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Preliminary Draft
Not to be quoted

FERTILIZER USE AND ITS DETERMINANTS : A REVIEW WITH SPECIAL REFERENCE TO SEMI-ARID TROPICAL INDIA

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Hyderabad, INDIA

September, 1978

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The semi-arid tropics covaring nearly two-thirds of the country's arable area, are spread over the states of Andhra Pradesh, Maharashtra, Karnataka, Madhya Pradesh, Tamil Nadu and parts of Uttar Pradesh, Haryana, Rajasthan and Gujarat. While the advent of irrigation in states like Tamil Nadu, Haryana, Uttar Pradesh and others has helped in transformation of the irrigated SAT* areas, bulk of SAT India continues to be characterized by low output, highly unstable agricultural system supporting fairly high population densities. Till recently, these were looked upon more as problem areas requiring famine relief and protection rather than areas capable of making positive contribution to country's agricultural growth.

Earnest efforts are now being made to rectify the imbalance. The share of dryland areas in development allocations is increasing; attempts to improve the technological base of agriculture in these areas have been intensified. The realization that irrigation will never reach a vast majority of SAT areas, has focussed attention on development of high - output technologied and farming systems capable of performing well under constrained and uncertain moisture situations.

Efficient soil fertility and water management have been identified as the key factors in this context and fertilizer use plays an important role in the new dryland agriculture technology. This paper focusses attention on fertilizer use in SAT India in terms of consumption levels, growth, farmers' practices and factors affecting farmers' demand for fertilizers. Information on these aspects is lacking; economists, like everyone else, were too preoccupied with the exciting changes taking place in irrigated agricultural regions of the country. As early as 1969, Desai [6] emphasized the importance of rainfed regions as potential source of future growth in fertilizer demand. A decade later, he had to reiterate the call [7]; apart from the work he followed up through these years [8, 9, 10], no systematic study was conducted on this problem.

* The abbreviation SAT has frequently been used for semi-arid tropics in this text.

Agro-biological scientists, on the other hand, have been more responsible. A large number and variety of experiments have been conducted under the All-India Coordinated Agronomic Experiments scheme, the All-India Coordinated Research Project for Dryland Agriculture, and the Sorghum and Millets Research Programmes of the Indian Council of Agricultural Research and agricultural universities in different states. These have established that most of the crops grown under dryland conditions do respond to fertilizers [17]. While there is need to further study the interactions of response with moisture (rainfall) variability, methods of application and other agronomic realities of dryland agriculture, successful diffusion of fertilizers requires an understanding of the status of fertilizer use and factors inhibiting its use at farmers' level.

This paper attempts to piece together information on various aspects of fertilizer use from different sources. A brief macro picture is first given covering consumption of fertilizers in India and in selected SAT areas. The growth pattern of fertilizer use is then discussed in aggregate terms. The second section deals with micro-evidence on fertilizer use practices of farmers. Finally, factors affecting adoption and use of fertilizers have been identified. A comparative framework has been followed, primarily to portray the SAT position in sharper relief.

I. CONSUMPTION LEVELS AND GROWTH IN FERTILIZER USE

Table 1 provides a synoptic view of consumption levels of fertilizers (total plant nutrients) in India. It shows that more than 50 percent of the total fertilizers are consumed in only four states of Punjab, Uttar Pradesh, Andhra Pradesh and Tamil Nadu. These account for only 30 percent of the gross cropped area of the country. The eastern states (Assam, Bihar, Orissa and West Bengal) account for about 17 percent of the area but consume only 11 percent of the fertilizers used. This clearly indicates concentration of fertilizer consumption in a few states [7, 10].

The states of Madhya Pradesh, Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu fall predominantly under the semi-arid tropics.[1] If we leave out Andhra Pradesh (where fertilizer use is high primarily on account of its concentration in 5-6 coastal-non-SAT districts) and Tamil Nadu (where very high irrigation levels obtain), a crude idea regarding fertilizer consumption in predominantly SAT areas can be had. Madhya Pradesh, Maharashtra and Karnataka account for nearly one-third of the country's cropped area but their contribution in total fertilizer consumption is barely one-fifth. This suggests that fertilizer use in SAT areas is comparatively lower. It is also low in Rajasthan and the eastern states.

The table reveals very high inter-state variability in adoption level as well as rates of application. As regard adoption, in seven states more than 60 percent of the farmers use fertilizers. All these are predominantly rice and wheat growing areas with the exception of Gujarat. The rate of application is also high - 76 to 128 kgs/ha. On the other extreme, five states have less than 35 percent adoption and low rates of application (Orissa being an exception). So far as the three states mentioned above are concerned, Madhya Pradesh, has very low rates of adoption and application. Maharashtra occupies an intermediate position and Karnataka has fairly high fertilizer use indicator values. One cannot really draw a consistent inference regarding fertilizer use based on state level data.

Table 2 gives the distribution of 384 districts in India over different consumption level intervals. Only 13 percent of the districts had consumption level above 20 thousand tonnes, but these 48 districts consumed more

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1 Parts of Uttar Pradesh, Haryana, Rajasthan and Gujarat are also included but state level data would nto reveal the SAT position.

Table 1. Fertiliser use in Indian agriculture

State		Fertiliser* consumption (1976-77) Th./tonnes	Share in India total	Share in India gross cropped area	Fertiliser use* per hectare of gross cropped area (kgs/ha) (1976 - 77)	Proportion of farmers using fertilisers (%)	Average rate of fertiliser* application per fert. hectare (kgs)
I.	Assam	4	0.1	1.8	1.3	6	49
	Bihar	155	4.6	6.4	14.5	42	50
	Orissa	62	1.8	4.3	8.5	21	91
	West Bengal	153	4.5	4.4	20.4	66	89
II	Punjab	372	10.9	3.5	61.6	92	91
	Haryana	138	4.0	3.0	26.6	69	77
	Uttar Pradesh	729	21.4	13.6	31.7	44	65
III	Rajasthan	99	2.9	10.6	5.5	31	55
	Gujarat	202	5.9	6.0	20.0	62	46
IV	Madhya Pradesh	137	4.0	12.5	6.4	15	46
	Andhra Pradesh	402	11.8	7.8	30.5	62	112
	Maharashtra	290	8.5	11.5	14.9	42	77
	Karnataka	206	6.0	6.4	19.0	50	105
	Tamilnadu	277	8.1	4.5	36.6	70	128
V	Kerala	85	2.0	1.8	23.1	65	92
	Himachal Pradesh	8	0.3	0.5	9.9	34	28
	Jammu & Kashmir	13	0.3	0.5	13.6	40	47
	All India	3411	100.0	100.0	20.1		

* In total plant nutrients (N + P + K)

SOURCE: Fertiliser Association of India, Fertiliser Statistics, 1978.
The last two columns from NCAER [22].

Table 2. Distribution of districts by consumption levels of fertilisers* : 1976-77

Consumption range (th. tonnes)	No. of districts	% share of all India consumption	No. of selected SAT districts
50 - 65		3.4	
25 - 50	31	30.1	-
20 - 25	15	9.7	9
15 - 20	30	15.2	7
10 - 15	49	17.5	12
5 - 10	39	9.1	13
Below 5	221	15.0	33
Total	384	100.0	74

* (N + P + K)

The 74 SAT districts belong to Andhra Pradesh, Madhya Pradesh, Karnataka and Maharashtra

SOURCE: Fertilizer Association of India, <u>Fertiliser Statistics, 1976-77</u>, New Delhi, Dec. 1977 than 43 percent of the total fertilisers. On the other extreme, over 58 percent districts had very low consumption levels (less than 5 thousand tonnes) and these consumed only 15 percent of the total. This underscores the concentration point mentioned earlier.

As an illustrative exercise, fertilizer consumption levels in 74 typically SAT districts[2] (in Andhra, Karnataka, Maharashtra and Madhya Pradesh) were examined and Table 2 gives the distribution of these districts also. One finds that while districts with very high consumption levels are rare in the SAT, the overall position in the intermediate range appears to be better than that for the country as a whole. For the latter, 58 percent of the districts had less than 5 thousand tonnes consumption; for the selected SAT districts, this percentage was about 44. Again, only 24 percent of the 384 districts consumed between 10 to 25 thousand tonnes; on the other hand, 37 percent of the 74 SAT districts fell in this category.

Further examination (Table 3) revealed that the Madhya Pradesh districts had lowest consumption levels - more than half of the selected districts used less than 2.5 thousand tonnes of fertilizers, only one consumed more than 10 thousand tonnes. On the other hand, 5 out of 10 Andhra districts consumed more than 15 thousand tonnes. On the whole, the Maharashtra districts appeared to fare relatively better - none of the 20 districts used less than 5 thousand tonnes, and 5 used more than 25 thousand tonnes. This table shows that while the consumption levels in SAT areas are generally low, there is considerable variation within SAT districts. Madhya Pradesh appears to be the most difficult SAT area.

Growth in Fertilizer Use

Growth of fertilizer use in Indian agriculture has been studied in depth by Desai [6, 7, 10]. Historical evidence indicates that though the use of fertilizers for field crops started in the late thirties, it was only during the First Five Year Plan that it really got a strong push. Consumption of the three types of fertilisers rose from about 81 thousand tonnes in 1952-53 to about 3 lakh tonnes in 1960-61 and 34 lakh tonnes in 1976-77. The growth, however, has not been monotonic and wide inter-year fluctuations

2 Districts were selected on the basis of the climatic definition of SAT to begin with. Then, we excluded those where irrigation exceeded 20 percent.

Table 3. Statewise distribution of 74 SAT districts by consumption levels: 1976-

Consumption[a] (th. tonnes)	Madhya Pradesh	Andhra Pradesh	Maharashtra	Karnataka	Total
20 - 25	-	2	5	2	9
15 - 20	-	3	2	2	7
10 - 15	1	1	7	3	12
5 - 10	2	2	6	3	13
2.5 - 5	11	2	-	1	14
Below 2.5	18	-	-	1	19
Total	32 (64)	10 (32)	20 (93)	12 (70)	74

a (N+P+K) total plant nutrients

Figures in parentheses indicate the share of the selected districts in total consumption of the state

SOURCE: Fertilizer Association of India, Fertiliser Statistics 1976-77, New Delhi, Dec. 1977 were witnessed. Recently, there was a sharp deceleration in 1972-73 and 1973-74 and a substantial decline in 1974-75. The last two years (1975-76 and 1976-77) were very impressive but Desai [7] cautions that this should not be interpreted as a definite acceleration of trend, it most likely implies a recovery along the pre-1972 trend. He also pointed out that the statewise base of growth in feritlizer consumption continued to be narrow and states like Uttar Pradesh, Punjab, Tamil Nadu Andhra Pradesh and Gujarat have accounted for bulk of the post-1975 growth in fertilizer consumption. These were the states which formed the base of growth in the sixties also. This continuing concentration raises fears about rapid future growth in fertilizer consumption in India.

The districtwise study on growth in fertiliser use [10] focussed attention on the concentration problem. They examined data on fertiliser comsumption for 286 districts over the period 1960-61 to 1968-69 and found wide inter-district variability in growth rates of fertilizer consumption. More than 80 percent of nitrogen (N) and phosphorus (P_2O_5) was consumed in less than one-third of the districts all through this period. On the other extreme, more than 50 percent of the districts accounted for only 10 percent of the total fertilizer consumption.

Extending the analysis to 1975-76 and 1976-77, the pattern was found to be persisting - 87 percent of the growth in nitrogen consumption between these two years was accounted for by only 81 (30 percent) districts, most of these were important in the sixties also [7]. Desai concluded that while there was some broadening of the districtwise base generating growth in feritlizer consumption, it was still quite narrow and dominated by the traditional growth generating districts throughout the last 15 years or so.

It was also shown that the performance of the southern reigon (Andhra, Kerala, Karnataka and Tamil Nadu) was very good with respect to both nitrogen and phosphorus use while that of the central (Madhya Pradesh, Rajasthan, Uttar Pradesh) and eastern (Assam, Bihar, West Bengal, Orissa) regions was very poor. The western region (Gujarat, Maharashtra) performed relatively better with respect to phosphorus use and the northern region (Punjab, Haryana) did better with respect to nitrogen growth [10]. The study also investigated the factors behind verying growth patterns. These shall be discussed later.

The SAT Region

We have attempted to interpret the results of this study by Desai and Singh [10] in terms of SAT regions. The study gives growth rates of fertiliser use for districts falling in different annual rainfall classes - less than 500 mm's, 501 to 750 mm's, 751 to 1150 mm's, and more than 1150 mm's. The last class is treated by the authors as assured rainfall category. We have interpreted the districts falling in 501 mm's to 1150 mm's class as belonging to semi-arid tropics.[3] Table 4 shows the distribution of districts by rainfall and irrigation classes.

The top half of the table reveals that 46 districts had high to very high growth rates of nitorgen use. Of these, 36 were located in the semi - arid region, the arid and assured rainfall areas had 5 each. Similarly, bulk of the medium growth districts were also located in the semi-arid region. Considering the distribution within each category, the arid region showed maximum contrast, 10 districts in the low to very low and 5 districts in the high to very high growth category. In the semi-arid and assured rainfall areas, these figures were 77 (46 percent) and 26 (22 percent) and 77 (75 percent) and 5 (5 percent), respectively. These figures clearly brought out the poor performance of the high rainfall districts. These belonged mostly to the eastern region. The semi-arid regions (and even the arid region) performed much better during the sixties.

With respect to growth in phosphorus use, the semi-arid areas stand out distinctly superior. Once again the assured rainfall regions were found to be lagging behind.

Classification by irrigation levels within each type of area provides a more realistic assessment. This reveals that all the districts in the high nitrogen growth class in arid region had higher irrigation, all the 10 low growth districts had low irrigation. This held for the semi-arid regions also - 37 percent of the high irrigation districts had high to very high growth, only 10 percent of the low irrigation districts fell in this category. The proportions of districts with low and very low growth were 30 percent and 58 percent for the high and low irrigation classes respectively. In the assured rainfall areas, irrigation does not seem to have made much impact. With respect to phosphorus use also, a similar trend was observed.

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3 The limitations of this classification are recognized. It was attempted in the hope that this will enable some broad judgements.

Table 4. Distribution of districts according to Normal Rainfall-cum-Levels of irrigation and growth rates of fertilizer (nutrient) use.

Normal rainfall category	Irrigation level	Number of districts according to different growth rate categories					Total Number of districts
		Very High	High	Medium	Low	Very Low	
	NITROGEN(N) USE	>1500	751-1500	301-750	101-300	<101	
I Arid (<500 mm)	<20%	-	-	-	2	8	10
	>20%	1	4	1	-	-	6
	Total	1	4	1	2	8	16
II Semi-Arid (501-1150 mm)	<20%	1	9	30	25	31	96
	>20%	10	16	23	13	8	70
	Total	11	25	53	38	39	166
III Assured Rainfall (>1150 mm)	<20%	-	2	15	11	40	68
	>20%	-	3	6	12	15	36
	Total	-	5	21	23	55	104
	Grand total	12	34	75	63	102	286
	PHOSPHORUS(P_2O_5) USE	>500	301-500	101-300	51-100	<50	
I Arid	<20%	-	-	1	-	9	10
	>20%	-	1	3	1	1	6
	Total	-	1	4	1	10	16
II Semi-Arid	<20%	5	8	29	19	35	96
	>20%	6	13	28	11	12	70
	Total	11	21	57	30	47	166
III Assured Rainfall	<20%	3	-	12	11	42	68
	>20%	1	3	7	6	19	36
	Total	4	3	19	17	61	104
	Grand Total	15	25	80	48	118	286

SOURCE: G.M. Desai and Gurdev Singh, Growth of Fertilizer use in district of India : Performance and policy implications, Centre for Management in Agriculture, IIM, Ahmedabad, 1973, (compiled from Tables 4.7 and 4.8).

Taking an overall view, and considering low irrigation situation, the semi-arid districts seem to have performed better than the arid and assured rianfall districts. Only 58 percent of the (96) districts in this class had low or very low growth of nitrogen use (57 percent for phosphorus use). In the arid and assured rainfall districts, the proportions were 100 percent and 75 percent respectively (90 percent and 78 percent for phosphorus use). Ten percent of the districts had high to very high growth rate of nitrogen use (13 percent for phosphorus use) in the unirrigated semi-arid areas. The corresponding figures for arid and assured rainfall areas were nil and 3 percent, respectively (nil and 4 percent for phosphorus use).

The above analysis, even though rather crude, provides some useful insights into the relative position of SAT regions *vis-à-vis* others. (1) The semi-arid (and also the arid) regions had higher growth of fertilizer use during the sixties as compared to the assured rainfall regions, more distinctly so with respect to phosphorus use; (2) Availability of irrigation seems to bring about a much greater impact on fertilizer use in the semi - arid (and also arid) areas. (3) With low levels of irrigation, growth rates fall substantially in the semi-arid regions but they still out-perform the assured rainfall areas; (4) High nitrogen growth districts were concentrated in the high irrigation areas. For phosphorus use, particularly, in the semi-arid areas, the correlation was not so strong; (5) Surprisingly, irrigation does not seem to have made a very significant impact on growth of fertilizer use in the assured rainfall areas.

The analysis led to the conclusion that extension of irrigation and spread of fertilizer use in unirrigated (both dryland and assured rainfall) areas hold the key to future growth in fertilizer use [7, 10].

Some Further Results

Data on fertilizer consumption for 72 SAT districts in Andhra, Madhya Pradesh, Karnataka, and Maharashtra were updated till 1976-77 and growth rates were worked out over the period 1969-70 to 1976-77. For almost all the districts, the trends were negative. This was so because the consumption levels recorded a decline till about 1974-75 [7]. The last two years witnessed a recovery but not sufficiently so to offset the negative trend. We than used the terminal year consumption figures and worked out the annual rates of increment. These have been given in Appendix I.

The procedure is crude but the results broadly support the above conclusions. About 36 percent and 48 percent of the districts had low to very low growth of nitrogen and phosphorus use, respectively. The percentages recording high to very high growth were 22 and 19 for nitrogen and phosphorus use. The results also showed that while Madhya Pradesh had very low growth rates for both the nutrients, Maharashtra and Karnataka had more than 40 percent districts having high to very high growth in nitrogen use. For phosphorus use, all the three states had about one-third of the selected districts in this category.

This exercise revealed that an improvement seems to have taken place in the growth rates in the SAT districts over the last few years as compared the situation in the sixties.

II. FERTILIZER USE PATTERN ON SAT CROPS AND FARMS

In order to understand the forces which lead to the above macro patterns, it is necessary to know the fertilizer practices of individual farmers. An attempt has been made in this section to provide information on the rates of fertilization of different crops, the extent of coverage and cropwise allocation of fertilizers, with special focus on the semi - arid regions of India.

Average Rates of Fertilizer Application and extent of Fertilizer Use: Aggregate Estimates.

Table 5 gives information of average rates of fertilizer application for important crops and also the percentage area covered [21].

The table gives an average picture. It shows that among food - grains, wheat, rice and maize are fertilized at higher rates than others. Nearly 50 percent or more of the irrigated area under these crops is fertilized. Pulses are fertilized at lower rates and the area covered is very small. Among non-food crops, sugarcane is fertilized at very high rates followed by cotton. More than 70 percent of the irrigated area under these crops receives fertilizers. Oilseeds are feritlized at much lower rates - lwoer even than most of the foodgrains. The study also showed that for the country as a whole, foodgrains account for nearly two-thirds of the total fertilizer used, rice and wheat dominating the picture. Sugarcane and cotton were the important claimants in the non-foodgrain category.

Fertilizer use falls drastically under unirrigated conditions and the dose does not exceed 30 kgs of nitrogen per hectare in any case and the percentage area covered is less than 16 percent for all crops except rice and cotton. It is interesting to observe that foodgrains are fertilized at higher rates as compared to cotton and oilseeds under unirrigated conditions.

The study also showed that the high yielding varieties were fertilized at much higher rates and the coverage was also higher [15]. A number of other classifications are given to show the effect of different factors on fertilizer use levels. These shall be discussed later.

Table 5. Rates of application and extent of fertiliser use on selected crops : All-India estimates : 1970-71

Crop	Nutrient	Proportion of fertilised area to total area under the crop		Rate of application per ha of fertilised area (kgs	
		Irrigated holdings	Unirrigated holdings	Irrigated holdings	Unirrigated holdings
Rice	N	65*	36	48	30
	P			10	6
	K			1	2
Wheat	N	69	16	54	28
	P			3	8
	K			1	5
Jowar	N	39	13	44	17
	P			13	9
	K			8	1
Maize	N	47	5	57	31
	P			2	10
	K			1	1
Other cereals	N	39	11	50	24
	P			4	17
	K			1	†
Pulses	N	15	3	36	9
	P			5	4
	K			1	†
Sugarcane	N	83	--	199	--
	P			30	--
	K			24	--
Cotton	N	70	31	61	22
	P			12	3
	K			7	1
Oilseeds	N	n.r.	n.r.	14	15
	P			19	10
	K			2	1

* Nutrientwise breakup not given.

† Less than 0.5 kgs.

n.r. : not reported

SOURCE: NCAER, 1974.

Figures for sorghum, pulses, cotton and oilseeds are of interest because these are important in SAT India, particularly under unirrigated conditions. The figures for these crops reveal very low spread of fertilizers for sorghum and pulses (13 and 3 percent, respectively). On the other hand, nearly 31 percent of the cotton area is fertilized. Unirrigated sorghum, cotton, and oilseeds receive about the same rate of total nutrients - 26-27 kgs per hectare, pulses are fertilized at much lower rate. The table also shows that while nitrogen is the most important nutrient in each case, the $N:P_2O_5$ ratio is significantly better for unirrigated sorghum and oilseeds as compared to cotton.

The recent NCAER study [22] gives state level estimates of rates of fertilization for important crops. Data on three states Andhra Pradesh, Maharashtra, Madhya Pradesh have been presented in Tables 6, 7, and 8, respectively to illustrate the position in semi-arid areas. These three states represent the high, medium and low fertilizer use areas.

Andhra Pradesh is one of the high fertilizer using states in the country (Table. 1). Information on rates of application reveals (Table 6) that high yielding and improved varieties are invariably fertilized at higher rates than local under irrigated conditions. For unirrigated crops, winter and summer paddy are exceptions. Traditional varieties are also fertilized at fairly high rates, even under unirrigated conditions. Crops like cotton, chillies and autumn paddy which occupy only 10 percent of the gross cropped area, have the highest rates under irrigated as well as unirrigated conditions. In fact, the unirrigated rates are higher for autumn paddy and cotton. The study also revealed that paddy and chillies accounted for a sizeable proportion of the total fertilizer used in the State.

The table shows that fertilizer use has diffused fairly widely in Andhra Pradesh and has spread to unirrigated crops also. One must note two features. Under unirrigated conditions, the heavily fertilized crops are cotton and chillies, both cash crops [8]. For other crops, though the unirrigated rates are high, the proportion of unirrigated area is very small. Secondly, the crops mentioned in the table cover only 48 percent of the gross cropped area. We have no information on fertilizer use for crops grown on more than half of the cropped area. These include sorghum, groundnut, pulses and other crops. These are obviously unimportant in terms of fertilizer use.

Table 6 Cropping pattern, average rates of fertiliser application per fertilized hectare by crops, variety and irrigation in Andhra Pradesh 1975-76.

Crop	% area under the crop	Average rates of application (kgs/ha)							
		HYV				Traditional varieties			
		N	P	K	Total	N	P	K	Total
Irrigated crops	*								
1. Autumn Paddy	5	84	30	14	128	62	13	4	79
2. Winter Paddy	22	80	27	4	111	74	21	3	98
3. Summer Paddy	7	99	35	9	143	70	16	7	93
4. Cotton	3	180	-	-	180	107	-	-	107
5. Sugarcane	2	184	75	13	272	136	26	4	166
6. Chillies	3	-	-	-	-	-	-	-	-
Unirrigated crops	@								
1. Autumn Paddy	1	44	114	-	158	39	10	10	59
2. Winter Paddy	8	-	20	-	20	54	11	3	68
3. Summer Paddy	10	58	-	-	58	91	4	-	95
4. Cotton	61	163	21	10	194	88	22	3	113
5. Chillies	41	166	104	-	270	102	34	8	146

* Percentage area under the crop (irrigated + unirrigated).

@ Proportion of unirrigated area.

SOURCE: NCAER, Interim Report : Fertiliser Demand Survey, Vol. 5, New Delhi, 1978.

Table 7. Cropping pattern, average rates of fertiliser application per fertilized hectare by crops, variety and irrigation in Maharashtra: 1975-

Crop	% area under the crop	Average rates of application (KG/HA)							
		HYV				Traditional varieties			
		N	P	K	Total	N	P	K	Total
Irrigated crops	*								
1. Paddy	10	75	16	9	100	48	15	11	74
2. Cotton	7	74	26	10	110	35	6	4	45
3. Sorghum (Kharif)	18	60	15	6	81	74	14	14	102
4. Wheat	8	65	19	13	97	58	14	6	78
5. Sorghum (Rabi)	16	17	7	4	28	53	3	3	59
6. Sugarcane	2	224	45	23	292	237	54	44	335
Unirrigated crops	@								
1. Paddy	66	50	14	12	76	38	8	5	51
2. Cotton	89	58	14	7	79	36	15	7	58
3. Sorghum (Kharif)	91	43	10	4	57	20	4	1	25
4. Wheat	34	82	9	8	99	73	5	5	83
5. Sorghum (Rabi)	89	75	6	-	81	29	4	3	36
6. Sugarcane	†	-	-	-	-	224	-	-	224

† Less than 0.5 percent.

@ Proportion of unirrigated area.

* Percentage area under the crop (unirrigated + irrigated).

SOURCE: NCAER, 1978, *op. cit,* Statement 4 and table 57.
NCAER, Interim Report of the Fertiliser Demand Survey, Vol.6, New Delhi, 1978.

TABLE 8. ...ttern, a... rates of application per fertilised hectare ...y crops, variety ... irrigation in ... a Pradesh : 1975-76

Crop	% area under the crop	Average rates of application (Kgs/ha)							
		HYV				Traditional Varieties			
		N	P	K	Total	N	P	K	Total
Irrigated crops	*								
1. Kharif paddy	25	60	21		81	29	6	4	39
2. Maize	4	50	6		56	38	6	-	44
3. Wheat	19	57	25		82	35	9	1	45
4. Sugarcane	+	44	5		49	79	20	3	102
Unirrigated crops	@								
1. Kharif paddy	88	50	-		50	19	3		22
2. Maize	85	-	-			19	2		21
3. Wheat	67	42	24		66	16	10		26

* Percentage area under the crop (irrigated + unirrigated)

@ Proportion of unirrigated area

+ Less than 0.5 per cent

Source: NCAER, Interim Report : Fertilizer Demand Survey, Vol.2, New Delhi, 1978

In Maharashtra (Table 7), the rates are higher for high yielding and improved varieties of paddy, cotton and wheat under irrigated conditions; for sorghum (both kharif and rabi) and sugarcane, the traditional varieties are fertilized at higher rates. Interestingly, for unirrigated crops, the superior varieties were always fertilized at significantly higher rates. In fact, the rabi sorghum (HYV) crop was fertilized at higher rate under unirrigated conditions. This thorws up some questions regarding response of traditional and high yielding varieties under irrigated and unirrigated conditions which need investigation.

With the exception of sugarcane, the rate for food and commercial crops were not distinctly different. Sugarcane and paddy accounted for bulk of the fertilizer used in the state. This implies that though the rates are high, the percentage area fertilized must be low for other crops, particularly in view of the fact that these two crops account for only 12 percent of the gross cropped area. It is also relevant to note that these crops are concentrated in the non-SAT areas of the State.

Madhya Pradesh is one of the poorest performers with respect to fertilizer use. Data on rates of application for different crops (Table 8) revealed significantly lower rates of fertilizer application as compared to the other states under irrigated as well as unirrigated conditions. The high yielding varieties were fertilized at higher rates. Paddy and wheat which occupy about 44 percent of the gross cropped area, consume bulk of the fertilizers used in the state and most of the area under these crops is unirrigated. Once again, we do not know the position regarding crops grown on nearly half the cropped area.

The above data suggests that we have very little information on crops like sorghum, pearl millets, pigeonpeas, chickpeas and groundnut - the typical crops of the semi-arid situation. It also reveals that irrigated crops and commercial crops are generally fertilized at high levels.

Fertilizer Use on SAT Farms

Evidence from micro-level studies suggests [6, 10] that farmers' fertilizer use allocations are based on the size and certainty of returns from fertilizer use for different crops. Roy [30] also found that profits from fertilization (determined by physical response and prices) was the main factor explaining inter-farm differences in fertilizer use.

However, very few empirical studies are available on fertilizer use on farmers' fields under dryland conditions. In view of the fact that very little fertilizer has been traditionally used in these areas, this lack of interest is understandable. The cropping pattern was dominated by low-value crops and, apart from cotton and perhaps groundnut, hardly any other unirrigated crop was fertilized. It has been argued that farmers used most of their fertilizers on the small parcels of wet lands where returns from its application were relatively assured [6]. An attempt has been made here to review the findings of some important studies in this area.

(a) Bellary-Panchamahals Study

Krishnaswamy and Patel [19] provide some information of the fertilizer use practices of 240 farmers from 24 villages in Bellary (Karnataka) and Panchmahals (Gujarat) districts for 1970-71. Both the districts reflect the characteristics of traditional semi-arid agriculture. Table 9 provides the available information on cropping pattern, fertilizer use levels, etc. on the sample holdings in each district.

Sorghum and pearl millet were the important cereals in Bellary and groundnut and cotton were the main cash crops. These four crops accounted for about 72 percent of the gross cropped area on the sample farms. In Panchmahals, paddy and maize were the most important cereals; wheat sorghum and pearl millets were also grown by the sample cultivators. Groundnut and cotton were the cash crops but the area under these crops was lower as compared to Bellary.

Fertilizer use was generally low in both the districts though the Panchmahals sample had relatively higher rates. In Bellary, some fertilizer was used for almost all the crops including inferior millet. Only for paddy and hybrid sroghum the farmers used more than 35 kgs of plant nutrients. Another striking feature was the relatively high level of phosphorus use in this area. The spread of fertilizer use was 100 percent for hybrid pearl millet, 74 percent for hybrid sorghum, 53 percent for paddy and 48 percent for groundnut. Only a small fraction of the area under other crops was fertilized. The Panchmahals farmers generally used higher rates of application, nitrogen playing a dominant role in almost all cases. The extent of area feritlized was, however, generally lwoer. Except for wheat, the rates were less than 35 kgs/ha for all crops.

Table 9. Levels of fertiliser application on farms in Bellary (Karnataka) (Gujarat) districts : 1970-71.

Crop	BELLARY DISTRICT % area under the crop	Fertiliser/acre N	P	K	Total	PANCHMAHAL DISTRICT % area under the crop	Fertiliser/acre N	P	K	Total
Paddy	0.2	39	-	-	39 (53)	21.9	15	†	-	15 (29)
Wheat	0.2	-	-	-	-	5.6	69	19	19	107 ([illegible])
Local Jowar	34.0[a]	1	7	5	13 (25)	2.1[a]	-	-	-	-
Hybrid Jowar	-	13	15	7	35 (74)	-	-	-	-	-
Local Bajra	4.2[a]	-	12	-	12 (16)	4.5[a]	18	-	-	18 (29)
Hybrid	-	-	12	-	12 (100)	-	18	1	-	19 (33)
Navane	-	2	7	2	11 ([illegible])	-	-	-	-	
Maize	0.1	-	-	-	†	16.4	20	4	†	24 (16)
Gram	†	-	12	-	12 (6)	-	-	-	-	-
Groundnut	21.0	2	8	2	12 (48)	13.2	23	11	†	34 (24)
Cotton	12.5	3	6	2	11 (34)	11.1	19	8	-	27 (54)
	72.2					74.8				
Other crops	27.8					25.2				

	Bellary	Panchmahal
% of farmers using fertilisers	38	41
Area fertilised as % of gross cropped area	31.5	20.4
Nutrients used for fertilised acre	14 kg	24 kg
Year when fertiliser was first used	1967	1961

[a] Total of HYV and local.

† Negligible

Figures in parentheses indicate percent of area under the crop for which fertiliser was used.

SOURCE: M.S. Krishnaswamy and K.V. Patel, Status of Dryland Agriculture, Vol.I, Centre for Management in Agriculture, I.I.M. Ahmedabad, 1973 (compiled from Tables 5.2, 5.16, 5.17, 5.20).

This table shows that fertilizer use was a recent practice on the sample farms, the Panchmahal farmers leading by 6 years. One gets the impression that the Bellary farmers being relatively recent adopters of fertilizers, were still experimenting. They tried to use fertilizers with the hybrids, as they were doubtless advised by the extension agencies but exercised caution regarding fertilization rates. They seemed to be relatively sure about paddy. As regards other crops, they appeared to be assessing the responses by applying low dosages to all the important crops. This pattern of behaviour appears consistent with the risk and poverty dominated environment of the SAT. The Panchmahals farmers, having some more experience, seemed to have formed their judgements regarding profitable levels of fertilizer application and applied fairly high levels to wheat crop. The proportion of area fertilized was lower but more or less evenly spread over all crops. Capital rationing and risk adjustment, both seem to operate through limiting fertilized area in Panchmahals; in Bellary, the level of application also seemed to be so influenced.

The data show two more important trends. Firstly, crops which occupied a sizeable proportion of the cropped area were generally fertilized at lower rates and to a small extent, perhaps because the farmers did not have enough liquid resources to cover the entire area. Higher fertilization rates were tried for crops which occupied smaller area. Secondly, the view that cash crops are always fertilized at higher rates does not appear to be true. In both the samples, highest rates were observed for cereals. The Panchmahals data indicates that the proportion of fertilized area may be larger for cash crops and, therefore, these could account for a larger proportion of the total fertilizer used. The latter view is probably correct but this data set does not provide conclusive evidence in this regard.

(b) AICRPDLA Agro-Economic Studies

We now present some indicative results from agro-economic studies conducted under the All India Coordinated Research Project on Dryland Agriculture [1], at various locations. Table 10 presents data on fertilizer use, etc. from three centres - Indore, Sholapur and Ahmednagar.

The Indore tract is dominated by wheat and gram. These crops were fertilized at relatively high rates, particularly wheat, and consumed 75 to 100 percent of the total fertilizer used on farms. Kharif crops are fertilized at significantly lower rates. Unfortunately, we do not know the area fertilized under each crop.

Table 10. Pattern and levels of fertiliser use : AICRPDA Agro-Economic Research Studies

Location	Crop	% area	Fertiliser use (kg/ha) N	P	K	Total	% area fertilised	% of adopters
Indore (Nainod) (1975-76)	Sorghum	16	2.8 (2)	1.3 (3)	-	4.1		
	Maize	5	3.7 (1)	1.3 (1)	-	5.0		
	Black Tur	6	4.8 (1)	2.7 (2)	-	7.5		
	Wheat	35	42.2 (74)	13.3 (65)	0.3 (100)	55.8		
	Gram	21	13.4 (14)	7.5 (22)	-	20.9		
	Others	17	-	-	-	-		
Indore (Jamburdi Hapsi)	Sorghum	14	-	1.5 (4)	-	1.5		
	Maize	4	-	2.5 (2)	-	2.5		
	Black Tur	8	5.5 (4)	6.5 (10)	0.7 (22)	12.7		
	Wheat	32	22.7 (65)	7.6 (44)	0.5 (56)	30.8		
	Gram	32	9.6 (28)	6.2 (37)	0.2 (22)	16.0		
	Others	10	-	-	-			
Sholapur	Jowar		18.9	2.8	-	21.7	10	23
	Bajra		40.0	11.2	-	51.2	19	24
	Groundnut		10.0	10.4	-	20.4	8	7
Ahmadnagar	Bajra (UI) Mixed	20	-	-	-	Nil		
	Rb. Jowar (UI, Mixed)	55	1.2	1.3	1.2	3.7		5
	Mung (UI)	8	-	-	-	Nil		
	Groundnut (UI)	2	-	-	-	Nil		

Figures in parentheses indicate proportion of total fertiliser used.

SOURCE: Compiled from various centre reports submitted in the second workshop on Agro-Economic Research in Drought-Prone Areas, 1978.

The Sholapur sample shows low extent of fertilization (in terms of area fertilized) but fairly good rates of application. Pearl millet was fertilized at the rate of 51 kgs per hectare. Fertilizer use is obviously in its early phases in this area and here also pearl millet scores over the cash crop groundnut. Fertilizer use is rare in the Ahmadnagar sample.

This table gives some important pointers. Firstly, it clearly shows that there is wide variation in application rates across locations for the same crop. Secondly, fertilizer use is not strictly confined to the superior crops (like sorghum, pearl millet, paddy, maize, groundnut etc). Crops like black tur and gram are also fertilized. This could be a consequence of high prices for these products but the data do show that farmers in the SAT areas can and do take to fertilizer use for any crop. Finally, farmers seem to be aware of relative responses of different crops to nitrogen and phosphorus application and use proportionately larger amounts of the latter for the pulse legumes like gram and black tur (pigeonpea) and groundnut. All these are important in the sense that the popularly held views are to the contrary.

(c) ICRISAT Village Level Studies

Under this project, data are being collected from 180 cultivator households belonging to six villages spread over three agro-climatic zones of semi-arid tropical India. Preliminary analysis was done showing fertilizer use in these villages and the results for 1976-77 have been presented in tables 11, 12, and 13.

The Mahbubnagar villages show wide variability in adoption levels, extent of fertilization, crops fertilized and rates of application. In Aurupalle, paddy is the only fertilized crop. The extent of adoption is low and the proportion of area covered with fertilizer is lower still. The rate of application, however, is comparable to that in the other village and is much lower than the state average for irrigated paddy (Table 6). Paddy is the dominant crop in Dokur (occupying 45 percent of the gross cropped area). All farmers use fertilizers and the entire area is fertilized. This crop alone accounts for more than 96 percent of the total fertilizer used. Groundnut is another crop fertilized at a comparable rate but the area fertilized is very small. Nearly one-third of the farmers use fertilizers on sorghum and vegetables but the rates are very low. Other crops are not foritlized at all. It needs to be mentioned that nearly 32 percent of the gross cropped area is irrigated in Dokur vilalge.

Table 11. VLS Data : Fertiliser use in SAT farms : Mahbubnagar, 1976 - 77.

Village/crops	% area of the crop in GCA	% area under crop fertilised	Rate of application/fert. ha				% of total fert. used on the crop				% number of farmers using fertiliser
			N	P	K	Total	N	P	K	Total	
AUREPALLE											
Paddy (H)	10.4	7.65	55	-	-	55	100	-	-	100	27

Other crops: Sorghum local (7.47), Sorghum mixture (19.2), Paddy L (3.7), Wheat M. (0.85), Other pulses P. (0.71), Groundnut P. (0.07), Other oilseeds - castor (46.9), Other oilseeds M (6.56), Vegetables and other crops (4.1)

Village/crops	% area of the crop in GCA	% area under crop fertilised	N	P	K	Total	N	P	K	Total	% number of farmers using fertiliser
DOKUR											
Sorghum (L)	2.08	34.1	3	7	3	13	0.25		4.3	0.9	33
Paddy (L)	2.7	100	38	-	-	38	4.8	-	-	3.9	100
Paddy (H)	42.1	100	49	7	3	59	93.5	89.5	89.4	92.8	100
G.nut (p)	15.8	6.0	25	22	9	56	1.1	6.3	6.2	2.0	20
Vegetables and other crops	1.8	39.5	11	-	-	11	0.4	-	-	0.3	33

Other cros: Sorghum M (10.3), Ragi P (1.9), Other cereals P (5.0) Other cereals (H) (0.7), Other pulses P (3.8), G. nut M (14.1).

L - Local; H - High yielding variety; M - Mixtures.

Table 12. VLS Data : Fertiliser use on SAT farms : Akola, 1976 - 77.

Village/crops		% area of the crop in GCA	% area under crop fertilised	Rate of application/ Fert. acre				% of total fertiliser used on the crop				% number of farmers using fertiliser
				N	P	K	Total	N	P	K	Total	
KANZARA												
Sorghum	(L)	2.17	100	13	4	2	19	4.8	3.8	4.5	4.5	33
	(H)	7.51	77.8	19	4	2	25	19.4	10.4	12.4	16.1	53
	(M)	18.7	5.7	16	4	2	22	2.9	1.9	2.3	2.6	13
Paddy	(L)	1.1	56.3	44	-	-	44	4.8	-	-	2.9	66
Wheat	(L)	0.9	100	97	28	16	141	14.6	9.4	11.3	12.5	100
	(H)	2.5	68.3	51	22	12	85	15.4	15.1	18.0	15.6	66
G.nut	(P)	3.3	70.1	1	9	-	10	0.6	8.4	-	2.6	66
Cotton	(L)	7.4	100	6	4	2	12	7.8	10.9	11.3	9.[illegible]	57
	(H)	1.3	67.[illegible]	22	8	4	34	3.2	2.6	3.2	3.[illegible]	100
	(M)	40.2	28.2	10	4	3	17	20.7	19.5	26.5	21.4	25
Vegetables & Other crops		0.3	30.9	11	-	-	11	0.2	-	-	0.2	100
Other crops : Chickpea P (2.9), Other pulses P (1.1), Other oilseeds P (0.3)												
KINKHEDA												
Sorghum (M)		37.9	2.3	16	-	-	16	5.1	-	-	3.1	7
Wheat (H)		2.4	100	61	25	19	105	54.6	60.7	62.9	57.3	60
Other pulses	(P)	2.3	45.4	22	-	-	22	8.6	-	-	5.2	20
	(M)	2.1	100	11	4	2	17	8.7	9.2	7.1	8.5	50
Cotton	(L)	1.3	80.6	11	-	-	11	4.3	-	-	2.6	50
	(M)	35.5	23.5	6	4	3	13	18.8	30.0	30.0	23.2	14
Other crops: Sorghum H (2.5), Bajra M (1.5), Paddy L (0.7), Paddy M (0.1), Wheat L (1.9), C.pea P (7.6) G.nut P (1.2), G.nut M (3.0).												

L - Local; H - High yielding varieties; M - Mixtures.

Table 13. VLS Data : Fertiliser use on SAT farms : Sholapur, 1976 – 77.

Village/crops		% area of the crop in GCA	% area under crop fertilized	Rate of application/ Fert. acre				% of total fertiliser used on the crop				% number of farmers using fertilisers
				N	P	K	Total	N	P	K	Total	
KALMAN												
Sorghum	(L)	38.0	0.5	17	–	–	17	6.4	–	–	6.3	3
	(H)	0.6	26.7	28	–	–	28	8.0	–	–	7.8	33
Paddy	(L)	2.9	24.9	6	–	–	6	8.0	–	–	7.8	6
	(H)	2.3	4.1	27	–	–	27	4.8	–	–	4.7	8
Wheat	(L)	1.5	2.0	40	–	–	40	2.3	–	–	2.2	11
	(H)	0.7	21.5	3	–	–	3	0.9	–	–	1.0	20
G. nut	(P)	2.2	24.3	8	–	–	8	8.0	–	–	7.8	8
Vegetables & other crops:		1.01	73.5	40	1	1	42	61.5	100	100	62.2	66.6
Other crops:	Sorghum M (19.3), Other cereal P (1.7), Other crops M (0.7), Redgram P (1.8), Redgram M (21.6), Chickpea P (2.0), Chickpea M (0.07), Other pulses P (2.5), Other pulses M (0.5), G.nut M (0.5).											
SHIRAPUR												
Sorghum	(L)	37.8	0.2	9	–	–	9	0.4	–	–	0.4	4
Paddy	(L)	2.7	2.7	12	–	–	12	0.6	–	–	0.6	14
Wheat	(L)	2.7	9.1	24	–	–	24	3.9	–	–	3.9	7
Vegetables, Sugarcane and other crops		5.9	78.6	32	–	–	32	95.2	–	–	95.2	70
Other Crops:	Sorghum M (12.6), Wheat H, M (0.5)(0.2), Other cereals P, M(2.9)(0.8), Redgram P, M(10.9)(2.2), Chickpea P, M (3.8)(0.3), Other pulses P, M (8.4) (0.6), G.nut P, M(4.1)(0.8), Other oilseeds P, M(1.2)(0.5).											

L – Local; H – High yielding varieties; M – Mixtures.

Fertilizer use is much more highly diffused in the Akola vilalges in terms of crops fertilized even though irrigation is practically negligible. (Table 12). In Kanzara, cotton and sorghum are the dominant crops occupying nearly 49 percent and 28 percent of the gross cropped area respectively. Both these crops are fertilized. The adoption levels appears to be higher for cotton and for the high yielding varieties. In both these crops, the percentage area fertilized as well as extent of adoption is higher for the pure as compared to mixed crop. Wheat, paddy, and groundnut have generally higher adoption rate. Cotton, wheat and sorghum account for nearly 84 percent of the total fertilizer used. The rates of application are surprisingly high for wheat. For other crops, (including paddy), the rates are much smaller and are lower than the state averages (Table 7). It is important to observe that mixed crops of sorghum and cotton are also fertilized at rates comparable to pure (local) crop.

In Kinkheda, wheat and cotton account for more than 80 percent of the fertilizer used. All the 2.4 percent area under the former is fertilized at fairly high rate. All other fertilized crops receive a very small rate. Once again one observes lower rates as well as lower percentage area overed for crops occupying larger areas. Sorghum and cotton are fertilized at much lower level as compared to green gram (other pulses). In this village also farmers use fertilizers on mixed crops of sorghum, cotton and pulses. Hybird sroghum, paddy, groundnut and local wheat were also grown in the village but no farmer used fertilizers on these and other crops like chickpea and pearl millets.

In the Sholapur villages (Table 13), vegetables and sugarcane (which occupy 1 to 6 percent only of the gross cropped area) use 62 to 95 percent of the total fertilizers. The number of adopters as well as the proportion of area fertilized is very low for other crops. No farmer has used phosphorus on any crop. Of the two villages, Shirapur has much lower fertilizer use. In both the villages, the rates are much lower than the state averages for all crops (Table 7).

The preliminary analysis of VLS data revealed that paddy, wheat cotton, groundnut and sorghum are the important crops on which fertilizers are used. With the exception of Akola, mixtures were not fertilized. Rates of application were generally higher for paddy and wheat but in all cases they were lower than the average state level figures. This shows that farmers in the SAT areas apply lower rates and that there is scope for extending coverage. In view of the extreme variability in net returns from fertilizer use under dryland conditions and also chances of loss associated with high dosages of fertilizers [1, 16], this appears to be rational. Indeed when farmers have access to irrigation, the rates as well as extent of adoption were found to be quite impressive. The coexistence of high and low levels in the same village indicates that the farmer is willing to use fertilisers. If he finds it profitable is prepared to go the whole way. There was some evidence to show that he does not mind applying fertilizers to crops like pulses also which have recorded sharp price rise over the last few years.

It was also noted that crops occupying relatively larger proportion of the cropped area are fertilized at lower rates [21]. On the other hand fertilizer responsive crops which are less important areawise (like paddy and wheat) are often fertilized at high rates. This may be due to (a) capital constraint which might restrict the quantity of fertilizer pruchased and (b) farmers' attempt to minimise large cash losses in the event of a crop failure.

Summing Up

The above results clearly indicate that farmers in the SAT areas are now generally aware of the importance of fertilizers and have started using fertilizers. While the percentage area fertilized was generally low, rates of application were often found to be moderately high. In general farmers concentrated on irrigated crops like paddy, wheat and vegetables. Unirrigated crops of sorghum, cotton and groundnut were also frequently fertilized but at very low rates. It was also observed that farmers were trying fertilizers on crops like gram, green gram and pigeonpea which have witnessed very sharp price increases recently. This indicated that if the returns were attractive enough, farmers would be willing to use fertilizers even under unirrigated conditions. This has been effectively demonstrated by some other studies also. For example, Desai [6] found that farmers in the unirrigated tracts of Kaira district (a SAT district incidentally) were using as much as 60 kgs N per hectare for unirrigated tobacco in 1964-65. A more recent study for Guntur district [8] also highlights the importance of returns from fertilizer use in determining the extent and level of fertilizer use.

One must also point out that there is evidence of extreme inter - group and inter-farm variability in level as well as extent of fertilizer use. Also adoption levels are rather poor. A much deeper probe is needed to identify the constraints inhibiting fertilizer use in the SAT.

III. FACTORS AFFECTING FERTILIZER USE

The above evidence on wide variability in the levels of adoption, nature and number of crops fertilized, the extent of area fertilized and rates of fertilizer application, over farms, crops as well as time [8] underscores the need for understanding the underlying reasons. Drawing basically from microeconomic factor demand theory, several workers [6,8,9,12,30] postulate that the size and certainty of returns from fertilizer use is the main determinant of fertilizer demand. Thus, prices (of inputs as well as output) play an important role as also the physical response from fertilizer application. Aggregative analysis usually consider price as the main determinant while micro-studies emphasize, apart from prices, factors which influence the response function and also factors which influence the adoption and diffusion of an innovation. The following sections discuss the analytical approaches used in macro and micro-studies on fertilizer demand.

A Macro-Level Analysis

(i) Price Factors

Two approaches have generally been used to measure the impact of price changes on fertilizer use. The normative approach uses fertilizer response functions and optimising behavior assumptions to obtain demand for fertilizers using production function or programming tools. Usually [23] they show highly inelastic demand with respect to both fertilizer and output prices. However, in view of the fact that this approach does not (usually) consider factors like risk and also the wide diversity in response functions across locations, varieties and other factors, its usefulness in understanding the impact of price changes on fertilizer demand is rather limited [35].

Direct estimation of fertilizer demand functions from time series data on fertilizer consumption, prices and the prices of farm products, is the other approach. Both static and nerlovian adjustment lag models have been used to derive aggregate fertilizer demand functions. A few such studies are available for India [6,25,26,29,27].

in response to the very high prices for these crops. The data also revealed that farmers were using proportionately higher levels of phosphorus for crops like gram, pigeonpea and groundnut. This indicated that they were aware of relative responses of different crops to the major nutrients.

Preliminary analysis of data from ICRISAT Village Level Studies indicated that farmers used fertilizers quite extensively on the irrigated crops like paddy, wheat or vegetables. These crops occupied small acreages generally, but accounted for most of the fertilizer used. Other crops commonly fertilized were sorghum, cotton, groundnut and green gram (in one village) but the adoption as well as extent and levels of use were low. Crops like pigeonpea, chickpea, pearl millet and castor were not fertilized at all. In general, the pure (sole) crop was given greater attention as compared to the mixtures. It was hypothesised that farmers in these areas were generally aware of fertilizers and their decisions to use fertilizers were influenced by the size and certainty of returns and capital constraints confronting them.

3. Factors affecting fertilizer use

Considerable variability was found to exist in levels of adoption, nature and number of crops fertilized, the extent of area fertilized and rates of fertilizer application over farms, crops as well as time. An attempt was made to find out what factors were responsible for this.

The macro models used to derive aggregate demand functions for fertilizers in India suggested a price elasticity of demand around -1.5 to -2.0. Irrigation was found to have a much greater influence on fertilizer demand. It has been argued that variables like rapid expansion in irrigation, diffusion of HYV in rainfed areas and diffusion of fertilizer use under unirrigated

Desai [6] used a static regression model relating fertilizer consumption per hectare with real price of fertilizer (fertilizer price/index of output prices) and irrigated area for each year from 1957-58 to 1964-65 with 12 states as observation points. Irrigated area turned out to be the dominant determinant of fertilizer use. Fertilizer price had negative coefficients and these were significant in five out of eight years. The price elasticity was not calculated. We worked back on the data and found the elasticities ranging from -1.84 to -3.60.

We also pooled the data for 12 states and eight years and using appropriate estimation procedure, obtained the following aggregate demand functions:

$$F_t = 4.46 + \underset{(0.017)}{0.090} I_t - \underset{(0.311)}{1.253} P_t$$

where F = fertilzier (total plant nutrients) consumed in kg per ha, I = Percentage irrigated area, and P = Price of fertilizer/price of output. Both the coefficients were highly significant and an elasticity value of -2.0 was obtained.

Parikh [25] attempted to derive a similar static demand functions using state level data from 1951 to 1961. Apart from fertilizer/output price ratio, irrigated area and trend were used as explanatory variables. The price coefficient did not turn out to be significant in any case. In a subsequent paper [26] he used data from 1958-59 to 1963-64 and employed covariance analysis technique to come up with a short run elasticity estimate of -1.2 and long run elasticity of -2.5. Rao's study [29], however, revealed smaller short run elasticity estimates. All these studies have shown the importance of irrigation as the major determinant.

It has been argued [35] that the influence of prices on fertilizer demand operates through two mechanisms - it directly affects the equilibrium demand level and also has an indirect effect through its impact on the rate of diffusion. Timer holds:

> "In arguing the role of price policy in speeding the rate of growth of fertilizer demand, it is essential to keep these mechanisms separate. For the direct impact, there is no substitute for the price role.

> For the indirect impact several substitutes are possible, including greater extension effort, fertilizer trials and demonstrations, an active private fertilizer marketing system, and so on. Whether they are better social investments than an incentive price policy is obviously an impirical issue to be resolved in specific contents." [35].

Desai [7] pleads strongly for the second option in context of rapid growth of fertilizer use in Indian agriculture and argues that:

> "...it is these efforts (growth in irrigated areas, diffusion of HYV on rainfed areas and diffusion of fertilizer use under unirrigated conditions), more than marginal manipulations of (fertilizer) prices which will determine the limits and pace of further growth in cultivators' demand for fertilisers" [7, parentheses added].

This obviously implies that the positive impact of such measures will offset the negative impact of price rise. The evidence on the impact of irrigation lends strong supports this view.

(ii) Other Factors

Some other variables which influence fertilizer consumption at the macro level are aggregate availability of fertilizers (domestic as well as import supplies), the efficiency and spread of the distribution system [7], the parameters of aggregate demand for agricultural products [35], technological change in both fertilizer production and agriculture, the status of fertilizer promotion and extension activities and, perhaps, the nature of distribution of productive resources in agriculture. Not much empirical work has been done on comprehensive macro models encompassing all these variables. Capital constraints (usually proxied by income) and education has also been used in some studies using static models [13, 14], and was found to affect fertilizer use.

The dynamic adjustment model assumes that variables like capital constraint and education effect fertilizer consumption through their impact on the rate of adjustment and some empirical testing of this proportion has been done (reported in 35), with respect to the effect of education on the speed of adjustment. The results indicate that education leads to a speeding up o* the rate of adjustment.

The study by David [4] on fertilizer demand of Asain rice farmers attempts to integrate micro and macro approaches. It uses cross-sectional farm level data from several countries and specifies a demand model which includes variables measuring differences in fertilizer response functions across locations in addition to fertilizer/product price ratio and liquidity position of the farmers. The results indicate that differences in response functions and prices play an important role in explaining fertilzier use on farms.

B. Micro-Studies on Fertilizer Demand

Most of the studies in India have looked at fertilizer use from the micro angel. A large number of variables - technological, economic, socio - psychological and environmental, have been hypothesized to influence farmers' decisions to use fertilizers. It has been postulated that the farmer has to make three basic decisions (i) whether to use fertilizers, (ii) which crop(s) to fertilize and (iii) at what rates [6, 10]. The first is basically a function of the state of awareness and knowledge of the farmer regarding fertilizer use on crops he commonly grows. The factors relevant here are the socio-psychological attributes influencing adoption and the level of extension activities. The other two decisions are made simultaneously and are primarily governed by profitability of fertilizer use at the farmers' level. Two factors are crucial here - the response to fertilizer application and fertilizer and output prices. Desai's work [6, 8, 9, 10] has shown that (i) the returns from fertilizer use must be quite substantial before farmers are induced to use fertilizers (ii) the allocation of fertilizers between crops is a function of relative profitability of fertilizer use and so long as capital constraints restrict the size of the fertilizer stock of the farmer, some crops and some proportion of the area will be left unfertilized, and (iii) the rate of fertilizer application is influenced by the nature of the response function, the discounting yardsticks used by farmers and the ability of the farmers to buy fertilizers.

The response function plays a crucial role in this process. Since it is affected by a large number of factors, the latter also became relevant determinants of fertilizer demand. This is how factors like variety (HYV or local, irrigation, soil type and fertility status use of organic manures, rotation, rainfall, etc. enter the picture. Variables which influence the technical efficiency of fertilizer use like method of application, time of application, choice of the fertilizer material, etc. also assumed importance in this context.

Factors like tenancy, farmer's asset or liquidity position, credit, markets etc. affect farmers' decisions to use fertilizers through their impact on profitability (tenancy) or his ability to buy and use fertilizers. Alongwith cropping pattern these are usually included to explain inter-farm differences in fertilizer use. Then we have variables influencing adoption like age, education, socio-economic status, extension contacts, farmer's attitude towards risk and subsistence, etc. [16].

The following paragraphs indicate the hypothesized effect of some important variables and also the results obtained in earlier studies.

<u>Response to Fertilizer</u>

Response to fertilizer determines the rate of application and also the crops to be fertilized. It has been shown that farmers' allocation of fertilizers among crops is determined by relative responses or relative profitability of fertilizer use [6, 9]. Similarly, differences response functions have also been found to explain variability in feritlizer application rates [4, 30]. It is not always possible to measure differences in response and several workers use factors which influence response to explain inter-farm or inter crop differences in fertilizer use. For example, a number of studies [10, 21, 22] show that both area fertilized and rates of application are higher for HYV than for local. <u>Irrigation</u> is one of the most important factors affecting response, not only in terms of shifting the response curve upwards, but also imparting stability. Hence, almost all studies show the positive influence of irrigation [24, 5, 34, 21, 6, 10, 8, 22]. Several have indicated concentration of fertilizer use on irrigated lands [10, 12]. <u>Rainfall</u> during the pre-sowing and growth periods of the crop also exercises a similar influence and its effect is likely to be much more important uder rainfed conditions. Use of <u>organic manures</u> affects fertilizer use in two ways. Some empirical studies [19] have shown negative association between use of organic manures and fertilizers as farm size increases and have infered that small farmers substituted organic manures for fertilizers. But others [1, 21] have generally reported complementarity between the two. Soil type and quality is another important variable affecting response but very few studies have used it to explain fertilizer use differences between farmers. There is so much heterogeneity in soil quality even within a small area that it is difficult to obtain data on plot-wise soil characteristic and capture this effect. Desai and Singh [10] attempted to examine growth of fertilizer use by broad soil types and found high growth of nitrogen use in district having deltaic alluvium and calcareous seirozenic soil types. With respect to growth in phosphous use, deltaic alluvium again ranked first followed by black or black puls others (mixed red and black, red and yellow, coastal alluvium) soil types. The latter are important in SAT India. Shetty [34] found fragmentation - another quality aspect of the farmer's land, to be an important factor influencing fertilizer use. The cropping history and fertilization practices followed on the plot in the preceding also affects fertilizer use. It is hypothesized that crops following legumes are fertilized at lower nitrogen levels and that if heavy rates of fertilization (particularly phosphorus) were used in the preceding season, fertilizer use in the following crop would be lower. While we have no evidence on the former, it has been reported [8] that crops following heavily fertilized chilli or tobacco crop in Guntru district were either not feritlized or feritlized at very low rates. On factors affecting technical efficiency of fertilizer use like time and method of application, choice of fertilizer material, etc. we have very little evidence from farmer's fields. The Guntur study [8] showed that farmers initially started with nitrogen use (as they seem to be invariably doing) on groundnut crop but quickly switched over to phosphorus. There is also clear evidence on a move towards more balanced use of fertilizers by farmers in the Guntur area. This study also shows that farmers used nitrogen mostly in the form of straight fertilizers and phosphorus in the form of complex fertilizers. It was infered that complex fertilizers have played an important role in promoting phosphorus use. These changes have come about gradually.

2. Farm Characteristics

Cropping patterns have been found to be an important factor explaining interfarm and inter-regional differences in fertilizer use [6, 8, 10, 21]. Fertilizer use varied directly with the proportion of irrigated crops and the proportion of market crops (not necessarily commercial crops). The NCAER [21] study suggested that the fertilization rates on a crop declined as the proportion of area occupied by the crop increases and also as the intensity of cropping increased. The effect of farm size on fertilizer use is rather ambiguous because it exerts two (opposing) kinds of influence. Since small farmers generally cultivate their holdings with greater intensity and fertilizer is a land augmenting factor, they tend to use more fertilizers per unit area as compared to the larger farmers. This implies a negative association between farm size and fertilizer use. On the other hand internal capital rationing and also poor access to the credit markets for small farmers often results in a negative association [4]. Not surprising, therefore, studies which use farm size as a factor explaining inter-farm differences in fertilizer use, come up with conflicting results. Most of them find negative association [5, 19, 22] and some report inconclusive results for different crops [21]. Almost all studies, however, shwo that adoption of fertilizers and the extent of area fertilized are positively correlated with farm size - at least in the intial phases [20,21,22,24].

Farmer's ability to buy fertilizers (liquidity) has been measured in terms of assets or income of the farmer and its effect on fertilizer use has been studied hypothesizing a positive association. The NCAER [21] study shows a positive influence for some crops but others find inconclusive results with respect to rates of application [4]. Once again, this variable was found to have a more powerful influence the acceptance, adoption and extent of area fertilized [3,32,34]. Credit is another variable which has been considered important. In the regression analysis attempted by NCAER [21] this variable emerged significant for only one crop though tabular analysis showed that this factor was quite important. The more comprehensive recent study [22] does not give a clear picture in this regard though in terms of reasons on non-adoption, this was frequent indicated to be very important [1,21,22]. The Guntur study [8] showed that capital was not a constraint in this area.

It has been hypothesized that tenant farmers apply lower rates of fertilizers. Some studies [21] support this hypothesis and others do not [6,8,20]. Most of the studies which investigated the impact of this variable on adoption, found the hypothesized negative association [33,34]. Some [6,8,3] again found no systematic association. It needs to be mentioned here that tenancy would affect profitability of fertilizers and hence its adoption and use depending upon the terms of tenancy [28]. For example, if the tenant bears the cost of all inputs and then has to part with some proportion of his output as rent, the profitability of fertilizer use for the tenant goes down and hence this form of tenancy will affect fertilizer use adversely. If however, the inputs and output are equally shared, or if the landlord pays for the cash inputs or if a fixed rent tenancy exists, the profitability does not alter because of tenancy. None of the studies have looked into this aspect and hence we do not get a clear picture.

Access to markets has also been considered as a factor affecting adoption and levels of use because of its impact on transportation costs of fertilizers. The study by Savale [32] shows negative association between adoption level of fertilizer and distance from the market. This variable has not been considered in most of the studies.

3. Sociological Factors

Age of the farmer was found to influence the adoption of fertilizers [34]. As regards level of fertilizer use, the NCAER [21] study found negative relationship in most of the cases suggesting higher conservatism of older farmers. Education level of the farmer exerts a positive influence on fertilizer use. The two studies which have examined its effect on the rate of application [5,21] did not find a significant association. However, this variable was found to influence adoption and diffusion of fertilizer use in the hypothesized manner [3,8,34].

The socio-economic status of the farmer is assumed to be positively associated with fertilizer use. However, its effect is also captured by variables like farm size, assets, income, education, etc., and in a functional relationship it rarely shows up. It has been argued [2] that in the early adoption stage of adoption, the relationship between adoption and economic status (measured as asset, etc.) is not a linearly rising one. Cancian that because of "upper middle class conservatism," the adoption curve dips down. When fertilizer use becomes fairly widespread, the conservatism is overcome and the adoption curve is monotonically increasing. This has important methodological implication in terms of specifying the nature of the adoption curve. The experience which farmers have about fertilizers is believed to be important in determining rates of fertilization [6]. The NCAER [21] study shows that farmers who have been using fertilizers for longer periods generally use higher levels.

The subsistence needs of the farmer measured usually by family size or consumption units in the family may prompt farmers with higher family consumption obligations to use more fertilizers. The results obtained [21] are inconclusive.

Some variables like extension or urban contact [34] and certainty of returns [6, 32] have also been argued to be important but not much work has been done to test these. The latter (uncertainty and risk) has received quite a bit of attention recently at the theoretical level. The fact that this could be an extremely important factor under unirrigated conditions is suggested by the result obtained on variability of profits from fertilizer use on maize, jowar and bajra [18]. We have collaborative evidence from the semi-arid areas [1] which shows that uncertainty regarding yield and fear of heavy loss due to crop failure is the major reason behind non-adoption of fertilizers by farmers in dryland areas.

Two methodological points need to be made in this context. It has been shown that the commonly used method of studying the characteristics of adopters and non-adopters with a view to identifying their influence, could lead to misleading conclusions. Classification of farmers as adopters and non-adopters at a point in time, does not really make sense because the same farmer often moves from one category to the other [8].

Secondly, it has been pointed out [11] that some of the factors are more relevent for acceptance and adoption (like education, experience, extension contact, etc) than for levels of application. In other words, the relative importance of various factors varies at different stages of the adoption process (awareness, trial, adoption, diffusion). Viewed in this light, the conflicting results obtained by various workers can be explained. Except for one study [8], this aspect has been ignored in others.

C. Analytical approaches

Some workers have used parametric programming procedures to examine the impact of factors like price changes, capital constraint and irrigation on fertilizer use [31,36], and have found the hypothesized effects to hold. Such studies always pertain to some kind of an average farm situation. A large number of factors cancel out during this averaging and it is not an easy task to parameterise all of them. Thus, this approach can provide only a restricted understanding of farmer's fertilizer use decisions. The normative nature of the analysis takes it farther away from real world situation.

Multiple regression analysis appears to offer a better alternative and has been attempted by NCAER [21]. The main problems here are the very large number of variables, high inter-correlations between them. The data requirement itself poses the most serious problem. Empirical work in this area has, therefore, been scanty and inadequate.

The choice and specification of variables requires considerable care, not only from multicollinearity angle but also from simultaneity point of view. Inclusion of factors like organic manures, variety etc., (decisions on which are jointly made with fertilizer use decisions) in the demand function creates simultaneity bias. Again some variables included in the model could represent more than one effect, for example farm size could depict economic status as well as land-fertilizer substitution. It is not easy to interpret the coefficient. The definition of the dependent variable itself matters a lot in choice and specification of causal variables. All the variables which are used to explain differences in fertilizer use per hectare of gross cropped area cannot be used as such when cropwise analysis is attempted. Finally, one needs to sort out factors which are important for adoption and factors which are useful for explaining differences in levels of fertilizer use. Both are influenced by the same set of variables but their relative importance differs. No one has attempted this and hence the results are often blurred.

SUMMARY

This review focusses attention on consumption levels, growth, farmers' practices and factors affecting farmers' demand for fertilisers. There is very little information on these aspects for the semi-arid tropical regions of India. An attempt has been made to put together all such studies in the hope that a pattern will emerge, which may be form the basis for more detailed studies in this area.

1. Consumption Levels and Growth

Scrutiny of the statewise fertilizer consumption figures revealed that more than 50 per cent of the total fertilizer consumed in the country was used in the states of Punjab, Uttar Pradesh, Andhra Pradesh and Tamil Nadu. Madhya-Pradesh, Maharashtra and Karnataka - the typical low irrigation SAT states, accounted for nearly one-third of the country's cropped area, but their contribution in total fertilizer consumption in the country was barely one-fifth. These and the eastern states seemed to be lagging behind in fertilizer consumption. Districtwise consumption figures supported the concentration aspect and only 48 districts (13 percent) consumed more than 43 per cent of the total fertilizer used.

Preliminary analysis of current (1976-77) fertilizer consumption levels in 74 SAT districts in the states of Andhra Pradesh, Maharashtra, Madhya Pradesh and Karnataka, revealed that while consumption of fertilizers was low in the SAT districts, the overall position appeared to be better than that for the country as a whole. Madhya Pradesh districts had very low consumption levels while Maharashtra appeared relatively superior in this respect. The results showed that there was considerable variation in fertilizer use levels within the SAT areas and state level figures were not very helpful. An attempt was made to interpret the results of an earlier study [10] in terms of growth of fertilizer use in SAT areas*. The exercise revealed that (i) the semi-arid (and also arid) regions had recorded higher growth of fertilizer use during the sixties as compared to the assured rainfall regions, more distinctly so with respect to phosphorus use (ii) availability of irrigation had a much greater impact on fertilizer use in the semi-arid and arid areas, (iii) with low levels of irrigation, growth rates in the semi-arid areas fall significantly but they were still better than the comparable (irrigationwise) assured rainfall areas (iv) districts with high irrigation had higher growth of nitrogen use but for phosphorus use, particularly in the semi-arid areas, the correlation was not so strong. Examination of the fertilizer use data upto 1976-77 for 72 districts in the semi-arid area pointed towards an improvement in the growth performance of those areas.

2. Fertilizer use pattern on SAT crops and farms

All India estimates of fertilizer use by crops revealed that a very small fraction (3-13 per cent) of the unirrigated area under sorghum and pulses (major SAT crops) was fertilized. While unirrigated sorghum, cotton and oil-seeds were fertilized at about 26-27 kgs per hectare, pulses received much less.

Latest estimates suggested an improvement in fertilization rates. Crop-wise estimates of fertilizer use for Andhra Pradesh, Maharashtra and Madhya Pradesh were examined. It was observed that in Andhra Pradesh, chillies and cotton were fertilzied at very high rates under unirrigated conditions. There with irrigated paddy, accounted for most of the fertilizer used in the state. This indicated low diffusion of fertilizer use for other unirrigated crops.

*Define crudely as districts receiving 500 mms to 1150 mms annual rainfall.

In Maharashtra, paddy and sugarcane occupying barely 12 per cent of the gross cropped area, consumed bulk of the states' fertilizer. Though crops like sorghum and cotton were also fertilized at high rates the extent of fertilization for these and other crops was poor. Fertilizer use in Madhya Pradesh was at a very low level and concentrated on paddy and wheat. It was observed that information on fertilizer use for crops like sorghum, pearl millet, pigeonpea, chickpea, groundnut, castor, etc - the typical crops of SAT agriculture was lacking.

Micro-level studies for SAT India revealed a clearer picture. The Bellary-Panchmahals study [19] revealed that the average rate of application was low and that there was considerable inter-crop variation in fertilizer use, ranging between 11 to 107 kgs per hectare. Almost all the major crops were fertilized. It was argued that during the early years of fertilizer use, farmers in the SAT areas experimented with almost all crops at low rates and coverage. Subsequently, they raised fertilizer levels for crops about which they were convinced. Capital rationing and risk showed their effect in terms of area fertilized. It was also found that crops which occupied sizeable areas were fertilized at low levels and with lower coverage. The data did not support the view that cash crops (like groundnut and cotton) were fertilized at higher rates as compared to cereals.

Results of studies conducted under the All India Coordinated Research Project on Dryland Agriculture [1] also showed that while there was wide variation in application rates between locations, the view that all SAT areas and crops were fertilized at low rates was not correct. It was also found that farmers were also fertilizing crops like gram and <u>tur</u> (pigeonpea) perhaps in response to the very high prices for these crops. The data also revealed that farmers were using proportionately higher levels of phosphorus for crops like gram, pigeonpea and groundnut. This indicated that they were aware of relative responses of different crops to the major nutrients.

Preliminary analysis of data from ICRISAT Village Level Studies indicated that farmers used fertilizers quite extensively on the irrigated crops like paddy, wheat or vegetables. These crops occupied small acreages generally, but accounted for most of the fertilizer used. Other crops commonly fertilised were sorghum, cotton, groundnut and green gram (in one village) but the adoption as well as extent and levels of use were low. Crops like pigeonpea, chickpea, pearl millet and castor were not fertilized at all. In general, the pure (sole) crop was given greater attention as compared to the mixtures. It was hypothesised that farmers in these areas were generally aware of fertilizers and their decisions to use fertilizers were influenced by the size and certainty of returns and capital constraints confronting them.

3. Factors affecting fertilizer use

Considerable variability was found to exist in levels of adoption, nature and number of crops fertilized, the extent of area fertilized and rates of fertilizer application over farms, crops as well as time. An attempt was made to find out what factors were responsible for this.

The macro models used to derive aggregate demand functions for fertilizers in India suggested a price elasticity of demand around -1.5 to -2.0. Irrigation was found to have a much greater influence on fertilizer demand. It has been argued that variables like rapid expansion in irrigation, diffusion of HYV in rainfed areas and diffusion of fertilizer use under unirrigated conditions need to be emphasised more than marginal manipulations of fertiliser prices in context of promoting rapid growth in fertiliser use in Indian agriculture.

At the micro-level, farmer's decisions on adoption, inter-crop allocation and level and extent of fertilizer use are influenced by the nature of response functions for different crops, factors which affect the response function, factors which affect the ability of farmers to use fertilisers and also those which affect the profitability of fertilizer use, attitude of the farmers towards fertilizers and sociological factors influencing it, and prices. This is a large set and variables which have been considered important are indicated below:

- availability of irrigation
- variety
- rainfall pattern and quantity
- use of organic manures
- crop rotation and fertilizer practices followed on the preceding crop
- time, method of application and choice of fertilizer material
- cropping pattern and intensity
- farm size
- farmer's liquidity/asset/income position
- availability of credit
- tenancy
- access to market
- age of the farmer
- education level
- socio-economic status
- experience with fertilizers
- subsistence needs and risk preferences
- risk preference
- prices of fertilizers, and outputs.

The hypothesised relation with respect to these variables have been discussed and the empirical findings noted. It was pointed out that empirical work on determinants of farmers' demand for fertilizers was constrained by a large number of relevant variables having high inter-correlations and paucity of data.

Irrigation, cropping pattern, capital rationing and size and certainty of returns from fertilizer use are perhaps the major determinants of farmers' demand for fertilizers in SAT areas. As has been shown, no empirical study exists which looks at fertilizer use problems in this environment. In view of the fact that fertilizers form one of the important elements of the technologies being evolved for dryland agriculture, the need for an intensive study on this aspect cannot be over-emphasised. Absence of knowledge regarding forces motivating farmers to use fertilizers and the magnitude of these forces could pose a major constraint when these technologies are finally offered to the farmers.

Appendix 1. Distribution of 72 SAT districts in terms of annual rate of increment in fertilizer use (1969-70 to 1976-77)

Annual rate of increase (tons)	Number of districts				
	Madhya Pradesh	Maharashtra	Andhra Pradesh	Karnataka	Total
			NITROGEN USE		
Below 100	15	1	3	1	20
101 - 300	12	1	1	2	16
301 - 750	4	10	2	4	20
751 - 1500	-	7	3	4	14
Above 1500	-	1	-	1	2
Total	31	20		12	72
			PHOSPHORUS USE		
Below 50	13	2	2	2	19
51 - 100	9	4	2	1	16
101 - 300	9	7	2	5	23
301 - 500	-	5	2	4	11
Above 500	-	2	1	-	3
Total	31	20	9	12	72

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