SUMMARY AND CONCLUSIONS

1. Summary

The more rapid development of Brazilian agriculture is greatly dependent upon the employment of modern inputs. Fertilizers are indispensable to increase land productivity ant it is due to this responsibility that we proposed to carry out this study about the demand for basic plant nutrients, in the short and long run, in the State of São Paulo.

The basic data for the analysis were obtained at the Instituto de Economia Agricola of the State Secretary of Agriculture and at the Associação Nacional para a Difusão de Adubos. The time series data cover the period 1948-72.

Two econometric models utilized in studies conducted by Griliches and Hsu in the United States and Taiwan, respectively, and

also by Cibantos, in the State of São Paulo, were tested.

Traditional Model (in logs)

$$y_t = a_o + a_1x_1 + a_2x_2 + \dots + a_nx_n + e_t$$

Distributed Lag Model (in logs)

$$y_t = ba_o + ba_1x_1 + ba_2x_2 + \dots + ba_nx_n + (1 - b)y_{t-1} + be_t$$

where: $y_t = N_t$ or P_t or K_t = apparent consumption of nitrogen, phosphorus or potassium;

$y_{t-1} = N_{t-1}$ or P_{t-1} or K_{t-1} = apparent consumption of nitrogen, phosphorus or potassium, lagged one year;

x_1 = real average price of nitrogen (P_N) or real average price of phosphorus (P_P) or real average price of potassium (P_K);

$x_2, x_3, \dots, x_n$ = variables that affect the consumption of nutrients regardless of their prices;

e = error term.

The models were adjusted in the power form (linear in the logarithms of the variables). The least square method was utilized, and the following was estimated for each model:

a) a determination coefficient (R^2) which explains the effects of the set of independent variables contained in the model over the dependent variable. The "F" test was used to test the regression effect.

b) the partial regression coefficients of the independent variables considered. Student's "t" test was used to test the null hypothesis.

The selection of the "best" equations was based on the following criteria:

a) consistency of results with demand theory;

b) statistical significance of the regression coefficients;

c) value of the correlation coefficients among the independent variables;

d) magnitude of the coefficient of determination.

Durbin-Watson's statistics and the sign sequence test were used to test the presence of serial correlation in the residuals.

Computation of the original data was conducted at the Data Processing Unit of the Instituto de Pesquisas Econômicas of the University of São Paulo.

The "best" equations, which permit a comparative analysis of the three nutrients studied (nitrogen, phosphorus and potassium) are given below. Equation I belongs to the traditional model and Equation II to the distributed lag model.

For Nitrogen:

Equation I (in logs)

$$N_t = -4{,}6711 - 0{,}6747\ P_N + 1{,}0173\ P_{pg} + 2{,}5015\ A + 0{,}3105\ D + 0{,}4256\ T$$

$R^2 = 0{,}9202$

Equation II (in logs)

$$N_t = -0{,}4079 - 0{,}4775\ P_N + 0{,}8981\ A + 0{,}1279\ D + 0{,}5718\ N_{t-1} + 0{,}1897\ T$$

$R^2 = 0{,}9433$ $\quad$ $b = 0{,}43$ $\quad$ $E_{LP} = 1{,}1151$

For Phosphorus:

Equation I (in logs)

$$P_t = -6{,}4677 - 0{,}4253\ P_P + 5{,}2004\ A - 0{,}6245\ R + 0{,}3300\ D$$

$R^2 = 0{,}8372$

Equation II (in logs)

$$P_t = -1{,}5178 - 0{,}3144\ P_P + 1{,}8499\ A - 0{,}4000\ R + 0{,}1719\ D + 0{,}5869\ P_{t-1}$$

$R^2 = 0{,}9399$ $\quad$ $b = 0{,}41$ $\quad$ $E_{LP} = 0{,}7611$

For Potassium:

Equation I (in logs)

$$K_t = -7{,}9691 - 0{,}6349\ P_K + 1{,}2525\ P_{pg} + 4{,}7706\ A - 0{,}5843\ R + 0{,}3702\ D$$

$R^2 = 0{,}8982$

Equation II (in logs)

$$K_t = -3{,}8336 - 0{,}3022\ P_K + 2{,}6544\ A + 0{,}1597\ D + 0{,}4931\ K_{t-1}$$

$R^2 = 0{,}9218$ $\quad$ $b = 0{,}51$ $\quad$ $E_{LP} = -0{,}5962$

Variables:

N_t = apparent consumption of nitrogen;

N_{t-1} = same as N_t, lagged one year;

P_t = apparent consumption of phosphorus;

P_{t-1} = same as P_t, lagged one year;

K_t = apparent consumption of potassium;

K_{t-1} = same as K_t, lagged one year;

P_N = real average price of nitrogen;

P_P = real average price for phosphorus;

P_K = real average price for potassium;

P_{pg} = price paid for farm inputs, excluding fertilizers;

A = cultivated area;

R = average physical yield;

D = auxiliary variable to capture influence of credit for the purchase of fertilizers;

T = trend.

2. Conclusions

From the results obtained and from the information collected when conducting the research, it may be inferred that:

1) Consumption of nitrogen, phosphorus and potassium tends to increase in the State of São Paulo. During the period 1948-72, total apparent consumption (N-P-K) increased by 25 times.

2) Utilization of phosphorus fertilizers by the farmers of the State of São Paulo is higher than that of nitrogen and potassium fertilizers, although the ratio of phosphorus and potassium, as compared to nitrogen, has decreased.

3) Consumption of fertilizers in 1972, in kg/ha of nutrient elements, was 29.4 kg for nitrogen fertilizers, 46.1 for phosphorus, 31.5 for potassium, and 107.0 kg for NPK. These figures are a clear indication that the State of São Paulo is at a higher level of consumption than the average for the whole country, and that this level may be compared to the levels utilized in regions having a developed agriculture.

4) The relatively unfavorable relationship between farm product prices/and prices paid for inputs (except fertilizers) existing during the period analyzed contributed negatively to a greater utilization of fertilizers, since the benefits resulting from the use of fertilizers are also dependent upon the utilization of supplementary inputs.

5) The real price of the three nutrients tended to decrease in the last few years. This reflected on an increase in use of fertilizers in the State. In 1972 the trend was to increase price nevertheless consumption continued to rise.

6) Brazilian production of nitrogen and phosphorus fertilizers tends to increase. It is expected that by 1975 domestic production of soluble phosphorus fertilizers will meet 85% of the country's demand; it is also expected that at that same date, Brazil will be self sufficient in regard to nitrogen fertilizers.

7) The establishment of a credit system for the purchase of fertilizers with the beginning of FUNTERTIL'S operations in 1966,brought about a considerable increase in the use of fertilizers from that date to present time. The influence of this program was measured in this study through a "dummy variable" which disclosed significant differences between the periods "before FUNFERTIL" and "after FUNFERTIL".

8) An analysis of the data referring to cultivated area in the State of São Paulo when related to consumption of fertilizers allows us to infer that the increase in level of consumption of fertilizers

was more a consequence of intensified use than of increased area, since whereas consumption increased 25 fold during the period analyzed, cultivated area increased less than two-fold.

9) The estimates obtained by equations I (traditional model) suggested that the real average price of the elements is a relevant variable in explaining demand for nitrogen and potassium and shows reasonable significance in explaining demand for phosphorus. The coefficient of the variable price was negative in all equations, as expected. The secular fall in real prices of fertilizers in the period analyzed was, therefore, an important factor in explaining increased consumption during that period.

10) The influence of the variable trend was only measured in regard to the demand for nitrogen, and was highly significant in the traditional model. Due to its high correlation with lagged consumption of phosphorus and potassium and with cultivated area, it was omitted from the models for these two elements. Still, it may be stated that trend exerts considerable influence on consumption of fertilizers in State of São Paulo agriculture.

11) The variable average physical yield of main crops did not show statistically significant results. Only in regard to demand for phosphorus did it exert some influence, still this influence was low and always showed a negative sign.

12) The variable prices received for farm products included in most equations tested (see appendix 2) was significant for the three elements although it always showed a sign contrary to that expected (negative sign). No theoretical justification for this was found. Such inversion was also found by Cibantos.

13) Cultivated area is a relevant variable in explaining demand for the three nutrients. In the traditional model its coefficient is highly significant, but part of this significance is lost when the variable lagged consumption is included, since the latter absorbs part of its explanation.

14) Similarly as in the studies on which this research was based, the distributed lag model showed a better adjustment when estimating the demand for fertilizer elements in the State of São Paulo as compared to the traditional model.

15) The results obtained through equations of the lagged model suggest, for all three elements, an inverse relationship between real price of nutrients and consumption in a given year and a direct relationship between consumption in previous year and consumption in the year under consideration;

15.1) for nitrogen, an adjustment coefficient equal to 0.43 was found, suggesting that approximately 43% of the disequilibrium between present consumption and that desired, in the long run, is eliminated in a year. The elasticity of demand for nitrogen in rela-

tion to real price is - 0.48 in the short run and - 1.12 in the long run. Therefore, the demand for nitrogen is relatively inelastic in the short run, that is, at a 10% variation in real price of nitrogen in a given year, coeteris paribus, it is expected that there would be a 4.8% variation in the opposite direction in its consumption. In the long run, demand is relatively elastic, that is, a 10% decrease in real price of nitrogen in a given year, coeteris paribus, corresponds to an increase in the order of 11.2% in the amount consumed;

15.2) for phosphorus, the adjustment coefficient found was in the order of 0.41, which is very close to the value found for the adjustment coefficient for nitrogen. The price elasticity of demand for phosphorus in relation to real price is - 0,31 in the short run and - 0,76 in the long run. Therefore, for both the short and the long run, the demand for phosphorus is relatively inelastic;

15.3) potassium presented an adjustment coefficient equal to 0.51, which was somewhat different from the values of the coefficients found for nitrogen and phosphorus. This value permits a convergence for a more rapid equilibrium of potassium than nitrogen and phosphorus. The price elasticity of demand for potassium in relation to real price is - 0.30 in the short run (very close to price elasticity for phosphorus) and - 0.60 in the long run, which leads to the conclusion that the demand for potassium is relatively inelastic, in both the short and long run.

15.4) for nitrogen, as well as for phosphorus and potassium , the influence of the credit system was highly significant, as measured by the dummy variables. The presence of the credit system since 1966 brought about a structural change in the demand function of the three nutrients, that is the function was shifted upward. Such a change reflects the importance which credit takes on in relation to the demand for fertilizers. Also, the high significance of this variable seems to be contributing to the less than 1 values for elasticities, found for phosphorus and potassium in the long run.

16) This study attempted to show the changes which are taking place in regard to consumption of plant nutrients in the State of São Paulo. With reference to real prices, the demand for nitrogen is becoming more elastic whereas the demand for phosphorus and potassium is becoming less elastic.

Suggestions for future research are as follows:

1) An analysis of the demand for fertilizers or basic plant nutrients in the periods 1948-65 and 1966-72 to assess more closely the extent of the influence exerted by the credit system.

2) An analysis of demand at the national level in terms of N, P_2O_5, and K_2O, separately, taking into account the different regions of the country.

3) Utilization of cross-section data to analyze the demand for fertilizers in the State of São Paulo, considering the various regions

and crops.

4) Analysis utilizing simultaneous equation models to determine the demand for the three primary nutrients (N, P_2O_5 and K_2O) since there seems to be a close relationship between quantities and prices of the elements, and thus the influence which one element exerts upon the other could be assessed.

5) Finally, the incorporation of new variables in the models utilized may contribute to a better understanding and explanation of the factors affecting the demand for fertilizers on the State of São Paulo farms.