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adoption or partial adoption of fertilizer for bajra by 63 per cent and 66 per cent of non-adopters respectively. The corresponding figures for jowar at Kovilpatti were 23 per cent and 57 per cent. Other reasons such as non-availability of inputs have also been given.[7]

3. The yield gaps between the survey farms and experimental/demonstration farms (for the same crop and location) could be due to partial coverage of area under modern inputs, lower input levels (especially fertilizer), besides environmental differences.

Conclusion

The study indicates a positive association between adoption rates and profitability of the new technology in dryland areas. It shows that the low value of crops need not necessarily be a constraint to the development of a viable technology as illustrated by the case of BJ-104 bajra at Hissar and K. Tall jowar at Kovilpatti. Nor is adoption inhibited by the so-called traditional attitudes of farmers.

PULSE PRODUCTION IN INDIA—A STATEWISE ANALYSIS

Kusum Chopra*

Traditionally pulses have been one of the cheapest sources of protein in the Indian diet, but so far only a few studies have indicated the problems concerning their production. A very clear declining trend in the daily per capita availability of pulses is observed since 1959 when this figure was around 75 grams. By 1971, this availability had dropped to 51.3 grams per capita per day which further declined to 39.1 grams in 1981.[1] This decline is due to an increase in the population, on the one hand, and a decline in the production of pulses which is largely affected by a decrease in the area under pulse crops. This phenomenon is particularly noticeable after 1960-61 time period as is indicated in Table I. It may be seen that in States where production has declined, the area under pulses has shown a decline too. States which largely indicate this trend are Haryana, Punjab, Uttar Pradesh, Bihar and to some extent, West Bengal. In States like Madhya Pradesh, Maharashtra, Orissa and Rajasthan, the area as well as production of pulses is showing a clearly rising trend. The area under pulses in Andhra Pradesh and Karnataka is almost stagnant. Gujarat and Tamil Nadu, however, are unimportant so far as their contribution to production of pulses is concerned. Orissa is also a State with relatively minor contribution but is emerging importantly as an increasing pulse production State.

7. See Rai and Singh, *op. cit.;* and Selvaraj *et al.*, *op. cit.*

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1. Government of India: Economic Survey, 1981-82, Ministry of Finance, 1982, p. 84.

TABLE I—AREA AND PRODUCTION UNDER TOTAL PULSES

(area in thousand hectares)
(production in thousand metric tonnes)

State	1950-51		1960-61		1970-71		1976-77	
	Area	Production	Area	Production	Area	Production	Area	Production
Andhra Pradesh ..	1,563·3	322·0	1,250·3	176·0	1,179·3	362·6	1,286·1	362·4
Bihar	1,971·1	744·7	2,331·9	1,200·1	1,250·1	678·6	1,420·1	697·1
Gujarat	462·6	130·8	511·7	169·3	423·2	165·2	448·1	186·8
Haryana	945·0	420·0	1,606·0	1,303·0	1,159·0	832·0	1,115·5	874·3
Karnataka	1,252·2	335·3	1,286·1	352·3	1,131·3	403·6	955·6	286·2
Madhya Pradesh ..	3,039·7	1,240·6	3,725·3	1,819·8	4,245·8	1,991·6	4,605·4	1,858·8
Maharashtra	1,947·6	813·2	2,351·2	988·9	2,490·7	775·9	2,805·3	977·1
Orissa	45·3	21·6	493·6	219·2	844·8	466·8	973·4	349·2
Punjab	N.A.	N.A.	903·0	709·0	414·0	308·0	396·8	332·9
Rajasthan	1,405·5	368·8	3,011·6	1,201·0	3,615·9	1,777·3	4,228·4	1,999·1
Tamil Nadu	441·5	72·1	426·5	113·0	481·6	116·5	544·7	156·0
Uttar Pradesh	4,345·2	3,022·8	4,547·7	3,824·8	3,724·8	3,069·2	3,042·7	2,581·4
West Bengal	614·4	382·1	774·3	391·0	664·9	375·0	738·1	417·5
Others	N.A.	N.A.	916·0	224·5	908·6	495·7	285·5	129·3
India	18,534·8	8,377·8	24,135·2	12,692·0	22,534·0	11,817·8	22,845·7	11,208·1

N.A. = Not available.

Table I also indicates that Andhra Pradesh, Bihar, Karnataka, Maharashtra, Madhya Pradesh, Rajasthan and Uttar Pradesh contribute nearly 75 per cent or more to India's area and production of pulses. A study of these States therefore can explain the trend in pulse production to a large extent. Besides these States, Punjab and Haryana are also considered for this study because although their contribution in relative terms is low, yet these States are important because they have indicated a consistently declining trend in pulse production in the last one and a half decade.

It may be mentioned here that States which are important for *kharif* crops and hence also for *kharif* pulses are, by and large, showing an upward trend in pulse production as well as in area under pulses, but States where largely *rabi* crops and hence *rabi* pulses are grown, are indicating a declining trend. This fact is elaborated in Table II, and it may be mentioned that while both the area and production under *rabi* pulses increased upto 1960-61, these showed a decline in the period thereafter, while in the case of *kharif* pulses, both the area and production increased after 1960-61. The yield of *rabi* pulses was almost stationary over time while it declined somewhat for *kharif* pulses. The table indicates that the share of *rabi* pulses in total pulses[2] has declined from almost 60 per cent in 1960-61 to 52 per cent in 1976-77. Similarly, their share in production also fell from almost 70 per cent in 1960-61 to 64 per cent in 1976-77. Gram, pea and *kesari* contributed to this decline. A decline in their production has occurred mainly due to a decline in area rather than yield. *Masur* is the only *rabi* pulse which is showing an increase both in its area as well as in production.

Looking at the irrigation levels one finds that in the States where the percentage of total irrigated to total cropped area is high, the relative share of pulse crops in the cropping pattern shows a decline. From Table III it is clearly noticed that the States where this irrigation level is close to 30 per cent or is above, are the ones where the relative share of pulses is declining. The higher this level of irrigation, the sharper is the relative decline. Clearly, Punjab, Haryana, Uttar Pradesh and Bihar come under this category. West Bengal, however, is an exception. In States where the share of area irrigated is below 20 per cent and in fact around or below 15 per cent, the acreage under pulses has shown a tendency to increase. The southern States, however, do not particularly conform to the above pattern, though with an increase in irrigation, pulses' acreage does show a fall, but this fall or the fluctuating pattern is not a sharp-edged pattern and hence these States may as well be treated as almost stagnating. Somewhat greater instability is noticed in the changing acreage under *kulthi* from 1964-65 both in Karnataka and in Andhra Pradesh. All other pulses are less prone to noticeable fluctuations. In Andhra Pradesh, whenever area under *kulthi* has declined, it has invariably been substituted by an increase in area under *mung* and vice versa. A perfectly consistent inter-pulse movement can, therefore, be observed.

2. This refers to a total of both *rabi* and *kharif* pulses here on which data were available separately. These figures may differ from the published data on total pulses which include even some of the minor pulse crops both in *rabi* and *kharif* and may also include some minor States and Union Territories which are not included in this study.

TABLE II—SHARE OF RABI AND KHARIF PULSES IN TOTAL PULSES*

(*per cent*)

	1950-51		1960-61		1970-71		1976-77	
	Area	Production	Area	Production	Area	Production	Area	Production
Rabi pulses	54·72	58·29	59·29	69·75	52·04	64·18	51·80	63·70
Kharif pulses	45·28	41·71	40·71	30·25	47·96	35·82	48·20	36·30
Share in total pulses								
Gram	39·49	41·12	41·97	51·18	36·75	46·62	37·42	50·71
Pea	5·31	8·38	5·17	8·46	4·13	6·74	3·03	3·84
Kesari	6·97	6·19	8·76	7·35	7·78	7·55	7·09	5·20
Masur	2·94	2·60	3·39	2·76	3·38	3·27	4·26	3·94
Tur	11·38	19·25	11·03	16·97	12·45	16·89	12·07	15·56
Urad	—	—	8·61	4·79	10·05	5·36	10·00	6·52
Mung	—	—	7·12	3·23	9·44	4·34	10·13	6·15
Moth	—	—	6·87	2·24	8·08	3.75	9·43	4·58
Kulthi	—	—	7·08	3·02	7·95	3·88	6·56	3·50

* To work out the shares, the totals of gram, pea, *kesari*, *masur*, *tur*, *urad*, *mung*, *moth* and *kulthi* are taken into account. Other minor pulses are not included here. The first four are taken to be as *rabi* pulses and the others as *kharif* though strictly speaking, some may be grown in both the seasons.

TABLE III—SHARE OF PULSES IN STATES' CROPPING PATTERN AND RATIO OF GROSS IRRIGATED AREA TO GROSS CROPPED AREA OF EACH STATE

State	1950-51	1960-61	1970-71	1976-77
I. Area declining States				
(*a*) Punjab				
(*i*) Pulses area as percentage to gross cropped area (PA/GCA)	N.A.	19·08	7·29	6·32
(*ii*) Gross irrigated area as percentage to gross cropped area (GIA/GCA)	N.A.	55·94	74·72	80·83
(*b*) Haryana				
(*i*) PA/GCA	27·23	35·04	23·30	21·12
(*ii*) GIA/GCA	—	26·29	44·99	51·08
(*c*) Uttar Pradesh				
(*i*) PA/GCA	21·77	20·93	16·05	13·14
(*ii*) GIA/GCA	26·15	25·49	35·95	42·07
(*d*) Bihar				
(*i*) PA/GCA	18·24	21·00	11·34	12·54
(*ii*) GIA/GCA	19·78	20·92	29·80	31·82
(*e*) West Bengal				
(*i*) PA/GCA	10·64	12·19	9·27	9·67
(*ii*) GIA/GCA	20·69	22·39	21·49	20·19
II. Area increasing States				
(*a*) Rajasthan				
(*i*) PA/GCA	13·75	21·49	21·62	25·02
(*ii*) GIA/GCA	12·80	12·50	14·66	17·61
(*b*) Madhya Pradesh				
(*i*) PA/GCA	19·75	20·48	29·65	22·08
(*ii*) GIA/GCA	5·91	5·16	7·41	9·88
(*c*) Maharashtra				
(*i*) PA/GCA	11·63	12·49	12·90	14·17
(*ii*) GIA/GCA	5·30	6·48	8·58	9·10
III. Area stagnant or fluctuating States				
(*a*) Andhra Pradesh				
(*i*) PA/GCA	14·70	10·58	10·50	10·84
(*ii*) GIA/GCA	23·58	29·39	31·64	35·03
(*b*) Karnataka				
(*i*) PA/GCA	13·04	12·15	12·88	9·69
(*ii*) GIA/GCA	6·43	9·22	12·45	14·87

N.A. = Not available.

Among the minor and emerging States, Orissa has irrigation level which is fluctuating and is below 20 per cent, but the share of pulse acreage is showing a consistently upward trend from 1955-56 when only 0.56 per cent of the State's gross cropped area was allocated to pulse crops, while after twenty years, this increased significantly to almost 15 per cent.

In the discussion so far, it has been noticed that there are some area shifts out of pulses into other lucrative and hence competing crops. The reasons for these shifts have varied from State to State and have differed for the declining, increasing and the stagnant regions. In the gram growing States, the downward trend got further accentuated around 1966-67 where the new technology for wheat was popularised. Even with a higher market price of gram, the farmers could not be allured to grow more of it because the advantage claimed from the gross income due to an increase in the yield of newer wheat varieties far outweighed the benefit in gram arising merely due to price increases. Hence, gram along with other *rabi* pulses could not withstand the tough competition offered by wheat. Except for *masur*, other *rabi* pulses like *kesari*, pea have also shown a decline in area under them after 1965-66. As mentioned earlier, *kharif* pulses show an increase in acreage particularly in the relatively dry region, but wherever irrigation has been made available, a change in the cropping pattern is noticed in those areas too.

A relative shift of acreage into or out of pulses vis-a-vis other competing crops and the causes leading to these shifts have, therefore, been studied in a time-series between 1950-51 and 1976-77. Area under the chosen pulse crop thus becomes the dependent variable and is studied against the competing crop/crops of the relevant season in terms of relative price, relative yield, area irrigated and rainfall of relevant sowing months which become the independent variables explaining the acreage shifts. Some variables are considered with a one year lag wherever necessary. A dummy variable and in some cases, variable in the form of a slope dummy for relative yield and for relative price are also introduced in the linear regression model to indicate the impact of technological inputs on the crops which compete with pulses or to study the change in the relative price behaviour.

The supply response model used here is that of Nerlove's partial adjustment model of distributed lags which is of the following form:

$$A_t = a + RY_{t-1} + b_2 RP_{t-1} + b_3 AI_t + b_4 R_t + b_5 A_{t-1} + U_t$$

where A_t = area under the pulse crop in thousand hectares;

RY = relative yield of pulse crop to the competing crop;

RP = relative price of pulse crop to the competing crop;

AI = percentage of gross irrigated area to gross cropped area;

R = rainfall of the relevant months of the sowing season;

t = time;

A_{t-1} = lagged area under the crop where its coefficient indicates adjustment to desired area;

U_t = error term.

Wherever dummy variable is used it is indicated by 'D' with values ranging between 0 and 1 and the slope dummies of relative yield and relative price are denoted as 'DRY' and 'DRP'.

In States where any pattern of a competing crop does not emerge clearly, as happens in dry regions where during the year the rainfall is sufficient, and the area under all crops goes up, the increase in area under pulses has been tested against variables like own price and own yield of the pulse crop itself which is under consideration, intensity of cropping or gross cropped area, proportion of area irrigated and a generally increasing trend in these. The results of the step-wise linear regression are summarised in Table IV and wherever the competing crop is taken, it is mentioned in the table itself. The important outcome of this exercise suggests that in almost all the States of the declining pulse region, where *rabi* pulses predominate, the proportion of area irrigated turns out very significantly and with a negative coefficient which means that with an increase in irrigation, the area under pulses shows a decline in these States. Also, the lagged dependent variable is significant in all the States of this region except Bihar. Interestingly enough, the values of the adjustment factor indicate that the farmers in Punjab and Haryana have an over-adjustment of planted pulse acreage to the desired acreage and since the acreage trend is a generally declining trend, over-adjustment means that the actual planted acreage declines more sharply. Besides these factors, relative yield in Punjab and Uttar Pradesh and relative price in Haryana are some other factors emerging importantly. In Bihar the effect of the adoption of new technology in the competing crop is captured by the negative coefficient of the dummy variable while as the decline in the slope of relative yield of pulses vis-a-vis the competing crop of wheat in Punjab and Haryana gets accentuated, the area under pulses falls.

In the States of increasing pulse region, for *rabi* pulses, an increase in the cropping intensity leads to an increase in some of the *rabi* pulses in Rajasthan and Madhya Pradesh. The area adjustment factor for Rajasthan is moderate while in Maharashtra, for fluctuating gram acreage, other institutional and technological factors assume an important role. Besides these factors, yield and price of *rabi* pulses provide incentives in Madhya Pradesh while rainfall of the sowing months is most significant in Maharashtra. For acreage fluctuations in *kharif* and total pulses, availability of water in the form of irrigation or rainfall is important in Rajasthan, Maharashtra, Andhra Pradesh and Karnataka. In Uttar Pradesh, the area irrigated is inversely related because *tur* is losing acreage to groundnut. Among other important variables, the acreage under some *kharif* pulses has increased due to a favoured price ratio in Uttar Pradesh, Andhra Pradesh and Karnataka. The adjustment factor indicates under-adjustment of planted acreage under *moth* in Rajasthan and under total pulses in Orissa.

These results endorse the view that in the region which largely grows *rabi* crops and is important for wheat production, usage of modern inputs due to higher irrigational facilities has led to a decline in the *rabi* pulse acreage because wheat has offered a tough competition to these crops and, in parti-

TABLE IVA—REGRESSION RESULTS (RABI PULSES)

Variables	Region I					Region II		
	Punjab	Haryana	Uttar Pradesh	Bihar	West Bengal	Rajasthan	Madhya Pradesh	Maharashtra
Dep. variable, area ..	Gram	Gram	Gram+pea	Gram+*kesari*	All *rabi* pulses	Gram	*Rabi* pulses	Gram
Competing crop ..	Wheat	Wheat	Wheat	Wheat	None	None	None	Wheat
Intercept	21869·6718	23549·9883	15095·9766	9822·730	2769·7153	— 100709·7578	— 25679·7578	2031·6758
RY_{t-1}	0·486 (3·505)**		0·631 (2·048)^b					
OY_{t-1}							10·565 (2·787)‡	
RP_{t-1}								
OP_{t-1}							4·207 (7·333)*	
AI_t	— 2·354 (— 7·053)*	— 1·786 (— 3·892)**	— 2·800 (— 2·815)‡			— 5·190 (— 4·031)*		
R_t				0·922 (2·586)‡				0·338 (4·370)*
CI						10·571 (8·070)*	3·852 (3·582)**	
GCA				— 4090·513 (— 5·622)*				
D								
DRY	— 0·285 (— 3·968)**	— 0·794 (— 4·773)**						
DRP								
A_{t-1}	— 0·397 (— 2·776)‡	— 0·270 (— 1·893)^b	0·649 (4·996)*		0·564 (3·832)*	0·500 (6·755)*		0·263 (1·795)^b
$1-\beta$	1·397	1·270	0·351		0·436	0·500		0·737
Degree of freedom ..	15	16	18	22	23	22	16	22
$\bar{R}^2$	0·98	0·86	0·95	0·60	0·39	0·88	0·85	0·54

TABLE IVB—REGRESSION RESULTS (KHARIF PULSES AND TOTAL PULSES)

Variables	*Kharif* pulses					Total pulses	
	Region I	Region II		Region III		Region II	
	Uttar Pradesh	Rajasthan	Madhya Pradesh	Andhra Pradesh	Karnataka	Maharashtra	Orissa
Dep. variable, area	*Tur*	*Moth*	All *kharif* pulses	*Mung*	*Kulthi*	Total pulses	Total pulses
Competing crop	Groundnut	None	None	*Kulthi*	Jowar	Jowar	None
Intercept	7741·7422	3478·0842	— 6935·2656	— 173·6549	1076·5413	19719·7188	— 5183·3125
RY_{t-1}						— 0·466 (— 1·885)*b*	
OY_{t-1}		— 0·274 (— 3·041)†					
RP_{t-1}	0·082 (1·802)*b*			0·093 (2·777)†	0·133 (2·638)‡		
OP_{t-1}							
AI_t	— 0·779 (— 5·219)*			1·097 (8·603)*	0·900 (1·851)*b*	6·428 (2·272)*a*	
R_t		0·971 (2·820)†			0·094 (2·547)‡	0·336 (1·746)*b*	
CI							0·139 (2·395)*a*
GCA			0·108 (18·427)*				
D							
DRY							
DRP							
A_{t-1}		0·736 (4·902)*					0·425 (2·756)‡
$1 - \beta$		0·264					0·575
Degrees of freedom	19	22	18	20	18	21	23
$\bar{R}^2$	0·63	0·66	0·96	0·99	0·36	0·35	0·68

Figures in parentheses are t-values.

* Significance at ·001 level. ‡ Significance at ·02 level.
** Significance at ·005 level. *a* Significance at ·05 level.
† Significance at ·01 level. *b* Significance at ·10 level.

cular, to gram. But in States of the relatively dry region, the acreage under *rabi* and *kharif* pulses has increased. The former responds mainly to higher cropping intensity along with improved yield and higher price of *rabi* pulses while *kharif* pulse acreage has positively responded mainly to irrigated area, and to a relatively favoured price ratio. Rainfall turns out significantly in both the seasons in this region.

A NEW STRATEGY FOR INCREASING OILSEEDS PRODUCTION: LESSONS FROM SAURASHTRA EXPERIENCE WITH GROUNDNUTS

Katar Singh and Ranjana*

Oilseeds occupy an important place in India's economy. They contribute about 6 per cent of India's gross national product and about 9 per cent of the value of all agricultural commodities produced in the country. They account for about 15 per cent of the gross cropped area in the country. But the area, productivity and production of oilseeds in India have all been fluctuating around very low levels for the last three decades. As a matter of fact, the index numbers of area, production, and yield of groudnut and of oilseeds in India in the year 1978-79 were only slightly higher than the corresponding indices in 1970-71. The oilseeds sub-sector has been totally bypassed by the recent Green Revolution in Indian agriculture. This is evidenced by the tardy increase in the yield of oilseeds in India relative to other crops (Table I).

There are numerous physical, technological, economic and institutional constraints on increasing area and per hectare yield rates of oilseeds. Lack of high-yielding varieties suitable for dryland conditions in which oilseeds are usually grown, risk of crop failure due to vagaries of monsoon rains, lack of institutional credit facilities, unremunerative prices and lack of an institutional mechanism for integrating production, processing and marketing of oilseeds are some of the major factors responsible for the stagnation of the oilseeds economy. This paper is aimed at outlining a strategy for increasing production of oilseeds in the country. The strategy is mainly based on the experience of the National Dairy Development Board (NDDB) with groundnuts in the Saurashtra Region of Gujarat. We begin with a brief review of the current state of affairs in India's oilseeds and edible oil economy.

PRESENT STATUS OF OILSEEDS AND EDIBLE OIL ECONOMY

Since oilseeds are the major source of edible oil in India, their production affects the domestic availability of edible oil in a big way. The continued stagnation in oilseeds production, on the one hand, and the continuously

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