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APPENDIX 1

INPUT CONSUMPTION AND OUTPUT PERFORMANCE PER HECTARE IN DIFFERENT DISTRICTS

Year	Hissar		Rohtak		Gurgaon		Karnal	
	Nitrogen consumption	Production of cereals	Nitrogen consumption	Production of cereals	Nitrogen consumption	Production of cereals	Nitrogen consumption	Production of cereals
1963-64	1·56	710	2·22	766	1·44	609	2·30	1109
1964-65	2·31	667	3·68	713	2·48	661	4·04	1195
1965-66	2·50	435	3·86	884	2·62	781	4·33	1094
1966-67	1·90	635	2·47	875	2·35	953	5·02	1188
1967-68	3·88	901	4·36	1005	5·01	887	11·95	1375
1968-69	6·36	629	7·73	1155	6·46	997	20·39	14·66
1969-70	6·61	1047	4·82	1286	5·76	1172	21·93	18·73
1970-71	7·98	1371	6·96	1408	7·09	1222	37·45	20·56

AN APPROACH FOR DEMAND ESTIMATION OF FERTILIZER USE

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Rapid and continuous growth in the use of fertilizer is necessary to achieve self-sufficiency not only in foodgrains production but also to increase the production of non-foodgrain crops such as cotton, sugarcane, oilseeds, etc., for domestic needs as well as for earning foreign exchange. Equally important is the correct estimation of demand for fertilizer use for arranging adequate supplies through effective fertilizer production programmes and rational imports policy to avoid wasteful investment and to save foreign exchange. Precise estimation of effective demand for different areas is helpful for rational allocation of available supplies.

Generally, the targets of fertilizer use being need-based with no consideration of past use pattern and the potential demand, are highly ambitious. This paper aims at evolving an approach to estimate the effective demand

for fertilizer use based on the past fertilizer use and potential demand. To simplify the discussion the scope of the study was restricted only to the use of nitrogen for Mysore State. Nevertheless, the approach can be used for phosphorus and potash use for other areas with equal advantage. More specifically, the objectives of this study are (*i*) to examine the past pattern of nitrogen use in the State, (*ii*) to estimate the potential demand for nitrogen use for the State, and (*iii*) to project the growth path of effective demand for nitrogen use for the State.

THE APPROACH

The past pattern of nitrogen use was examined by fitting linear and semi-log equations to fertilizer use data for the State from 1960-61 through 1969-70,[1] as given below :

(*i*) Linear equation, $Y = a + bt$

(*ii*) Semi-log equation, $Y = e^{(a+bt)}$

where Y is the use of nitrogen and t indicates years from 1960-61 to 1969-70 (1 to 10).

Projections upto 1978-79 were computed from both the above equations and compared with the actual use during 1970-71, 1971-72 and 1972-73. The projections from both the equations were critically examined for their reliability.

A restricted growth equation with potential demand at a particular point of time as maximum attainable level of effective demand for the State was used as given below :

$Y = M e^{-abt}$ where

Y is the effective demand for fertilizer use and t indicates year to which Y corresponds beginning from 1960-61 = 1, M is the potential demand.

The potential demand under the existing set-up (1972-73) was computed from the area under different crops (irrigated and unirrigated), the area under high-yielding varieties (HYVs) of different crops[2] and nitrogen rates[3] of

1. Nitrogen use data for the years 1960-61 through 1968-69 was taken from Annexure 2, Table IX of the study by W. B. Donde and D. D. Brown: Effective Demand for Fertilisers in India, May, 1971, and for the year 1969-70, Department of Agriculture, Government of Mysore.

2. The data on the area under different crops (1971-72), and the area under HYVs (1972-73) were taken from the Department of Agriculture, Government of Mysore. The area under different crops was adjusted for 1972-73 to make it consistent.

3. The data on nitrogen rates for different crop varieties were used from Fertiliser Statistics 1971-72, Fertiliser Association of India, December, 1972.

application for different crop varieties under irrigated and dry conditions with the help of following aggregation model :

$$\hat{D}_p = \Sigma A_i R_i + \Sigma A'_i (R'_i - (R_i), \text{ where}$$

$\hat{D}_p$ is the estimate of potential demand (in kg.) of nitrogen use for the State, A_i and A'_i are the total area (hectare) under the local and high-yielding varieties of 'i'th crop, R_i and R'_i are nitrogen rates (kg./hectare) for the local and HYVs of 't'th crop respectively. (For any crop, irrigated and rainfed area were treated as two different crops.)

The estimates for the year 1978-79 were computed by increasing the area under high-yielding varieties, irrigated area under different crops, and gross cropped area at linear growth rates of 20, 10 and one per cent per annum from 1972-73 levels to 1978-79.

PAST PATTERN OF NITROGEN USE IN THE STATE

The level of nitrogen use during 1960-61 was at 10,906 tonnes. It increased to 87,473 tonnes during 1969-70. The average annual increment was worked out at 7,377 tonnes. It was found that during the first half of the 'sixties the absolute increase in the use of nitrogen was much lower than the absolute increase during the second half, *i.e.*, 24,179 and 52,388 tonnes respectively. This was primarily due to the introduction and spread of HYVs of major cereals on about 0.41 million hectares during the second half of the 'sixties. Moreover, larger increment in the gross irrigated area during the early 'sixties (63 thousand hectares) compared to that during the late 'sixties (99 thousand hectares) also contributed to larger absolute increase in nitrogen use during 1966-67 to 1969-70. The increasing increments in the nitrogen use in the successive years pointed out that the average annual increment was not the appropriate measure to study the growth in use of nitrogen for the State. Thus the annual compound growth rate was computed. It shows that from 1960-61 to 1970-71 the use of nitrogen in the State grew at a compound growth rate of 29.9 per cent per annum. Though the compound growth rate was sufficiently high the absolute level of use was felt low.

PROJECTIONS FOR NITROGEN USE

(*a*) *Linear and Semi-Log Projections*

Linear and semi-log projections of nitrogen use for the years 1970-71 to 1978-79 along with the actual use during 1970-71 to 1972-73 are given in Table I. It was found that linear projections were below the actual use for

TABLE I—ACTUAL AND PROJECTED USE OF NITROGEN FOR MYSORE STATE

(*thousand tonnes*)

Year	Actual use*	Linear projections	Semi-log projections
1970-71	92·2	77·8	81·6
1971-72	87·6	85·2	101·4
1972-73	107·6	92·6	125·8
1973-74	—	99·9	156·2
1974-75	—	107·3	193·9
1975-76	—	114·7	240·8
1976-77	—	122·1	298·9
1977-78	—	129·4	371·1
1978-79	—	136·8	460·7

* Department of Agriculture, Government of Mysore.

all the three years. This was because of the nature of growth linear equation implies, *i.e.*, constant absolute increments against increasing increments expected in the use of nitrogen for this period. On the other hand, semi-log projections except for 1970-71 were significantly above the actual use. The projected use for the year 1972-73 was unachievable under the given conditions. For the years 1973-74 and onwards these projections are of fantastic magnitudes *e.g.*, 4,607 thousand tonnes for the year 1978-79 (more than 400 per cent of 1972-73 actual use). This was due to the ever increasing absolute increments, *i.e.*, constant ratio of change, the semi-log equation implies. It is clear from the magnitude of these projections that this rate of growth is not possible to prevail even in the short run.

(*b*) *Restricted Growth Phenomenon*

Because over a period of time the chronological series are not likely to show either a constant amount of change or a constant ratio of change, both the linear as well as semi-log equations are not suitable for projecting nitrogen use especially for the long run. However, it is more likely that an increasing series will show an increasing increment but a decreasing rate of change or even a decline in the amount of change. This is because in a spatially limited universe the amount of increment for a particular unit of time at any point in a single cycle of growth is proportional to two things, *i.e.*, (*i*) the absolute level already achieved at the beginning of the unit interval under consideration, and (*ii*) the amount yet to be achieved, *i.e.*, the difference between ultimate attainable under *ceteris paribus* conditions and the level already attained.

(*c*) *Projections under Restricted Growth*

Considering the above facts in view, a restricted growth equation was used to estimate the effective demand for nitrogen use taking potential demand as the maximum level of effective demand attainable.

(*i*) *Potential Demand for Nitrogen Use*

The estimates of potential demand for nitrogen use were computed from aggregation model given earlier for the existing set up (1972-73) as well as for the changed set-up (1978-79). Accordingly, the estimates worked out at 4,00,000 and 5,00,000 tonnes of nitrogen use. Table II gives the potential by groups of crops. These groups are :

Group I .. Sugarcane, cotton, tobacco, chillies, potato and other plantation crops;

Group II .. Rice, jowar, maize, bajra and wheat;

Group III .. *Ragi*, barley and other minor millets; and

Group IV .. Oilseeds, pulses and other miscellaneous crops.

TABLE II—BREAK-UP OF POTENTIAL DEMAND BY GROUPS OF CROPS FOR MYSORE STATE

(*thousand tonnes*)

Groups of crops	Estimated potential demand	
	Existing (1972-73)	Anticipated (1978-79)
I	72	93
II	235	309
III	45	47
IV	48	51
Total	400	500

These groups were made on the assumption that in general the cultivators first take up the fertilizer use on group I crops and then extend its use to other groups in order of II, III and IV respectively.

The increase in the potential demand over a period of time (for 1978-79) was attributed to group I and II crops because the anticipated increase in the irrigated area and the diffusion of HYVs on the irrigated as well as unirrigated areas will result in more use of nitrogen under these groups only. Moreover, any improvement in the cropping pattern due to shift in crops or due to increase in gross cropped area was expected to be in favour of group I and II.

(ii) Projections from Restricted Growth Equation

The restricted growth equation was fitted to 10 years nitrogen use data from 1960-61 to 1969-70 for Mysore State for the existing (1972-73) and anticipated (1978-79) potential demand. Projections arrived at from the two equations are shown in Table III.

TABLE III -PROJECTION OF NITROGEN USE FROM RESTRICTED GROWTH EQUATIONS FOR DIFFERENT LEVELS OF POTENTIAL DEMAND

(thousand tonnes)

Year	Projected effective demand for potential demand at	
	4,00,000 tonnes	5,00,000 tonnes
1970-71	85·9	86·8
1971-72	97·7	99·3
1972-73	109·9	112·3
1973-74	122·4	125·9
1974-75	135·1	139·9
1975-76	147·9	154·3
1976-77	160·6	168·8
1977-78	173·3	183·4
1978-79	185·9	198·0

The comparison of estimates with the actual use during 1970-71 to 1972-73 showed that for both the equations the projected use was lower by 6.3 and 5.4 thousand tonnes for the existing (1972-73) and anticipated (1978-79) potential. However, the actual use was above the projections during 1971-72 and 1972-73. The projection for the year 1972-73 on the basis of existing potential demand of 400 thousand tonnes during 1972-73 was close to the actual use during 1972-73. The little difference of 2.3 thousand tonnes could be due to the abnormal weather conditions during 1972-73. In the long run owing to the changing potential demand, the estimates on the basis of existing potential worked out to be 186 thousand tonnes, might be on the lower side. However, the estimates of effective demand of 198 thousand tonnes for the year 1978-79 using the anticipated potential demand for 1978-79 (5,00,000 tonnes) could be more realistic.

It is clear from the estimates of effective demand at different levels of potential demand that with the increase in the potential demand the effective demand also increases. Obviously the difference between the estimates from the series of estimates of effective demand is increasing over a period of time.

The change in the effective demand due to the change in the potential demand implied the increased increments for a longer period for the projected part of the growth curve by pushing the point of deflection higher to the left, *e.g.*, for 400 thousand tonnes of potential demand the point of deflection is during 1976-77 at between 148 to 161 thousand tonnes of effective demand while for 500 thousand tonnes of potential demand the point of deflection was shifted to during 1979-80 between 198 to 213 thousand tonnes of effective demand for nitrogen use.

From the above discussion it follows that to achieve the targetted use of 291 thousand tonnes of nitrogen (estimated by the Department of Agriculture, Government of Mysore) by 1978-79, more rapid growth in the use of nitrogen is required. The rate of growth, however, is the function of actual nitrogen use in the past and the potential demand for certain point of time. Since the actual use is given, the only scope to increase the effective demand is through increasing the potential demand. This could be achieved through a rapid growth in the irrigated areas and the spread of the high-yielding varieties. Evolving new strains more responsive to fertilizer use of not only cereals but of all important crops suitable for the irrigated and unirrigated areas will be helpful to increase the potential demand. In fact the increase in the effective demand will create an atmosphere suitable for more rapid growth in the effective demand than what our model explains on the basis of past use pattern when these structural changes were absent.

APPENDIX

ESTIMATED PARAMETER FOR DIFFERENT GROWTH FUNCTIONS

Growth function	Value of M (thousand) tonnes)	Estimated regression coefficient		Value of R^2
		$\hat{a}$	$\hat{b}$	
$Y=a+bx$	—	—3332·73	7376·77	·889*
$Y=_e a+bx$	—	9·14727	·216285	·968*
$Y=M/_e abx$	300	1·32628	—·09914	·953*
,, ...	400	1·38801	—·08704	·958*
,, ...	500	1·43563	—·07959	·961*
,, ...	800	1·53257	—·06753	·964*

* Significant at ·01 level.

Note : Values of $\hat{a}$ and $\hat{b}$ except for the linear function are in log form.