FERTILIZER POLICY IN THE DEVELOPING COUNTRIES — THE CASE OF BRAZIL *

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RESUMO

O trabalho discute a importância dos adubos minerais na elevação dos rendimentos agrícolas.

É mostrada em seguida a evolução do consumo de adubos minerais no Brasil acima da curva de tendência histórica e das metas fixadas, discutindo-se as possíveis causas do fenômeno.

As perspectivas do consumo são discutidas.

É sugerido que a experiência brasileira possa ser útil a outros países em desenvolvimento em condições semelhantes, com as adaptações necessárias.

INTRODUCTION

The classical roles of the agricultural sector of the economy are well known:

(1) providing abundance of food and fiber to meet the needs of the population;

(2) supplying raw materials for the industry;

(3) providing exportable surpluses for the obtention of the hard currency needed for the establishment of a competitive industry.

In order to fulfill these roles it is compulsory to seek a balance among three types of productivity:

(1) the productivity of the soil — plant system or that of the soil-plant--animal chain:

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(2) the productivity of the work force;

(3) the productivity of the capital

By this way, the improvement and the expansion of the Agricultural activities will support the take off and play a major role in the sustained growth of the economy as awhole.

When a developing country — Brazil and others — has the need for increasing agricultural production, a priority has to be set as to which type of productivity should be given prominence. Usually the three of should receive equal treatment only after the stage of sustained growth is reached. In the beginning, however, it seems that more emphasis should be placed in points (1) and (2): labour is plentifull, capital resources are either scarce of poor by distributed (or both), productivity of soils, plants and animals is low.

If this basic assumption is accepted, the problem to solve could be summed up as follows:

> maximize the productivity of the soil-plant system or that soil-plant-animal chain — in economical terms;

one should not forget however, that ecological equilibrium has to be preserved and, therefore, maximization coild conceivably not be desired in the long run.

The production or yield of a given crop is the result of the interplay of several factors:

> yield — function of variety, climate, soil, cultural practives, diseases and pests, man.

In seeking to raise total production, two alternatives could be thought of: expansion of the cultivated land by the displacement of the agricultural frontier; increase in the level of production of the some cultivated area through the application of the needed in puts to obviate limiting factors. At first glance, it would appear that the first alternative would be the easiest one. Estimates prepared by the Food and Agriculture, Organization (F. A. O.) of the United Nations, point out, however, that no more than 25 per cent of the additional food and fiber required by the developing countries could be obtained by cultivating new land — unless massive capital investments are made in order to put into use land which is under unfavourable conditions. The other alternative, there fore, should be sought for, at least in short and medium range plans. Other factors being kept constant, fertilizers are the main responsible for the obtention of accelerated gains in productivity, that is, production per unit area. The existence of a close, direct, cause-and-affect relationship between fertilizer usage productivity is abundantly proved in world, regional and national scales (see MALAVOLTA, 1969, 1970; PARKER, 1963; WILLIANS & COUSTON, 1962; CUMMINGS & GLEASON, 1971):

(1) the more intensive use of fertilizers in developing nations could raise production of several commodities by a factor as high as four;

(2) fertilizers participate with as much as forty percent in relation to other compenents (seed, irrigation, etc.) in the increase in yield.

FERTILIZER USE IN BRAZIL (*)

Table 1 shows the evolution of fertilizer consumption in Brazil in the period 1950/71, as well as the participation of imports as percentage of the total used each year. It is shown that in a little more than twenty years the usage incresead thirteeenfold; the rate of increase was nearly twice as fast as that observed in a worldwide scale. A graphic presentation is given in Figure 1. The participation of the local industry was kept almost constant percentwise.

The pattern of distribution in the several groeconomical regions is summarized in Table 2. Which indicates that the more heavely cultivated ones have a larger share of the total consumption, as one would expect; only one third of the total cultivated land receives fertilizers.

As shown in Table 3, three cash crops (sugar cane, coffee and cotton) receive from half to two thirds of the total tonnage applied; expansion of usage, therefore, would take place to a large extent in crops such as coffee, grains and beans and others in which the dosages applied are well below the recommended ones — provide other factors are kept constant; it should be stressed, however, that the presented figures bear a higth degree of uncettainty due to the lack of more precise and up dated statistics .

The evolution of consumption of nutrints (sum of N, P_2O_5 and K_2O) per unit area cultivated land is shown in Figure 2. The sharp increase in the period 1967-71 is noteworthy; due to this dramatic break in the previous historical frend, fertilizer applied per hectare increase from 7 to 30 kg. Causal reasons for this new frend of accelerated annual increases will be discussed in the next section. In passing, however, some backgroud information should be provided. In the period 1950-60, as recalled by CIBANTOS (1972, pp. 18-21) consumption grew at the rate of 16,5% per year; during 1961 to 1964 the country faced economical and political problems which unfavourably affected the production process of the agricultural section and, as part of it, the use of fertilizers: in 1961, for instance there was in effect a decrease of 17% in relation to the previous year; the increase between 1961 and 1966 was less than 1% per year; after 1964 political and economical stabilization of the country began and steps were taken to raise agricultural production; consumption of fertilizers was one of the components of the general agricultural policy which encompassed many aspects from land reform to social security in the rural areas to facilities for export; as a result in the five year period going from 1967 to 1971 the annual rate of increase of fertilizer use was 34%.

(*) This paper was already written when statistics for consumption in 1973 became available: N — 411604 tons, P_2O_5 — 874935; K_2O — 459983, total — 1746523 tons; increase over 1971 — 41 per cent.

Present needs of fertilizers were calculated by using three different criteria, namely: (1) maintenance of soil fertility through the application of the actual amounts of N, P and K which are exported by the 28 major crops; (2) the same plus additional amounts introduced according to generally accepted coefficients (MALAVOLTA, 1967, pp. 462-464); (3) supply of the elemens according to recommended rates. The results summarized in Table 4 show a fairly good agreement between the last two criteria. The gap between todays needs and consumpition are of the order of 7 million metric tons in roud figures. This means that Brazil is using roughly one sixth of the amounts actually required by the major corps. If one considers the artificial forests (over 1 million ha) and some of the pastures (over 100 million ha are natural pastures) the total requirements of nutrients would easily reach a grand total of 10 million matric tons. The same criteria could, of course, be projected by taking into account the know historical trend in the annual expansion of cultivated land.

Data from Table 1 were used to fit four different types of regression equations (first, second and third degree and exponential) for each of the nutrients and for their total; extrapolations were made in each case for consumption in the years 1975, 1980, 1985 and 1990; the results obtained appear in Table 5. In all cases best fitting, as revealed by the R^2 value, was provided by the third degree equation. This approach of course, carries all the restrictions which affect this type of extrapolation. According to the best equation the country would reach a consumption commensurate with present needs only in 1985 — not considering the likely expansion of cultivated land. SEITEC (1973-b, pp. 8-18) estimated the demand for fertilizers in 1975 by using and econometric equation in which the variables were cultivated land and gross agricultural product; when the latter was optimistically assumed to grow at the rate of 7% the total consumption would be 2.052.806 tons which is very close to the value of 2.161.000 tons fiven by the third degree equation. Purther speculations in this respect, part of the realm of futurology are not worth while: as pointed out by SEITEC (1973, p. 21) none of the methods (econometric or others) which have been tried to study the demand of fertilizers in Brazil were able to explain the jump in consumption which took place from 1967 to day.

FERTILIZER POLICY IN BRAZIL

In preceding sections attention was drawn to the sharp increase in fertilizer consumption in the period starting shortly after the year 1964. An attempet will be made next to explain background situation and actual steps which, when put together, resulted in such a steep raise withim a relatively short time. A Comprehensive fertilizer policy was first proposed by MALAVOLTA (1964) in a symposium sponsored by the Brazilian Association for the Advancement of Science (Sociedade Brasileira para o Progresso da Ciência) and reiterated before the National Council of Economics (Conselho Nacional de Economia (MALAVOLTA, 1966). Emphasis was made with respect to the need of: short range steps such as credit, minimum prices, facili-

ties for importation, modernization, expansion and installation of local industries; long range plans with respect to farmer education, research and self sufficiency in production of fertilizers.

Research on the use of fertilizers in Brazil started in the end of the XIX Century, almost one hundred years ago (see DAFERT et al., 1929). Due mainly to the efforts of two single institutions, the Institute of Agronomy (Instituto Agronômico) at Campinas and the College of Agriculture (Escola Superior de Agricultura «Luiz de Queiroz») of the University of São Paulo at Piracicaba, both in the State of São Paulo, information was gained and accumulated through research work to permit the estabelishment of pratical recommendations for the use of fertilizer so the the classic questions what? how much? Whem? will it pay? could be answered withen acceptable limits. To this effect thousands of experiments were carried out all over Brazil with the main crops; coffee, sugar cane, cotton, corn, rice, beans and more recently, cocoa.

Results of the experimental work were adapted and transferred to the farmer by the extension agencies and by the fertilizers industry itself through their salesmen and agronomists. More recently a campaign of simple experiments and practical demonstration of the use of fertilizers and the benifts there of in cultivators fields was launched in some of the less developed regions of Brazil. Such a campaign, a joint effort of the Brazilian Association for the Diffusion of Fertilizers (Associação Nacional para Difusão de Adubos — ANDA) a private organization supported by funds provided for by the fertilizer industry and by National Development Bank of Brazil (Banco Nacional do Desenvolvimento Econômico, BNDE) and F. A. O. was first suggested by MALAVOLTA (1964). Analysis and interpretation of data obtained in thousands of demostration and experiments are carried out by the College of Agriculture of the University of São Paulo at Piracicaba. Table 6 gives the distribution of simple experiments and demonstrations according to region and crop. For a discussion of results and trends see VEGA (1972) and ANDA (1972). It is estimated that nearly 15 thousand have benefited from the program so far.

A credit policy designed to increase the use of fertilizers was defined in the year 1966 in the form of an indirect subsidy. In the first phase the Federal Government absorved the total interest owed by the farmer to the supplier; the latter was paid in full and promptly ob official or private banking agencies: the farmer would pay back after marketing the products. In the second phase (1970) the farmer pays 7% interest per year, well below the rate of devaluation of the currency. It is estimated that on the very first year of implementation the new policy led to: savings of the order 3 million dollars; use of additional volume of 300000 tons of fertilizers. A shown in Figura 3 there as in the years 1966/71 a close relationship between credit money and fertilizer used. Despite the limitations in credit which took place in 1971 the upward trend in consumption did not stop. This suggests that a although credit played a major roles other factors also intervened in the phenome-

non, as discussed in the following item. The so called «invisible in put», farmer education, has certainly contributed: in a nationwide survey of 2700 farmes SEITEC (1973-a. p. 2) has found that in general there is significant motivation for the use o fertilizers. The rather realitively large weight of credit in the increseased use of fertilizers was assessed by KNIGHT (1971, pp. 171-172) and CIBANTOS (1972, pp. 31-35) on regional scales by using econometric models.

The examination of the evolution of price indexes for fertilizers and agriculture products in the period 1950/71 shows a favorable trend in the relationship (Table 7). Real average prices of N, P_2O_5 and K_2O show a definite downward tendency as indicated in Figura 4. The minimum prices fixed in the regional scale plus the effective garantee of official purchase was to a large extent a determining factor of the beneficial results observed in the period 1966/71. The increase in the value of the agricultural products usually was larger than that observed in non agricultural goods: in the period 1970/73 the average price of coffee increased 97% whereas the price of other goods (shole sale) was raised less that 70%. The analysis prepared by SEITEC (1973-a, p. 15) has stressed also that the way the consumption of fertilizers reacts to variations in profit is quite sensitive, as antecipated by the discussion.

As already mentioned, the examination of Table 1 indicates a slight decrease in the percentage of participation of imports in total consumption: from 85 in 1950 to 81 in 1971. Local production, however, was raised from 13.3 to 213.7 thousand tons, a six teenfold increase. This expansion of the mostly private industry was to a large degree the result of the governmental policy in defining priorities as well as in providing capital resources and legal means for implementing them. Plants already in operation or under instalations will produce in 1975 366.5 thousand tons of N and 749.5 thousand tons of P_2O_5; a production of 300.000 tons of K_2O is expected in 1976. The situation ensofar raw products are concerned is the following; know reserves of natural gas are estimated in 26 x 10^9 cubic meters; rock phosphate deposits (usually low grade) — 340 million tons; potassium — 500 million tons. It is that in the next years. Brazil will continue to depend on imparts both of raw products and of finished fertilizers. The known stages of development in the fertilizers industry will take place: the uncertainty exists with regards of assigning exact figures in the axis of xx which shows time as an independet variable (HARRE et al. 1971). In order to produce locally the 10 million tons of fertilizers that the country requires at present an investiment of the order of 1.4 billion dollars would be necessary. F. A. O. (1969) estimated in 12 billion dollars the total investiment for additional plants to produce the fertilizer neeeded by the developing countries in 1985. Data assembled by the TVA (1970) led to a cost of 18.1 billion dollars. The calculation for Brazil was based in the rule-of-thumb that a plant designed to produced 1000 tons of fertilizers per day would cost U. S. $ 60 million, according to PARKER & NELSON (1966).

Physical facilities for import, storage and distribution represent a bottleneck for further development in the use of fertilizers in Brazil. Port ter-

minals are still inadequate to handle and to store the volumes fast and efficiently. Inland trans por takes place mostly in bags carried by trucks; railroad transportation in bulk is still the exception. Despite these handicaps the private industry, responsible for nearly one hundred percent of production, importation, distribution and marketing has been able to supply the needed fertilizer in the right place in the right time.

SUMMARY

This paper deals initially with the role of mineral fertilizers in increasing agricultural production: the relationship between the two variables is illustrated within global, regional national and local contexts. The pattern and trends in fertilizer usage in Brazil are presented next, namely: increase in consumption in the period 1950/72; regional distribution; consumption as related to crops and cultivated land. It is shown that in less than a quarter or century fertilizer use has increased in the country nearly 12 fold, whereas world consumption was raised 7 fold, thus exceeding estimates based in several criteria. Steps taken to secure the raise in fertilizer consumption above the historical trend are discussed: research experience for outlining fertilization recomendations; the transfer of the knowledge to the farmer by the extension work both official and private; the credit policy and special incentives for the purchase of fertilizer; the national policy for minumum proces of agricultural products; the implantation of a national fertilizer industry. It is considered that the Brazilian experience adapted to similar local conditions in other developing countries, presents a possibility for achieving beneficial results without inflationary reflexes in the economy.

ACKNOWLEDGEMENTS

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NOTE ADDED

This paper had already been completed when it became apparent that due to the curtailing in shipment of oil from Middle East Sources the Brazilian effort to increase fertilizer usage could be jeopardized at least in the short run. Bilateral agreements with suppliers of raw materials (either traditional or not) should be negotiated. Local production (expansion and installation of new plants) should be intensified on the other hand, production of electrolytic hydrogen using the energy of the new hydroelectric plants shoud be evaluated.

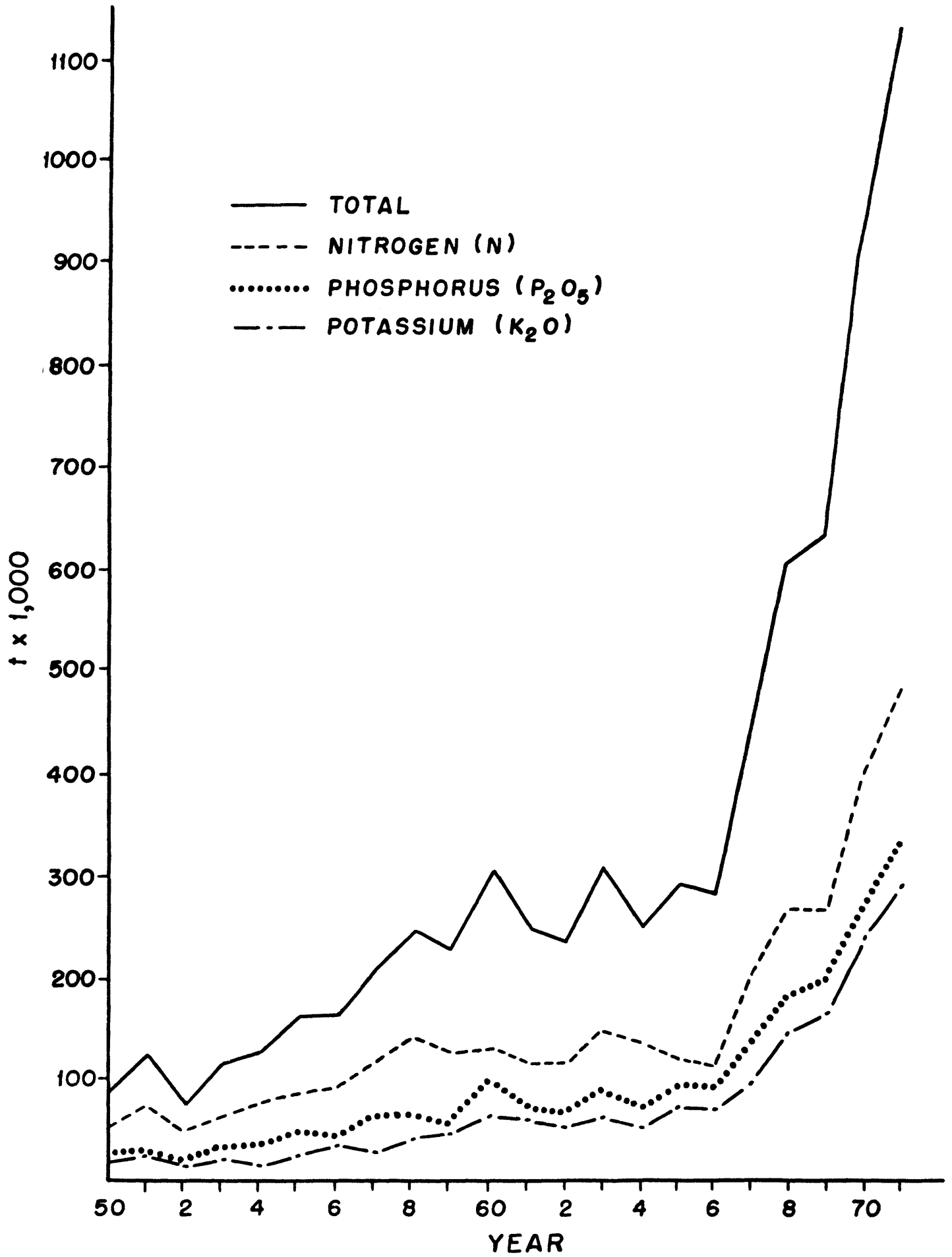

FIGURE 1 - *Evolution of consumption of fertilizer in Brazil in the period 1950 - 1971.*

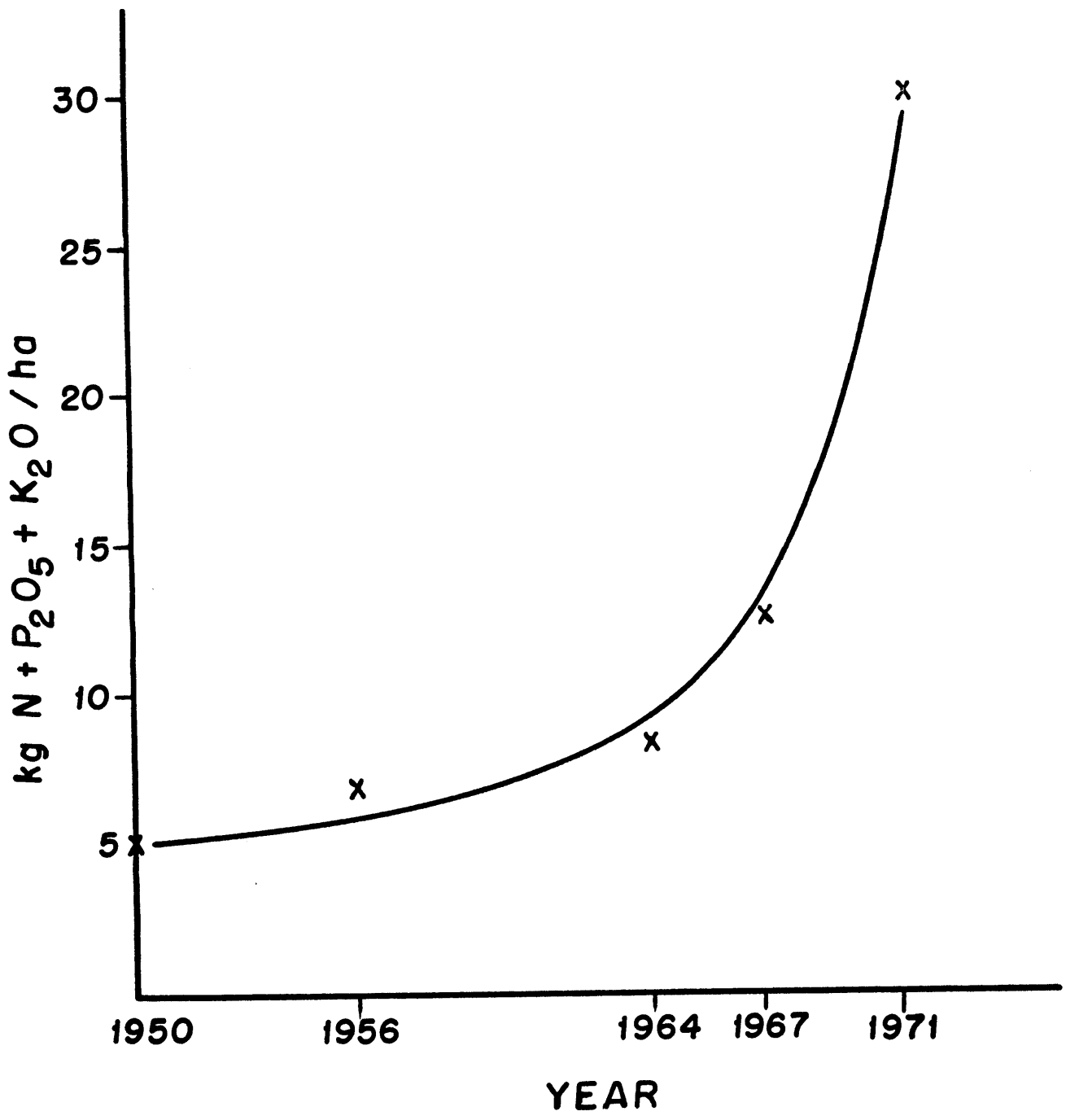

FIGURE 2 - Evolution of consumption of nutrients per unit area in Brazil.

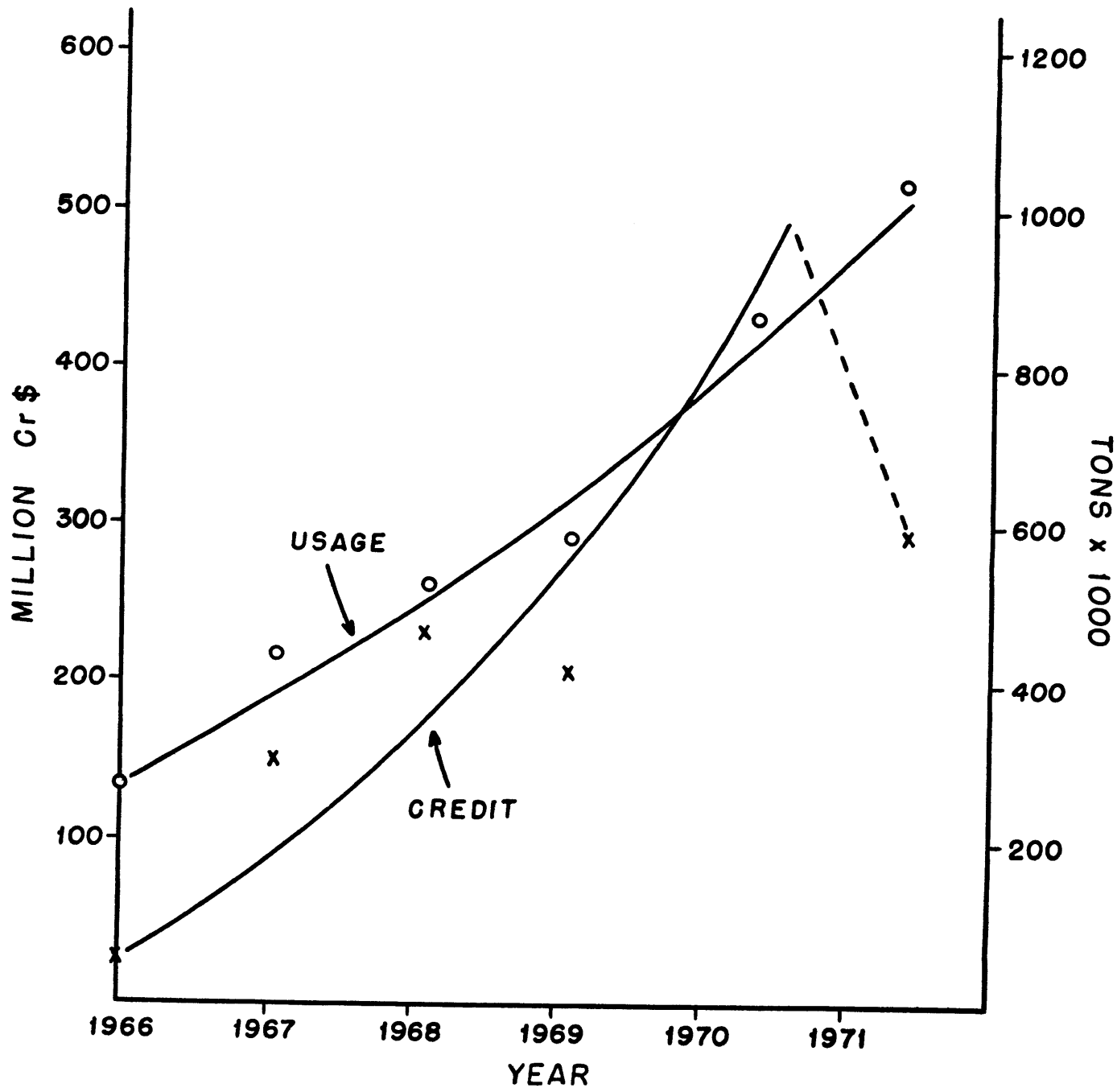

FIGURE 3 - Trends in fertilizer use and credit.

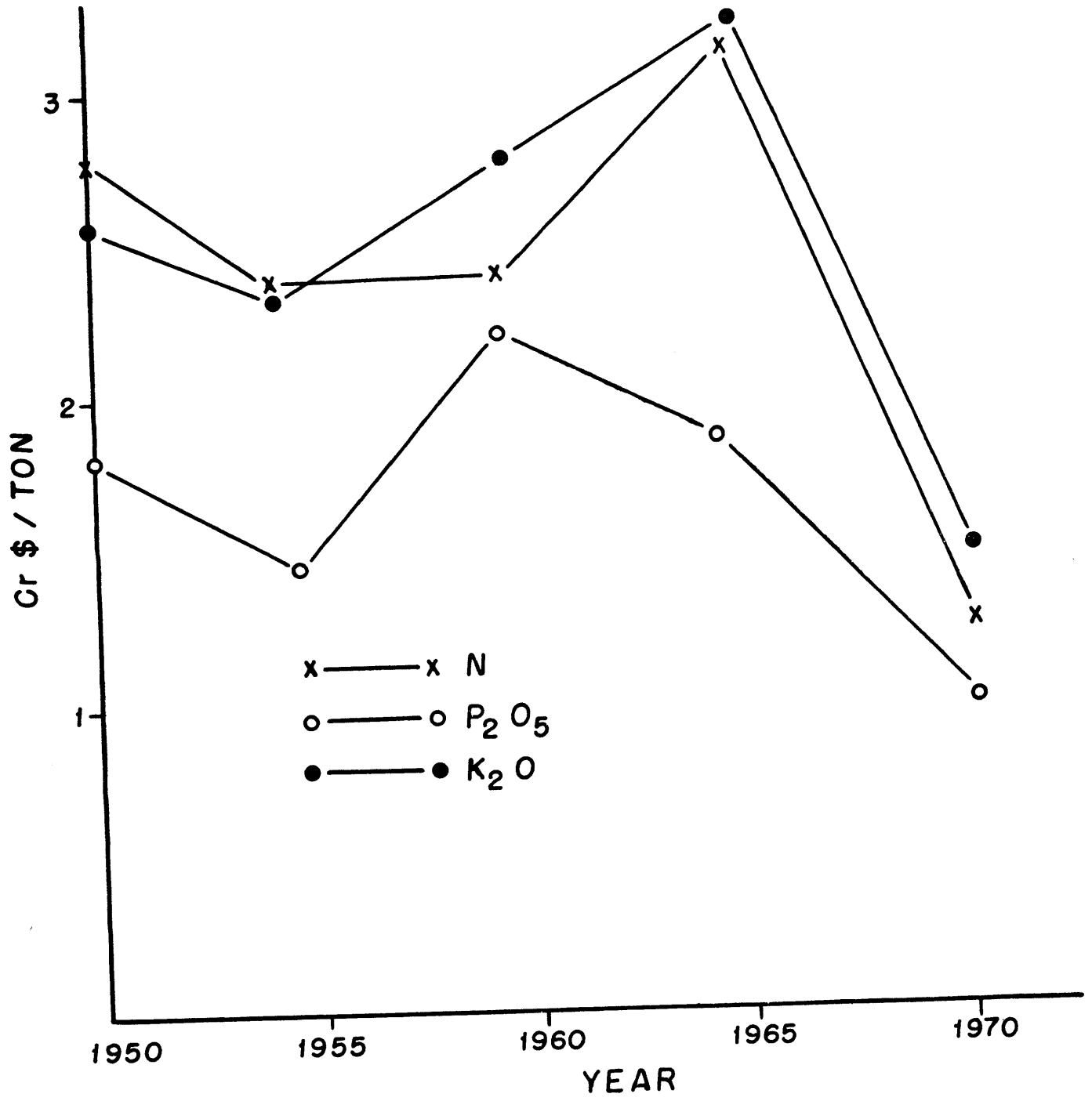

FIGURE 4 - Trends in real average prices of fertilizers.

Year	tons of N	P_2O_5	K_2O	Total	Total %	Imports %
1950	14187	50836	23523	88546	100	85
1951	18561	73569	28709	120389	136	88
1952	10605	46923	15347	72875	82	77
1953	20579	64816	31226	116621	131	85
1954	17762	77389	28348	123494	139	89
1955	22951	88575	49523	161049	181	84
1956	30238	93559	41632	165429	186	85
1957	28558	118689	60189	207436	234	79
1958	41390	143349	65082	249821	282	77
1959	44785	124005	57425	226215	255	65
1960	66760	131591	106155	304497	343	65
1961	55064	118761	70727	244557	276	61
1962	50284	119793	68127	238204	269	59
1963	62061	153385	91750	307196	346	65
1964	50808	135052	69564	255424	288	58
1965	70569	120097	99732	290398	328	66
1966	71134	116648	93337	281119	317	68
1967	103382	204606	136937	444925	502	74
1968	144320	273094	184295	601709	679	78
1969	164430	265665	200292	630385	711	79
1970	235121	403190	272716	913693	1031	81
1971	291975	486127	347002	1125004	1271	–

Table 1 - Evolution of consumption of fertilizers in Brazil

Region	Cultivated land % of total	Area fartilized % of cultivated	Consumption % of total
North	2	< 1	< 1
North east	17	6	9
Center South	58	45	65
South	23	38	25
Brazil	100	35	100

Table 2 – Consumption of fertilizer in geoeconomical region (estimates)

Crop	consumption % of total	% of recommended
Sugar cane	20 - 30	50 - 60
Coffee	20 - 25	20 - 25
Grains and beans	10 - 15	2,5 - 5
Cotton	10 - 15	15 - 20
Vegetables	5 - 10	40 - 50
Other	15 - 20	5 - 10
Total	100	14

Table 3 – Estimates of fertilizer consumption in the main crops

Criteria	1.000 tons N	P_2O_5	K_2O	Sum
1. Export, 28 crops	2172.4	384.4	1705.6	4262.4
2. Same + correction coefficient	3103.0	1972.0	3410.0	8485.0
3. Recommendation, 28 crops	2299.8	3393.8	2532.3	8225.9
Average 2. and 3.	2746.4	2682.9	2971.1	8355.4

Table 4 – Estimate of the Brazilian present needs of fertilizers according to three criteria

Nutrient	Equation	R^2	Usage, 1000 t: Actual 1971	Calculated 1975	1980	1985	1990
Nitrogen (N)	YE= - 34939.07 + 9423.65 X	0.6878	292	210	257	304	351
	YE= 47577.40 - 11205.47 X+ 896.91 X^2	0.8873		362	562	806	1096
	YE= - 22212.89 + 21616.20X - 2592.59 X^2 + 101.14X^3	0.9647		565	1169	2115	3477
	YE= $10^{(4.026239 + 0.0580566\ X)}$	0.9301		343	670	1307	2550
Phosphorus (P_2O_5)	YE= - 4671.11 + 13883.35X	0.6564	486	356	426	495	564
	YE= 107670.00 - 14201.92X + 1221.09X^2	0.8189		564	841	1179	1578
	YE= -22603.20+ 47064.24X - 5292.56X^2+ 188.80X^3	0.9375		942	1975	3621	6023
	YE= $10^{(4.6861410 + 0.0367187\ X)}$	0.8307		437	667	1019	1554
Potassium (K_2O)	YE= - 29237.48 + 11010.92 X	0.7102	348	257	312	367	422
	YE= 5739.00 - 10647.19 X + 941.65 X^2	0.8765		417	632	894	1203
	YE= -23685.96 + 27484.36X - 3112.39X^2+ 117.50X^3	0.9555		652	1338	2414	3970
	YE= $10^{(4.2681680 + 0.0509552\ X)}$	0.8982		392	704	1266	2277
Total	YE= - 69132.42 + 34351.38 X	0.6865	1126	824	995	1167	1339
	YE= 212718.40 - 36111.34 X + 3063.59 X^2	0.8612		1345	2037	2883	3882
	YE= - 68849.89 + 96307.39 X - 11014.83 X^2 + 408.07X^2	0.9560		2161	4488	8161	13488
	YE= $10^{(4.884261 + 0.0449939\ X)}$	0.8931		1132	1901	3192	5358

Table 5 – Actual usage (1971) and projections bases on several regression equations

Region	Rice	Bean	Crop Cotton	Corn	Sugar-cane	Others
North-east	183	283	515	340	44	168
Center	168	88	–	142	–	–

Table 6 – Number of simple experiments and demonstration plots in the program developed by ANDA in collaboration with F.A.O.

Year	Price index for fertilizers	Price index of agricultural products
1950	97	114
55	82	110
60	58	75
65	124	75
71	68	84

Table 7 – Evolution of price index for fertilizers and agricultural products (1948/52 = 100)