	-	175	-	63
		2nd	120	180	-	65
		3rd	135	175	-	64
		4th	130	180	64	65
	Dec.	1st	147	190	69	65
		2nd	147	180	69	66
		3rd	140	175	67	66
		4th	150	180	67	72
Two Months' Average			138.40 (100)	179.40 (100)	66.80 (100)	65.80 (100)
			UJJAIN	RAJKOT	UJJAIN	BARAICH
1973	Nov.	1st	135	219	126	75
		2nd	150	219	127	75
		3rd	145	235	131	80
		4th	158	214	115	80
	Dec.	1st	161	214	112	85
		2nd	183	225	113	90
		3rd	210	247	-	90
		4th	198	-	107	-
Two Months Average			167.50 (121)	225.30 (125)	118.70 (178)	82.10 (125)

Sources: Rathod and Kashive [11], No.13, May-August 1974, and Government of India *Bulletin of Agricultural Prices* [5].

of 34 per cent the average November-December price during the same period rose by 21 per cent, which is quite in line with the price increase of 25 per cent of groundnuts and maize over that period. In case of jowar in Ujjain extraordinary shortages of this crop in that area are responsible for the steeper price rise; in other markets, e.g. Akola and surrounding areas, prices for jowar also increased by 21 per cent.

These, in comparison to other crops normal rises in prices for soybeans, are indicating that the increasing production was observed by an increasing demand. This growing demand for soybeans cannot only be attributed to a general shortage of vegetable oil in India, because soybeans have only less than half the oil content of groundnuts, and there is no preference for soyoil over groundnut oil. The rise in soybean prices during expansion of production is due to an increasing awareness of the qualities of soybean protein and a consequent increase in demand for this product. The pharmaceutical industry is using soymeal or soybeans on a large scale for the production of antibiotica, and some industrial soymeal is also used and even exported for feed purposes. To a lesser extent (but at an increasing rate) soybean processors are producing soymeal of edible quality, which is processed into food products (see Table 3).

Table 3. Recorded Soybean Processing Capacity in India

Type of Processing Plant	Recorded[1/] as Operating in 1974			Expected[1/] to be Operating in 1975		
	No. of plants	Capacity (tonnes/day) Total	Capacity (tonnes/day) Average	No. of plants	Capacity (tonnes/day) Total	Capacity (tonnes/day) Average
- Producing Edible Quality Soymeal -						
Screw Press Expellers	4	7	1.8	5	8	1.6
Solvent Extraction Plants	2	120	60	4	240	60
Extrusion Cookers Plant	1	*	*	1	*	*
Soymilk Extraction Plant	1	*	*	1	*	*
- Industrial Quality Soymeal -						
Screw Press Expellers	1	4	4	1	4	4
Solvent Extraction Plants	3	145	48	5	335	67
Total	12	276		15	587	

* Experimental Stage

1/ According to information by the individual firms.

Sources: Rathod and Motiramani [10, 11] and personal communication, Government of India Directorate of Oilseeds Development.

It is reported that soybeans are processed into Dal (split pulses)[8/] and sold as such, by mixing it with dal of customary pulses. To which extent this form of "fortification by adulteration" is practised could not be determined.

The exact number of soybean processing plants in India is unknown, but informed sources[9/] estimate that at present about 12 mills are operating, five of which are of the solvent extraction type with an average capacity of about 50 tonnes per day each, five are screw press type expellers with an average capacity of about 2 tonnes per day each, and two are special types, one an extrusion cooker plant and another a soymilk plant, both still more or less at the experimental stage, although not far from entering the commercial market.

At the present annual production of about 45,000 tons of soybeans in 1974 in India the total capacity of these plants of 276 t/day, or 83,000 tonnes per 300 days in a year, can be utilized for soybeans to only about 50 per cent capacity. However, most of the solvent extraction plants that are reported to process soybeans are in fact mills which were originally set up and still continue to process groundnuts and other oilseeds. Not all of these plants are adapted to produce edible soymeal. Only if these mills are equipped with an additional toasting device and if they observe certain hygienic standards can they produce a soymeal of edible quality

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8/ A method of making dal from soybeans was developed by Spata, Nelson and Singh [12].

9/ Personal information from Dr.K.L.Rathod, Editor of "*Soybean Marketing Information*", and from the Government of India Directorate of Oilseeds Development, Hyderabad.

The estimated average costs of processing one ton of soybeans by different methods range between Rs 174 to Rs. 640 (Table 4). The estimate of Rs. 174/ton refers to a solvent extraction plant of 10 t/day capacity, if used at full capacity. A plant of 100 t/day capacity would process at costs of about Rs 75/ton (see Figure 4). These economies of scale in solvent extraction plants promise some additional incentives to the soybean industry as larger scale plants find sufficient quantities of soybeans for processing at full capacity. However, when adding the costs for industrial processing of say Rs. 175/ton and for transportation of say Rs 75/ton 10/ to the agricultural production costs (see Table 5) it is found that for soybeans the former contribute only 15 to 20% while, the latter account for 85 to 90% of the sum of these costs.

Consequently, if the observed trend of lowered production costs for protein and energy from soybeans relative to competing crops of about 10% per year continues for several more years then this effect will, for the near future, contribute most of the increasing incentive in expanding the area under soybeans. Nevertheless, it must be stressed that in the long-run the cost reducing effects of economies of scale in soybean processing and marketing will not be negligible, if the plants are placed at optimum locations and laid out such that provision is made for later expansions of the facilities within the plant.

10/ Assuming solvent extraction in a plant with a capacity of 10 t/day (100 t/day).

Table 4. Average Costs of Processing Soybeans by Different Methods

Method of Processing	Extrusion cooking 1/ (capacity 20 t/day)	Solvent Extraction 2/ (capacity 10 t/day)	Screw Press Expelling 2/ (capacity 1 t/day)	Milk Extraction 3/ (10,000 litres/day = 1 t/day).	Preparation of Dal 4/
	Rs./ton	Rs./ton	Rs,/ton	Rs./100 litres	Rs./ton
Variable costs	84	43	100	38.78	490
Fixed costs for capital	172	131	89	7.67	150
Total Average costs	256	174	189	46.45	640

Sources: 1/ Rathod and Williams [9].
2/ Williams and Rathod [14].
3/ Communication of Director of Research Services, Krishi Vishwa Vidyalaya, Jabalpur to Lok Sabha question No.2112 on value of soymilk, August 1974.
4/ Spata, Nelson and Singh [12].

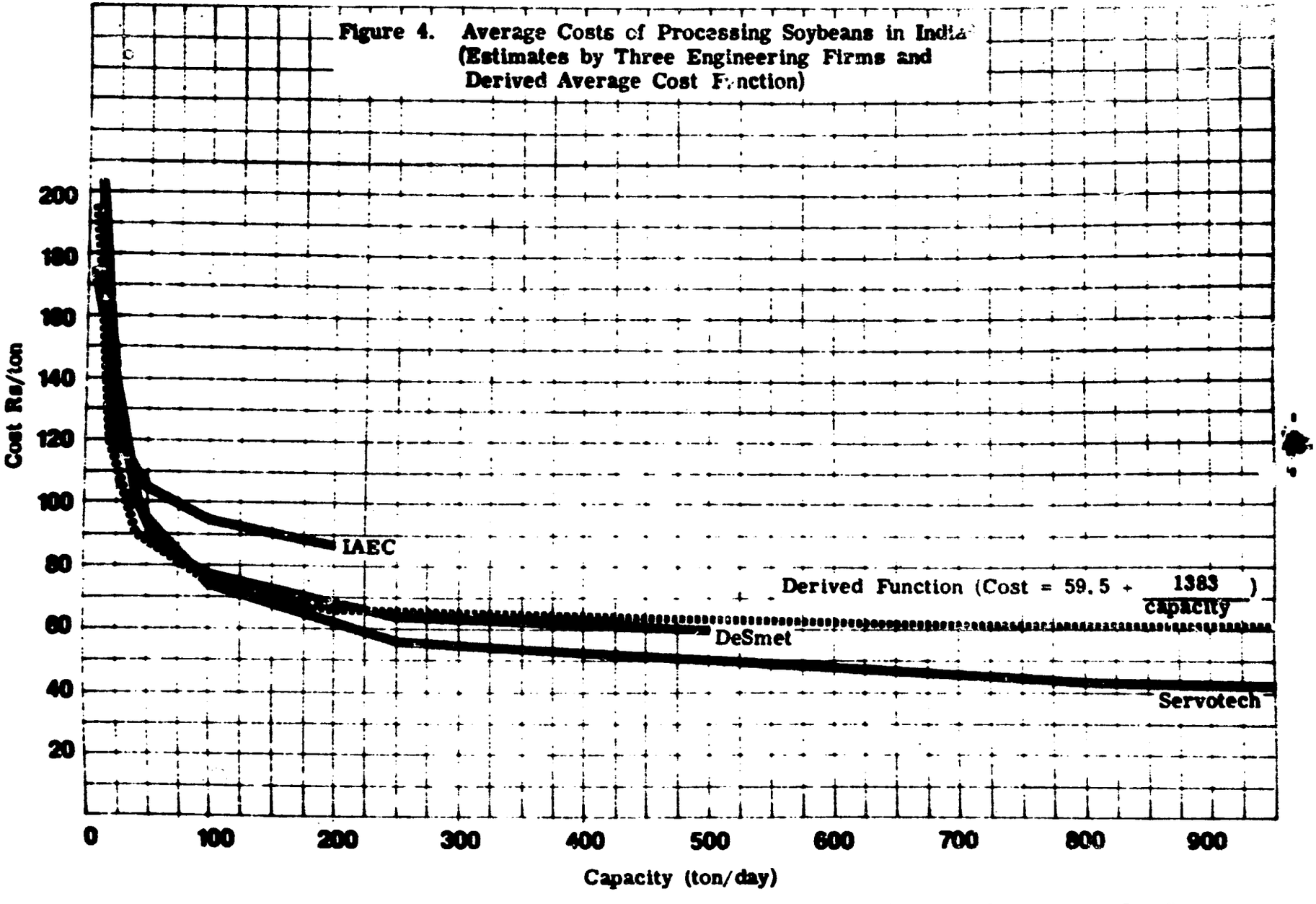


Figure 4. Average Costs of Processing Soybeans in India (Estimates by Three Engineering Firms and Derived Average Cost Function)

Source: M. von Oppen, "Soybeans Processing in India : A Location Study of an Industry to Come". INTSOY Series No.4, University of Illinois, Urbana, 1974.

Table 5. Production Costs of Protein (Rs./50 grams) and Energy (Rs./2500 K.Cal.)

	SOYBEANS		GROUNDNUTS		JOWAR		MAIZE	
	Protein	Energy	Protein	Energy	Protein	Energy	Protein	Energy
Agricultural Production costs (1)	.14	.72	.30	.66	.51	.76	.32	.52
Industrial Prcoessing plus transportation costs (2)	.03 (.02)	.15 (.09)	.03	.06	-	-	-	-
Total costs	.17 (.16)	.87 (.81)	.33	.72	.51	.76	.32	.52

(1) Average costs 1970-73

(2) Estimates 1971-72 - for soybeans Rs.250/ton; figures in brackets refer to processing costs of Rs. 150/ton.

- for groundnuts Rs. 125/ton.

Source: Computed from data in Figures 2 and 3 and from Table 4.

The optimal location of a soybean processing plant is determined by the regional densities of soybean production, by the location of consumption centres for soymeal (e.g. food industry) and soyoil (vanaspati industry), by costs of processing (economies of scale) and costs of assembling soybeans and by absolute and relative costs of long distance transport of soybeans and soyproducts. Without going into all of the critical details of this field, some general principles should be spelled out:

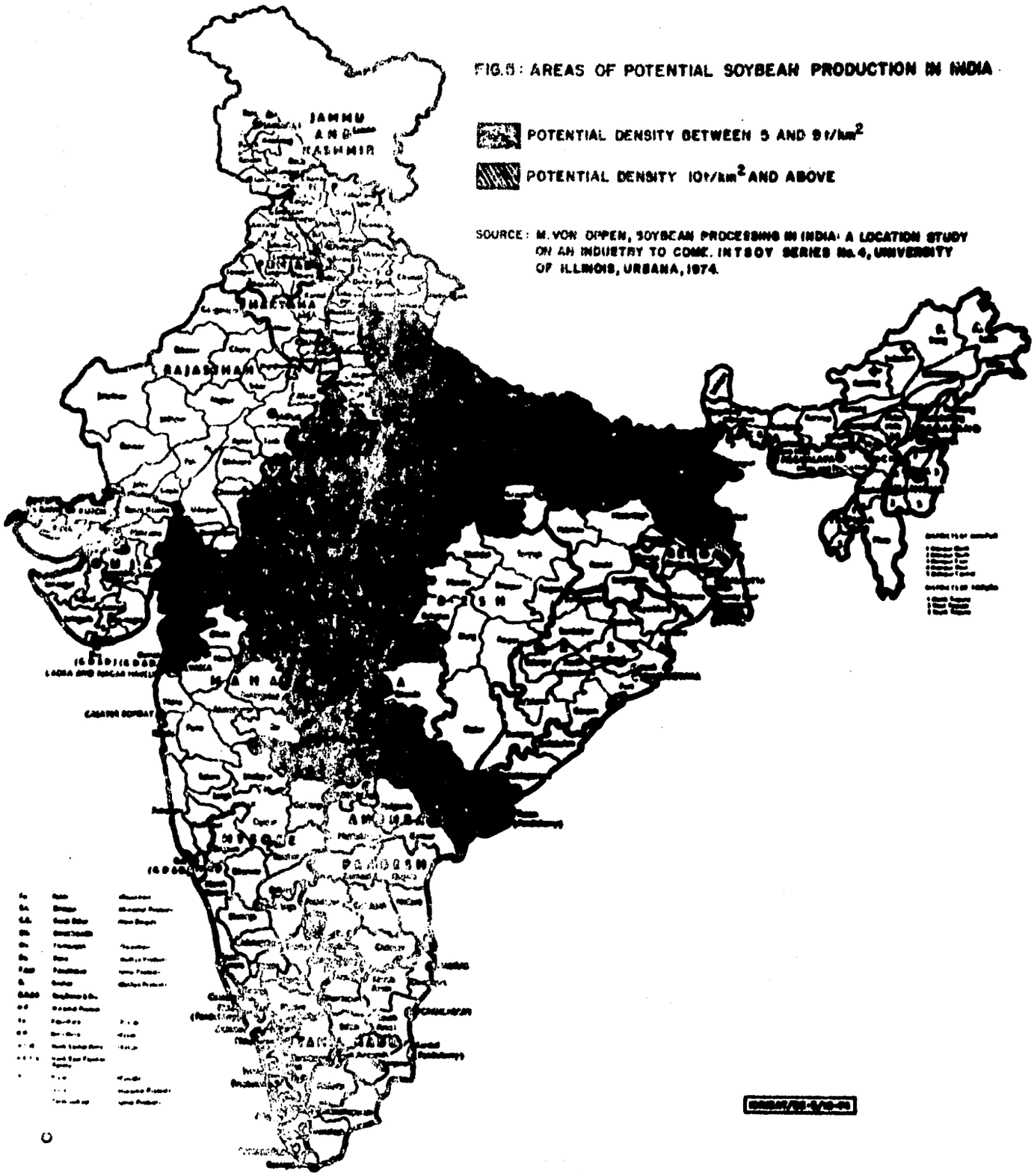
1. Soybean cultivation will be predominantly developed in North Central India (see Figure 5), where soybeans are expected to find a place in cropping patterns as an intercrop (e.g. in cotton), or on land presently under kharif fallow or by competing successfully against some of the present kharif crops. This forecast is proving to be quite correct although until now cultivation has expanded faster in the northern part of the area indicated in Figure 5 (i.e. in Madhya Pradesh and Uttar Pradesh) and to a lesser extent in the east, west and south (Bihar, Gujarat, Maharashtra and Andhra Pradesh). This is because, against earlier estimates, the varieties presently available are apparently not that well suited for interculture in cotton and for the southern latitudes. However, according to Government sources, soybean production is being promoted also in Karnataka from 1974 onwards as varieties have been found which are suitable for this area.

FIG.5: AREAS OF POTENTIAL SOYBEAN PRODUCTION IN INDIA

POTENTIAL DENSITY BETWEEN 5 AND 9 t/km^2

POTENTIAL DENSITY 10t/km^2 AND ABOVE

SOURCE: M. VON OPPEN, SOYBEAN PROCESSING IN INDIA: A LOCATION STUDY ON AN INDUSTRY TO COME. INTSOY SERIES No.4, UNIVERSITY OF ILLINOIS, URBANA, 1974.



2. It is economical to process soybeans in the vicinity of the areas where they are produced. The Indian Freight Rates for Rail Shipments classify soybeans such that the costs of transporting one tonne of soybeans over 500 km. are Rs. 47.80. In comparison to these costs, the shipping over the same distance of 1.7 quintals of oil costs Rs. 7.84 and of 8.0 quintals of soycake costs Rs. 15.20; that is in total an amount of Rs 23.04. In other words about Rs 25/- per ton or over 50% of transportation costs are saved when shipping the soyproducts rather than transporting soybeans.

3. The average costs of soybean assembly increase as processing plants increase in size, because the hauling distances become larger. At the same time due to economies of scale, average processing costs decrease. The minimum of the sum of these costs indicates that the optimum plant size at present production densities is around 50 t/day and around 100 to 150 t/day when (by 1979?) the target of about 400,000 hectares is reached (see von Oppen [11] Table 11).

Out of the 12 plants with a combined capacity of 276 t/day recorded as presently processing soybeans, only eight plants with a total capacity of 150 t/day are located within our potential soybean production area, the others being located in places like Aligarh, Calcutta, Bombay and Poona. Unless these enterprises are able to realize considerable savings in costs exceeding Rs. 25/ton (e.g. by utilizing sunk capital

in buildings or equipment etc.) their location at the present system of rail rates places them at a definite disadvantage in comparison to the other plants located within the areas of soybean production.

ROLE OF GOVERNMENT

After extensive research initiated and supported by the Government of India and by USAID had proved the potential for soybean production in India, soybeans were included in the oilseeds development programme in kharif 1970 by a centrally sponsored scheme for demonstrations. In addition, a centrally sponsored scheme for soybean development was sanctioned during 1971-72 for the States of Madhya Pradesh, Maharashtra, Gujarat and Uttar Pradesh. This scheme provided for:

1. a subsidy of 25% on cost of seed subject to a maximum of Rs. 60 per quintal during first year,
2. 25% subsidy on insecticides,
3. staff at field level to ensure timely supply of inputs and provide technical guidance to the farmers, and
4. training of extension staff in the cultivation techniques of soybeans.

Arrangements were also made for the import of inoculum to meet the needs of the 1971-72 programme and for domestic production of the 1972-73 requirements. A support price of Rs. 85/quintal was to be paid by the Food Corporation of India which, even after a premium of Rs. 15/Quintal was added, did not provide incentive for farmers to sell to FCI. An All-India Co-ordinated Research Project on Soybeans was initiated with a budget of Rs. 180,000 for the period 1969-74.

Thus in the early phase of the soybean development programme *soybean production* was emphasised. At the same time the development of *marketing* facilities was left relatively undisturbed, although in order to avoid a build up of overcapacity in solvent extraction the Government was somewhat reluctant to license new soybean processing facilities.

In the present Five-Year Plan period, (1974-79) basically the same approach is continued. The production targets were adjusted by postponing the 400,000 ha. level for 5 years from 1974 to 1979. About Rs. 25 million were set aside for continuation of the centrally sponsored production development programme. The budget for the All-India Co-ordinated Research Project on Soybeans was extended to Rs. 525,000. Apart from certain plans which have been discussed for almost five years, no real efforts have so far been initiated to establish a government owned solvent extraction plant and protein food factory.

(Latest versions of these plans are to locate a factory of 300 tons/day in Faridabad near New Delhi).

Rather than mislocating an oversized plant, it would probably be better to leave the soybean industry develop on its own along free enterprise lines. On the other hand, it is true that the soyprotein food industry has yet to develop considerably and that active and efficient government support could prove beneficial. A plant of the capacity of about 50 t/day located in Central Madhya Pradesh (e.g. Bhopal or Indore) would probably serve the purpose, requiring about 15,000 tons of soybeans. Estimating that in this region during the first year in say 1975 perhaps about 10,000 tons of soybeans could be purchased locally (area under soybeans in 7 districts of western Madhya Pradesh in 1973: 13,000 ha.) an additional 5,000 tons of soybeans would be required to utilize the plant at full capacity. This quantity could almost certainly be imported on the basis of foreign food aid. If efficiently operated and promoted by an accompanying production development programme, the plant could be running on domestically produced soybeans from 1976 onwards.

CONCLUSION

The assessment of the past development of agricultural production and industrial processing and marketing of soybeans in India, and of the position of the Government suggests the following: Soybeans are gaining

competitive strength in agricultural production, processing and marketing as the area under soybeans expands. This is due to an aggregate accumulation of experience in technology and because of an increasing awareness among consumers of the potential uses of soybeans. Public support so far has been limited to promoting the development of agricultural production, while mostly private industries (especially the pharmaceutical and vanaspati industries) absorbed the quantities produced and processed them for final consumption. Even though in India during the past four years expansion of soybean acreage has been slow, in comparison to other countries there are reasons to expect that the development of soybean acreage will continuously accelerate. North Central India, where we primarily expect soybeans to be grown, covers a large area of roughly 800,000 square kilometers (about three times the size of Romania) and present production of soybeans is still spread relatively thinly (.05 t/km^2) over that area. A doubling of the present soybean area may still require about two or even three years. However, when a production density of .1 t/km^2 is reached, it will be possible for a plant with a capacity of 50 tonnes per day to assemble its required 15,000 tonnes per year from an area of about 150,000 km^2, i.e. an area which, if circular, would have a radius of about 230 km. Even though the radius would be the maximum and the average distance would be about 150 km. these are fairly long but feasible distances to assemble soybeans by truck. It is at this level of about .1 t/km^2 that we can expect several sizeable plants to begin to process soybeans quite economically. In the soybean development programme,

special efforts should be made to concentrate rather than spread further development and extension work, preferably in areas where there is already a processing plant.

According to the experience in other countries, once a production density of .1 t/km^2 is reached, the precondition for a rapid increase in the expansion of area under soybeans is given. Therefore, unless unforeseen restrictions develop (e.g. licence problems, extreme weather hazards, crop diseases etc.) we can conclude from the development of production costs and supply and demand in the past four to five years in India and from experience in other countries, that the soybean development during the next two or three years is likely to remain behind the targets set in the Fifth Five Year Plan; however, during the following two to three years an increase will take place which exceeds that envisaged in the annual targets of that period. In summary, the target for 1979 of over 400,000 ha. under soybeans appears quite likely to be reached.

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