AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

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Batch 64

1. SUBJECT CLASSIFICATION
A. PRIMARY: Food production and nutrition — AF25-0000-G635
B. SECONDARY: Soil fertility,fertilizers,and plant nutrition--India

2. TITLE AND SUBTITLE
Changing basis of demand for fertilizer in Indian agriculture

3. AUTHOR(S)
Desai,G.M.; Mellor,J.W.

4. DOCUMENT DATE: 1969
5. NUMBER OF PAGES: 27p.
6. ARC NUMBER: ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Cornell

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)
(In Cornell int.agr.development reprint no.37)
(In Economic and political weekly,v.4,no.39)

9. ABSTRACT

10. CONTROL NUMBER
PN-AAE-055

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Demand
Estimates
Government policies
India

13. PROJECT NUMBER

14. CONTRACT NUMBER
CSD-1438 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

CSD-1938 Rec.
Cornell C PN-AAE-055

Changing Basis of Demand for Fertilizer in Indian Agriculture

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Reprint No. 27
1970

PROGRAM ON COMPARATIVE ECONOMIC DEVELOPMENT
Center for International Studies
Goldwin Smith Hall
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Ithaca, New York 14850

Reprinted from
ECONOMIC AND POLITICAL WEEKLY
Vol. IV, No. 39, Review of Agriculture, September 27, 1969

CHANGING BASIS OF DEMAND FOR FERTILIZER IN INDIAN AGRICULTURE

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John W. Mellor

Summary:

To attain the need-based targets, fertilizer use in the country must grow by over 600 thousand tons per year for at least 6 to 7 consecutive years. What is the likelihood of cultivators' demand growing continuously by this huge unprecedented magnitude? What public policy measures are needed to generate such a growth in demand? In this article such questions are studied by identifying the past sources of growth in effective demand for fertilizer and examining their strength for further continuous growth. The main conclusions of the study are: (i) bulk of the growth in fertilizer use till mid-1960's was due to its diffusion on irrigated areas under a few fertilizer responsive commercial crops and old varieties of rice and wheat, (ii) this source of rapid growth in demand has nearly exhausted itself, (iii) despite a favorable impact of the current High Yielding Varieties Programme, it appears that growth in demand for fertilizer will slow down much before the need-based targets are attained, (iv) to avoid this, concerted government policy is needed to accelerate improvement in the currently available varieties of foodgrains, development of fertilizer responsive varieties of crops grown under unirrigated conditions, and expansion of the irrigated acreage.

Introduction

A number of agencies and investigators have recommended a vast increase in inorganic fertilizer use in India by mid-1970's (Table 1). Though the various targets differ, all of them are derived from a common objective -- rapid increase in foodgrain production to meet greatly increased consumption needs, without dependence on huge imports.

1. The authors may be reached respectively at the Indian Institute of Management, Ahmedabad, India and Department of Agricultural Economics, Cornell University, Ithaca, New York, U.S.A.

TABLE 1. AMOUNT OF FERTILIZERS DISTRIBUTED IN 1967-68 AND VARIOUS NEED-BASED TARGETS OF FERTILIZER USE FOR 1970's

	Nitrogenous	Phosphatic	Potassic	Total
	Figures in million metric tons of N, P_2O_5 and K_2O			
Distribution in 1967-68	1.05	0.42	0.21	1.68
Need-based Targets for 1970-71 suggested by				
Committee on Fertilisers	2.40	1.00	0.77	4.17
USAID (Standstill)[1]	1.96	0.98	0.49	3.43
USAID (Minimum Acceptable)[2]	2.69	1.34	0.67	4.70
Holst (for food self-sufficiency in 1976)	1.96	0.88	0.43	3.27
Holst (for food self-sufficiency in 1971)	2.50	1.10	0.60	4.25
Need-based Targets for 1973-74 suggested by				
Ministry of Food and Agriculture	3.73	1.74	1.11	6.58
Fertiliser Association of India	3.80	1.90	0.90	6.60
Need-based Targets for 1975-76 suggested by				
USAID (Standstill)	3.08	1.54	0.77	5.39
USAID (Minimum Acceptable)	4.37	2.18	1.09	7.64
Holst (for food self-sufficiency in 1976)	3.88	1.96	0.97	6.81

Notes: 1. These targets are derived from requirements of foodgrains which implies no change in dietary levels, and self-sufficiency by mid-1970's.

2. These targets are derived from requirements of foodgrains which implies some improvement in dietary levels and self-sufficiency by 1970-71.

Sources: Committee on Fertilisers: Government of India, Ministry of Food and Agriculture, Department of Agriculture, Report of the Committee on Fertilisers (New Delhi, 1965).
USAID: United States Agency for International Development Mission to India, Fertilizer Proposal for Increased Agricultural Production (New Delhi, American Embassy, 1964), Mimeographed.
Holst: The World Food Problem, A Report of the President's Science Advisory Committee (The White House, May 1967), Volume II, pp. 673-711.
Ministry of Food and Agriculture: C. Sahai, Developments of Fertiliser Industry in India (New Delhi, The Fertiliser Association of India, 1968).
Fertilizer Association of India: Ibid.

Fertilizer must play an increasingly important role in agricultural production as the opportunity to bring new land under cultivation diminishes. Greater output per acre through the use of new varieties and multiple cropping is universally associated with increased fertilizer use.

Despite rapid growth in fertilizer use in recent years, meeting even the minimal need-based targets will require further acceleration in the trend. The problem of further increasing fertilizer use is neither one of attaining some fixed level nor one of just maintaining the upward trend. It is a problem of continually raising the present level of use by huge, unprecedented annual increments (Table 2).

TABLE 2. PAST GROWTH IN FERTILIZER USE AND GROWTH NEEDED BEYOND 1967-68 TO ATTAIN NEED-BASED TARGETS

	N	P	K	N P K
	(Figures in 000 metric tons of nutrients)			
Average annual increment in use:[1]				
During 1952-53 to 1960-61	21	6	3	30
During 1960-61 to 1967-68	110	44	22	176
Average annual increment in use needed beyond 1967-68 to attain the target recommended by:[2]				
(i) The Ministry of Food for 1973-74	446	219	148	813
(ii) The Fertiliser Association for 1973-74	458	246	116	820
(iii) USAID for 1975-76 "Standstill"	415	220	109	744
(iv) Holst for 1975-76	354	192	94	640

1. Estimated by fitting Y a bt to the data on distribution of fertilisers between 1952-53 and 1967-68 by least squares.

2. Estimated by subtracting 1967-68 levels of use from targets recommended by various agencies and then dividing the remainder by number of years between 1967-68 and the target date.

Attainment of the need-based targets of fertilizer use depends on (a) enlargement of the supplies, (b) creation of adequate and efficient distribution channels (including provision of credit), and (d) growth in cultivators' demand. In the past attention in India was focused largely on problems of supply and distribution. The scope of discussion here is restricted to the demand aspect. Clearly greater supplies and improved

distribution channels will not result in continuously raising use if cultivators do not find it profitable to do so. The specific questions to which we address ourselves are: (i) What is the likelihood of cultivators' demand growing continuously by magnitudes required to attain the need-based targets of use? (ii) What public policy measures are needed to generate adequate cultivators' demand for fertilizer?

The maximum quantity of fertilizer profitable for cultivators to use depends on (a) the state of technology, (b) price relationships between crops and fertilizer, and (c) the availability of complementary inputs, particularly irrigation and management. If these conditions are unchanging, the maximum quantity of fertilizer profitable for cultivators to use is constant, and the actual level of use would grow towards this level as more and more farmers adopt fertilizer use. The size of returns from fertilizer use is the single most important factor determining the speed with which farmers adopt fertilizer use. Higher these returns, faster would be the diffusion of fertilizer use among farmers, and hence more rapid would be the growth in effective demand towards the fixed optimal quantity determined by the state of technology, price relationships and availability of complementary inputs. A change in any of these three conditions would not only change the optimal quantity but would also change cultivators' returns from fertilizer use, and therefore, the rate of growth in effective demand towards the optimal quantity.

It is the argument of this paper that the bulk of the growth in fertilizer use in India between the early 1950's and mid-1960's was due to gradual acceptance of fertilizer use by farmers on two major foodgrains and a few non-foodgrain commercial crops grown mainly under irrigated conditions. The growth in use during this period is considered growth under relatively constant fertilizer production functions because of the absence of any major change in the varieties of crops. It is further argued that while improvement in the price situation after 1960-61 brought a marked acceleration in this process of diffusion of fertilizer use on a few crops, it neither significantly raised the average rates of fertilizer application on these crops nor accelerated the spread of fertilizer use to hitherto unfertilized crops.

The above interpretation of the growth in fertilizer use till mid-1960's has important implications for the policy required to fulfill fertilizer use targets. Clearly, the demand would continue to grow rapidly so long as most of the land under crops which responds significantly to fertilizer use is not fertilized and the price situation is at least as favorable to the cultivators as in the mid-1960's. What is more, the limits of rapid growth in cultivators' demand for fertilizer have been further extended by the current High Yielding Varieties Programme. However, it is our contention that the limits of rapid growth in cultivators' demand for nitrogenous fertilizers as determined by these two forces are lower -- about 2 million tons of nitrogen -- than the target of over 3.5 million

tons suggested by the Ministry of Food and Agriculture for 1973-74.[1] Thus it appears to us that a problem on the demand side is in the offing. The precise nature of this problem is the slowing down of the rate of growth in demand for nitrogen as the level of its use in the non-plantation agriculture of the country approaches 2 million tons per year. At this stage further rapid growth in demand for fertilizer will require a new, rapid succession of improved crop varieties which respond to increasing rates of fertilizer application, substantial further expansion of the irrigated acreage and increased double and triple cropping. The purpose of this presentation is not to say that current targets cannot be met, but to focus attention on the vigorous policy measures required to meet them. These arguments are elaborated below first by developing a conceptual framework to analyze the problem of growth in cultivators' demand for fertilizer, and then by examining the empirical evidence on the growth in cultivators' demand for fertilizer.

A Conceptual Framework

An individual cultivator's demand for fertilizer is an outcome of two decisions: whether to use fertilizer and how much to use. In the final analysis these decisions are governed by his returns on fertilizer. These returns depend on (a) physical response to fertilizer use, (b) price of the crop, and (c) cost of fertilizer. If the cultivator knows with certainty these three parameters when he makes the two decisions on fertilizer use, he would demand the "optimum" amount of fertilizer. As the physical response and price of crop are uncertain, the cultivator's expected returns would be usually lower than those estimated from realized production function, realized crop price and cost of fertilizer. If these subjectively estimated returns, discounted for yield and price uncertainty are very small, then the cultivator may not adopt fertilizer use out of inertia. On the other hand, if the returns over cost of fertilizer are significant and he opts to use fertilizer, his effective demand may still be lower than the optimum amount because he does not know the optimum rate under condition of his farm, and also because of cautiousness. He is particularly likely to choose a lower rate if the returns from the optimum rate are only slightly higher than those from a substantially lower rate. In such a situation, if the fertilizer production function is unstable due to variations in weather conditions, he would continue to operate at a much lower percent of the optimum rate even in the subsequent production periods.

What is true of an individual cultivator is also true of all cultivators taken together. For a given state of technology and level of crop and

1. The focus of analysis in this paper is on nitrogenous fertilizers which still account for over 60 percent of fertilizers used in India.

fertilizer prices there would be an equilibrium level of total demand as represented by the sum total of optimum rates of application on all farms. Against this, the total effective demand in any production period would be the effective demand of all cultivators as determined by their subjective notions of fertilizer production functions on their farms, expected crop prices and cos. ·. fertilizer.

The above distinction between equilibrium and effective demand for fertilizer, identification of reasons for discrepancy between the two, and recognition of the crucial importance of the size and certainty of returns in determining the effective demand are useful in understanding the problem of growth in effective demand for fertilizers.

Visualize an economy with no fertilizer use at some point of time. Even for this point of time, it is possible to conceptualize the equilibrium level of total demand from (a) fertilizer production functions on all farms, (b) prices of crops, and (c) cost of fertilizer. Let us assume that these factors are constant over time, and therefore, the equilibrium level of total demand is unchanging.

In such an economy, initially fertilizer use would be an innovation and the total effective demand would be much lower than the total equilibrium level. But it would grow over time as increasing number of cultivators adopt the use on seeing the beneficial experience of the innovators, and as those who have already adopted the use move towards their individual optimum levels. The strength of these two forces which would determine the rate of growth in total effective demand would be a function of the spread of knowledge among cultivators. This in turn would depend on size of returns on fertilizer use. Initially the rate would be low because only the most enterprising cultivators would adopt the use. However, their experience would have a strong demonstration effect on cultivators growing fertilizer responsive crops with availability of complementary inputs on their farms because their returns on fertilizer use would be high. This would accelerate the growth in effective demand. But eventually the growth in effective demand would slow down in this static world because the cultivators who have not yet adopted the use are those who do not expect high returns from fertilizer use on crops they grow, particularly under the conditions on their farms. It must be remembered that physical response to fertilizer does vary from farm to farm. The other reason for slowing down of the growth in effective demand is that those who had adopted the use find that raising the rates of application to optimum levels brings only small increments in returns because of the law of diminishing marginal returns.

What influence will an effective extension service have on growth in effective demand? Clearly the extension work will speed up the diffusion process by reducing the uncertainty in the minds of cultivators and thus ·ccelerate the growth in effective demand. However, this influence would

be strongest only in the early stages when fertilizer is a relatively unknown input and even cultivators who grow fertilizer responsive crops and operate under favorable conditions are not quite certain about returns from its use. Once they have adopted the use, the influence of extension work on rate of growth in effective demand would diminish because beyond this stage the non-adopters are those who lack incentive to use fertilizer under conditions on their farms rather than awareness about the existence of this input.

Thus far the discussion has been in the over-simplified framework in which values of the three parameters which determine the total equilibrium demand for fertilizer were unchanging over time. The aim of the discussion was to point out that (i) even under such conditions once some cultivators start using it effective demand for fertilizer would grow over time, (ii) there would be an upper limit to growth in total effective demand represented by the sum total of the optimum rates on all farms, (iii) the rate of growth in effective demand would be determined by the rate of diffusion of fertilizer use among cultivators and the speed with which individual cultivators raise their rates of application to optimum levels, and (iv) the growth in effective demand would be low in the initial stages, then accelerate, and finally slow down after cultivators whose returns from fertilizer use are high have adopted the use at near-optimum rates. Now we broaden the framework by dropping the assumption of constancy in the parameters and examine the influence of change in them on (a) total equilibrium demand and (b) rate of growth in effective demand for fertilizer.

Since total equilibrium demand is the sum total of optimum rates of application on all farms, and as these rates are derived from fertilizer production functions, crop prices and cost of fertilizer, any change in the set of values of these three factors will affect the total equilibrium demand. It will also have an impact on the rate of growth in effective demand because the size of cultivators' returns depends on them. The degree of this impact will depend on the number of cultivators whose returns are affected, and the extent to which they are affected. For instance, improvement in the fertilizer production function of crops grown on a relatively small proportion of land (e.g., tobacco) will have a much smaller impact on the rate of growth in effective demand than that of a sustained improvement in the prices of crops grown by a large majority of cultivators (e.g., foodgrains). On the other hand, a definite improvement in the availability of a complementary input such as irrigation or in the varieties of crops commonly grown will have a more decisive impact on growth in effective demand than an uncertain improvement in product prices or small reductions in cost of using fertilizer, because the former would increase incentive to use fertilizer in a much larger measure than the latter.

Major Conclusions of an Empirical Investigation

The objective of this investigation was to identify main sources of growth in effective demand for fertilizer by analyzing the fertilizer use pattern up to 1964-65, and then use this knowledge to study the problem of continuous rapid growth in fertilizer use from the viewpoint of cultivators' demand. In the absence of any major change in the varieties of crops, the period prior to 1965-66 can be considered one of relatively constant fertilizer production functions in India. It is, therefore, possible to interpret the growth in demand for fertilizer during this period as growth resulting from diffusion of fertilizer use and change in price relationships under relatively constant technology. A very large scope to increase fertilizer use under the old technology has been estimated by a number of investigators who have approached the problem from normative angle.[2] Our positive approach, based on the observed fertilizer use pattern, proves useful in determining the limits up to which one can expect rapid growth in demand under the old technological conditions, and thus indicate the nature and importance of structural changes required to get further acceleration in effective demand for fertilizers. The past fertilizer use pattern was examined at three levels of observation, namely cultivators, districts and states, and the following major conclusions were reached.[3]

Use Pattern Within Groups of Cultivators:

Analysis of fertilizer practices of 36 samples of cultivators between 1954-55 and 1963-64 in different parts of the country showed that within each sample the relative spread and rates of fertilizer use on different crops were unequal, and that in this variation there was a consistent pattern (Tables 3 and 4).[4] Certain non-foodgrain fertilizer responsive

2. For instance see Government of India, Ministry of Food and Agriculture (Department of Agriculture), Report of the Committee on Fertilisers (New Delhi, 1965); also Roy L. Donahue, Estimates of Fertiliser Consumption in India in 1970-71 (New Delhi: Fertiliser Association of India, 1966).

3. Only the major conclusions are reported here. For discussion on nature and source of fertilizer use data, methodology employed, and details of results obtained, see Gunvant M. Desai, Growth of Fertilizer Use in India, Past Trends and Future Demand, Occasional Paper No. 24, Cornell University--USAID Prices Research Project, Department of Agricultural Economics, Cornell University, Ithaca, New York, 1969.

4. Precision in understanding growth in fertilizer use, both past and future, requires systematic study of cultivators' behavior. In this study we have depended on ad hoc use of data gathered largely for other purposes. Development of a systematic reporting system would greatly improve the results.

TABLE 3. SPREAD OF FERTILIZER USE ON DIFFERENT CROPS

District, State	Crop	Percentage of areas under crops which received nitrogen(N), phosphorus(P) and mixtures(M)[1]						
		1954-55 N-P-M	1957-58 N-P-M	1958-59 N-P-M	1959-60 N-P-M	1961-62 N-P-M	1962-63 N-P-M	1963-64 N-P-M
Ferozepur, Punjab[2]	Rice		2 0 0					
	Wheat		10 * 0					
	Maize		7 0 0					
	Cotton		17 0 0					
	Other Fgs.[3]		* 0 0					
Ludhiana, Punjab	Wheat					61 21 0	74 23 0	81 51 0
	Maize						46 8 0	59 22 0
	Sugarcane					47 0 0		
	Garden Crops					78 33 0		
	Cotton						25 2 0	26 2 0
	Groundnut						58 13 0	57 22 0
	Other Fgs.					7 3 0		
Pali, Rajasthan	Wheat					1 1 0	5 3 0	3 * 0
	Maize						4 3 0	5 1 0
Barabanki, U.P.[4]	Rice		22 0 0				54 0 0	
	Wheat		25 0 0				29 0 0	
	Sugarcane		23 0 0					
	Garden Crops		32 0 0					
	Oilseeds		0 0 0					
	Other Fgs.		* 0 0					
	Fodder Crops		8 0 0					
Meerut, U.P.	Rice				10 0 0			
	Wheat				8 0 0			
	Maize				20 0 0			
	Sugarcane				42 0 0			
	Garden Crops				21 0 0			
	Cotton				4 0 0			
	Other Fgs.				* 0 0			

TABLE 3. (continued)

District, State	Crops	Percentage of areas under crops which received nitrogen(N), phosphorus(P) and mixtures(M)[1]						
		1954-55	1957-58	1958-59	1959-60	1961-62	1962-63	1963-64
		N-P-M	N-P-M	N-P-M	N-P-M	N-P-M	N-P-M	N-P-M
Aligarh, U.P.	Wheat					6 1 2	19 2 3	35 3 51
	Maize					7 0 0	18 * *	25 1 1
	Bajara					3 0 0	14 1 1	15 * 1
	Barley					1 0 0	5 1 0	14 1 1
	Sugarcane					9 0 0	19 1 3	40 3 1
	Cotton					7 0 0	13 2 1	25 1 2
	Other Fgs.					1 0 0		
Varanasi, U.P.	Rice					32 0 0		
	Wheat					12 0 0		
	Sugarcane					21 0 0		
	Garden Crops					22 0 0		
	Other Fgs.					4 0 0		
Shahabad, Bihar	Rice					45 5 0	53 24 0	67 50 0
	Wheat					16 2 0	29 16 0	48 44 0
	Sugarcane					77 5 0		
	Potatoes					96 23 0		
	Other Fgs.					13 4 0		
Sambalpur, Orissa	Rice						3 3 0	
Raipur, M.P.	Rice			14 * 0		33 17 0	25 16 0	24 16 0
	Wheat					28 0 0		
	Garden Crops					9 9 0		
	Oilseeds					2 2 0		
	Other Fgs.					3 3 0		
Bhandara, Maharashtra	Rice						10 5 0	

TABLE 3. (continued)

District, State	Crop	Percentage of areas under crops which received nitrogen(N), phosphorus(P) and mixtures(M)[1]						
		1954-55 N-P-M	1957-58 N-P-M	1958-59 N-P-M	1959-60 N-P-M	1961-62 N-P-M	1962-63 N-P-M	1963-64 N-P-M
Surat, Gujarat	Rice						16 4 0	
	Jowar						3 1 0	
	Cotton						7 1 0	
W. Godavari, Andhra	Rice	27 10 5				36 9 *		62 25 10
	Sugarcane	51 0 72				62 5 *		90 15 0
	Garden Crops	38 0 0						
	Banana					36 0 0		50 4 0
	Chillies					36 0 0		70 4 0
	Tobacco	54 0 9				40 12 0		70 22 0
	Groundnut					5 7 0		
	Millets	* 0 0						
	Pulses					0 4 0		
Krishna, Andhra	Rice					60 53 3		
	Sugarcane					59 3 23		
	Garden Crops					41 11 8		
	Tobacco					68 38 7		
	Oilseeds					6 28 0		
	Millets					1 1 6		
Mandya, Mysore	Rice						65 56 0	
	Sugarcane						93 88 0	
	Ragi						8 8 0	
Thanjavur, Madras	Rice					48 26 7	61 43 4	39 12 12
Coimbatore, Madras	Rice	22 2 0				78 52 51		
	Sugarcane					79 0 16		
	Tobacco					46 0 21		
	Cotton					4 0 1		
	Oilseeds					2 0 2		
	Millets					1 0 1		

TABLE 3. (continued)

District, State	Crop	Percentage of areas under crops which received nitrogen(N), phosphorus(P) and mixtures(M)[1]						
		1954-55 N-P-M	1957-58 N-P-M	1958-59 N-P-M	1959-60 N-P-M	1961-62 N-P-M	1962-63 N-P-M	1963-64 N-P-M
Palghat, Kerala	Rice						34 3 35	
Alleppey, Kerala	Rice						22 16 58	

* Less than 0.5 percent.
1 Where more than one rice crop was grown in a year, the spread is calculated by taking a weighted average of the percentage of areas fertilized in different seasons, weights being areas under rice in different seasons.
2 Findings for 1957-58 relate to 1957-59.
3 Other foodgrains.
4 Findings for 1957-58 relate to 1956-58.

The spread of potash, in samples where it was used in straight form, was as follows:

District, State	Crop	1961-62	1962-63	1963-64
Shahabad, Bihar	Rice	3	15	30
	Wheat	1	15	29
Mandya, Mysore	Rice		5	
	Sugarcane		3	
Alleppey, Kerala	Rice		5	

SOURCES: Compiled from information given in: Reports of the Expert Committee on Assessment and Evaluation, Intensive Agricultural District Programme, 1961-63 and 1960-65 (New Delhi: Ministry of Food and Agriculture, Government of India) and "Fertilizer Practices followed by the Farmers," Agricultural Situation in India, June 1964, pp. 213-220.

TABLE 4. RATES OF FERTILIZER USE ON DIFFERENT CROPS

(lbs./acre)

District, State	Crop	Rates of nitrogen(N), phosphorus(P) and fertilizer mixture(M) application on different crops[1]						
		1954-55 N-P-M	1957-58 N-P-M	1958-59 N-P-M	1959-60 N-P-M	1961-62 N-P-M	1962-63 N-P-M	1963-64 N-P-M
Ferozepur, Punjab[2]	Rice		15 0 0					
	Wheat		16 4 0					
	Maize		21 0 0					
	Cotton		21 0 0					
Ludhiana, Punjab	Wheat					19 8 0	21 14	0 25 15 0
	Maize						20 17	0 18 16 0
	Sugarcane					19 0 0		
	Garden Crops					65 22 0		
	Cotton						20 22	0 22 16 0
	Groundnut						12 9	0 14 13 0
Pali, Rajasthan	Wheat						19 10	0 14 20 0
	Maize						28 13	0 20 32 0
Barabanki, Uttar Pradesh[3]	Rice		14 0 0					
	Wheat		12 0 0					
	Sugarcane		22 0 0					
Meerut, Uttar Pradesh	Rice				12 0 0			
	Wheat				11 0 0			
	Maize				10 0 0			
	Sugarcane				19 0 0			
	Cotton				8 0 0			
Aligarh, Uttar Pradesh	Wheat					13 14 97	13 12 105	11 5 63
	Bajara					11 0 0	13 5 64	9 15 61
	Maize					5 0 0	8 13 110	12 10 79
	Sugarcane					13 0 0	19 8 186	23 22 100
	Cotton					6 0 0	21 5 86	13 21 70

TABLE 4. (continued)

District, State	Crop	Rates of nitrogen(N), phosphorus(P) and fertilizer mixture(M) application on different crops[1]						
		1954-55 N-P-M	1957-58 N-P-M	1958-59 N-P-M	1959-60 N-P-M	1961-62 N-P-M	1962-63 N-P-M	1963-64 N-P-M
Varanasi, Uttar Pradesh	Rice					8 0 0		
	Wheat					16 0 0		
	Sugarcane					19 0 0		
Shahabad, Bihar	Rice					13 31 0	7 5 0	7 5 0
	Wheat					13 24 0	14 12 0	12 6 0
	Sugarcane					8 38 0		
	Potato					23 104 0		
Sambalpur, Orissa	Rice						17 11 0	
Raipur, Madhya Pradesh	Rice			10 3 0		9 6 0	12 11 0	13 12 0
	Wheat					2 2 0		
	Garden Crops					36 13 0		
Bhandara, Maharashtra	Rice						11 7 0	
Surat, Gujarat	Rice						25 19 0	
	Jowar						17 4 0	
	Cotton						19 10 0	
W. Godavari, Andhra Pradesh	Rice	17 13 0				21 22 0	22 22 0	85 21 24 79
	Sugarcane	66 0 0				73 0 0		
	Tobacco	36 0 0				51 0 0		
Krishna, Andhra Pradesh	Rice					13 27 0		
	Sugarcane					126 51 0		
	Tobacco					23 19 0		
Mandya, Mysore	Rice						29 21 0	
	Ragi						13 11 0	
	Sugarcane						108 62 0	

TABLE 4. (continued)

District, State	Crop	Rates of nitrogen(N), phosphorus(P) and fertilizer mixture(M) application on different crops[1]						
		1954-55 N-P-M	1957-58 N-P-M	1958-59 N-P-M	1959-60 N-P-M	1961-62 N-P-M	1962-63 N-P-M	1963-64 N-P-M
Thanjavur, Madras	Rice					26 23 118	15 18 71	16 21 146
Coimbatore, Madras	Rice	32 27 0				32 0 0		
	Sugarcane	43 0 0				64 0 0		
	Tobacco	29 0 0				29 0 0		
	Cotton					25 0 0		
Palghat, Kerala	Rice						29 4 86	
Alleppey, Kerala	Rice						15 26 157	

1 Where more than one rice crop was grown in a year, the average rates are calculated by taking weighted averages of the rates of application in different seasons, weights being equal to areas under the crop in different seasons.
2 Findings for 1957-58 relate to 1957-59.
3 Findings for 1957-58 relate to 1956-58.

The rates of potash application, where it was used in straight form, were as follows:

District, State	Crop	1961-62	1962-63	1963-64
Shahabad, Bihar	Rice	27	6	4
	Wheat	24	11	5
Mandya, Mysore	Rice		39	
	Sugarcane		116	
Alleppey, Kerala	Rice		20	

SOURCES: Compiled from information given in: Reports of Expert Committee on Assessment and Evaluation, Intensive Agricultural District Programme, 1961-63 and 1960-65 (New Delhi: Ministry of Food and Agriculture, Government of India); and "Fertilizer Practices followed by the Farmers," Agricultural Situation in India, June 1964, pp. 213-220.

commercial crops such as sugarcane, tobacco and garden crops were fertilized most commonly. In many cases rice was fertilized as extensively as the leading commercial crop but at lower rates. Fertilizer use on wheat was common but generally the spread was lower than on rice while the rates, when both were grown in the same sample, were not strikingly different. The other foodgrains, however, were fertilized much less commonly and at low rates. Among the important non-foodgrain commercial crops, sugarcane and tobacco were more often fertilized and at higher rates than cotton. Among oilseeds only groundnut was fertilized, and that too much less commonly and at low rates.

For each sample, the overall distribution of fertilizer between foodgrain and non-foodgrain crops was governed by the relative importance of various commonly fertilized crops in the crop pattern. In samples where fertilizer responsive commercial crops occupied significant proportion of cultivated land, only a small fraction of fertilizers were used on foodgrains and vice versa.[5] Finally, behind all these features of relative spread of fertilizer use on different crops the same force -- varying levels of profitability of fertilizer use on different crops -- seemed to be working (Table 5).

The average rates of nitrogen application on different crops (Table 4) were in most cases significantly below the optimum rates determined from the average all-India production functions (Table 5). Furthermore, from the findings on fertilizer practices of cultivators at different points in time (Tables 3 and 4), the main source of growth in fertilizer use till the mid-1960's appears to be increase in proportions of fertilized areas of a few crops rather than rise in the rates of application. The most satisfactory explanation for these features was found in the small size of increments in returns from fertilizer use beyond 50 to 75 percent of the optimum rates on the existing varieties of crops (Table 5). It is clear from the table that while the improvement in price situation between the late 1950's and the early 1960's raised substantially the returns from fertilizer use at the prevailing rates of application (which were 50 to 75 percent of the optimum rates), it did not raise the marginal returns so dramatically because of the nature of the fertilizer production functions of the old varieties of crops. From this it is easy to see why the improvement in price situation speeded up the diffusion of fertilizer use on a few crops but did not significantly raise the actual rates of application.

As the above findings relate to random samples of cultivators from selected (rather than representative) districts, the generality of the above findings was tested by analyzing the fertilizer use pattern among various districts within different states, and also among different states

5. This was true even for districts covered by the Package Programme which shows that administrative arrangements had little effect on cultivators' allocation of fertilizers among various crops.

TABLE 5. RETURNS OVER COST OF NITROGEN AT OPTIMUM RATES AND AT 50% AND 75% OF OPTIMUM RATES

Crops	Price Situation	Optimum Rates*	Returns over cost of nitrogen at: 50% Opt. Rate	75% Opt. Rate	Opt. Rate	Increment in returns over cost of nitrogen between: 50% and 75% of Opt. Rate	75% and 100% of Opt. Rate
		in lbs./ acre	in Rupees/acre			in Rupees/acre	
Rice	I	36	29	36	38	7	2
	II	41	43	54	58	11	4
Irri. Wheat	I	46	40	50	54	10	4
	II	51	59	74	78	15	4
Unirri. Wheat	I	22	9	11	12	2	1
	II	26	15	19	20	4	1
Jowar	I	33	9	11	12	2	1
	II	43	18	23	24	5	1
Bajara	I	34	10	15	16	5	1
	II	42	21	26	28	5	2
Maize	I	41	24	30	32	6	2
	II	43	32	40	42	8	2
Ragi	I	32	12	15	16	3	1
	II	39	22	27	29	5	2
Sugarcane- N. India	I	149	136	169	179	33	10
	II	164	225	281	300	56	19
Sugarcane- S. India	I	222	48	59	64	11	5
	II	330	144	179	189	35	10
Potato	I	153	225	282	302	57	20
	II	165	405	507	541	102	34
Irri. Cotton	I	40	9	13	18	4	5
	II	40	18	26	36	8	10
Unirri. Cotton	I	20	2	4	6	2	2
	II	20	6	9	12	3	3

* The returns from fertilizer use on different crops were calculated from fertilizer production functions estimated by Hopper from data on fertilizer trials on farmers' (see, W. D. Hopper, "Planning Yardsticks for Fertilizer and Irrigation," Agricultural Situation in India, September 1965, pp. 463-477), and prices of crops and nitrogen in 1958-59 and 1963-64. Two sets of prices were used by us to study the impact of improvement in price situation on returns from fertilizer use. These prices, in Rupees per quintal, were: Set I (1958-59 price situation) Rice 48.50, Wheat 42.00, Jowar 34.00, Bajara 38.00, Maize 36.00, Ragi 34.00, Barley 36.00, Sugarcane (N. India) 3.65, Sugarcane (S. India) 4.25, Cotton-lint 280.00, Jute 25.00, Groundnut 48.00, Potato 20.00, Nitrogen 187.00; Set II (1963-64 price situation) Rice 60.00, Wheat 50.00, Jowar 40.00, Bajara 44.00, Maize 42.00, Ragi 40.00, Barley 42.00, Sugarcane (N. India) 5.00, Sugarcane (S. India) 5.80, Cotton lint 360.00, Jute 34.00, Groundnut 58.00, Potato 30.00, Nitrogen 172.00.

of the country. The aim of the analysis was to test the hypothesis that the same forces were governing the use pattern revealed among higher levels of observations.

Use Pattern Among Districts Within Different States

Data on average annual rates of fertilizers in various districts within different states revealed wide cross-sectional differences (Table 6). Multiple regression analysis of these data showed that this feature was largely due to variations among districts with respect to crop patterns and levels of irrigation.[6] A high proportion of total sales as well as growth in sales in each state were concentrated in a few districts in which levels of irrigation were high and where crops such as rice, wheat, sugarcane, potato, tobacco dominated the crop pattern. On the other hand, districts with low levels of irrigation and hence in whose crop pattern these crops were less important shared a low proportion of the total fertilizers sold in the states. This confirms that variations in use patterns of fertilizer were related to variations in profitability of its use.

Use Pattern Among Different States

The fertilizer use pattern in various states between 1956-57 and 1964-65 showed persistent cross-sectional differences in the levels and striking variation in the growth-patterns over time (Figure 1). Throughout the 9-year period, the level of fertilizer use in some states (e.g., Rajasthan and Madhya Pradesh) remained substantially below that in some other states (e.g., Madras and Andhra Pradesh). Similarly, the growth patterns varied between two extremes of little growth in Rajasthan and Madhya Pradesh to dramatic growth in Punjab and Andhra Pradesh.

The above features of inter-state variation were mainly due to underlying differences among states in levels of irrigation and relative prices of nitrogen and crops.[7] Of the two factors, irrigation was more important in determining the cross-sectional variation in levels. However, by itself high level of irrigation in a state was not sufficient to generate a rapid growth in fertilizer use under the price conditions of the period up to 1960-61. This is clearly brought out by the growth curve for Punjab. On the other hand, once the price situation improved the growth in fertilizer use was related to levels of irrigation. In states with high levels of irrigation (e.g., Madras, Punjab, Andhra Pradesh) there was a remarkable acceleration in the growth of fertilizer use. Against this, a similar improvement in the price situation did not lead to growth at comparable

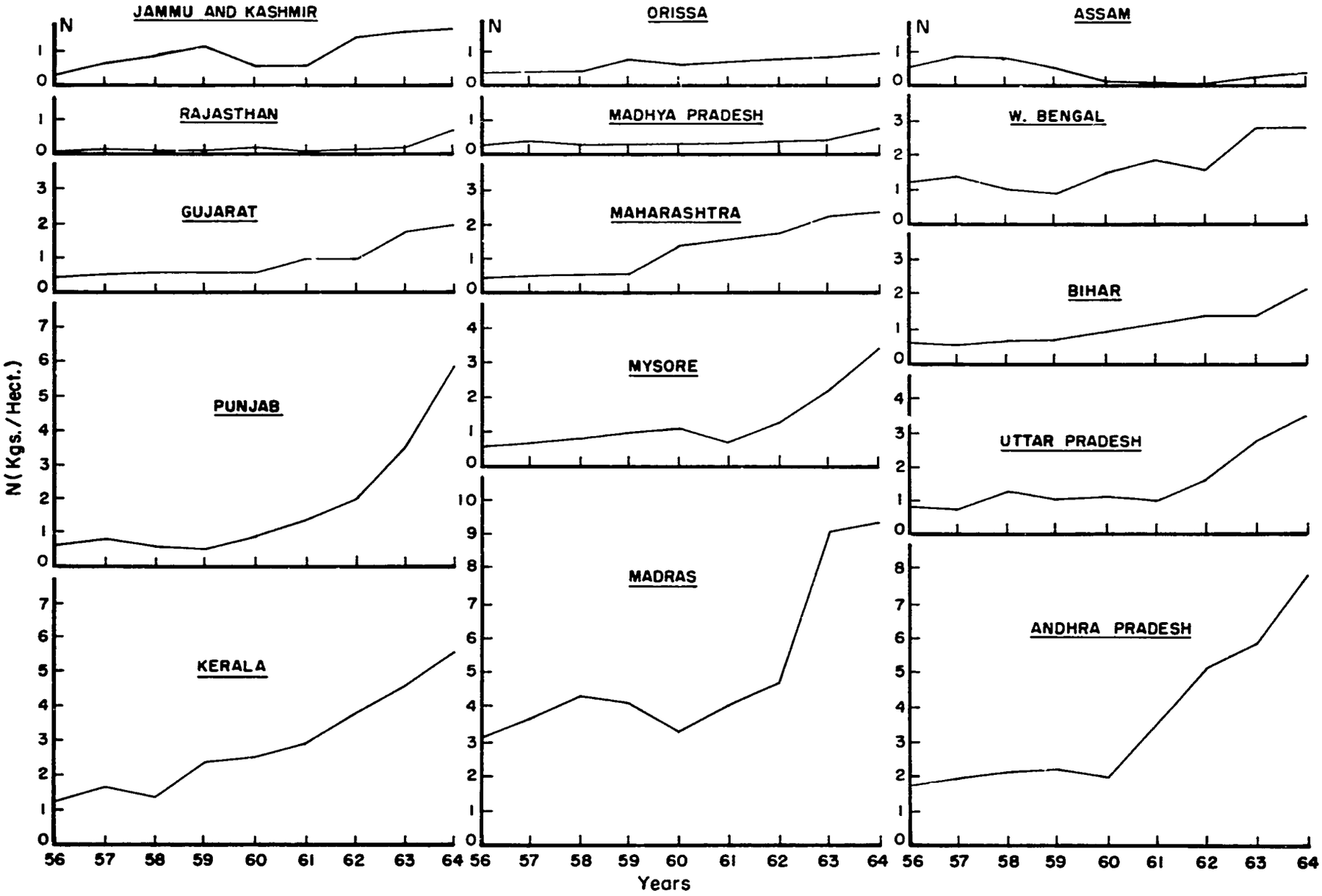
6. See Desai, op. cit., Chapter V for details of regression analysis.

7. See Desai, op. cit., Chapter VI for details of regression analysis.

TABLE 6. CROSS-SECTIONAL VARIATION IN NITROGEN SALES AMONG DISTRICTS WITHIN STATES

	Ref. Year	No. of Dists.	Average Annual Sale of N tons	Limits of Variation Lowest tons	Limits of Variation Highest tons	S.D. tons	C.V. percent
Andhra Pradesh	1959-60	20	1,297	137	3,806	1,229	95
	1964-65		4,554	603	14,049	3,847	85
Assam	1961-62	11	4	0	11	3	75
	1964-65		106	3	319	103	98
Bihar	1959-60	17	509	16	3,333	820	161
	1964-65		1,366	73	5,602	1,541	113
Gujarat	1960-61	17	434	0	2,520	652	150
	1964-65		1,519	3	6,341	1,759	116
Kerala	1959-60	9	571	175	1,446	404	71
	1964-65		1,416	680	3,002	742	52
Madhya Pradesh	1959-60	43	131	5	1,199	258	196
	1964-65		338	39	3,154	583	173
Madras	1961-62	12	1,586	73	4,203	1,072	68
	1964-65		4,631	26	8,478	2,325	50
Maharashtra	1961-62	25	682	14	3,375	717	105
	1964-65		2,082	83	5,916	1,663	80
Mysore	1961-62	19	684	68	3,383	801	117
	1964-65		1,847	151	8,302	1,840	100
Orissa	1959-60	13	369	12	2,242	714	194
	1963-64		430	23	2,223	655	152
Punjab	1959-60	18	398	0	975	279	70
	1964-65		3,164	15	9,326	2,151	68
Rajasthan	1959-60		45	0	404	79	175
	1964-65		397	0	4,233	832	209
Uttar Pradesh	1959-60	48	495	0	2,709	529	107
	1964-65		1,598	288	4,211	1,077	67
West Bengal	1959-60	15	717	46	2,541	690	96
	1964-65		1,448	131	5,186	1,690	117

FIGURE 6-2 GROWTH IN NITROGEN USE IN DIFFERENT STATES BETWEEN 1956-57 AND 1964-65



rates in states with low levels of irrigation (e.g., Gujarat, Madhya Pradesh, Maharashtra).

Implications for Further Rapid Growth in Demand

In the absence of widespread replacement of the existing varieties of crops by varieties more responsive to fertilizer use between the early 1950's and mid-1960's, the growth in fertilizer use duing this period can be considered growth under relatively stable fertilizer production functions. Viewed thus, the above findings on the past use pattern lead to the conclusion that the growth in cultivators' demand for fertilizer during this period was mainly due to diffusion of fertilizer use on irrigated areas under two major foodgrains and a few fertilizer responsive non-foodgrain commercial crops; and the improvement in price situation after 1960-61 brought a marked acceleration in this process.

Inasmuch as the findings on the past use pattern reveal the importance of the absolute size of returns in generating effective demand for fertilizer, and the role irrigation and crop pattern play in determining the returns under the old technological conditions, it is clear that the cultivators' demand for fertilizer would continue to grow rapidly so long as irrigated areas under most crops and unirrigated areas under a few crops such as sugarcane, vegetables and spices are not fertilized and the price situation is at least as favorable as in the early to mid-1960's, the period to which the bulk of the findings on the past growth in fertilizer use relates.

An attempt was made to study this question by estimating the limits up to which cultivators' demand for nitrogenous fertilizers can be expected to grow rapidly under postulated conditions. For this purpose, first the potential for growth in demand as a result of diffusion of fertilizer use on various crops under conditions with respect to varieties, crop pattern, levels of irrigation and prices prevailing between 1962 and 1964 was estimated. These estimates were then scrutinized to arrive at limits of rapid growth in demand from this source by drawing on the analysis of past fertilizer use pattern discussed above. Finally, these limits were adjusted upwards to illustrate the impact of the replacement of old varieties by new varieties of crops under the current High Yielding Varieties Programme. This latter exercise is based on some recent investigations of cultivators' fertilizer practices on new varieties.

Table 7 gives the estimates, based on these assumptions, of growth in demand for nitrogenous fertilizers for different crops.[8] Estimates I

8. These estimates were made separately for each state. Table 7 gives only the totals for all states. For break-up by states as well as for other details of the methodology see Desai, op. cit., Chapter VII.

TABLE 7. ESTIMATES OF POTENTIAL FOR GROWTH IN DEMAND FOR NITROGEN UNDER THE OLD TECHNOLOGICAL CONDITIONS

Crops	Estimate I	Estimate II
	(in 000 tons of N)	
Group A:		
Sugarcane	174	252
Spices	94	120
Potatoes	37	50
Other Vegetables	47	70
Fresh Fruits	57	77
Tobacco	21	26
Sub-total Group A	430	595
Group B:		
Irri. Rice	400	490
Irri. Wheat	151	192
Sub-total Group B	551	682
Group C:		
Jute	12	20
Irri. Cotton	36	50
Irri. Oilseeds	4	8
Sub-total Group C	52	78
Group D:		
Irri. Jowar	13	19
Irri. Bajara	6	8
Irri. Maize	12	17
Irri. Ragi	3	9
Irri. Barley	28	42
Irri. Other Cereals	1	2
Irri. Pulses	25	38
Sub-total Group D	91	135

TABLE 7. (continued)

Crops	Estimate I	Estimate II
	(in 000 tons of N)	
Group E:		
Unirri. Rice	345	477
Unirri. Wheat	110	152
Sub-total Group E	455	629
Group F:		
Unirri. Cotton	78	116
Unirri. Groundnut	35	70
Sub-total Group F	113	186
Group G:		
Unirri. Jowar	154	218
Unirri. Bajara	123	154
Unirri. Maize	36	52
Unirri. Ragi	16	25
Unirri. Barley	16	23
Unirri. Other Cereals	27	38
Unirri. Pulses	120	171
Sub-total Group G	492	681
Total, All Crops	2,184	2,986

are arrived at by multiplying irrigated and unirrigated areas under various crops by rates which are roughly equal to the average rates observed among samples of cultivators in different parts of the country during the early 1960's. To see how these estimates would change if the more usual assumption is made that farmers apply fertilizer at near-recommended rates, another set of rates were developed by adjusting the observed rates upwards. It should be clear from the earlier presentation that there is little evidence to support this assumption that these higher rates will be applied by farmers under the assumed technological conditions. Estimates II are made by multiplying the acreage figures by these latter set of rates.

The crops are divided in the table into following seven groups on the basis of the findings on the speed with which fertilizer use was being adopted on different crops:

Group A: sugarcane, spices, vegetables, fresh fruits, tobacco
Group B: irrigated rice, irrigated wheat
Group C: irrigated cotton, jute, irrigated oilseeds
Group D: irrigated foodgrains other than rice and wheat
Group E: unirrigated rice and unirrigated wheat
Group F: unirrigated cotton and unirrigated groundnut
Group G: unirrigated foodgrains other than rice and wheat

The table indicates that if we assume the conditions with respect to crop pattern, crop varieties, levels of irrigation and relative prices of nitrogen to crops prevailing between 1962-63 and 1964-65, then at the "expected" rates of application the estimate of potential for growth in demand for nitrogen would be about 2.18 million tons. It would go up to 2.99 million tons if we assume that cultivators would generate demand at rates arrived at by adjusting the expected rates upwards.

These two estimates, however, do not indicate the limits up to which demand for fertilizer can be expected to grow very rapidly because they represent the potential for growth in demand for almost all non-plantation crops. It is virtually certain that demand for fertilizer will continue to grow only slowly when the diffusion is more or less complete for crops in Groups A to D, and the use is spreading mainly to crops in Groups E to G which have low returns from fertilizer use. This is clearly brought out by the analysis of the past fertilizer use pattern at each of the three levels of observation. In the context of rapid and huge increase in fertilizer use discussed at the outset, the most relevant question is not whether demand for this input will grow or not, but will it grow fast enough to attain socially desirable levels by mid-1970's. It is, therefore, necessary to examine the estimates in Table 7 from the viewpoint of rapid growth in demand.

The analysis of the past fertilizer use pattern reveals that rapid growth of fertilizer use, despite widespread improvement in the price situation, was confined to irrigated areas under almost all crops and unirrigated areas under only a few fertilizer responsive commercial crops. These crops are in groups A, B, C and D in Table 7. Viewed thus, the limits of rapid growth in demand for nitrogenous fertilizers appear quite low -- 1.12 million tons of nitrogen on the basis of expected rates and 1.49 million tons on the basis of the expected rates adjusted upwards.

How does the introduction of currently available high yielding varieties of rice, wheat, jowar, bajara and maize modify the above conclusion? As one of the chief characteristics of the new varieties is that they shift the fertilizer production functions upwards, it is obvious that they would

increase the returns from fertilizer use and thus raise the above limits of rapid growth in effective demand for fertilizers. Quantification of this impact is, however, difficult due to lack of sufficient information on fertilizer production functions of the new varieties under farm conditions, farmers' fertilizer practices on them, additional cost of labor, seed, insecticides, etc. associated with replacement of varieties, and acreage under the five foodgrains on which replacement of the varieties would be technically feasible and economically profitable.

If we assume that (i) the near term limits of replacing the old varieties by the current new varieties are set by irrigated areas under these crops, (ii) in the short run, the irrigated areas under the five foodgrains used in calculation above (about 48 million acres) represent the amount of areas on which replacement of varieties would be technically feasible and economically profitable,[9] and (iii) per acre average increment in rates of nitrogen application due to change in varieties would be 40 pounds for wheat, and 20 pounds each for rice, jowar, bajara and maize, then the total additional demand for nitrogen as a result of change in varieties would be about 0.54 million metric tons.[10] Thus, inclusive of the impact of the replacement of varieties of the five foodgrains, the lower limit of rapid growth in cultivators' demand for nitrogen would be 1.66 million tons and the upper limit would be 2.04 million tons.

9. It may be noted that this implies about 50 percent increment over the original target of 32.5 million acres of the High Yielding Varieties Programme.

10. These incremental rates imply different average rates of application on the new varieties in different parts of the country because the cultivators who will adopt the new varieties are likely to have different rates on the old varieties. On the lower side the per acre average rates of nitrogen application on the new varieties are thus assumed to be 60 to 65 pounds for wheat, 40 to 45 pounds for rice, and 30 to 35 pounds each for jowar, bajara and Maize. On the higher side they are assumed to be 80 to 85 pounds for wheat, 55 to 60 pounds for rice, and 40 to 45 pounds each for jowar, bajara and maize. For some empirical support for these rates of application on the new varieties see M. Meenaksi Malaya and P. P. Maddappa, Planning and Implementation in Agriculture, Studies in High Yielding Varieties Programme, Vol. I Paddy (ADT 27) in Madras State, Indian Institute of Management, Ahmedabad, 1967, p. 81; and Desai, B. M. and Desai, M. D., New Strategy of Agricultural Development in Operation, A Case Study of the Kaira District in Gujarat, Agro-Economic Research Centre, Sardar Patel University, Vallabh Vidyanager, 1968, p. 105. The rates of application on wheat are based on unpublished findings of T. V. Moorti for a study of tube well irrigation in Aligarh district of Uttar Pradesh.

These figures are considerably lower than the targets of nitrogen use recommended by various agencies for 1970's -- roughly over 3.50 million tons by 1973-74. They are also lower than the present estimates of over 3.25 million tons of expected capacity for the production of nitrogenous fertilizers by then. Thus it appears to us that vigorous policy efforts are needed to avoid the slowing down of the growth in cultivators' demand for nitrogen as it approaches about 2 million tons per year.

What kind of a public policy is needed to raise these limits of rapid growth in cultivators' demand for fertilizers? In view of the importance of significant returns to cultivators from fertilizer use in generating rapid growth in their demand for this input, it is obvious that improvement in marketing channels alone cannot raise these limits substantially. Nor would provision of cheap credit be sufficient to sustain continuous rapid growth beyond limits indicated above as it would not raise the returns from fertilizer use in a large measure. While continuous reductions in the prices of fertilizers through a stream of cost reducing innovations in fertilizer industry would fulfill the above objective, it may not be feasible in the short run. Similarly it may not be feasible to maintain the high prices of agricultural commodities of past 2 to 3 years. Nor might such a policy be desirable because of the adverse effects of such prices on growth in the non-agricultural sector.

Under these circumstances, the solution to the problem of sustaining continuous rapid growth in cultivators' demand for fertilizers lies mainly in accelerating the pace of the following three structural changes: (i) continuous improvement in the currently available new varieties of crops, (ii) development of new fertilizer responsive varieties of crops such as jowar, bajara, cotton, groundnut, commonly grown under unirrigated conditions, and (iii) expansion in irrigated acreage. Efforts in these directions will maintain a rapid growth in demand for fertilizer by continuing the process of technological change underway in the present irrigated areas and by broadening its base. The structural changes mentioned above are more difficult to achieve than the measures which provided the past rates of growth but success could be achieved by a concerted effective government policy.

REPRINT SERIES

1. Fei, John C. H. and Ranis, Gustav, "Agrarianism, Dualism, and Economic Development," in Adelman, I. and Thorbecke, E., editors, *The Theory and Design of Economic Development*, The Johns Hopkins Press, Baltimore, 1966.
2. Vanek, Jaroslav, "Payments Unions Among the Less Developed Countries and Their Economic Integration," *Common Market Studies*, Fall 1966.
3. Vanek, Jaroslav, "Protection Tarifaire des Industries Naissantes Subventions et Bien-etre Economique," *Revue Economique*, November 1966.
4. Vanek, Jaroslav, "Towards a More General Theory of Growth with Technological Change," *The Economic Journal*, December 1966.
5. Mellor, John W., "Production Problems and Issues in Agricultural Development," *Journal of Farm Economics*, December 1966.
6. Kahn, Alfred E., "The Tyranny of Small Decisions: Market Failures, Imperfections, and the Limits of Economics," *KYKLOS*, 1966.
7. Liu, Ta-Chung, "The Tempo of Economic Development of the Chinese Mainland, 1949-65," *An Economic Profile of Mainland China*, the Joint Economic Committee, Congress of the United States, February 1967.
8. Vanek, Jaroslav, "A Theory of Growth with Technological Change," *The American Economic Review*, March 1967.
9. Dowd, Douglas F., "Some Issues of Economic Development and of Development Economics," *Journal of Economic Issues*, September 1967.
10. Staller, George J., "Patterns of Stability in Foreign Trade: OECD and COMECON, 1950-1963," *The American Economic Review*, September 1967.
11. Vanek, Jaroslav, "Economic Planning in Yugoslavia," in *National Economic Planning*, Max F. Millikan (ed.), a Conference of the Universities-National Bureau Committee for Economic Research, National Bureau of Economic Research, New York, 1967.
12. Staller, George J., "Czechoslovakia: The New Model of Planning and Management," *The American Economic Review*, May 1968
13. Galenson, Walter, "Social Security and Economic Development: A Quantitative Approach," *Industrial and Labor Relations Review*, July 1968.
14. Vanek, Jaroslav and Studenmund, A. H., "Towards a Better Understanding of the Incremental Capital-Output Ratio," *The Quarterly Journal of Economics*, August 1968.
15. Vanek, Jaroslav, "The Factor Proportions Theory, The n-factor Case," *KYKLOS*, October 1968.
16. Mellor, John W., "The Functions of Agricultural Prices in Economic Development," *Indian Journal of Agricultural Economics*, January-March, 1968.
17. Mellor, John W. and Dar, Ashok K., "Determinance in Development Implications of Foodgrains Prices in India, 1949-1964," *Journal of Agricultural Economics*, November 1968.
18. Liu, Ta-Chung, "A Monthly Recursive Econometric Model of United States: A Test of Feasibility," *The Review of Economics and Statistics*, February 1969.

19. Mellor, John W., Three Reviews of Indian Agriculture (a) Agricultural Production Trends, (b) Marketing, (c) Village Studies.

20. Bertrand, Trent J., "Rural Taxation in Thailand," *Pacific Affairs*, Summer 1969.

21. Mellor, John W., "Production Economics and the Modernization of Traditional Agricultures," *Australian Journal of Agricultural Economics*, June 1969.

22. Davis, Tom E., "The Economic Development of Chile: Past and Present," *The Overall Development of Chile*, University of Notre Dame Press, Notre Dame, 1969.

23. Bertrand, T. J. and Vanek, J., "Growth with Technological Change, Variable Returns to Scale, and a General Saving Function," *Rivista Internazionale di Scienze Economiche e Commerciali*, August 1969.

24. Vanek, Jaroslav, "Decentralization under Workers-Management: A Theoretical Appraisal,: *The American Economic Review*, December 1969.

25. Mellor, John W., Agricultural Price Policy in the Context of Economic Development," *American Journal of Agricultural Economics*, December 1969.

26. Lele, Uma, "Agricultural Price Policy," *Economic and Political Weekly*, August 1969.

27. Desai, Gunvant M. and Mellor, John W., "Changing Basis of Demand for Fertilizer," *Economic and Political Weekly*, September 1969.