

PRODUCTION FUNCTIONS AND ECONOMIC OPTIMA
FOR CORN AND GRAIN SORGHUM UNDER FERTILIZATION
ON IRRIGATED EXPERIMENTAL PLOTS IN WEST-CENTRAL KANSAS

by

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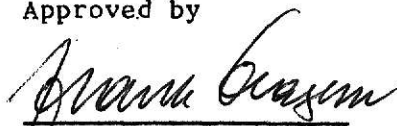
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INTRODUCTION

The importance of fertilizer use in production of agricultural products cannot be over-emphasized. Increasing use of fertilizer is taking place all over the world. In the State of Kansas for example, total fertilizer consumption has increased from 617 thousand tons to 1,216 thousand tons between 1964 and 1971. The reason for this upward trend is because farmers find that the value of the increased yields of their crops not only pays for the cost of the fertilizer used but for some other costs of production as well.

A. OBJECTIVES OF STUDY

The question foremost in the minds of farmers concerning fertilizers is how much they should use. The answer to this question can be found by determining the type of relationship which exists between fertilizer and yield of agricultural products and use economic principles to determine the profit maximization level of fertilizer application. The main objectives of this study therefore are:

1. To derive production functions using experimental yield data from Tribune Branch Experiment Station. In this study, a production function is defined as the functional relationship which exists between an input and an output. The outputs are corn and grain sorghum and the inputs are nitrogen, phosphorus and potassium fertilizer nutrients.
2. To see whether yearly variations exist in response of corn and grain sorghum to these fertilizer nutrients.

3. To derive response curves from the production functions derived.
4. To determine derived demand for the fertilizers.
5. To determine the most profitable rate of fertilizer application under farmers' conditions for both crops.
6. To show the effects of changes in prices of the fertilizers on the most profitable rates of application and returns to fertilizers above their costs.
7. To show the effects of changes in prices of products on the most profitable rates of fertilizer application and returns to fertilizers above their costs.

These were the initial objectives but it was later discovered that the design of the experiment does not allow all the objectives to be fulfilled for phosphorus and potassium fertilizer nutrients. The analysis is therefore concentrated on the response of corn and grain sorghum to nitrogen and also on finding the year when the response to phosphorus and or potassium become statistically significant.

B. PLAN OF ANALYSIS

The content of this thesis include section II where the tools of analysis and design of the experiment the advantages and disadvantages of the methods used are explained; section III contains a summary of the analysis of variance results while section IV gives a break-down of the predicted equations by year and groups of years. Section V deals with application of the economic principles and derivation of results of the study.

II. ANALYSIS OF DATA

A. ORIGIN OF DATA

The data for the analysis reported in this study was obtained from the Agronomy Department of Kansas State University. These were experimental results conducted from 1961-1970 for corn and grain sorghum on irrigated land at the Tribune Branch Experimental Station in West-Central Kansas. Nitrogen (N), phosphorus (P_2O_5) and potash (K_2O) were applied in various combinations. Nitrogen was applied in variable rates of 0, 40, 80, 120, 160 and 200 pounds per acre while phosphorus was only at two levels 0, 40 and potash at 0, 40 pounds per acre. The yields obtained from the experiment under various fertilizer combinations are shown in Table 1 for corn and in Table 2 for sorghum. For each year from 1961-1965 in the case of corn, there were 18 fertilizer treatments each replicated five times but from 1966, each of these replicates was sub-divided into two. Thus there were 90 observations per year from 1961-65 and 180 observations per year from 1966-1970. For sorghum, there are 90 observations per year for 1961-1963 and 180 observations for 1964-1970.

The soil moisture was kept at a constant level each year and it was not considered a limiting factor in production of either corn or sorghum. The water was applied in pre-plant stage and in sufficient amounts.

Production functions had been fitted to the 1961-1965 data by Yung Liu¹ but the objective of this analysis is to fit production functions to the entire data for corn and grain sorghum from 1961-1970. In the earlier study it was reported that there was no crop response to phosphorus and

¹Yung Liu, "Corn and Grain Sorghum Response to Fertilizers on Irrigated Land in West-Central Kansas. "Masters' Thesis, K.S.U. 1968.

potash. This present analysis will up-date the results and see if there is any statistically significant response to P_2O_5 and K_2O in later years of the experiment.

B. REGRESSION ANALYSIS

Multiple regression analysis was used to fit some production functions to the data, and find the one that gives the best fit for each year and for all the years combined. This type of analysis can be used to derive the best prediction of the values of Y (the yield of corn or sorghum) under various fertilizer treatments.

There are various forms of multiple regression procedures which can be used. These are enumerated by H. Smith and N.R. Draper² as All Possible Regressions, Backward Elimination Procedure, Forward Selection Procedure and Stepwise Regression Procedure. The Stepwise Procedure re-examines at every stage of the regression the variables incorporated into the model in previous stages. If a variable has been the best single variable to enter at an early stage, at a later stage it may become superfluous because of the relationships between it and other variables now in the regression.

The steps involved in Stepwise Procedure are as follows:

Suppose we have five variables Y, X_1 , X_2 , X_3 , X_4 in which Y is the dependent and X_1 , ---, X_4 the independent variables:

Step 1. The stepwise procedure starts with a simple correlation matrix and enters into regression the X variable which is most highly correlated with Y. Suppose this to be X_4 .

² H. Smith and N.R. Draper, Applied Regression Analysis John Wiley & Sons. Inc. New York. 1967.

Step 2. Considering the partial correlation coefficients as before, it now selects as the next variable to enter regression, that X variable whose partial correlation with the response is highest. Assume this to be X_1 .

Step 3. Now we have the regression equation of the form $Y = f(X_4, X_1)$ and the method now examines the contribution X_4 would have made if X_1 had been entered first and X_4 entered second. (This the forward selection procedure does not do). If the value of the partial F value for X_4 is significant at 0.05 probability, X_4 will be retained. If it is not, X_4 will be kicked out and X_1 retained. Let us assume X_4 is retained.

Stepwise method will consider the next X variable with the highest correlation with Y. If this is X_2 , it is brought into the model.

Step 4. A regression equation of the form $Y = f(X_4, X_1, X_2)$ is now determined by least squares. Partial F-tests for the variables X_1 and X_4 are made to determine if they should be retained in the regression equation. Let us assume now that X_4 now has a partial F value which is not statistically significant at 0.05 probability level, it drops out of the equation.

Step 5. The only remaining variable is X_3 . The same procedure is carried out as above. Let us assume that X_3 also drops out then the stepwise regression procedure terminates and chooses as its best regression equation $Y = f(X_1, X_2)$. If it is a straight line equation, we obtain

$$Y = a + bX_1 + cX_2.$$

If it is a quadratic equation like the ones used in this analysis, if $X_2 = X_1^2$ then we obtain:

$$Y = a + bX_1 + cX_1^2.$$

The signs of the coefficients b and c will be denoted and their t -values reported. The R value for the whole equation will be given. R^2 is obtained by squaring R and it gives the percentage of the variation in the observed Y values that is explained by the fitted regression equation. Thus it measures the goodness of fit of the estimated regression equation. The R , R^2 values including the T values are reported for each regression equation in Appendix B.

Choice of Procedure

Due to the foregoing points, Stepwise Regression analysis is recommended by some authors as the best method of variable selection. Examples of such authors are H. Smith and N.R. Draper³ and M.A. Effroymsen⁴. It is therefore the tool chosen for these analyses. The only difference is that no alpha level of rejection has been specified. This allows additional variables that would have not entered the program under the usual stepwise procedure.

Assumptions and Disadvantages of this type of Analysis

Least Square Regression analysis, of which the stepwise method is one is not faultless. The assumptions made are as follows:⁵

1. The expected value of the error is zero. In an equation like $Y = a + bN + cN^2 + e$, e is the error which is due to the fact that the postulated independent variables do not

³ H. Smith and N.R. Draper, Ibid., p.172

⁴ M.A. Effroymsen, 'Multiple Regression Analysis' in the book Mathematical Methods for Digital Computers by Ralston A and Wilf H.S. John Wiley & Sons Inc. New York 1967.

⁵ Earl O. Heady and John L. Dillon, Agricultural Production Functions Iowa State University Press, Ames, Iowa. 1961. p.111

completely explain Y. There might have been some input factors or minor importance not taken into consideration.

2. The covariance between the error associated with one value of Y and that associated with another value of Y is zero.
3. The variance of the error associated with one value of Y is the same as the variance of the error which is associated with any other value of Y.
4. The covariance between the error and each of the independent variable is zero.
5. The independent variables observed are measured without error.

If all these assumptions are fulfilled, the production function estimated parameters will be unbiased and of minimum variance. Therefore there arises the problem of how to estimate and interpret the obtained production functions. There is no way of obtaining satisfactory estimates of production functions from very poor data no matter how accurate the statistical tool is. If either of the assumptions 1 and 5 does not hold, the result obtained is biased even if the others which are meant to minimize the variance hold true.

Advantage of Least Squares Estimation

This is the least expensive compared with other methods which could be used and the simplest to carry out.

C. TYPES AND PROPERTIES OF ALGEBRAIC EQUATIONS⁶

There are numerous forms of algebraic equations which can be used in deriving production functions. The simple quadratic form $Y = a + bX - cX^2$ with a minus before the c denotes diminishing marginal returns. It allows both a declining and negative marginal productivity but not both increasing

⁶ Earl O. Heady and John L. Dillon, Ibid., pp. 73-81.

and decreasing marginal products. The square root form $Y = a - bX + cX^{0.5}$ allows both a diminishing total product and also diminishing marginal products. The Cobb-Douglas function of the form $Y = aX^b$ assumes constant elasticity of production over all ranges of input which means that each percentage increase in input adds the same percentage amount to output. Secondly the total product curve is asymptotic to the origin and so the function does not allow diminishing total yields. It allows either constant, decreasing or increasing marginal productivity but not a combination of these. The polynomial function of the form $Y = m - aR^x$ called the Spillman-Mitscherlich function, provides a curve which is asymptotic to the maximum yield m such that aR^x approaches the limit zero but never quite equals it. It is therefore not suitable for data where diminishing total products are encountered. It also assumes that the elasticity of production changes but the ratio of marginal products is constant over all ranges of output.

The 1.5 power function has similar characteristics to the simple quadratic form. Each of these functions except the polynomial form, which is more difficult to work with, is used to fit production functions to the data. The quadratic form is used in the economic analysis because it offers greater flexibility than the others. Other reasons for this choice are explained in section V.

D. DESIGN OF EXPERIMENT

In the quadratic functions reported in this study it is not possible to include P and K as independent variables because the treatments of P and K were either at zero or 40 lbs/acre level of application. Each time an attempt is made to bring P and K and P^2 and K^2 , or $P^{0.5}$ and $K^{0.5}$

into the same equation, the values of P , P^2 , $P^{0.5}$ are read to be the same thing. Similarly K , K^2 and $K^{0.5}$ appear the same. Thus it is not possible to report equation of the forms:

$$Y = a + bN + cN^2 + dP + eP^2 + fK + gK^2$$

$$Y = a + bN + cN^{0.5} + dP + eP^{0.5} + fK + gK^{0.5}$$

There can only exist a linear relationship between two points 0 and 40 for P and K . A quadratic function is not possible. Hence, in this analysis, we are left with a single variable resource N while others P and K are considered fixed at certain levels of application or enter the production functions as dummy variables.

In order to include P and K as independent variables, one would expect P and K to run from 0, 40, 80, 120, 160, 200 like the levels of Nitrogen. In this way it would be possible to determine yield isoquants between N and P , P and K and N and K if responses are statistically significant. The least cost combination of these nutrients would also be determinable. The treatments contained combinations of $P = 40$, $K = 0$ while N varies from 0 to 200 and $P = 40$, $K = 40$ while N is variable but does not contain $P = 0$, $K = 40$ while N varies. The first allows one to measure the response of corn and sorghum yields due to the 40 lbs of P_2O_5 but the missing treatment would have allowed a measurement of corn and sorghum yield responses to 40 pounds of potash alone.

These treatments might have been considered unnecessary at the time the experiment was designed because the soil test in West-Central Kansas indicated high availability of potassium and phosphorus but low availability of nitrogen. This therefore explains the reason why the treatments were given lower and fewer applications of phosphorus and potassium than nitrogen.

III. ANALYSIS OF VARIANCE OF YIELD DATA

Due to the incomplete fertilizer treatment levels for P and K, an analysis of variance was carried out on the raw experimental yield data shown in Appendix A, Tables 1 and 2 for corn and sorghum. In order to find out the year when the effects of phosphorus and potassium become statistically significant, two way analysis of variance was performed using each year's data, for the 1961-1965 pooled data, 1966-1970 pooled data and 1961-1970 pooled data. This analysis enables one to find whether the effects of N, P, K are significant or not and whether there is any significant interaction effect between nitrogen and the other nutrients. For the 1961-1965 pooled data, 1966-1970 pooled data for corn and 1966-1970 pooled data for sorghum, where there are equal numbers of observations per year, a three-way analysis of variance was carried out to find whether there is any significant interaction effect between nitrogen and the years or not.

The results are as follows:

1. For corn, the effect of phosphorus is not statistically significant for the first five years 1961 to 1965 but becomes significant for the last five years 1966-1970.
2. The sorghum experiment was started in 1959 and that of corn in 1961. In the case of sorghum the effect of phosphorus is not significant for the years 1959 to 1965 but becomes significant from the eighth year, 1966.
3. The effect of potassium is not significant for both crops for all the years.

4. The three-way analysis of variance indicated a significant interaction effect between nitrogen and the years which means that the effect of nitrogen on the yields of corn and sorghum is not the same for all years. This is not unexpected because there are many variations between years brought about by weather and changes in plant populations which can account for these differences. However, there was no major cultural change made which can account for the difference in the effect of nitrogen over the years. Thus the coefficient of determination (R^2) values obtained for the regression equations for the 1961-1970 pooled data for each crop are less than the R^2 values obtained for each year's regression equations reported in section V.

Economic Implications

The above results indicate that under irrigation in West-Central Kansas the farmer may not need to apply phosphate fertilizer in addition to nitrogen for the first five years of producing corn and seven years for sorghum. From the sixth year for corn and eighth year for sorghum, application of phosphate fertilizer will raise the yield and the profitability levels due to phosphate application.

It would be more desirable for the farmer to use production functions derived from yearly data than from an average of several years because the effect of nitrogen varies from year to year significantly. However, this is not possible because the farmer cannot predict in advance, for example, whether 1973 conditions will be exactly like 1968, 1970 or 1972. If he could make this prediction it would be better to use the production

function derived from 1968, 1970 or 1972 data respectively than to use that derived from the ten-year average data. However, using the predicted equation from the ten-year pooled data assumes equal chances for each year's condition occurring in 1973. Therefore it will be to the farmer's advantage over a long period of time to use the ten-year pooled data. This assumes 1973 will be an average year of the preceding ten years. If this is not the case the amount of nitrogen applied may not be that which will maximize profit that given year.

Due to the above mentioned points the production functions derived from the ten-year 1961-1970 pooled data will be used to demonstrate the economic principles in section V although all the production functions are recorded in section IV for each year's data and for the groups of years. The 1961-1965 pooled data can be taken as representing years when the effect of phosphorus is not significant while 1966-1970 pooled data can be taken as representing those years when the use of phosphate fertilizer is justified. The 1961-70 pooled data will, however, represent all the years both those when phosphate fertilizer is needed and those when it is not needed.

IV. PREDICTED EQUATIONS

Production functions have been fitted to the data by year; in groups of five years; and whole ten-year data together. Each of the yearly and pooled data were sorted into the three P and K treatment levels with N variable from 0-200 lbs/acre. Each year therefore has four groups of production functions namely when $P=K=0$; $P=40$, $K=0$; $P=K=40$ and when P and K are variable.

To each of the sorted data when $P=K=0$; $P=0$, $K=40$ and $P=K=40$ were fitted the quadratic, square - root and Cobb-Douglas functions. The 1.5 power functions were fitted to the pooled data when P and K are variable in addition to the already mentioned three. The whole ten-year data was broken into two parts - the 1961-1965 pooled data and the 1966-1970 pooled data because the analysis of variance showed significant response to phosphorus after 1965 for each crop. Production functions were fitted to the soil test years (1961, 1965 and 1968) grouped data and similarly to the non-soil test years (1962, 1963, 1964, 1966, 1967, 1969 and 1970). The whole ten-year data was then grouped together and production functions were fitted as described above.

Alpha level of 0.05 has been chosen as the rejection level for any of the variables coming into the functions. Therefore only functions which have all their variables with significant t-values at 0.05 are recorded.

Due to the presence of zero values in the treatments, for example when $N=0$, $P=0$, $K=0$, a constant 1 has been added to prevent the possibility of taking the log of a zero number. Therefore for the Cobb-Douglas functions

and the 1.5 power functions the predicted N value is reduced by 1 lb/acre.

Thus if we calculate N to be 121 lb/acre as the most profitable level of N the actual N needed is 120 lb/acre and not 121 lb/acre.

All the predicted equations are recorded in Appendix B.

V. ECONOMIC ANALYSIS

A. CHOICE OF PRODUCTION FUNCTIONS

Having obtained so many production functions by year and groups of years, the next step is to choose those functions for the two crops which will be used to illustrate and apply the economic principles. It would be best to illustrate the economic analysis with all the functions but time will not allow. As mentioned in Section II, the quadratic functions offer more flexibility than the Cobb-Douglas functions. Close examination of the treatment means under the various levels of N indicated that yields at high levels of nitrogen tend to decrease for both crops thus making the Cobb-Douglas functions unsuitable because with constant elasticities they do not show diminishing total yields.

The square root function also has no significant difference in its predictive power from that of the quadratic as far as the R^2 values are concerned. However, when considered by individual years the square root form does not appear as suitable as the quadratic form. For corn, the coefficients of the square root functions are not significant at alpha level of 0.05 for 1962, 1963, 1965, 1966, 1967 and 1968 for the treatment P_0K_0 and for the years 1961, 1963, 1964, 1966 and 1967 for the treatment P_1K_0 and 1962-1967 for treatment P_1K_1 . For sorghum, the square root coefficients are not significant at 0.05 alpha level for treatment $P_0K_0^*$ in 1964 and 1965, in 1963 and 1964 for treatment $P_1K_0^*$ and for treatment $P_1K_1^*$ in 1964 and 1965.

* P_0K_0 means $P = 0$ and $K = 0$ lbs/acre

P_1K_0 means $P = 40$ and $K = 0$ lbs/acre

P_1K_1 means $P = 40$ and $K = 40$ lbs/acre

The quadratic function appears to be significant at 0.05 alpha level for all experiments for both corn and sorghum. In order to give full comparison of the response of yield to nitrogen, phosphorus and potassium for all the years, the quadratic function is preferred to the square root form. Since the 1.5 power function has not given a significantly higher R^2 values than the quadratic, for ease of calculation, the quadratic is preferred.

B. RESPONSE TO P AND K BY YEAR

In the light of the above mentioned points and in order to trace crop response to phosphorus and potassium above nitrogen effect over the years graphically and tabularly, the quadratic functions have been used. Tables 3 and 4 show the estimated total, marginal and average yields of corn and sorghum respectively for each treatment P_0K_0 , P_1K_0 , P_1K_1 and when all nutrients are considered variable. The equation number of each predicted equation from which the table values are calculated is indicated at the top of each column. Figures C1 and S1 are obtained by graphing each column specified in Appendix C, Tables 3 and 4 against various nitrogen levels.

C. MARGINAL YIELDS AND ESTIMATED YIELDS OF CORN AND SORGHUM

Due to the points mentioned in Section III the production functions derived from 1961-1970 pooled data are used in the economic analysis presented in this section.

Estimated Yields:

The estimated yields are obtained by substituting various values of N into the equations to obtain the estimated yield values. The estimated yields of corn for equations (265), (266), (268), (269), (272), (273), (275) and (276) when $N = 10$ with P, K considered variable at 0 and 40 lbs/acre are as follows:

$$Y = 65.2495 + 1.0651N - 0.0030N^2 \dots\dots\dots(265)$$

$$Y = 65.2495 + 1.0651(10) - 0.0030(10^2)$$

$$Y = 75.60 \text{ bushels/acre.}$$

$$Y = 59.8987 + 1.0651N - 0.0030N^2 + 0.2007P \dots\dots\dots(266)$$

$$Y = 59.8987 + 1.0651(10) - 0.0030(10^2) + 0.2007(40)$$

$$Y = 78.28 \text{ bushels/acre with P assumed to be 40 lbs/acre.}$$

$$Y = 62.2873 - 0.00916 + 8.3830N^{0.5} \dots\dots\dots(268)$$

$$Y = 62.2873 - 0.0916(10) + 8.3830(10^{0.5})$$

$$Y = 87.88 \text{ bushels/acre.}$$

$$Y = 56.9365 - 0.0916N + 8.3830N^{0.5} + 0.2007P \dots\dots\dots(269)$$

$$Y = 56.9365 - 0.0916(10) + 8.3830(10^{0.5}) + 0.2007(40)$$

$$Y = 90.55 \text{ bushels/acre with P assumed to be 40 lbs/acre.}$$

$$Y = 63.7350 + 1.5016N - 0.0003N^{1.5} \dots\dots\dots(272)$$

$$Y = 63.7350 + 1.5016(10) - 0.0003(10^{1.5})$$

$$Y = 63.7350 + 1.506(10) - 0.0003(31.6227)$$

$$Y = 78.74 \text{ bushels/acre.}$$

$$Y = 58.3842 + 1.5016N - 0.0003N^{1.5} + 0.2007P \dots\dots\dots(273)$$

$$Y = 58.3842 + 1.5016(10) - 0.0003(31.6227) + 0.2007(40)$$

$$Y = 81.42 \text{ bushels/acre with P assumed to be 40 lbs/acre.}$$

$$\text{Log } Y = \text{Log } 4.0591 + 0.1032 \text{ Log } N \dots\dots\dots(275)$$

$$Y = \text{antilog } 4.0591(N^{0.1032})$$

$$Y = \text{antilog } 4.0591(10^{0.1032})$$

$$Y = 73.46 \text{ bushels/acre}$$

$$\text{Log } Y = \text{Log } 4.0190 + 0.1032 \text{ Log } N + 0.0082 \text{ Log } P \dots\dots\dots(276)$$

$$Y = \text{antilog } 4.0190N^{0.1032}P^{0.0082}$$

$$Y = \text{antilog } 4.0190(10^{0.1032})(40^{0.0082})$$

$$Y = 72.74 \text{ bushels/acre with } P \text{ assumed to be } 40 \text{ lbs/acre.}$$

For grain sorghum the estimated yields for equations (572), (573), (576), (577), (583), (584), (587) and (588) when $N = 10$ and P, K considered variable at 0 and 40 lbs/acre are calculated as follows:

$$Y = 38.1239 + 0.4834N - 0.0016N^2 \dots\dots\dots(572)$$

$$Y = 38.1239 + 0.4834(10) - 0.0016(10^2)$$

$$Y = 42.79 \text{ cwt./acre}$$

$$Y = 35.4679 + 0.4834N - 0.0016N^2 + 0.0996P \dots\dots\dots(573)$$

$$Y = 35.4679 + 0.4834(10) - 0.0016(100) + 0.0996(40)$$

$$Y = 44.13 \text{ cwt./acre with } P \text{ assumed to be } 40 \text{ lbs/acre}$$

$$Y = 35.9642 - 0.1381N + 4.6448N^{0.5} \dots\dots\dots(576)$$

$$Y = 35.9642 - 0.1381(10) + 4.6448(3.162)$$

$$Y = 49.27 \text{ cwt/acre.}$$

$$Y = 33.3082 - 0.1381N + 4.6448N^{0.5} + 0.0996P(577)$$

$$Y = 33.3082 - 0.1318(10) + 4.6448(3.162) + 0.0996(40)$$

$$Y = 51.06 \text{ cwt/acre with } P \text{ assumed to be } 40 \text{ lbs/acre.}$$

$$Y = 37.1821 + 0.7202N - 0.0002N^{1.5} \dots\dots\dots(583)$$

$$Y = 37.1821 + 0.7202(10) - 0.0002(31.6227)$$

$$Y = 44.38 \text{ cwt/acre}$$

$$Y = 34.5261 + 0.7202N - 0.0002N^{1.5} + 0.0996P \dots\dots\dots(584)$$

$$Y = 34.5261 + 0.7202(10) - 0.0002(31.6227) + 0.0996(40)$$

$$Y = 45.71 \text{ cwt/acre with } P \text{ assumed to be } 40 \text{ lbs/acre}$$

$$\text{Log } Y = \text{Log } 3.5297 + 0.0824 \text{ Log } N \dots\dots\dots(587)$$

$$Y = \text{antilog } 3.5297N^{0.0824}$$

$$Y = (34.1137)(1.2089)$$

$$Y = 41.24 \text{ cwt/acre}$$

$$\text{Log } Y = \text{Log } 3.4878 + 0.0824 \text{ Log } N + 0.0085 \text{ Log } P \dots\dots\dots(588)$$

$$Y = \text{antilog } 3.4878N^{0.0824}P^{0.0085}$$

$$Y = (32.7139)(1.2089)(1.0318)$$

$$Y = 40.81 \text{ cwt/acre with } P \text{ assumed to be } 40 \text{ lbs/acre.}$$

For all other values of N the estimated yields can be calculated in the same way. These are shown in Tables 3 and 4 for the quadratic equations. Values for other equations can be tabulated in a similar fashion.

Marginal Yields:

The marginal yields are obtained by finding the first derivative of Y with respect to N. These are shown below for equations (265), (268), (272) and (275):

$$Y = 65.2495 + 1.0651N - 0.0030N^2 \dots\dots\dots(265)$$

$$\frac{dY}{dN} = 1.0651 - 2(0.0030)N \dots\dots\dots (i)$$

$$Y = 62.2873 - 0.0916N + 8.3830N^{0.5} \dots\dots\dots (268)$$

$$\frac{dY}{dN} = -0.0916 + \frac{0.5(8.3830)}{N^{0.5}} \dots\dots\dots (ii)$$

$$Y = 63.7350 + 1.5016N - 0.0003N^{1.5} \dots\dots\dots (272)$$

$$\frac{dY}{dN} = 1.5016 - (1.5)(0.0003)N^{0.5} \dots\dots\dots (iii)$$

$$\text{Log } Y = \text{Log } 4.0591 + 0.1032 \text{ Log } N \dots\dots\dots (275)$$

$$Y = \text{antilog } 4.0591(N^{0.1032})$$

$$Y = 57.9222N^{0.1032}$$

$$\frac{dY}{dN} = (0.1032)(57.9222)N^{0.8968} \dots\dots\dots (iv)$$

Average Yields:

Average yields are obtained by dividing the total yield by the total pounds of nitrogen applied. For example, if $Y = 160$ Bu./acre when 130 lb/acre of N is applied, the average yield per pound of nitrogen is 160 divided by 130 which is 1.23. Thus for equation (265), the average yield is given by:

$$\frac{Y}{N} = \frac{65.2495 + 1.0651N - 0.0030N^2}{N} = \text{Average yield.}$$

By substituting various values of N by an increment of ten pounds per acre the average and marginal yields columns for Tables 3 and 4 are obtained.

D. OPTIMAL FERTILIZER APPLICATION

From Tables 3 and 4 when the marginal yield for each equation is observed to be zero indicate the point of optimum application of N and the optimum yield obtainable. Additional use of N above the optimum level results in the decreasing yields.

**THIS BOOK
CONTAINS
NUMEROUS PAGES
WITH DIAGRAMS
THAT ARE CROOKED
COMPARED TO THE
REST OF THE
INFORMATION ON
THE PAGE.**

**THIS IS AS
RECEIVED FROM
CUSTOMER.**

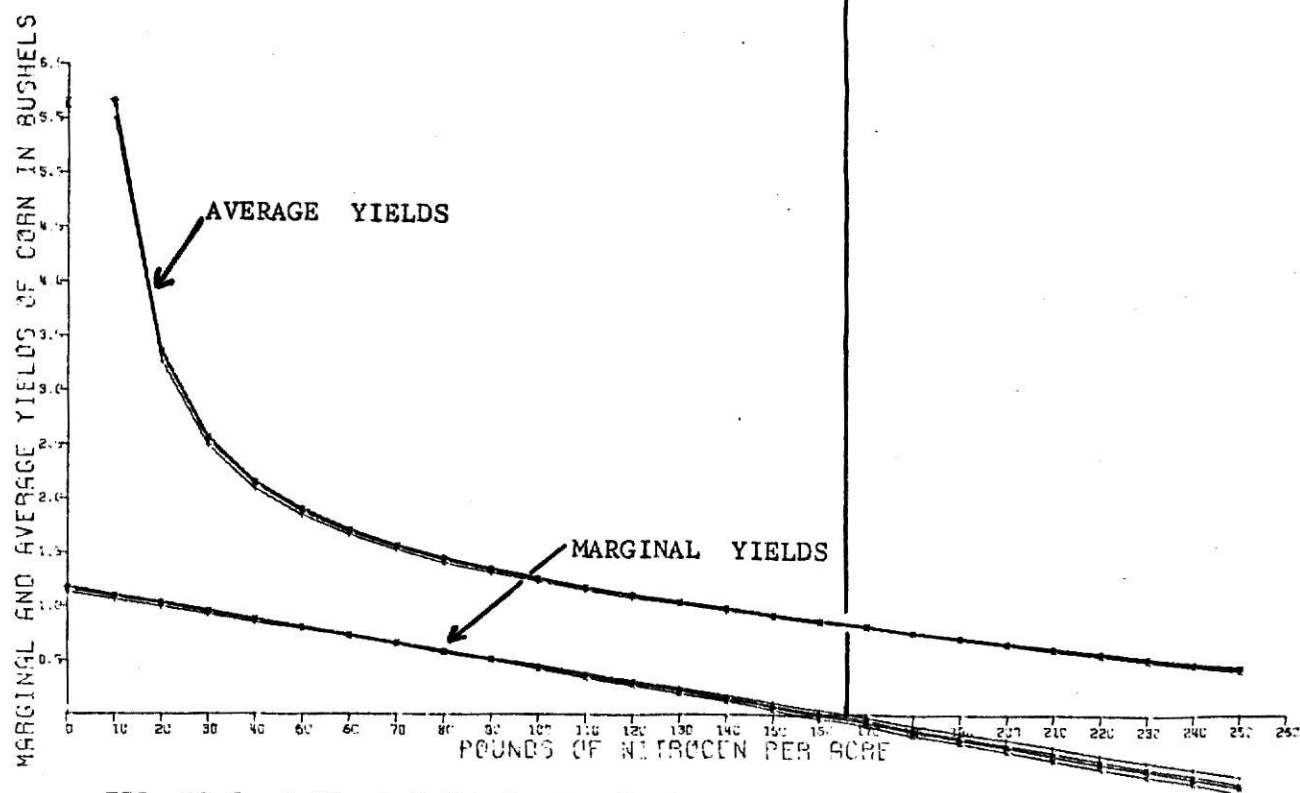
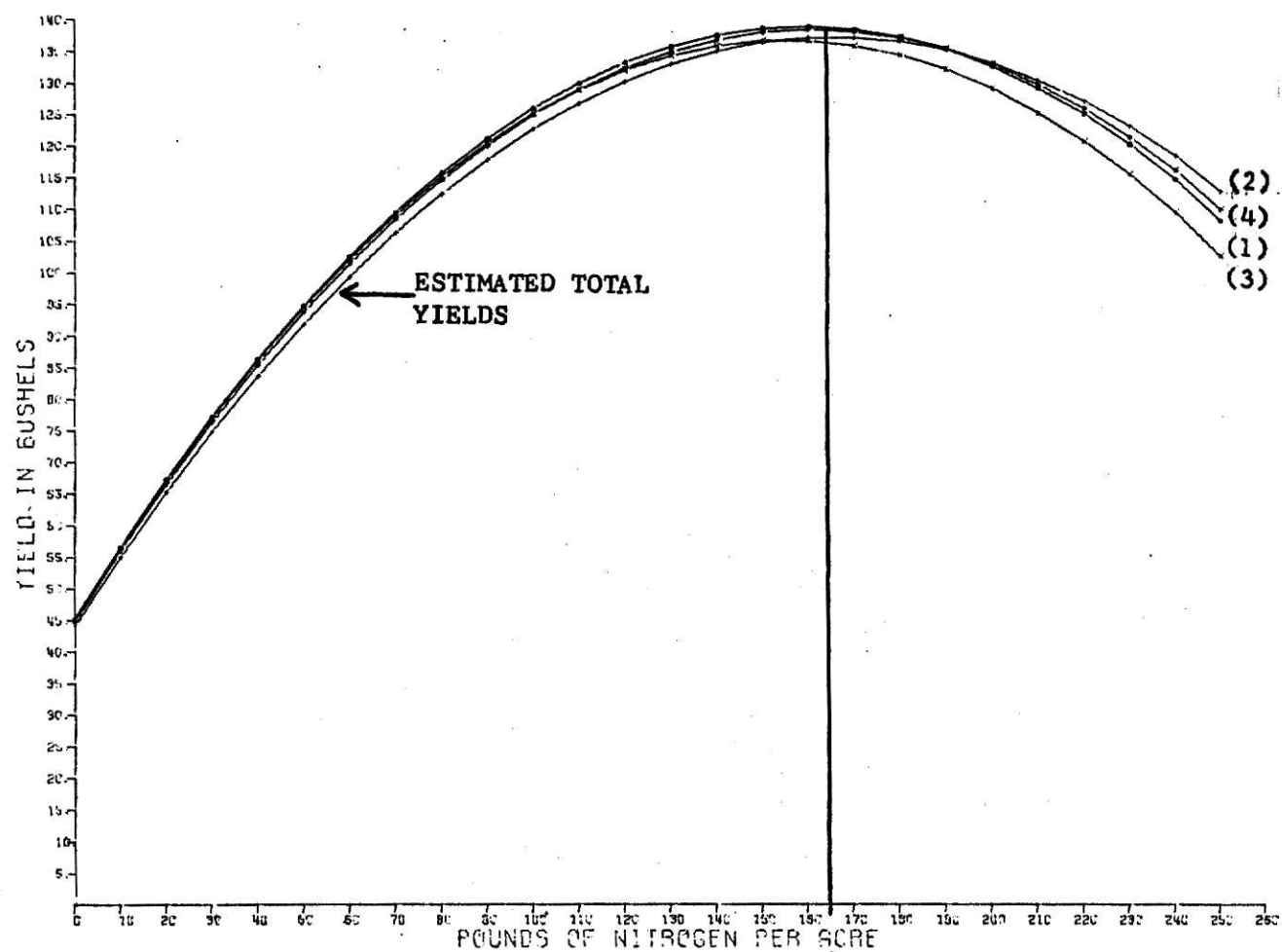


FIG. C1.1 Estimated Total, Marginal and Average Yields of Corn, 1961.

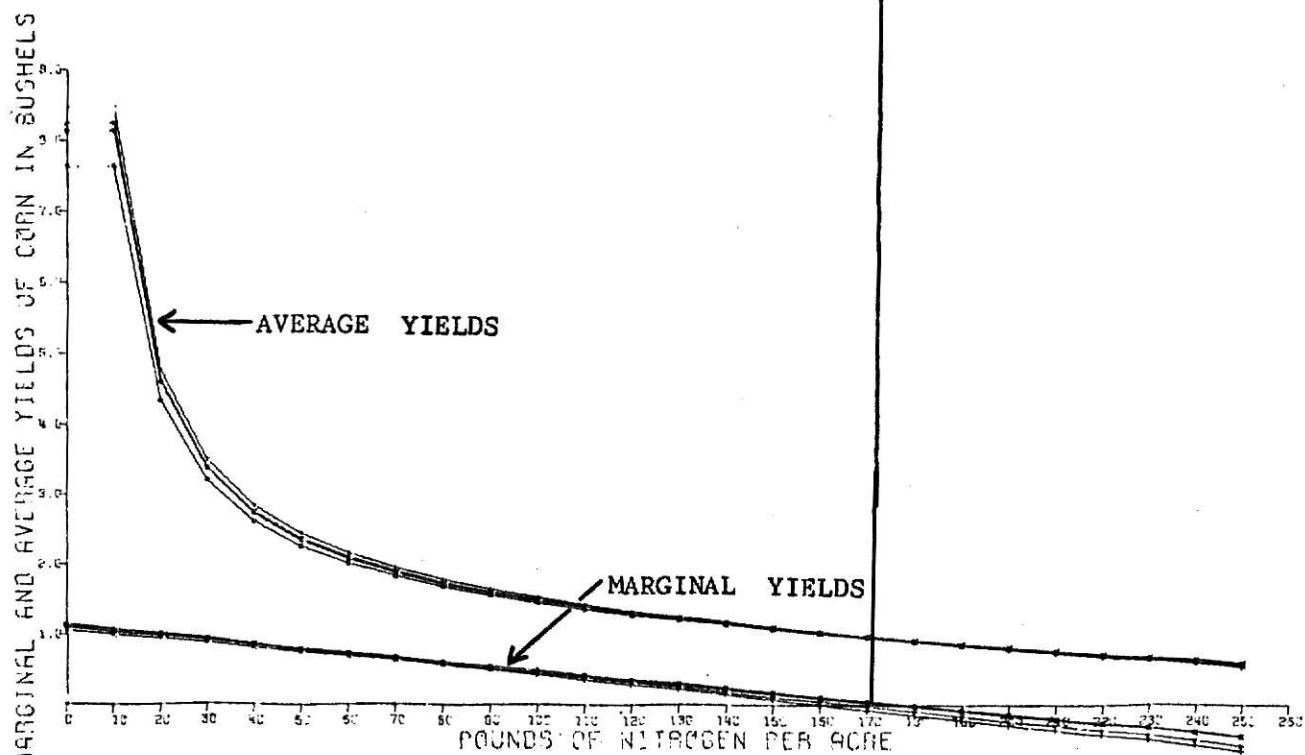
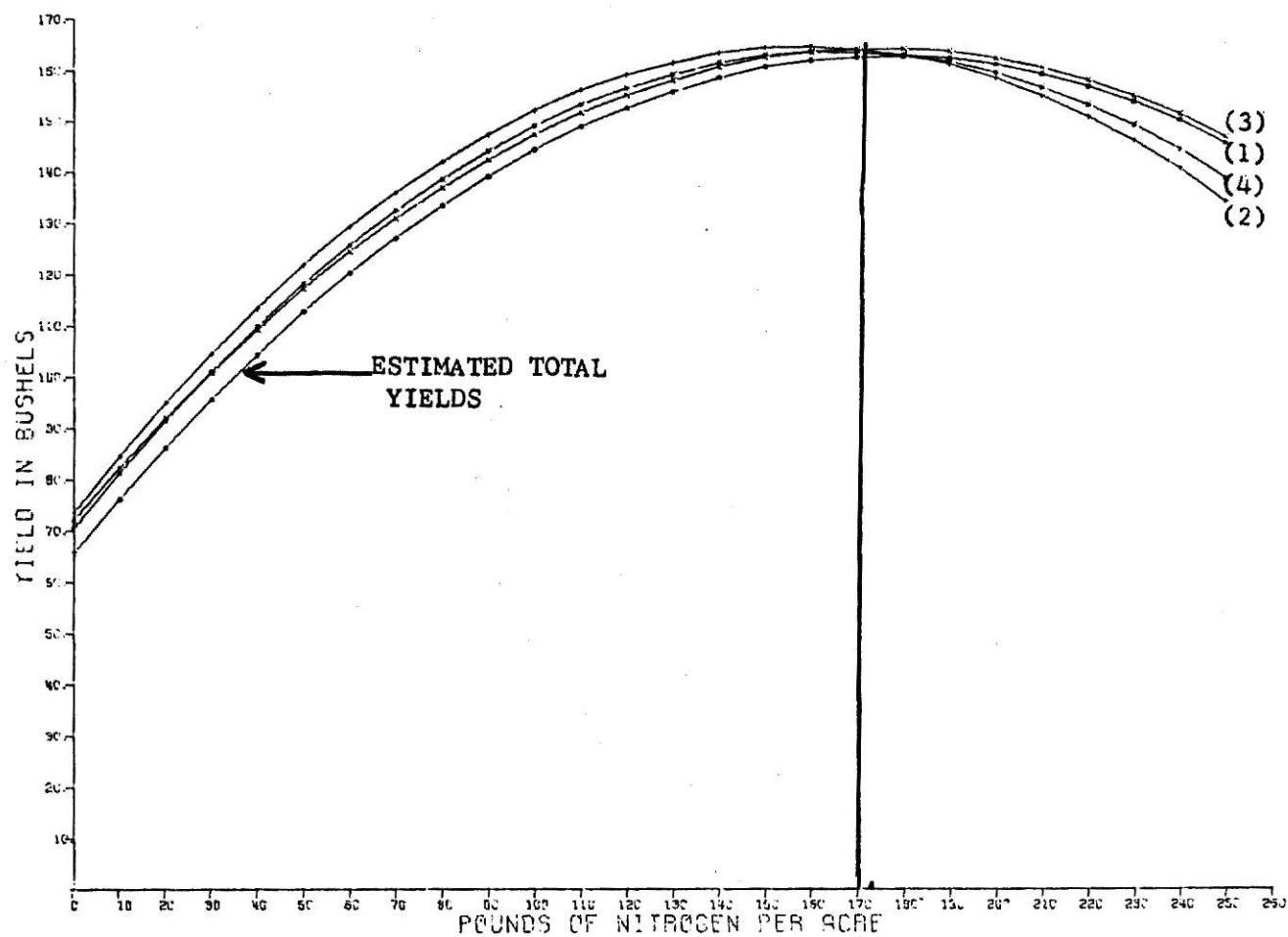


FIG. C1.2 Estimated Total, Marginal and Average Yields of corn, 1962.

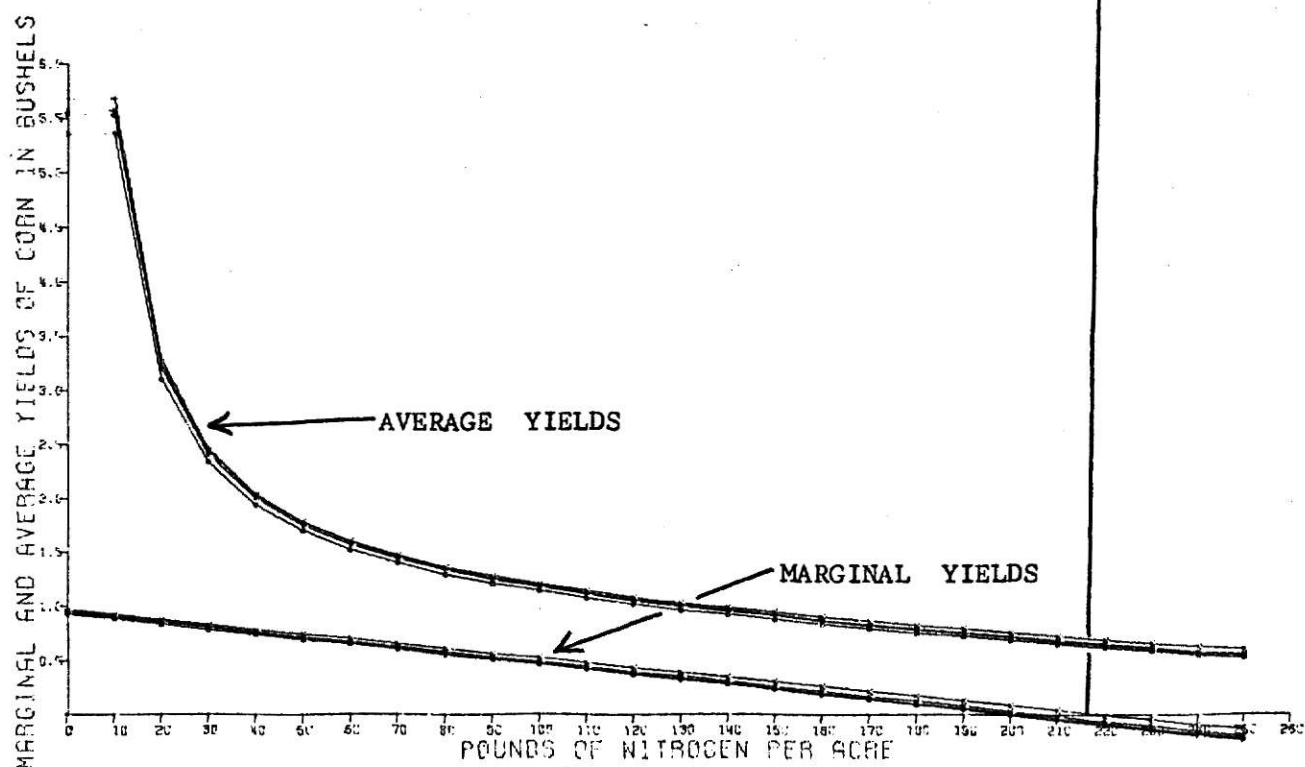
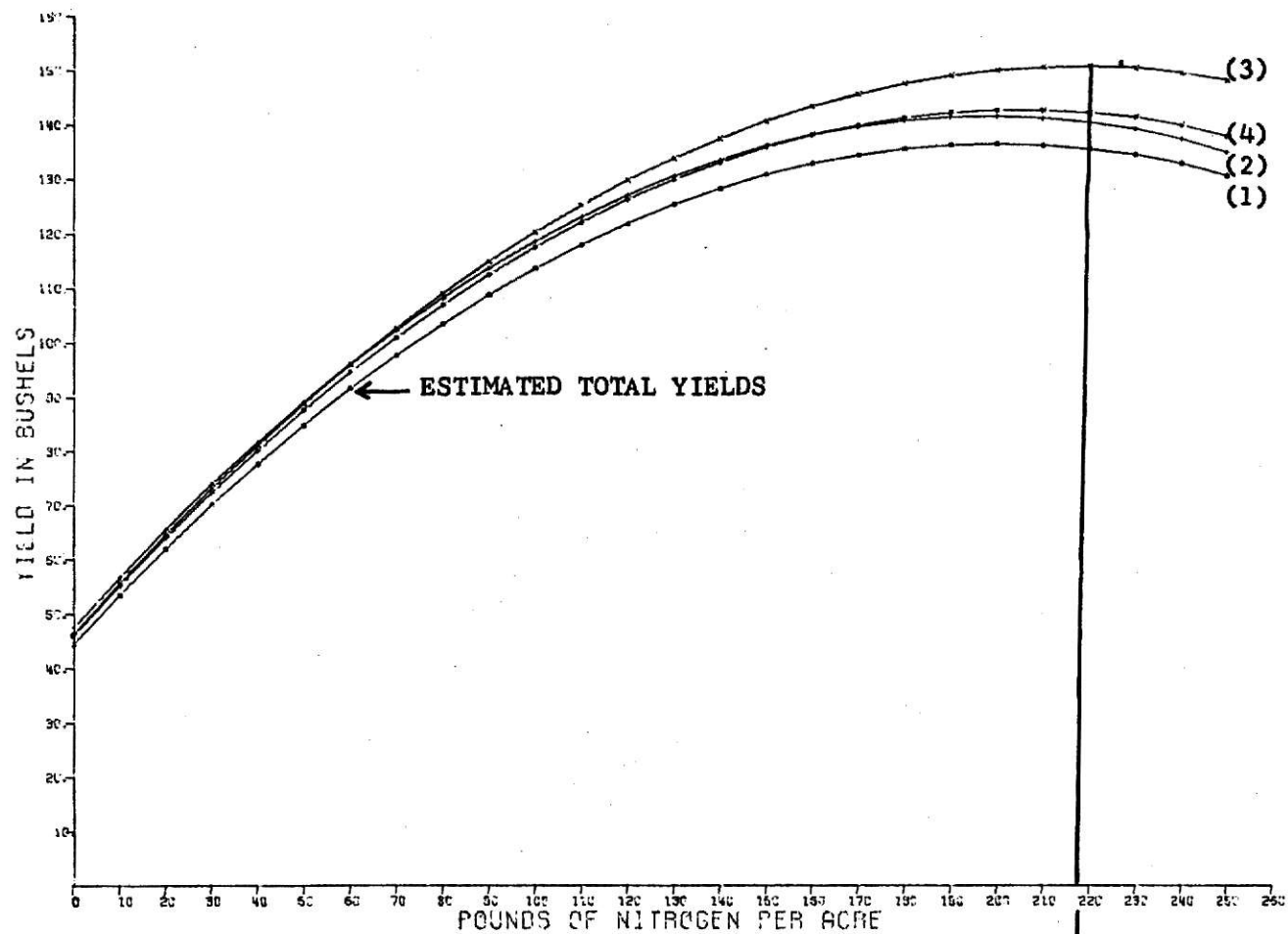


FIG. C1.3 Estimated Total, Marginal and Average Yields of corn, 1963.

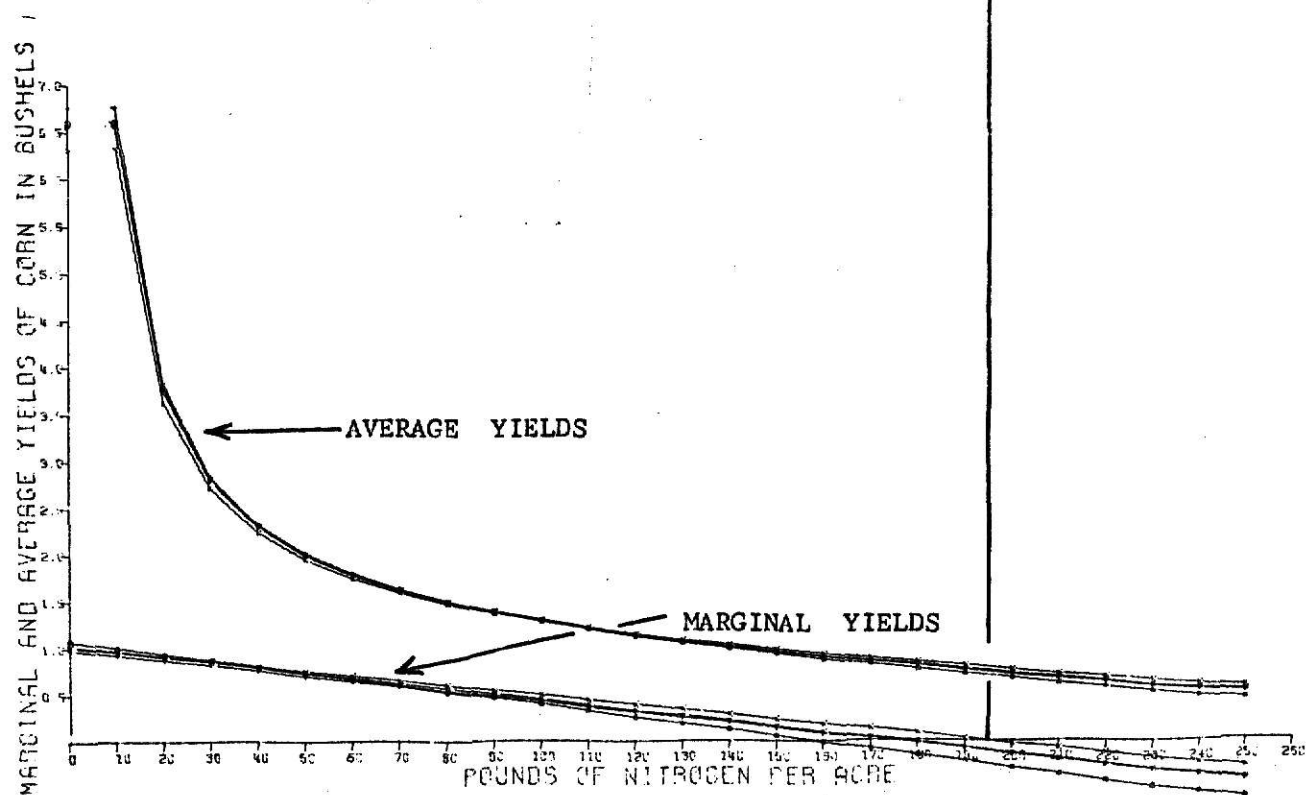
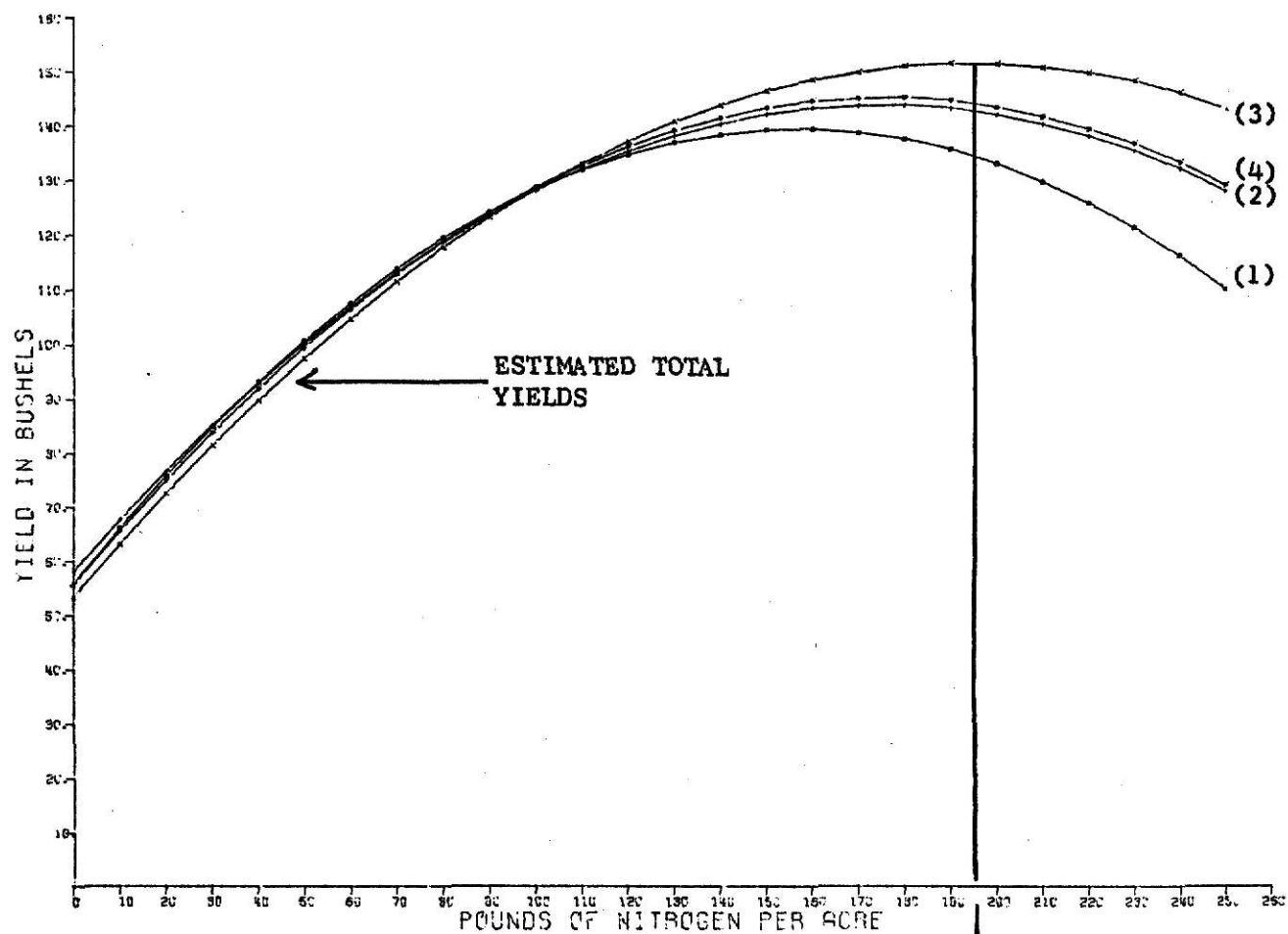


FIG. C1.4 Estimated Total, Marginal and Average Yields of corn, 1964.

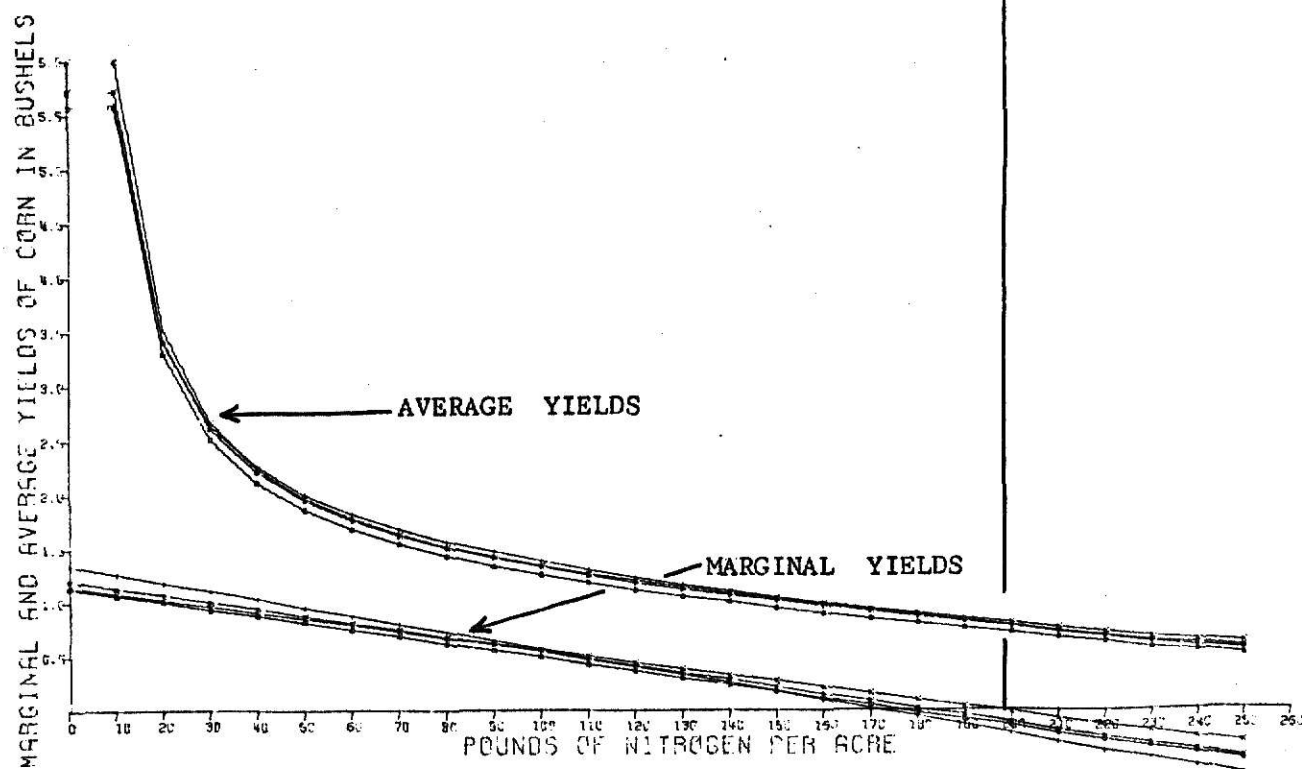
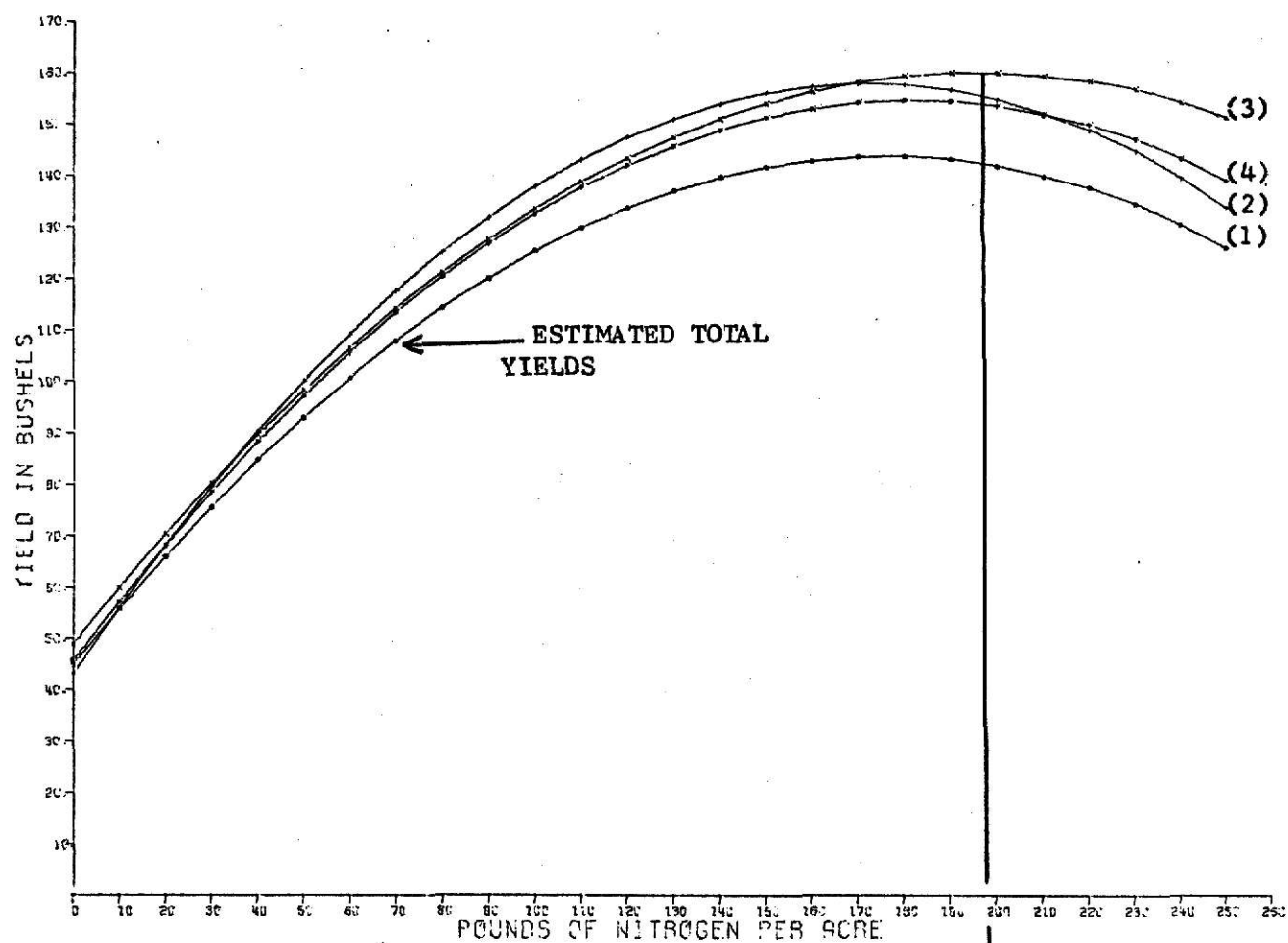


FIG. C1.5 Estimated Total, Marginal and Average Yields of corn, 1965.

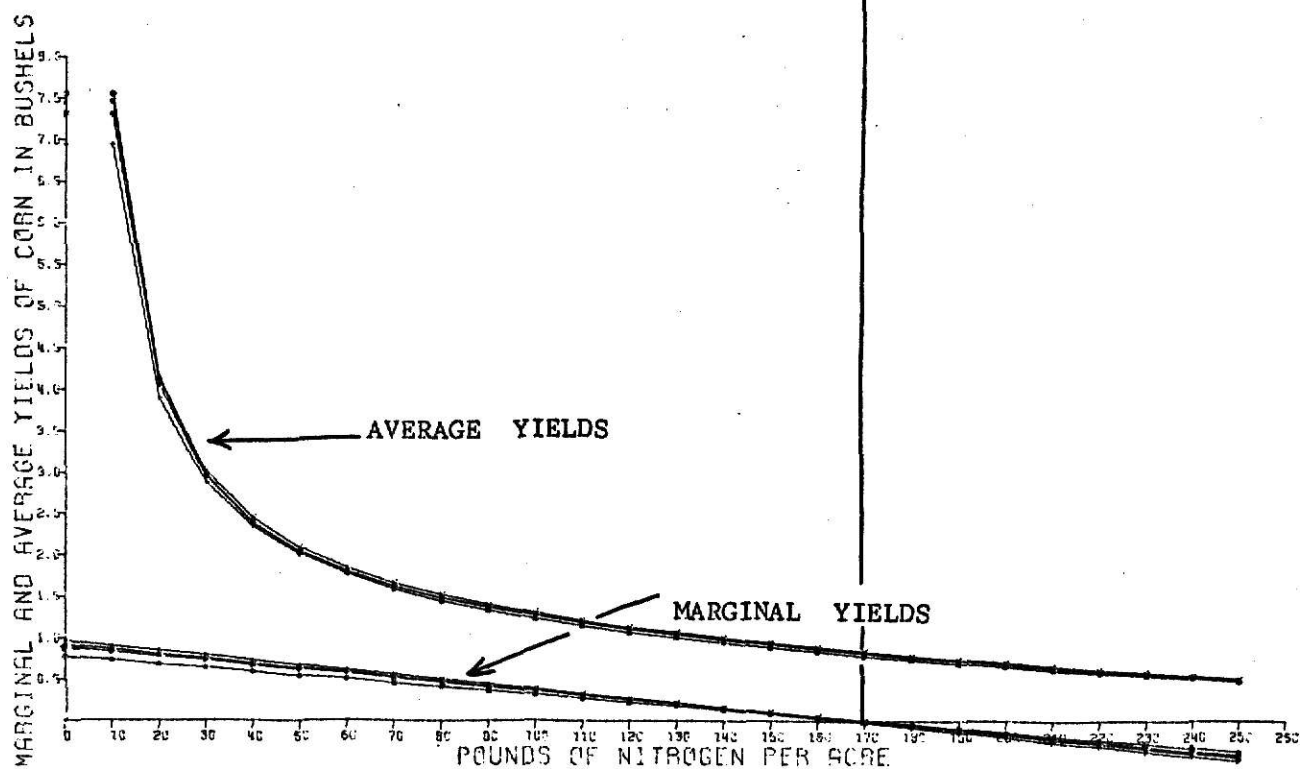
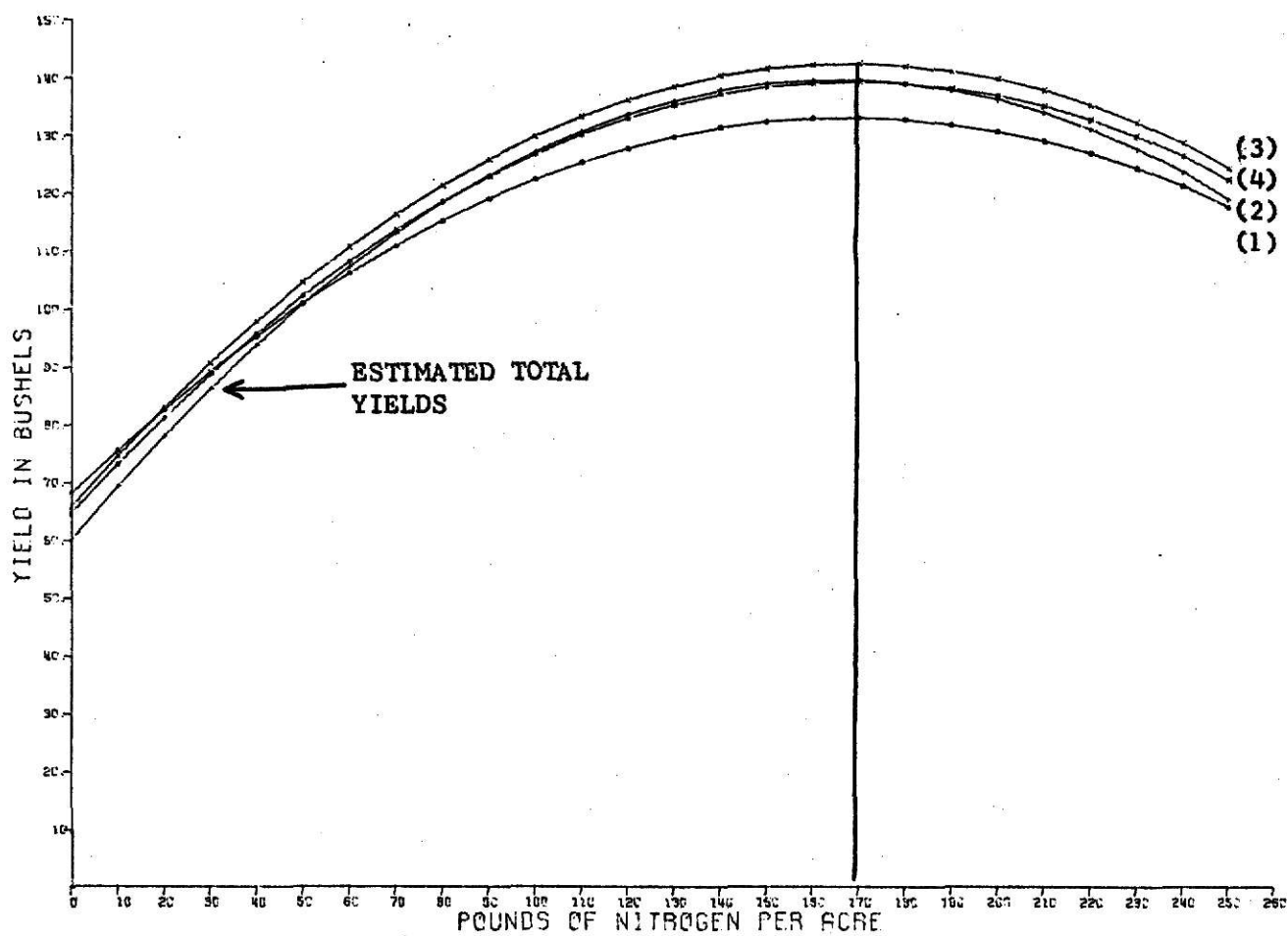


FIG. C1.6 Estimated Total, Marginal and Average Yields of corn, 1966.

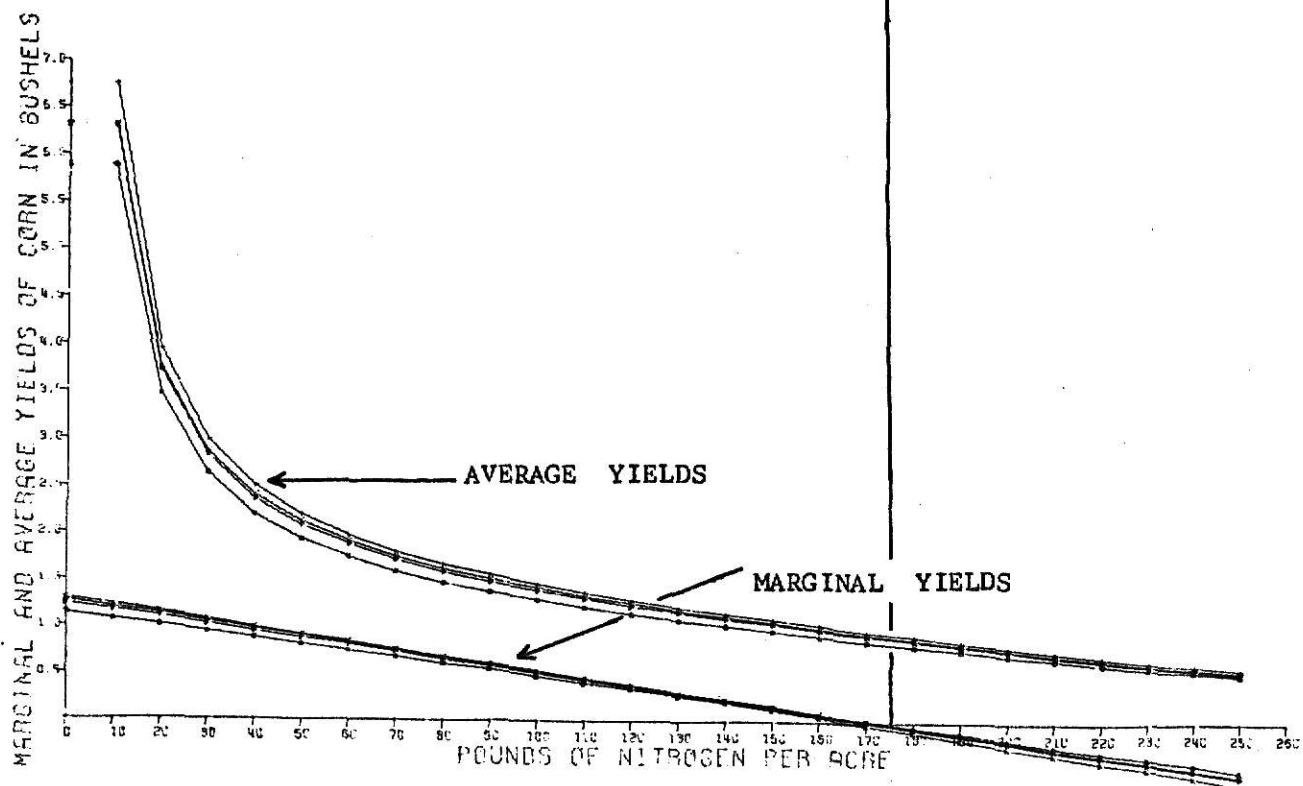
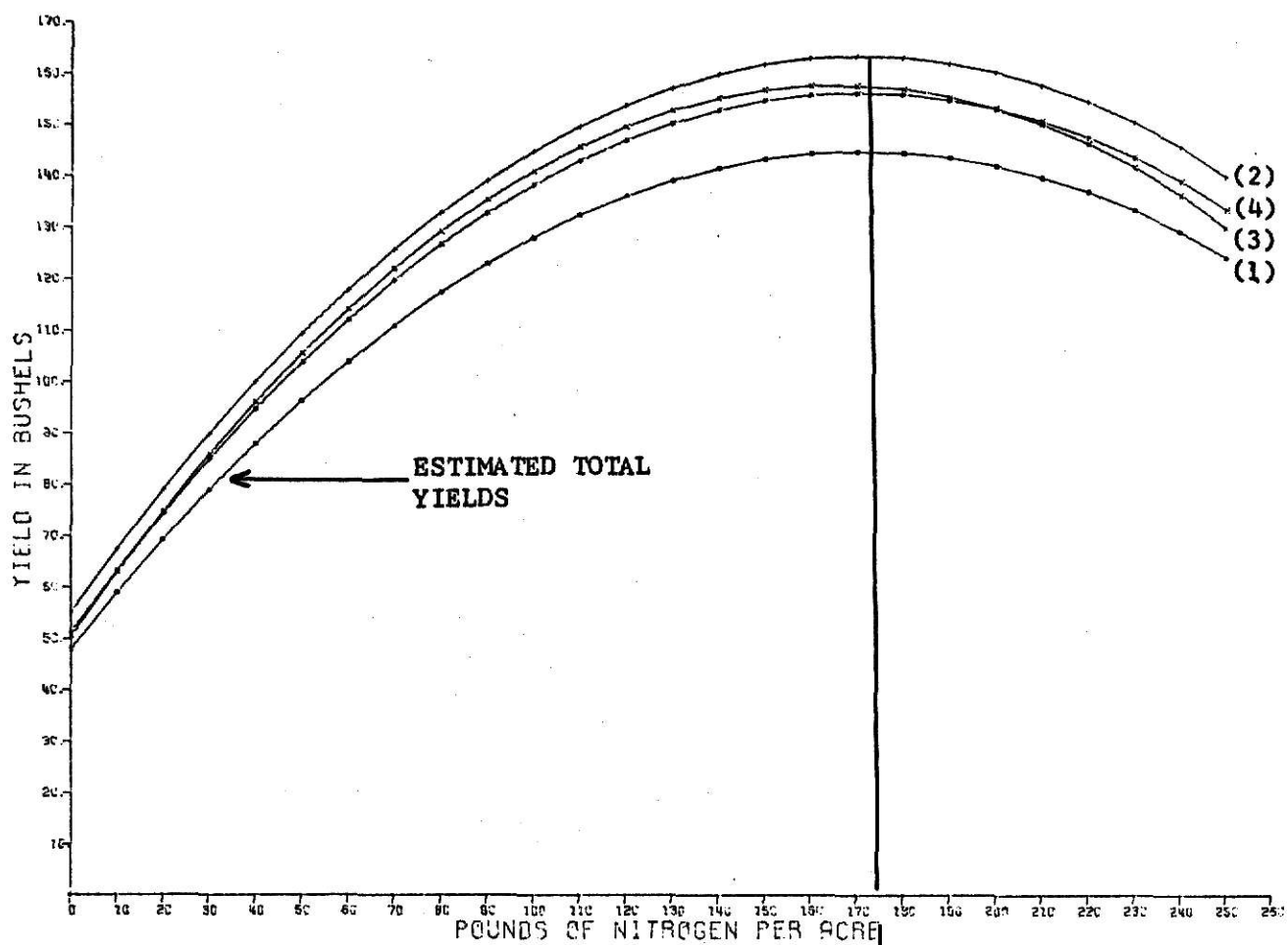


FIG. C1.7 Estimated Total, Marginal and Average Yields of corn, 1967.

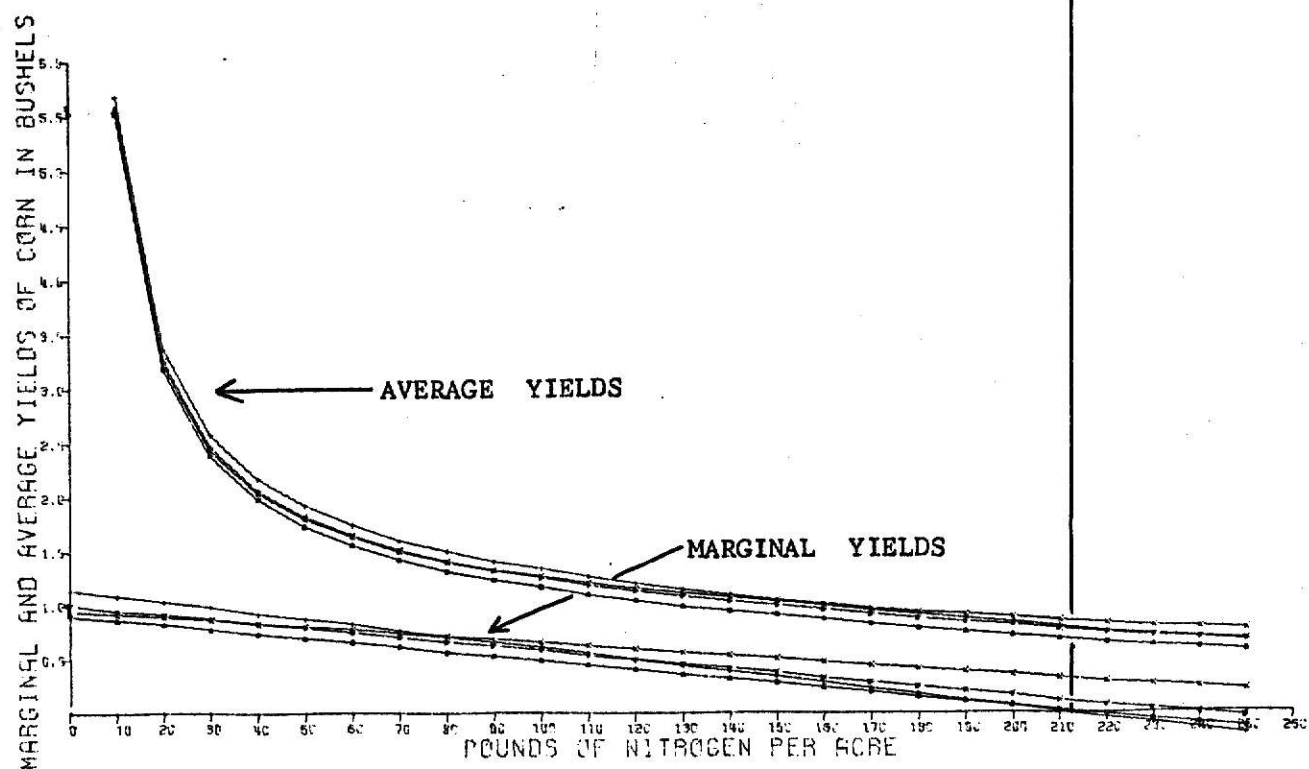
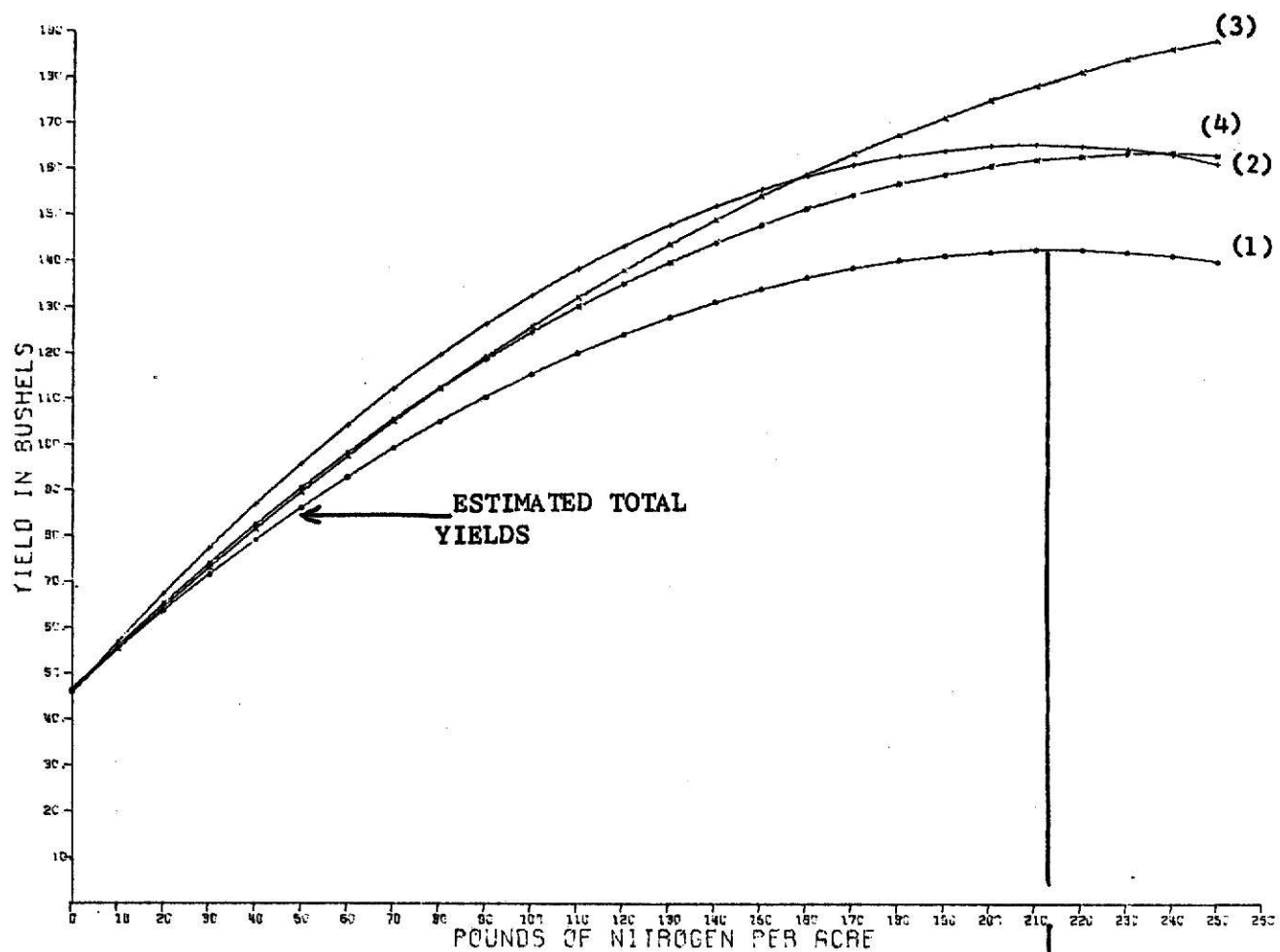


FIG. C1.8 Estimated Total, Marginal and Average Yields of corn, 1968.

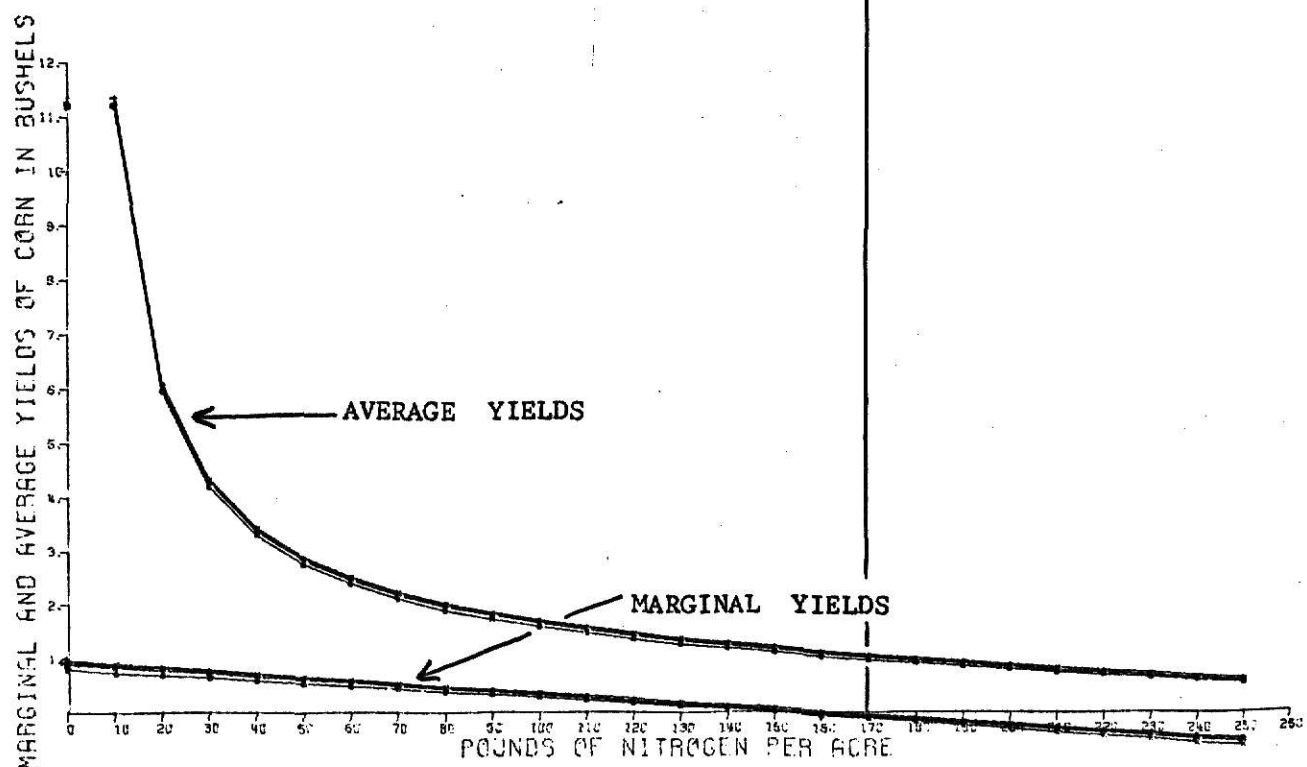
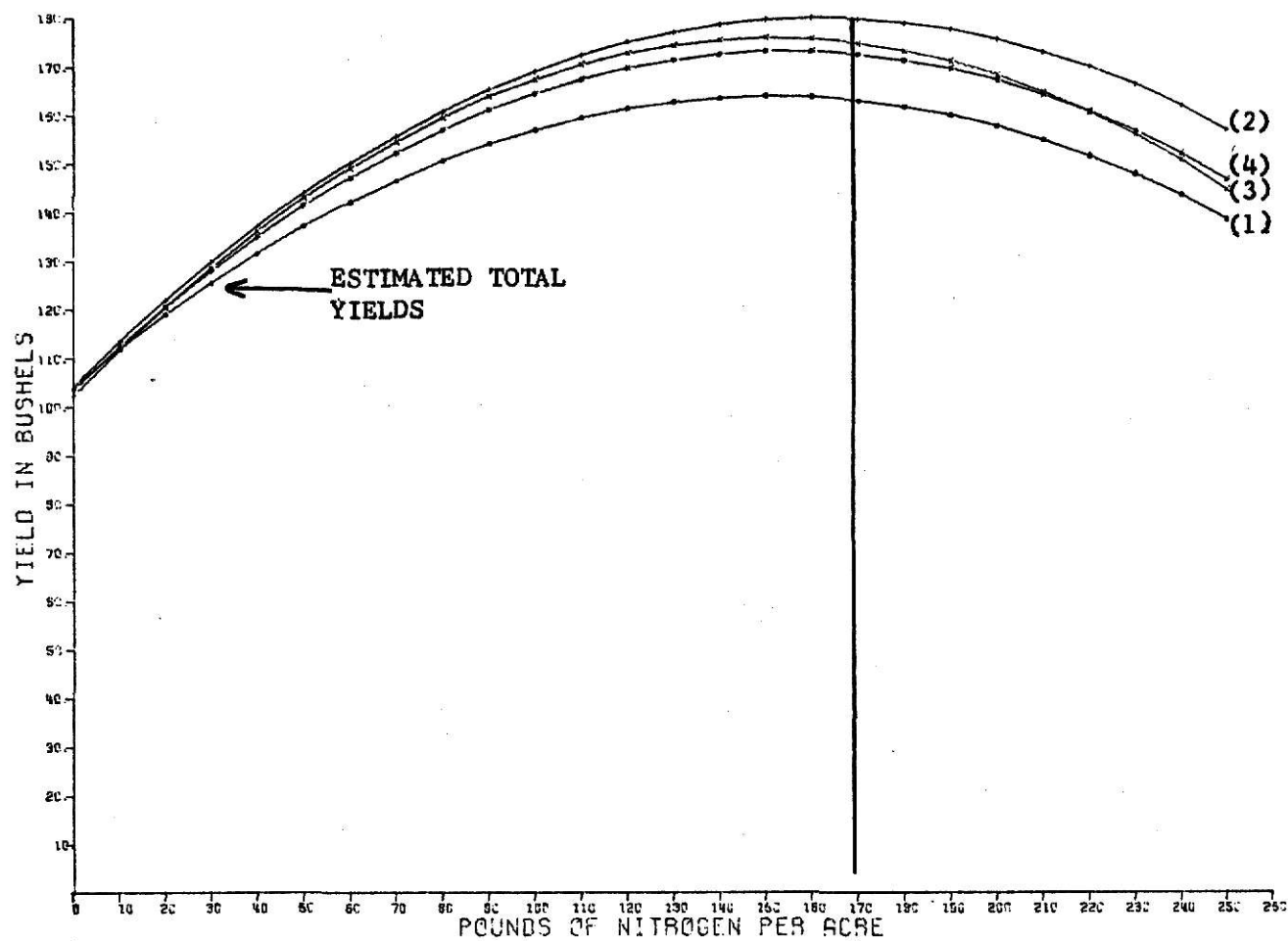


FIG. C1.9 Estimated Total, Marginal and Average Yields of corn, 1969.

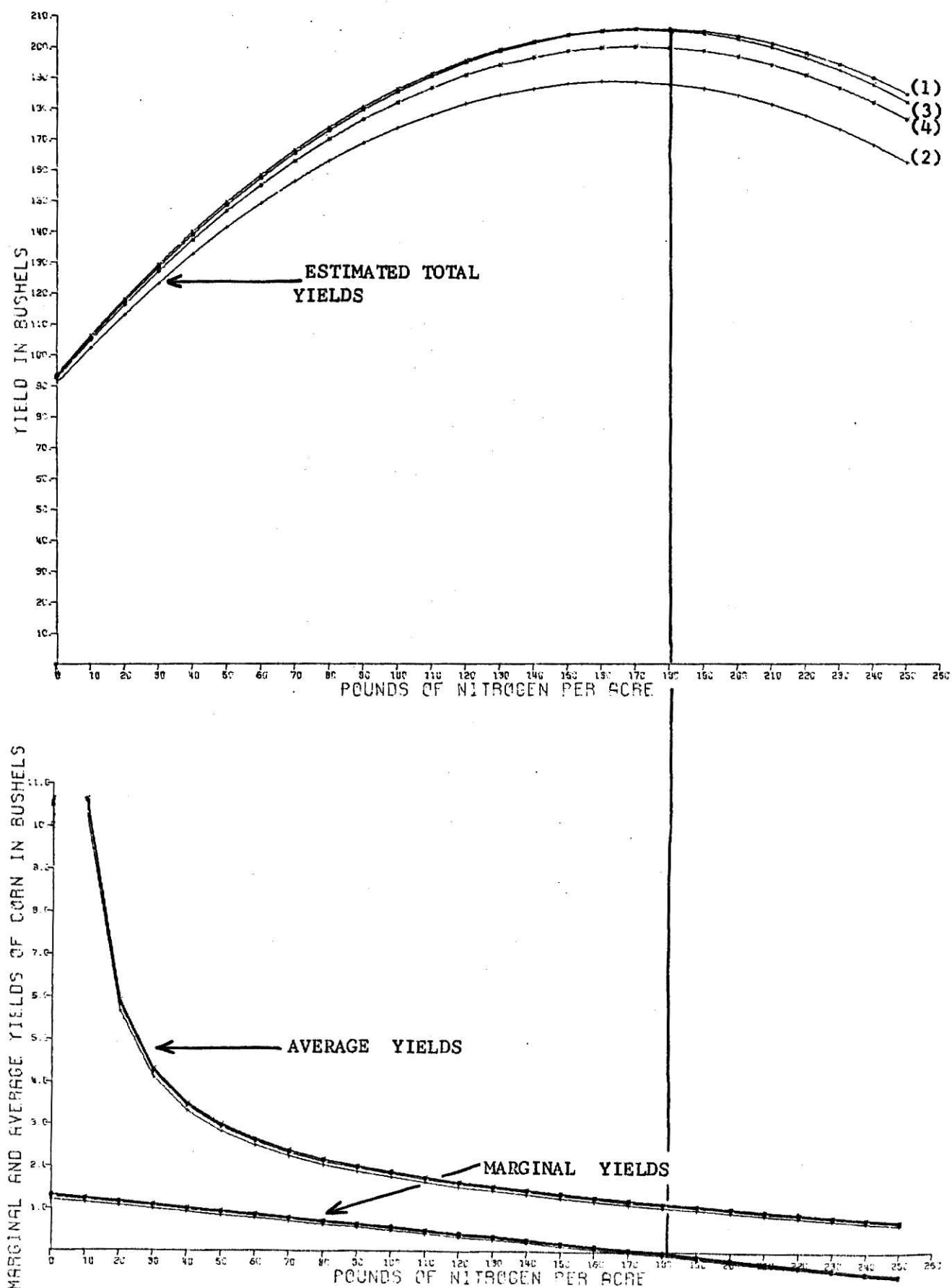


FIG. C1.10 Estimated Total, Marginal and Average Yields of corn, 1970.

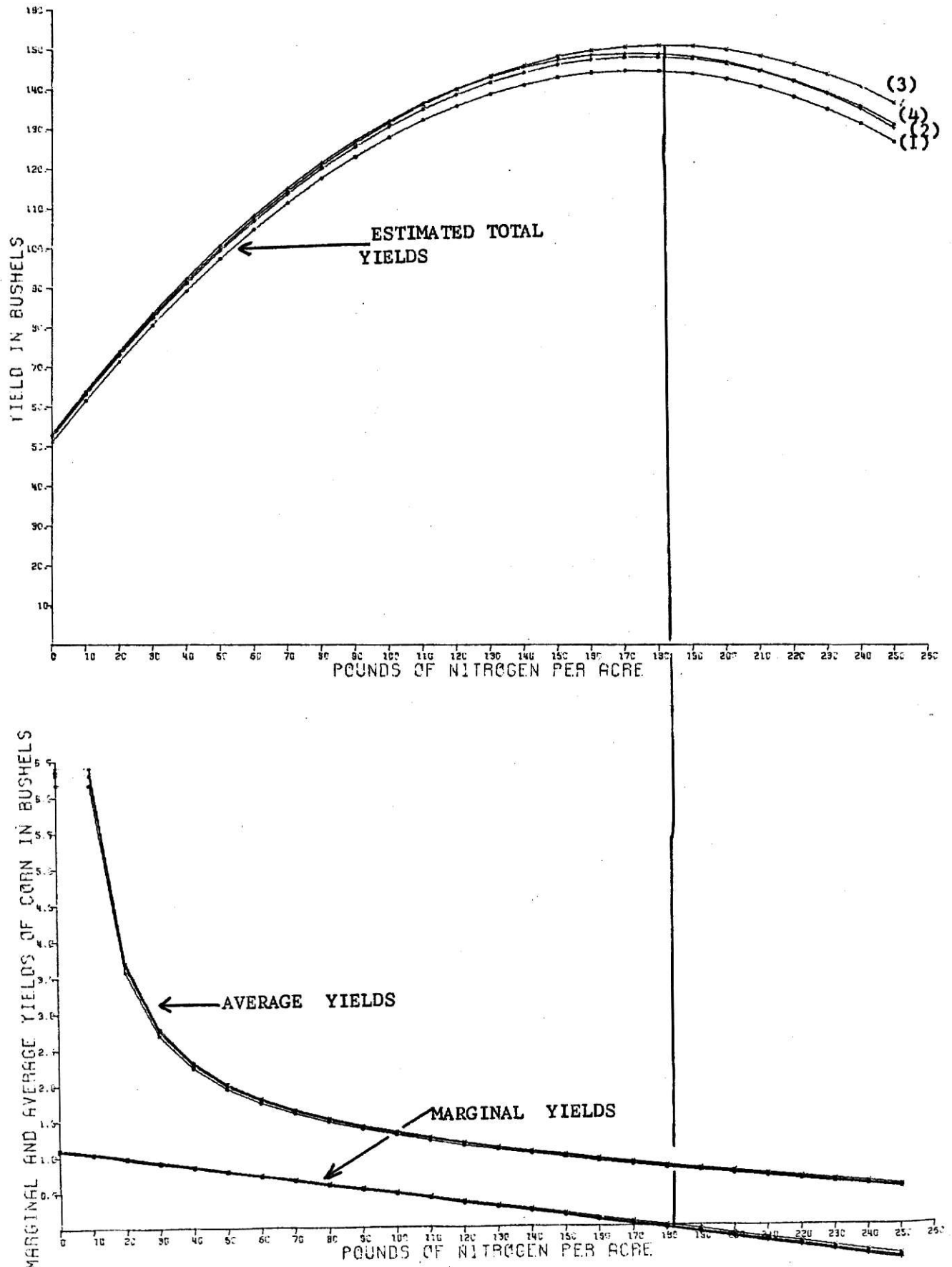


FIG. C1.11 Estimated Total, Marginal and Average Yields of corn, 1961-1965.

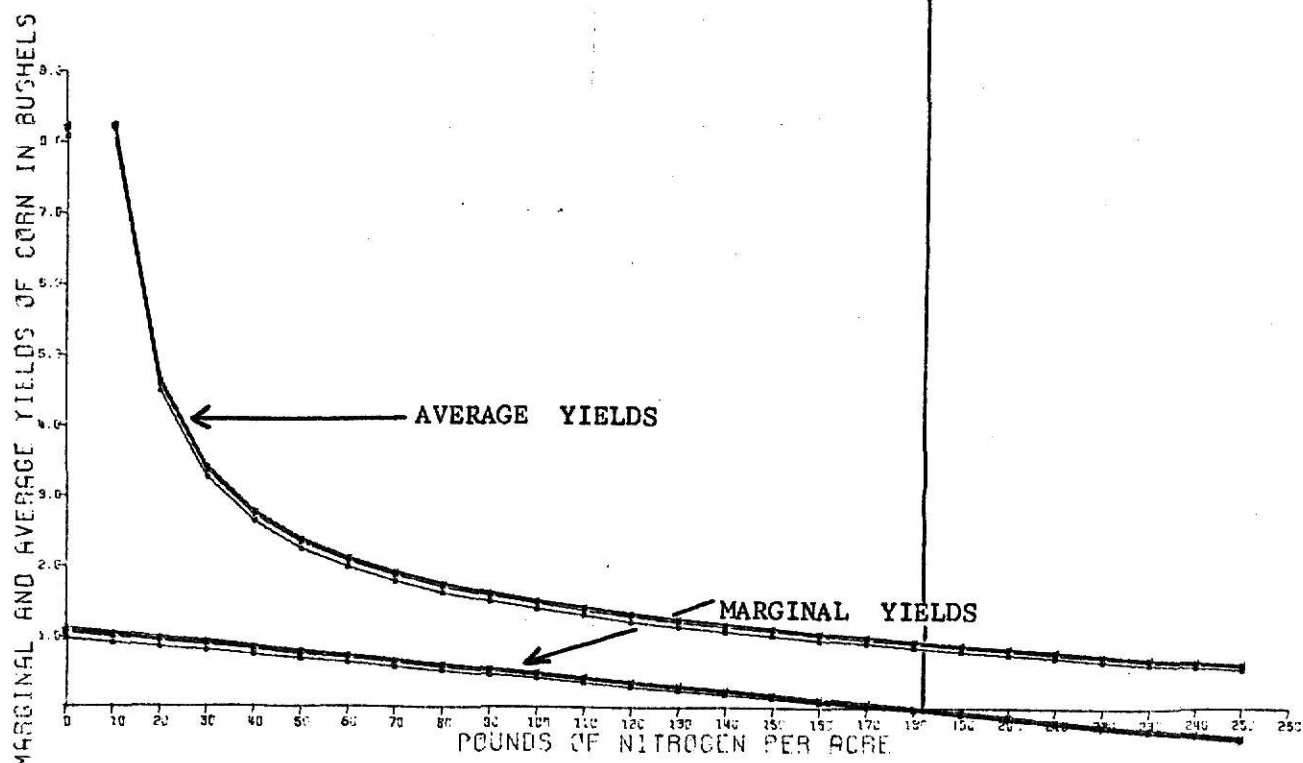
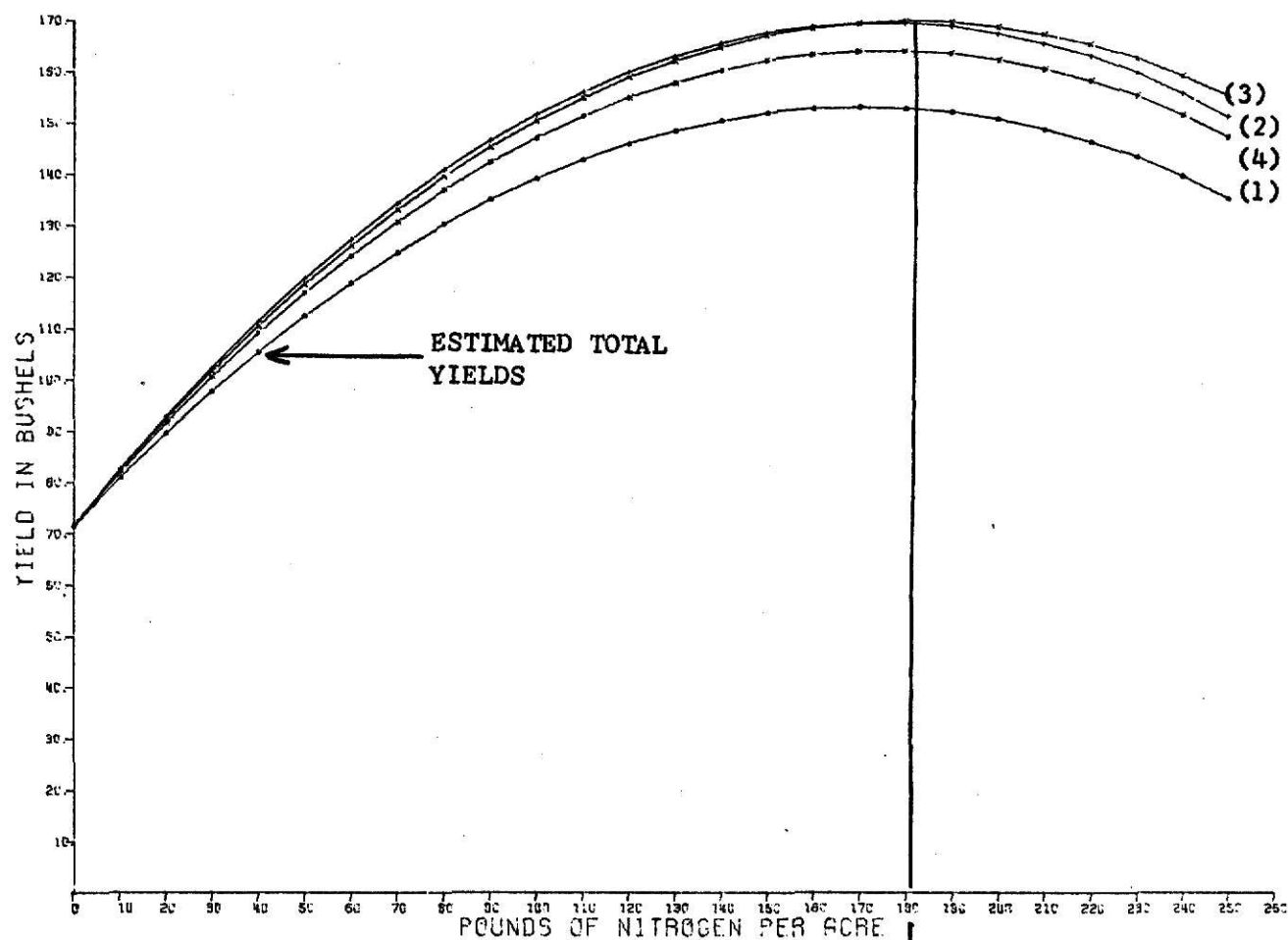


FIG. C1.12 Estimated Total, Marginal and Average Yields of corn, 1966-1970.

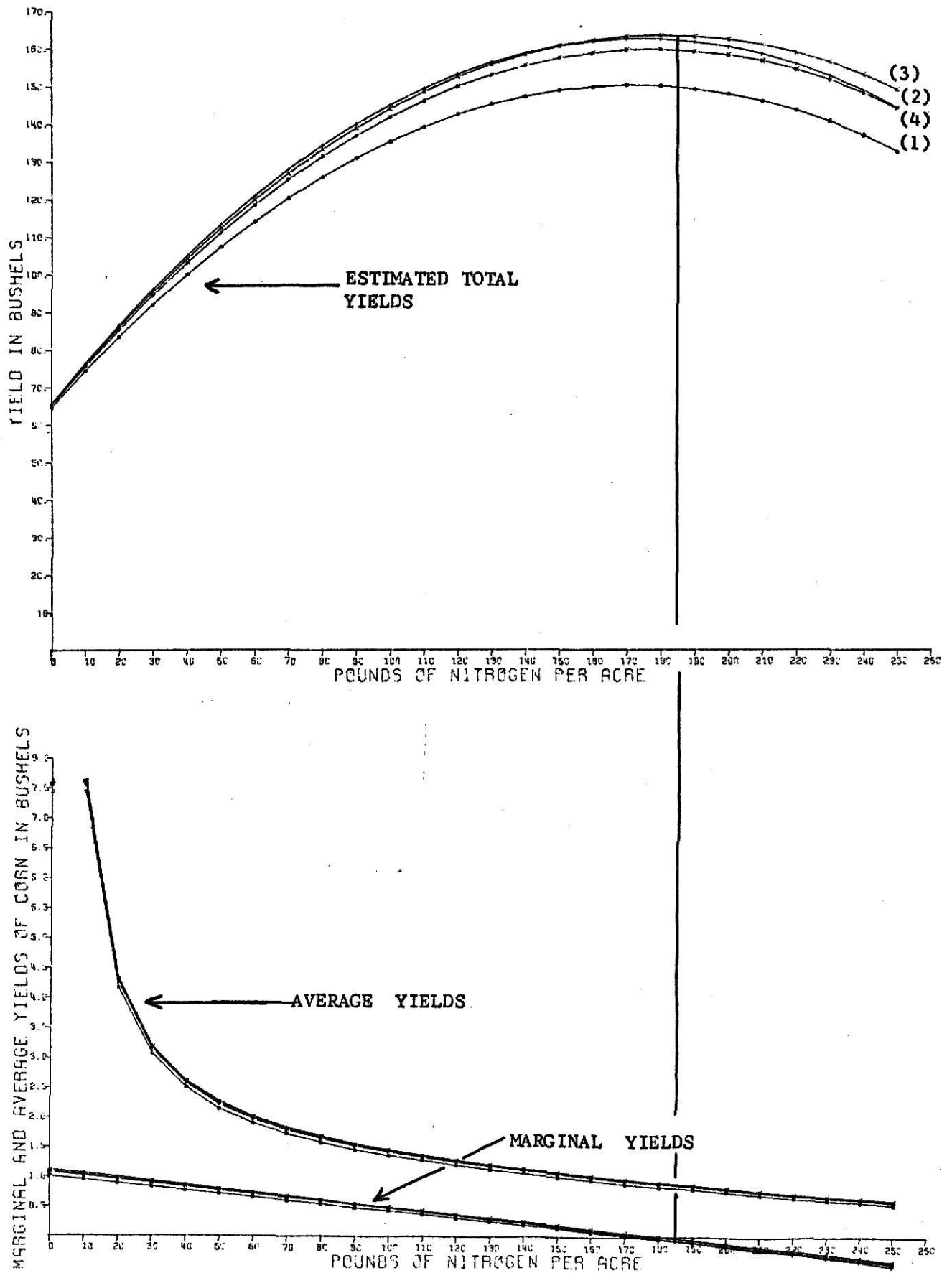


FIG. Cl.13 Estimated Total, Marginal and Average Yields of corn, 1961-1970.

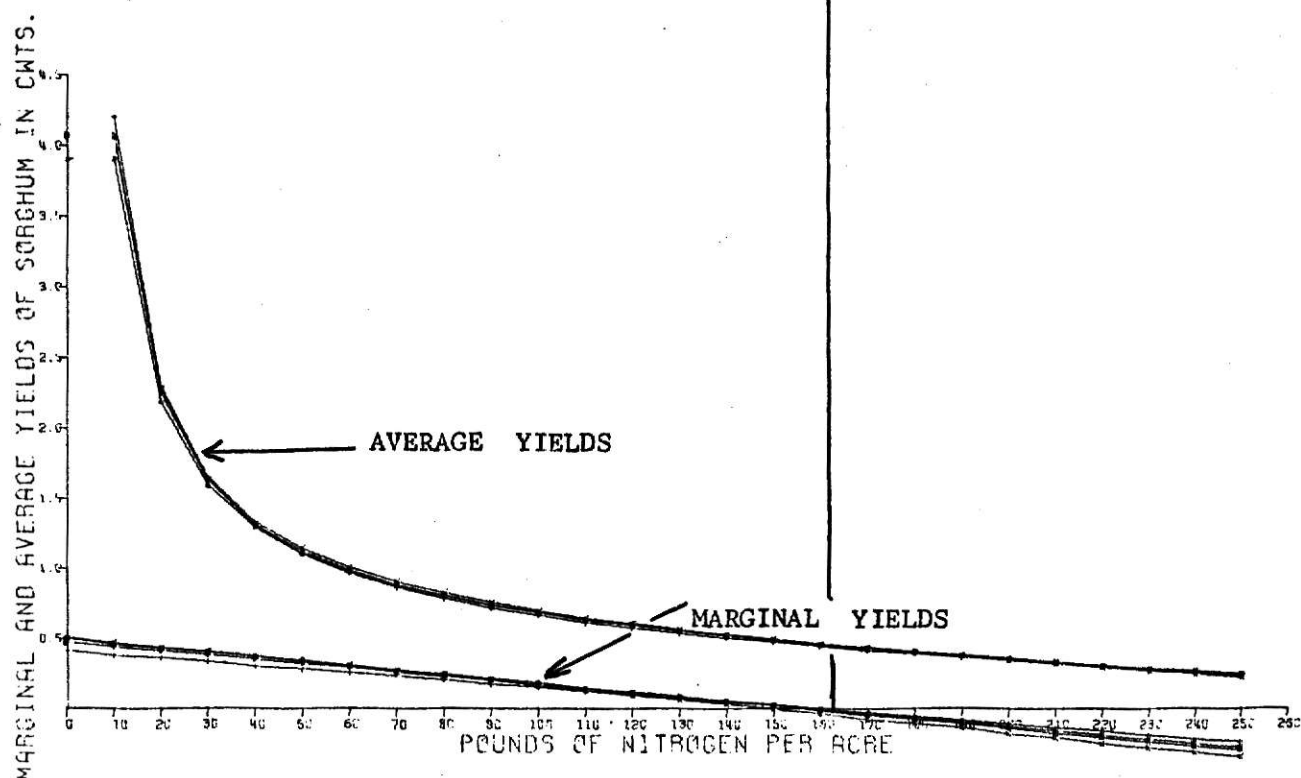
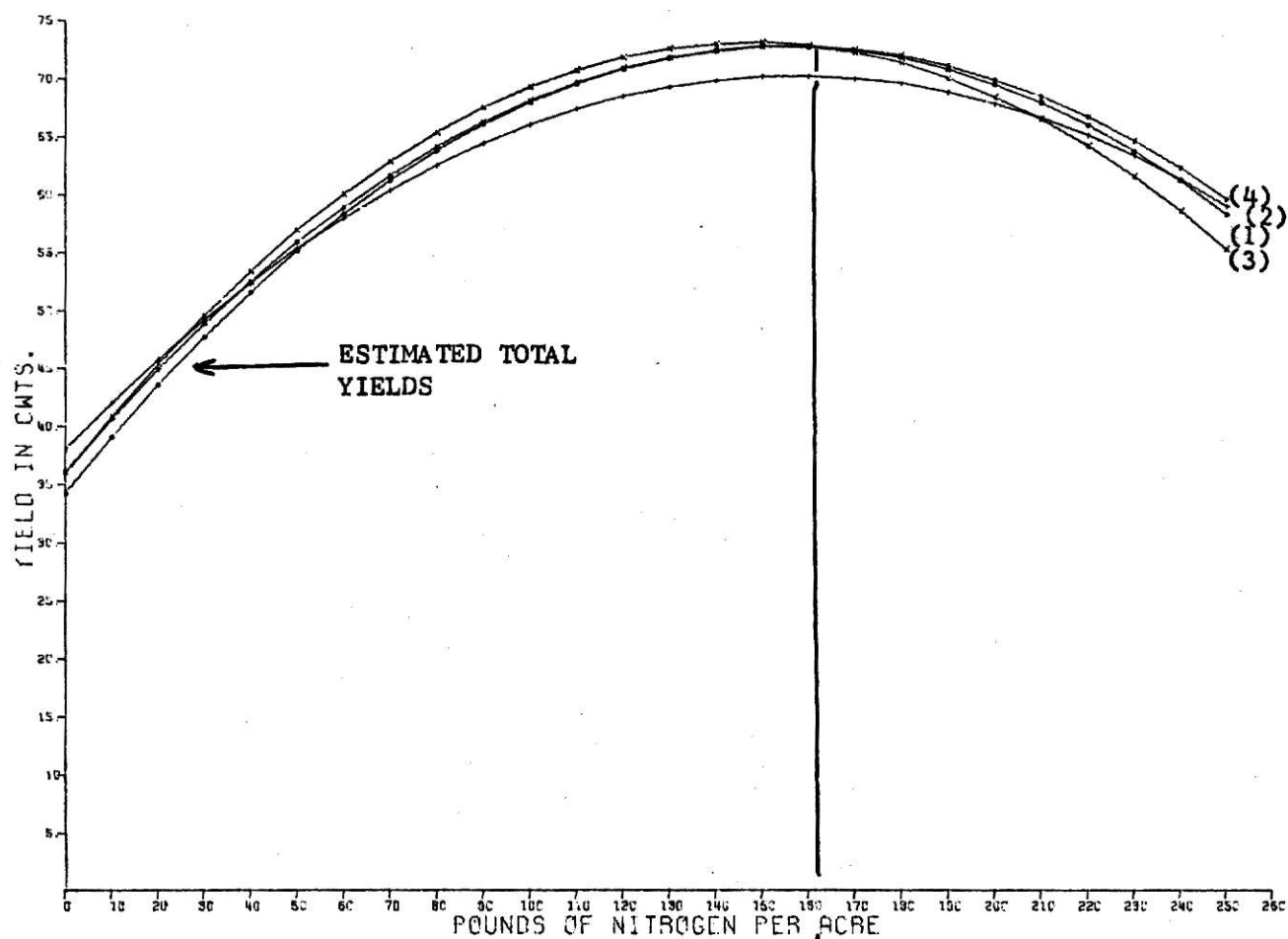


FIG. S1.1 Estimated Total, Marginal and Average Yields of grain sorghum, 1961.

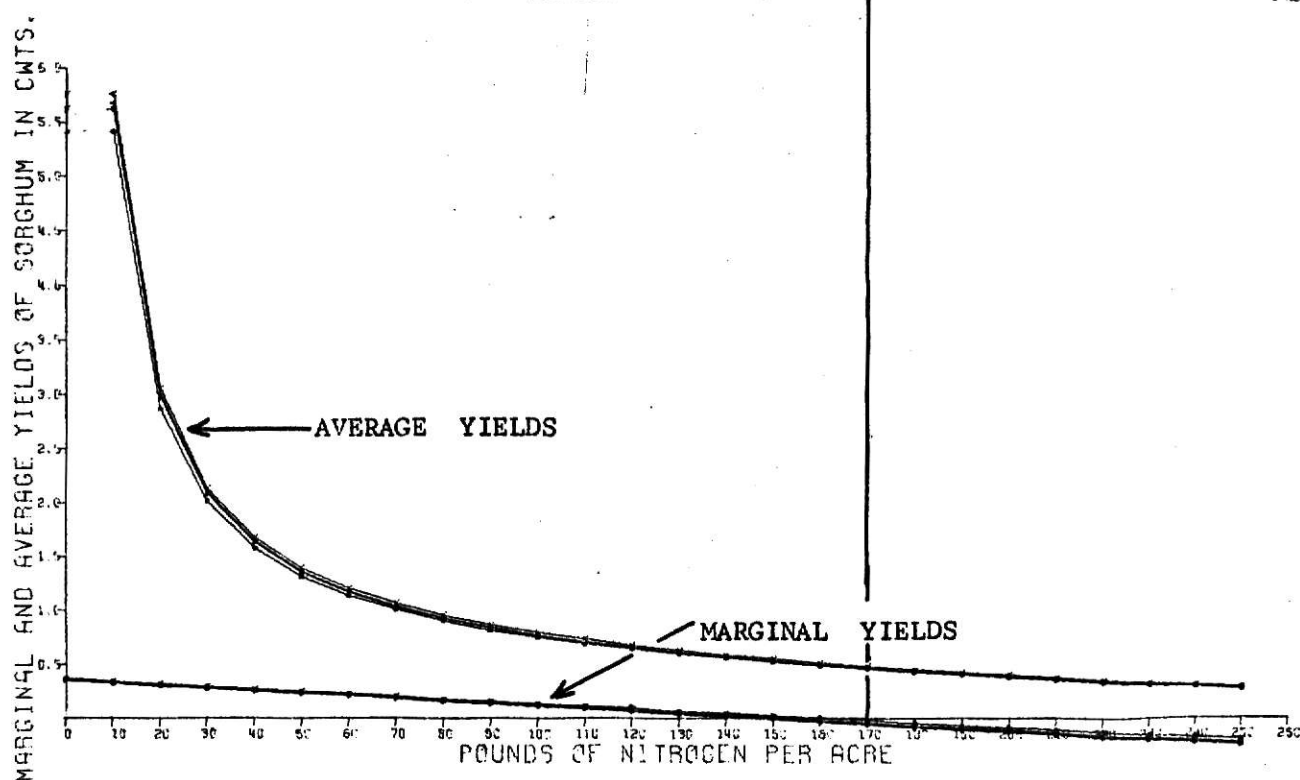
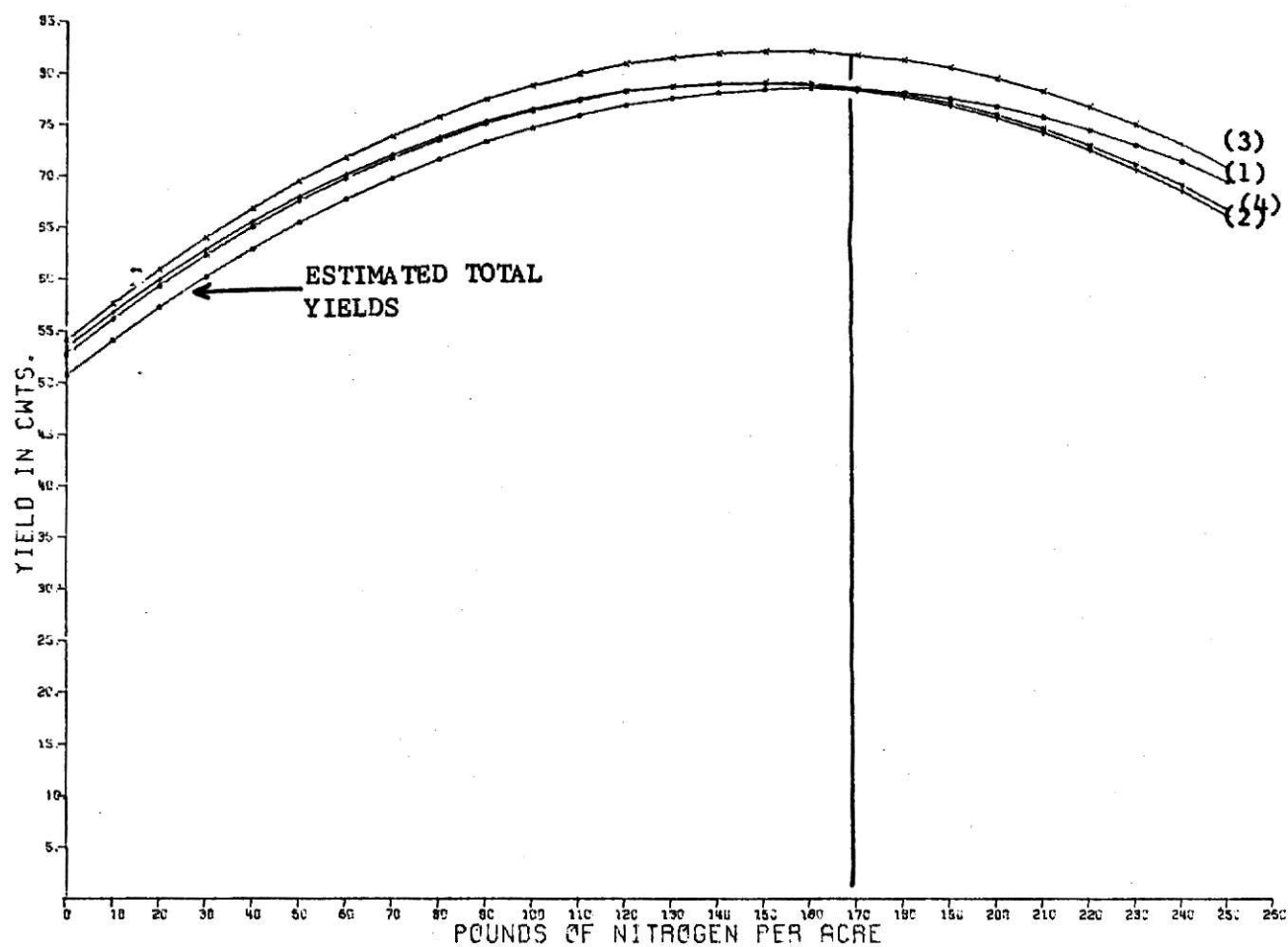


FIG. S1.2 Estimated Total, Marginal and Average Yields of grain sorghum, 1962.

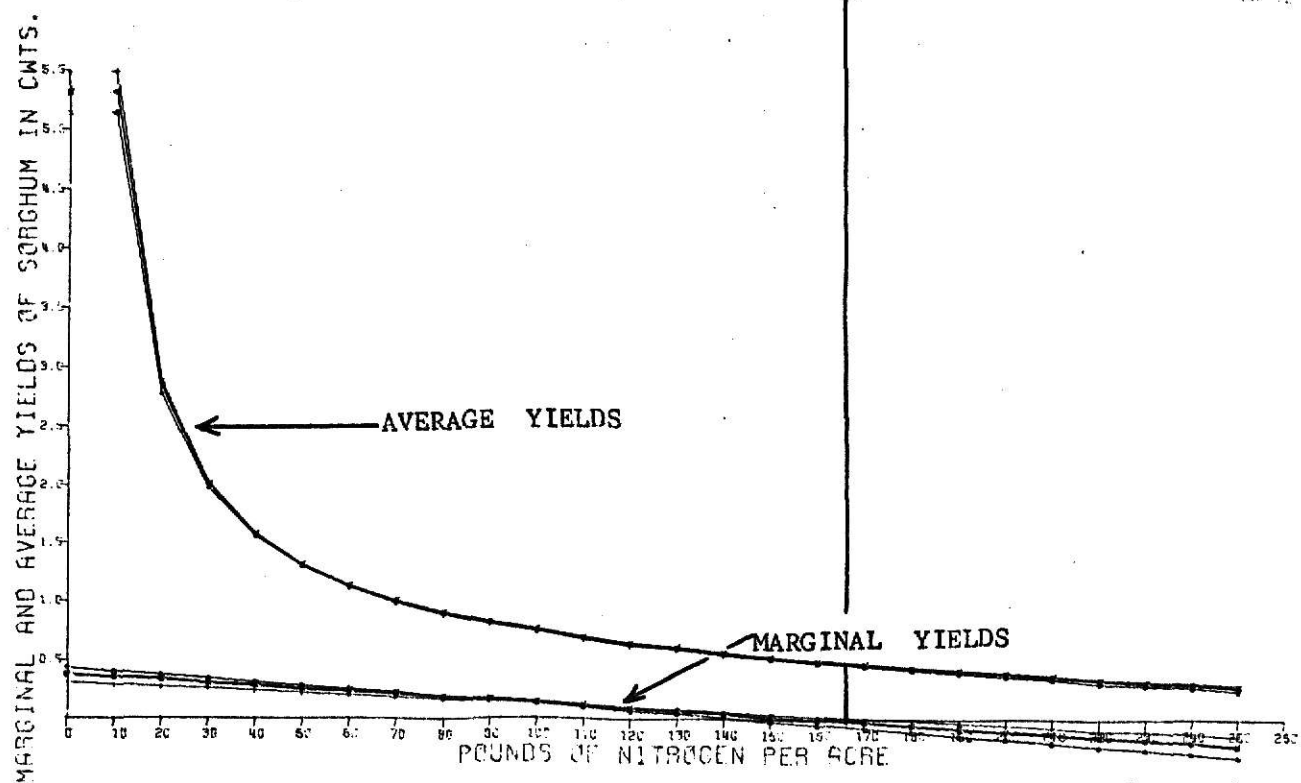
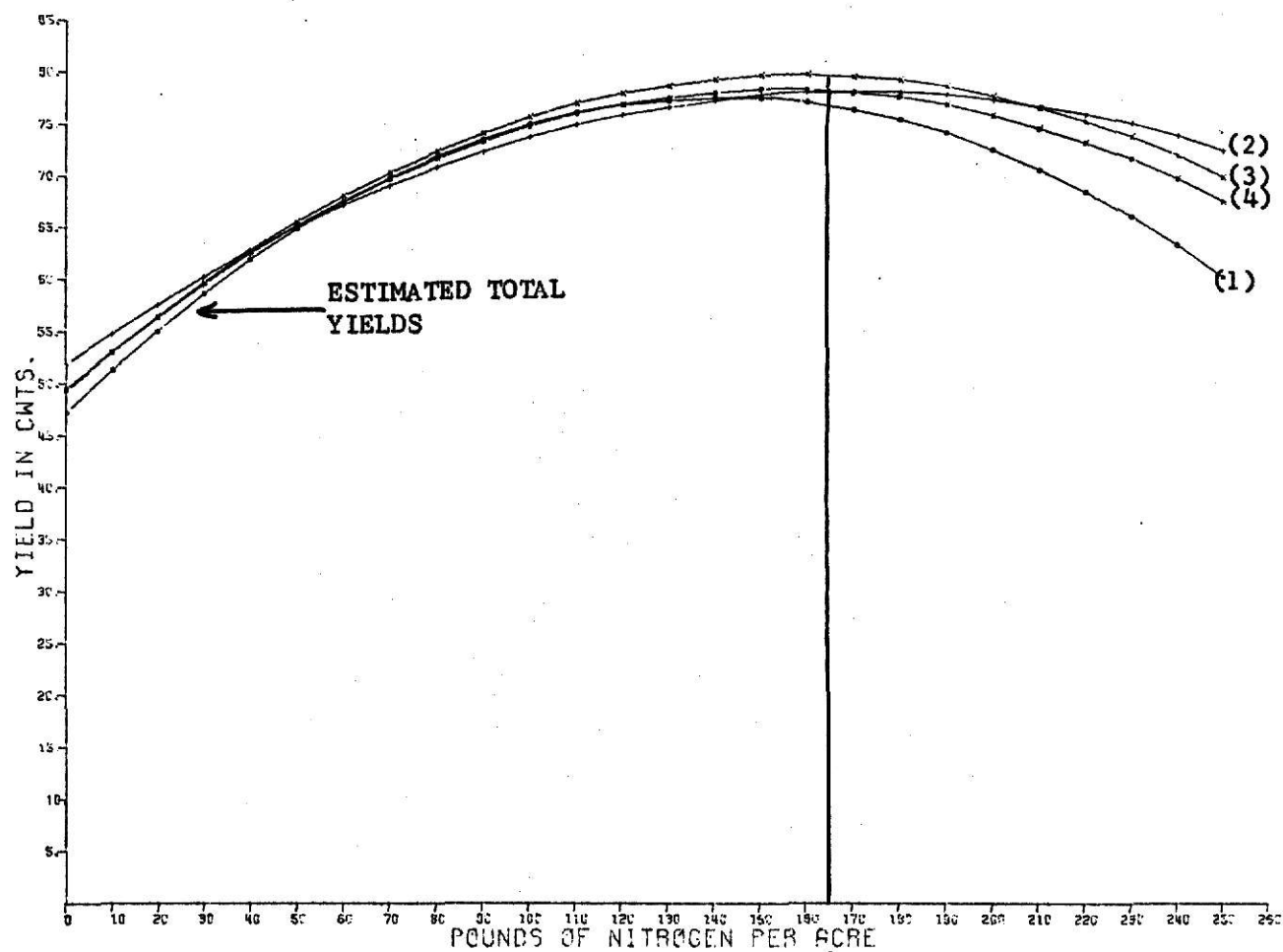


FIG. S1.3 Estimated Total, Marginal and Average Yields of grain sorghum, 1963.

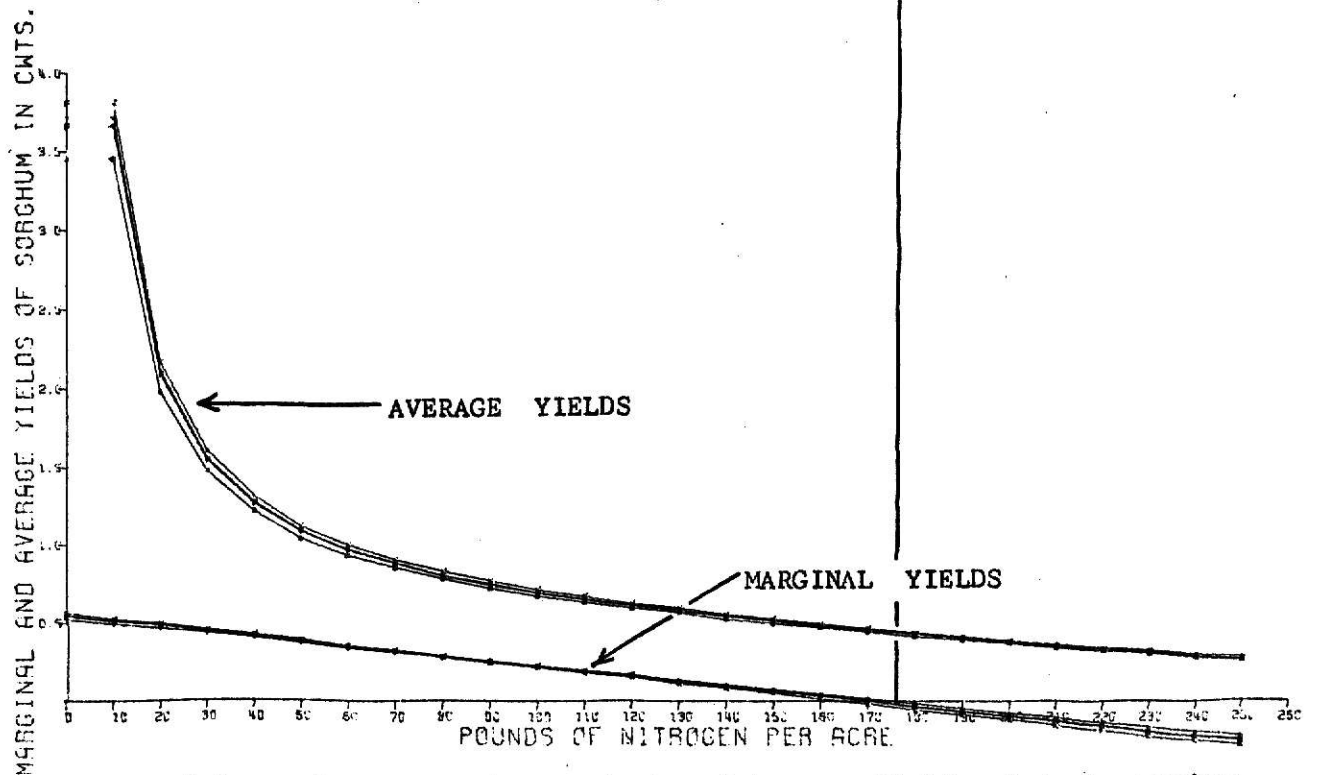
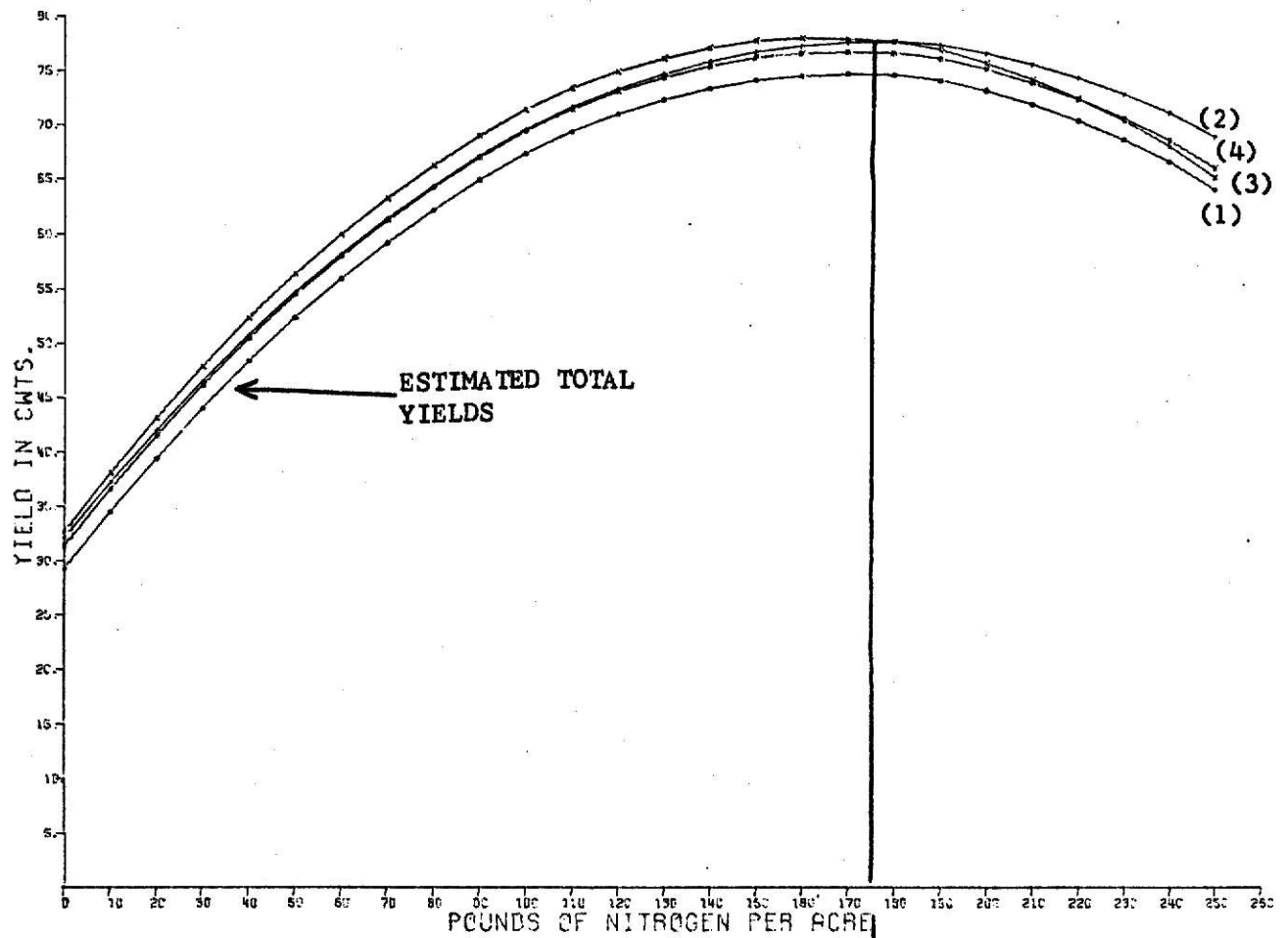


FIG. S1.4 Estimated Total, Marginal and Average Yields of grain sorghum, 1964.

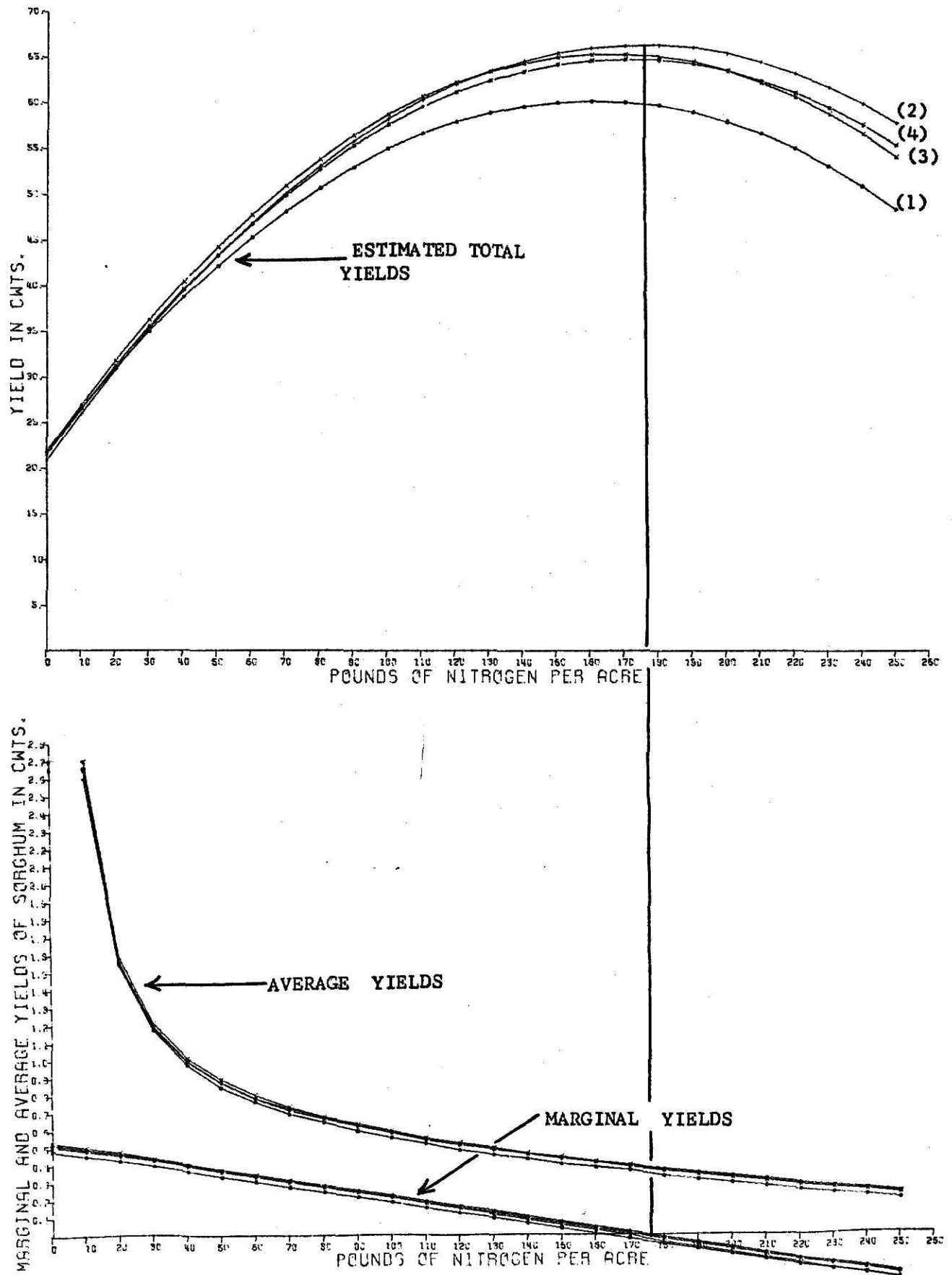


FIG. S1.5 Estimated Total, Marginal and Average Yields of grain sorghum, 1965.

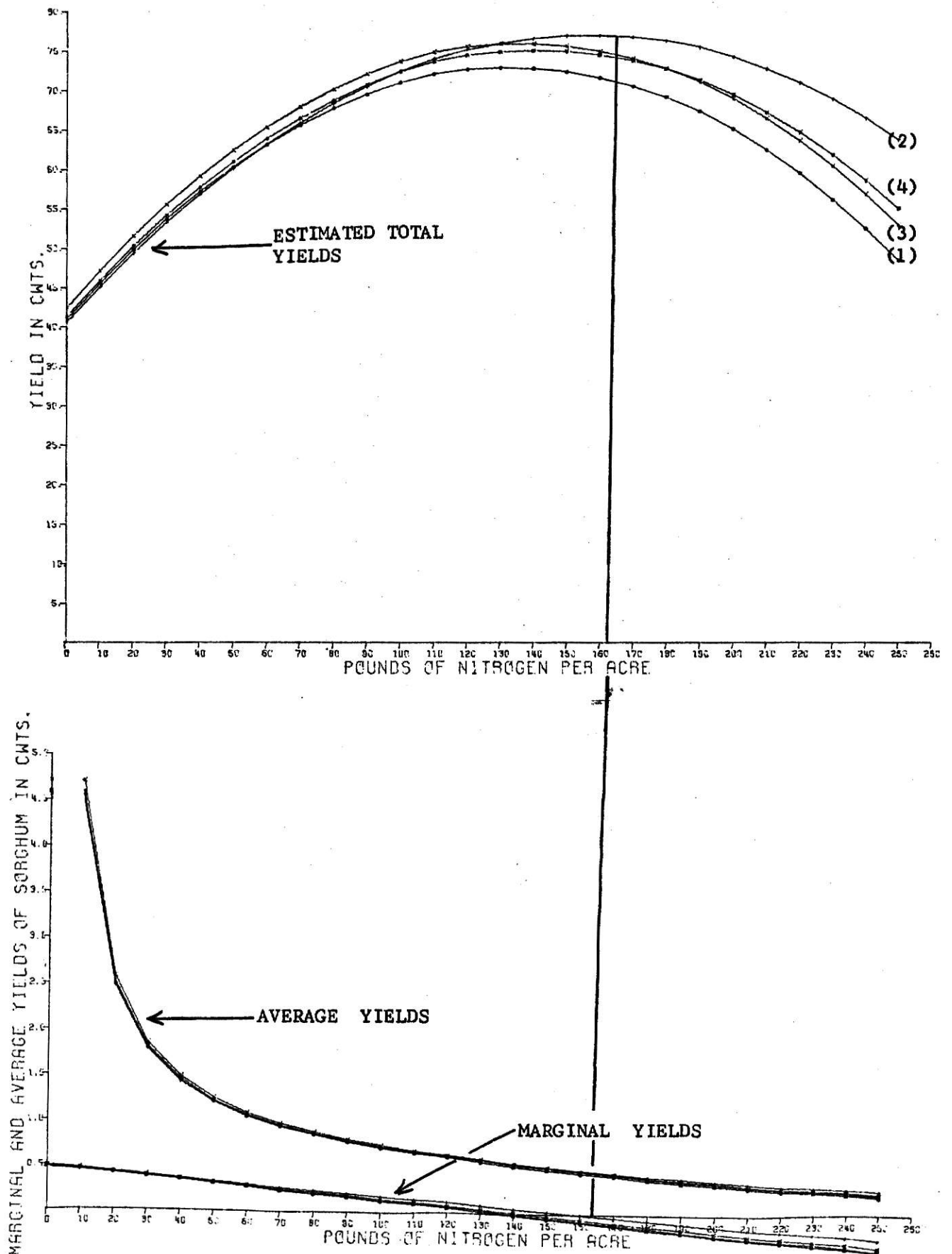


FIG. S1.6 Estimated Total, Marginal and Average Yields of grain sorghum, 1966.

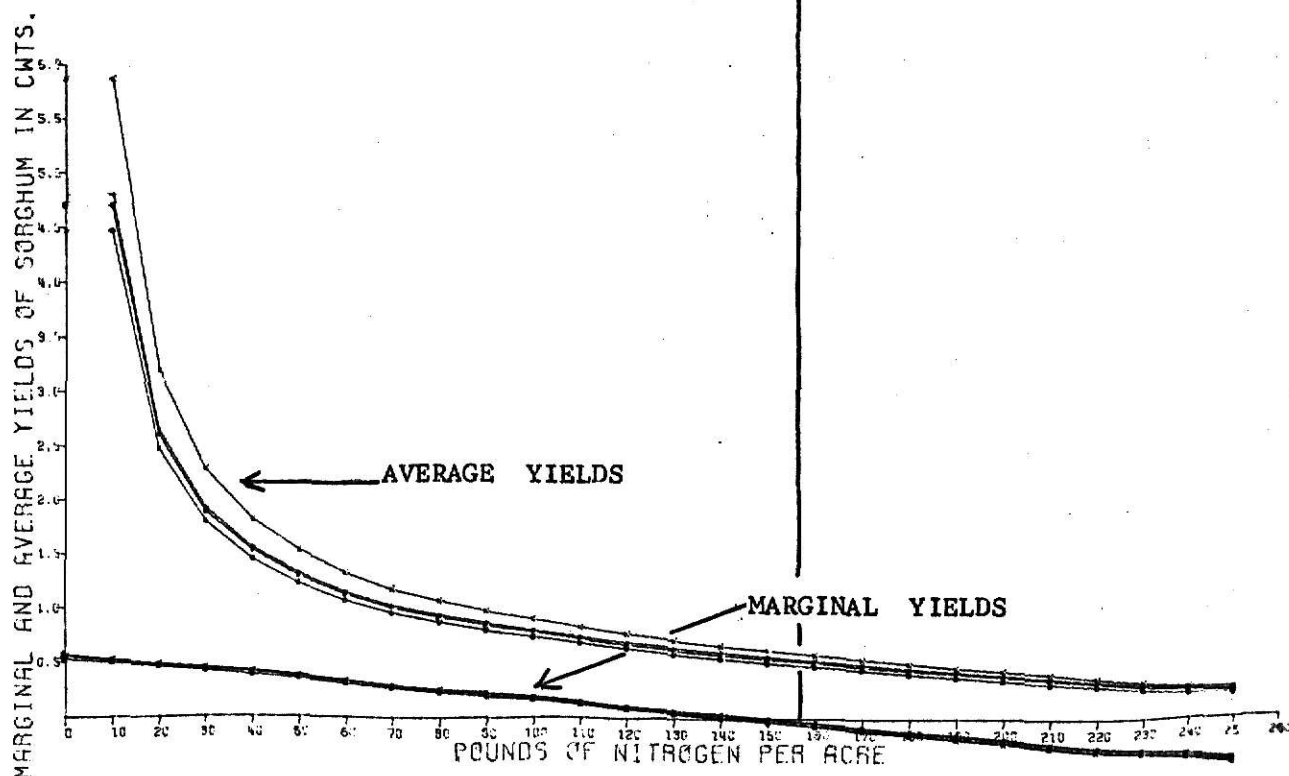
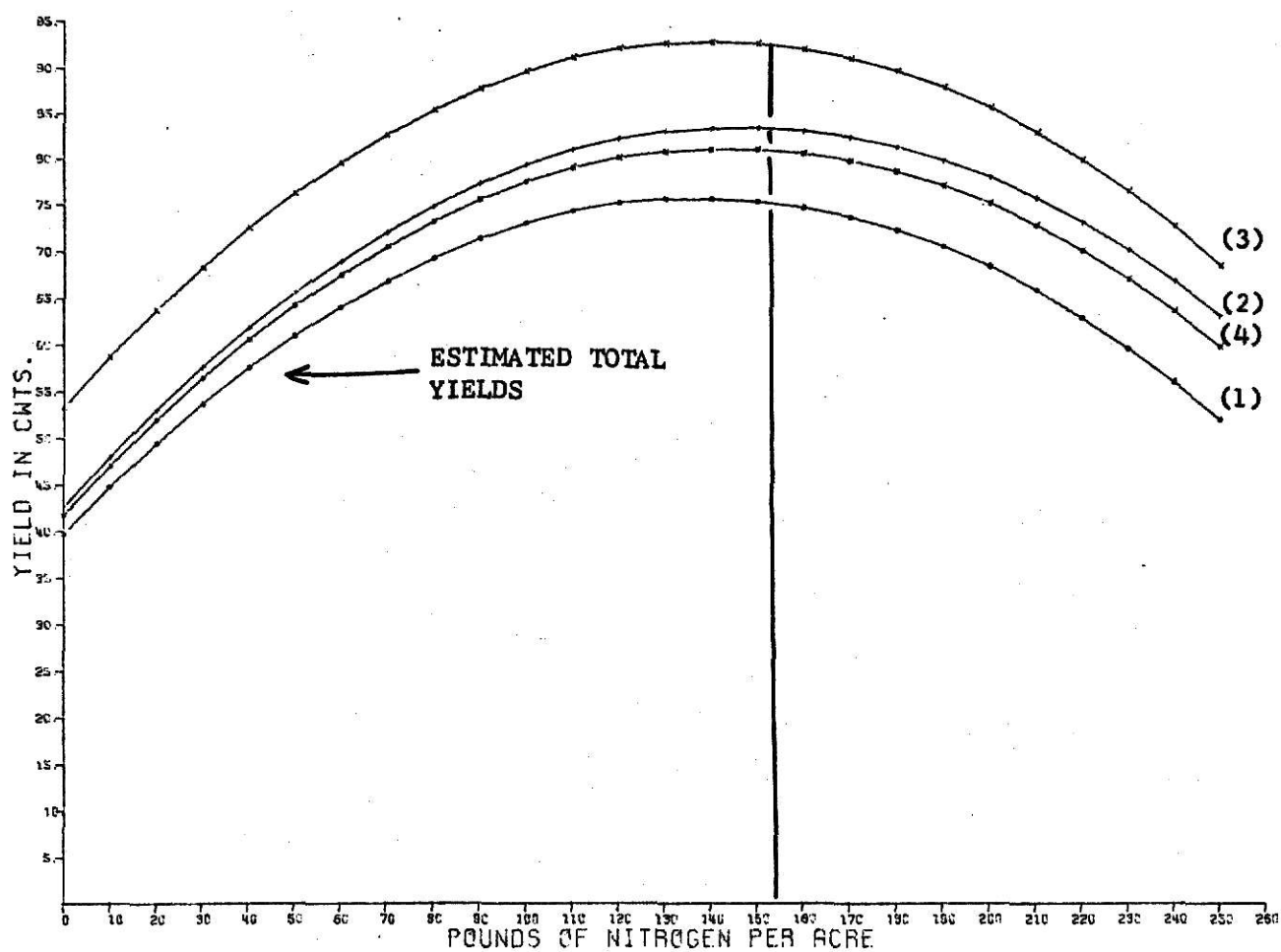


FIG. S1.7 Estimated Total, Marginal and Average Yields of grain sorghum, 1967.

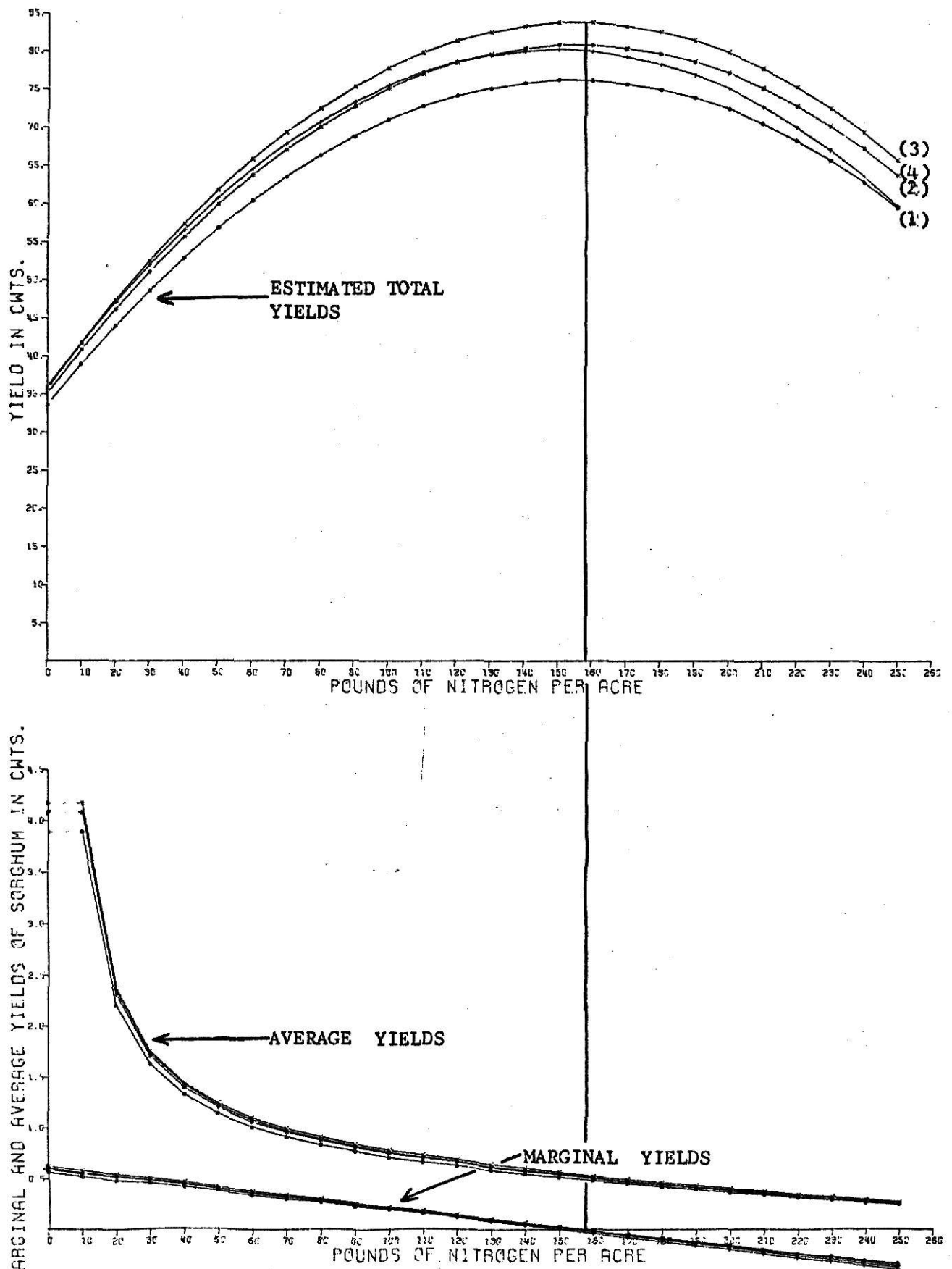


FIG. S1.8 Estimated Total, Marginal and Average Yields of grain sorghum, 1968.

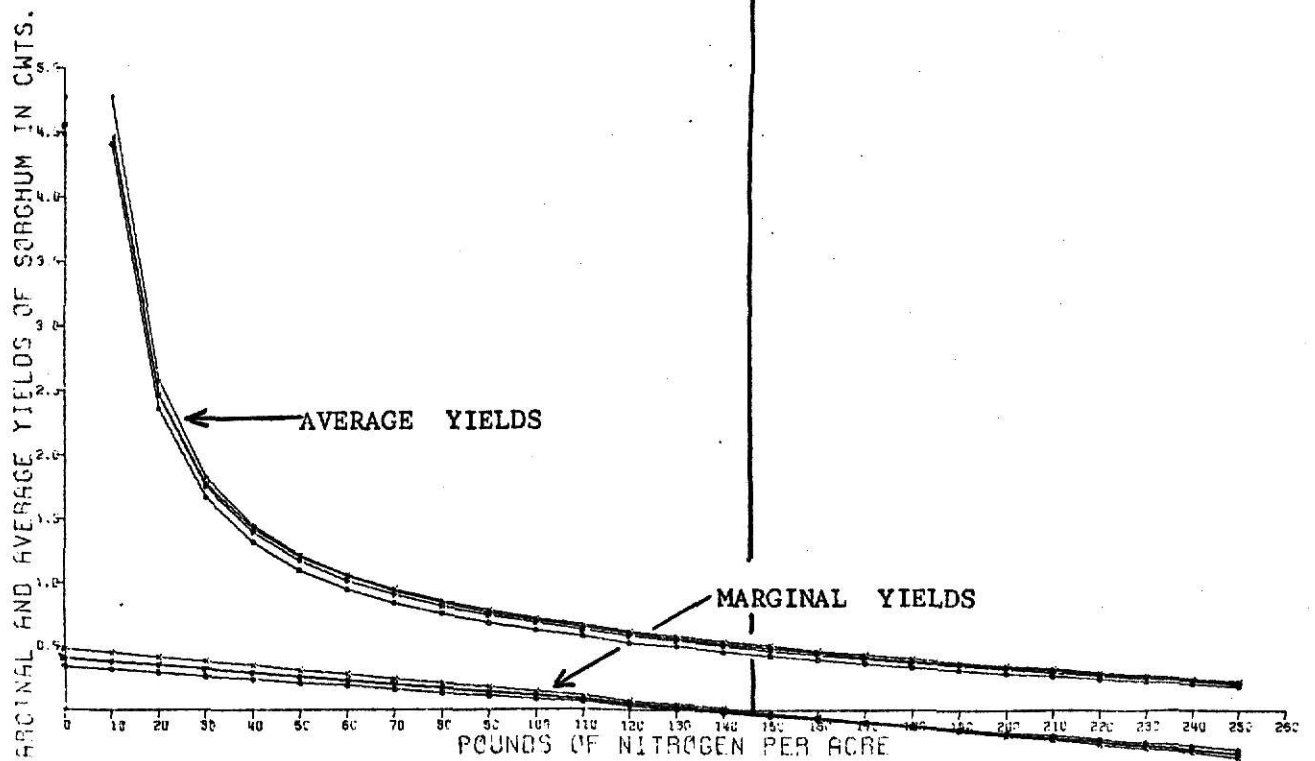
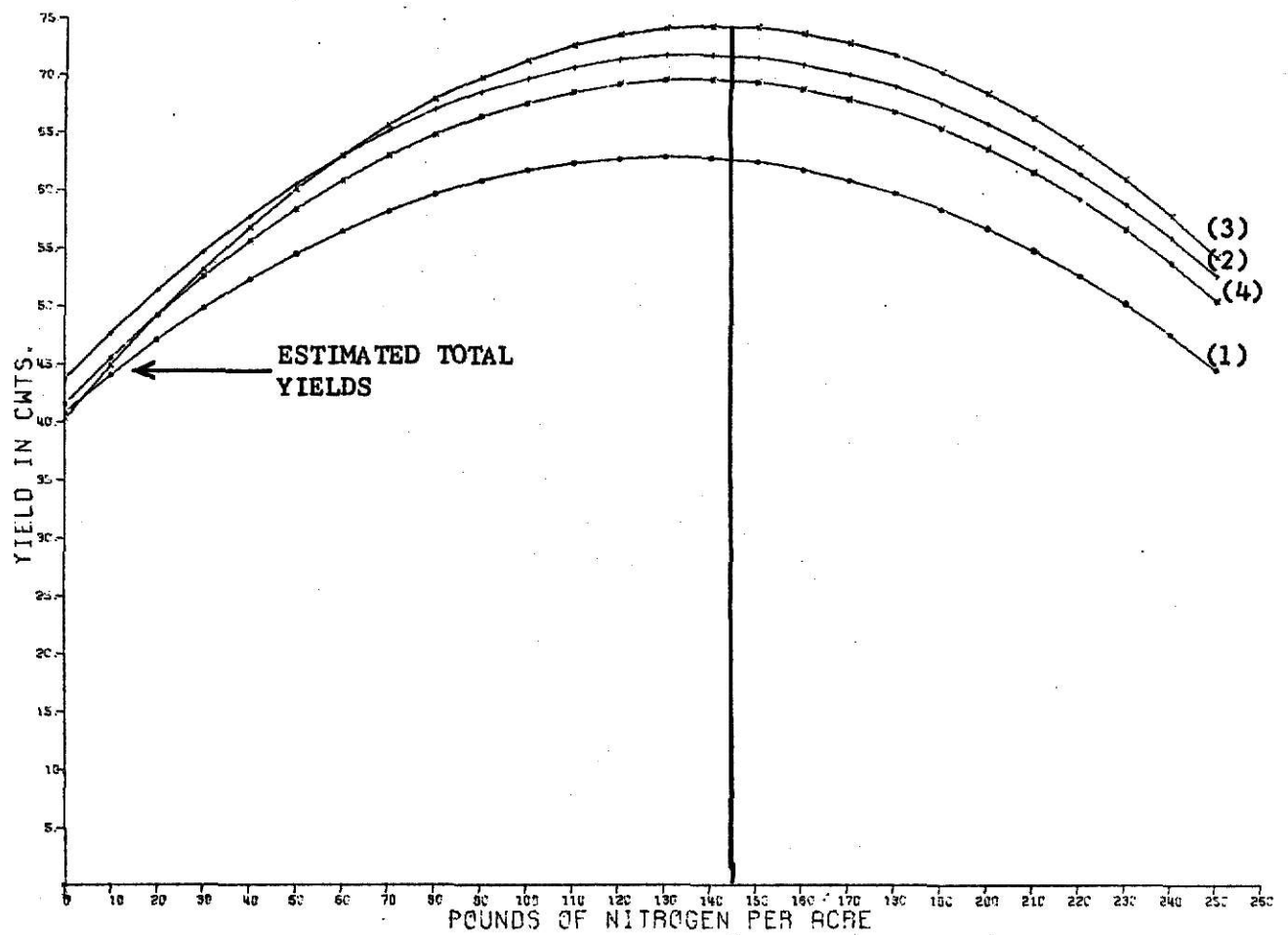


FIG. S1.9 Estimated Total, Marginal and Average Yields of grain sorghum, 1969.

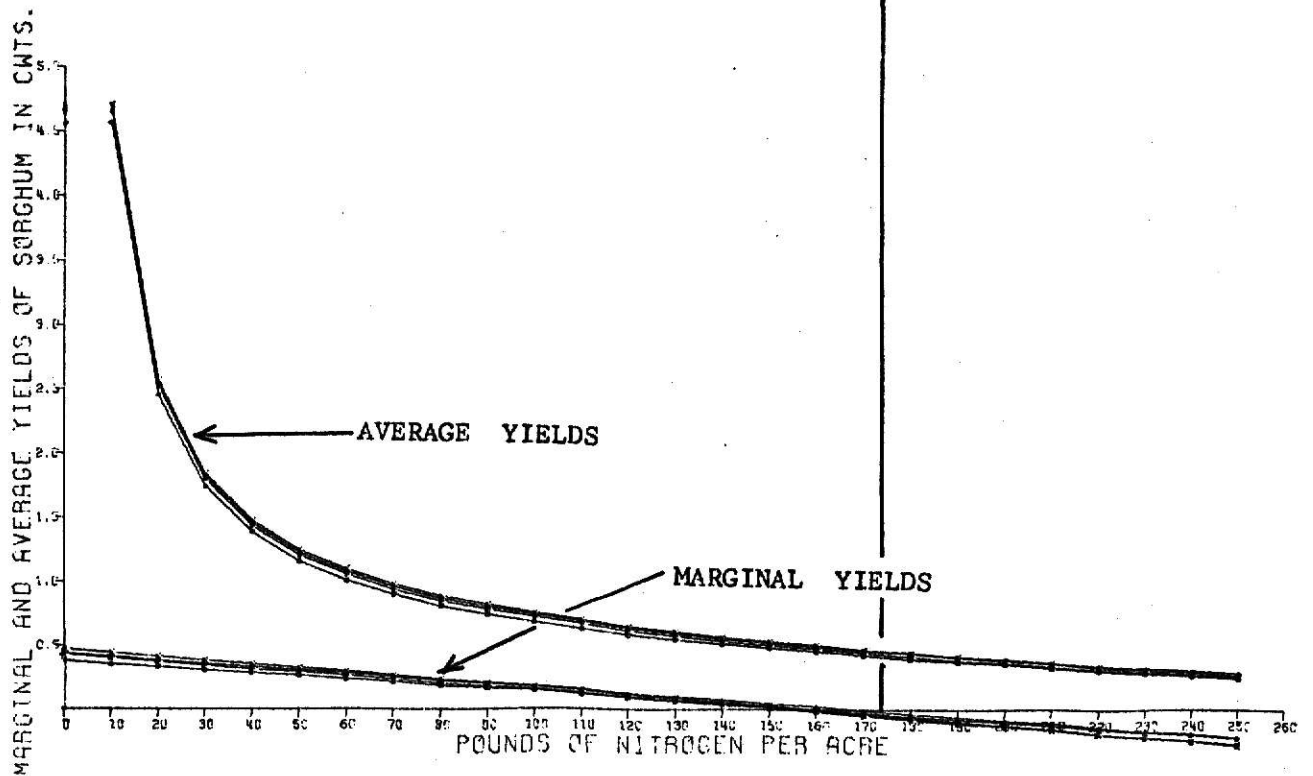
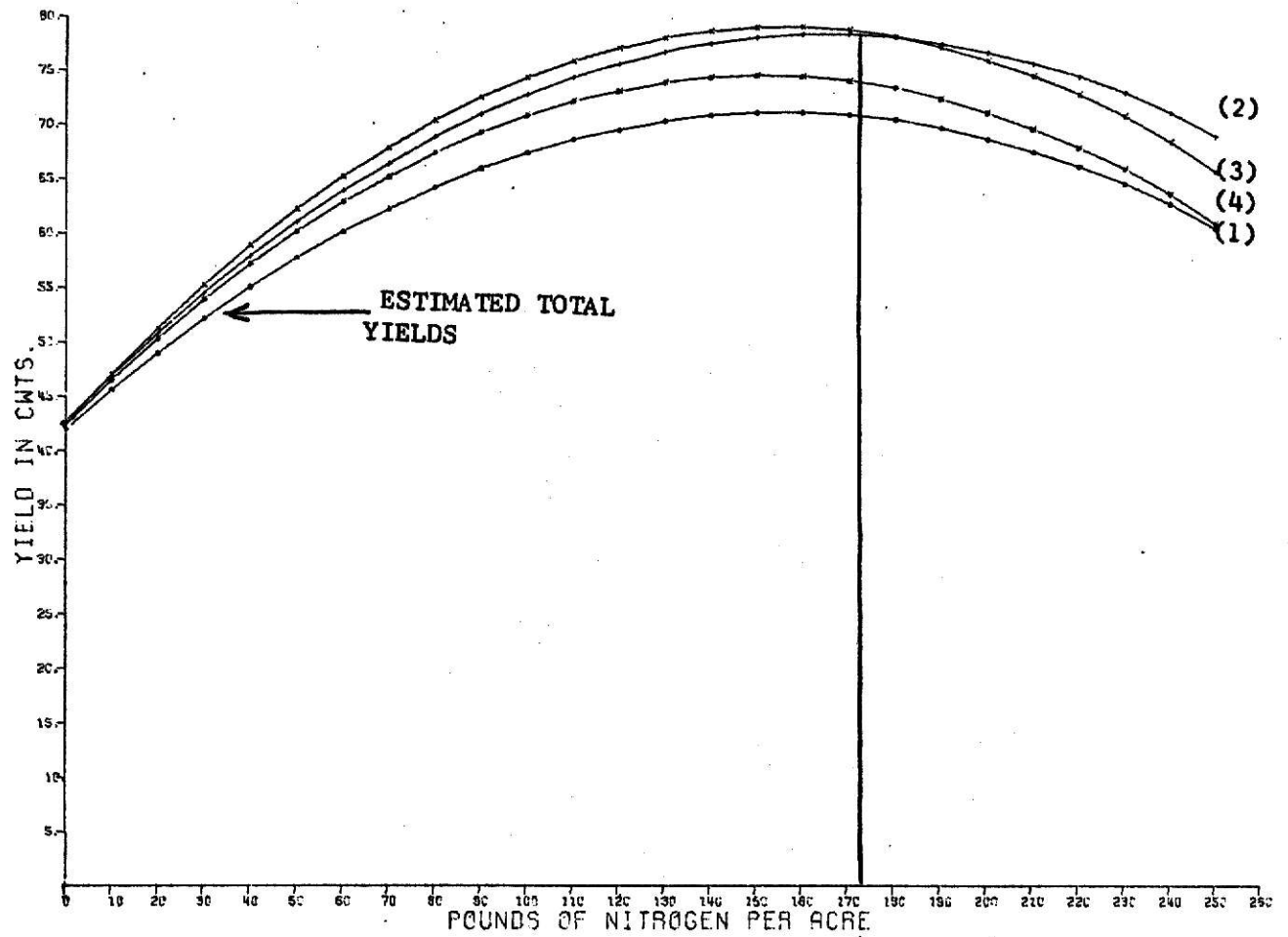


FIG. S1.10 Estimated Total, Marginal and Average Yields of grain sorghum, 1970.

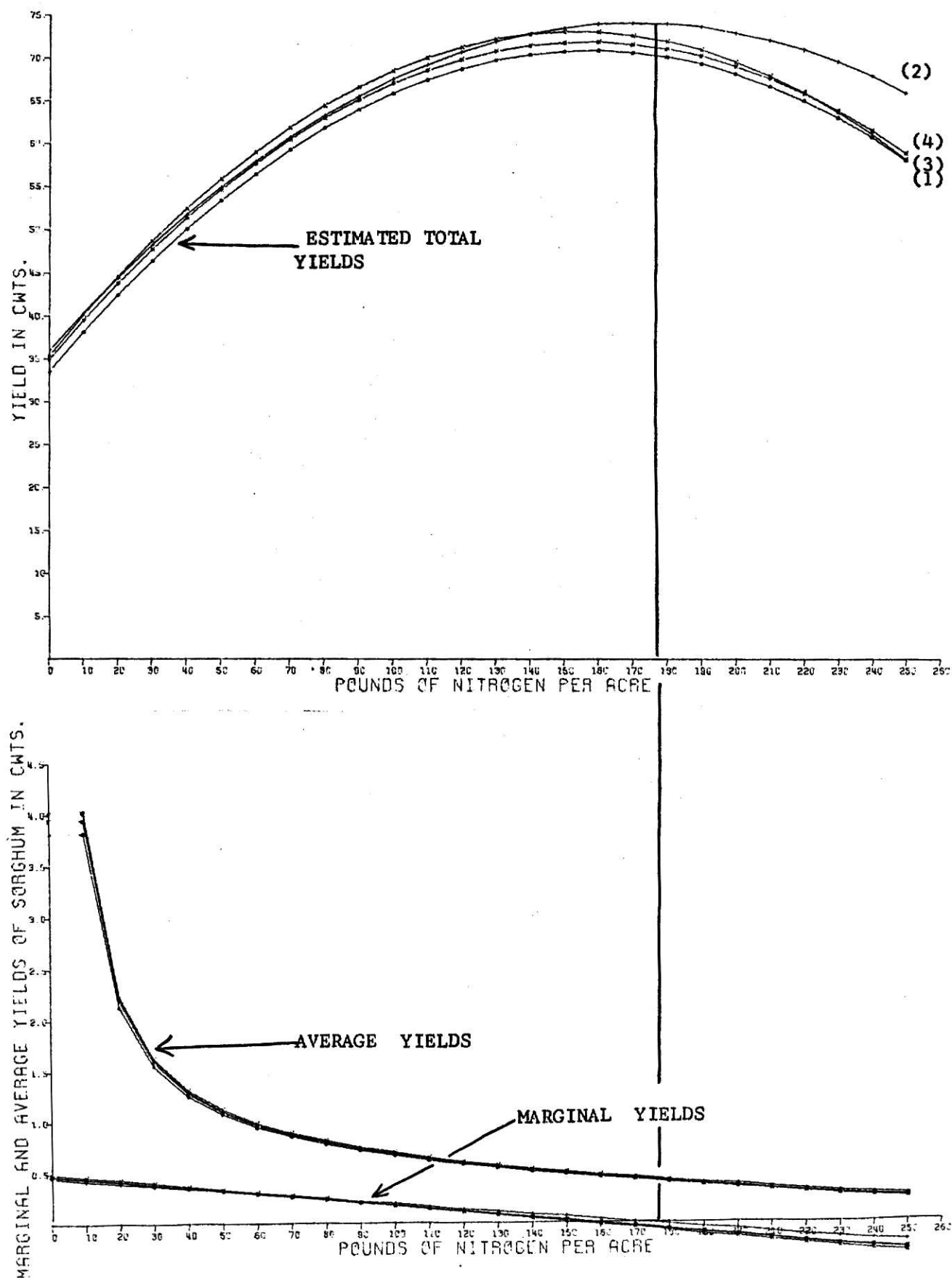


FIG. S1.11 Estimated Total, Marginal and Average Yields of grain sorghum, 1961-1965.

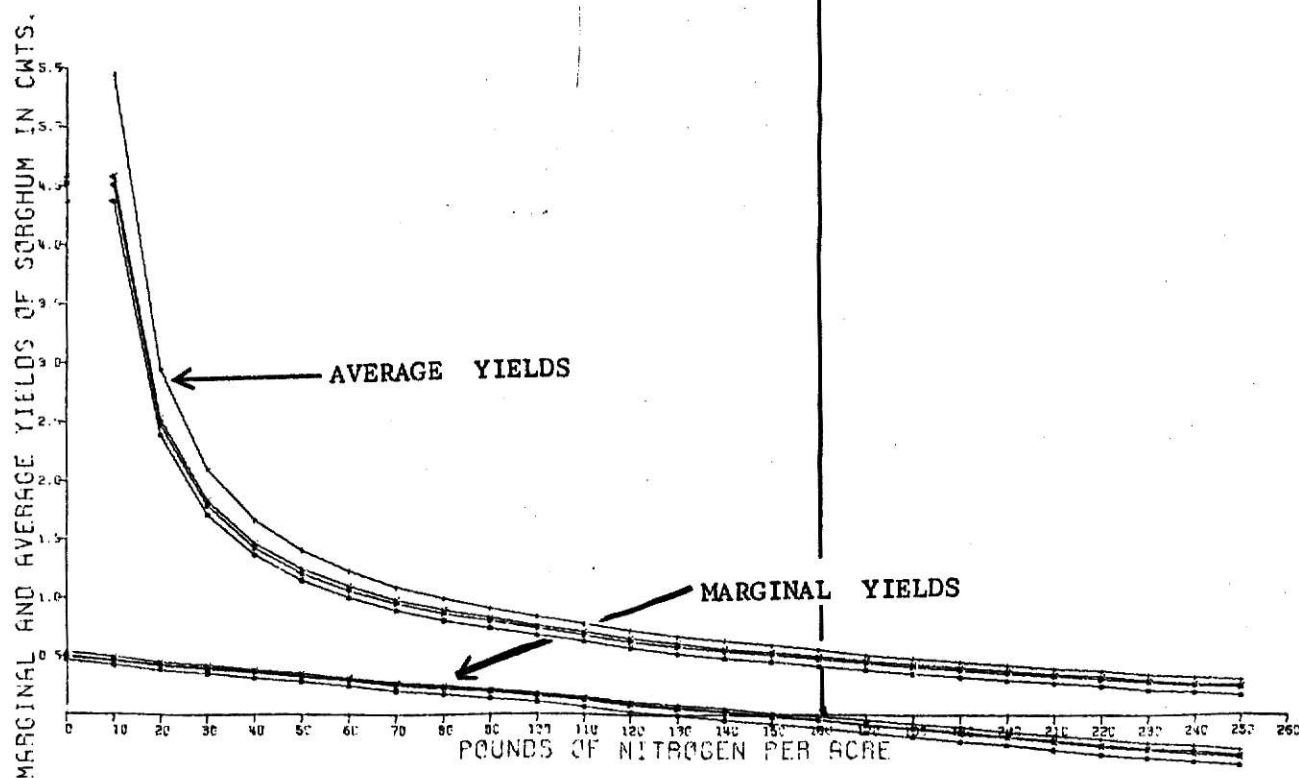
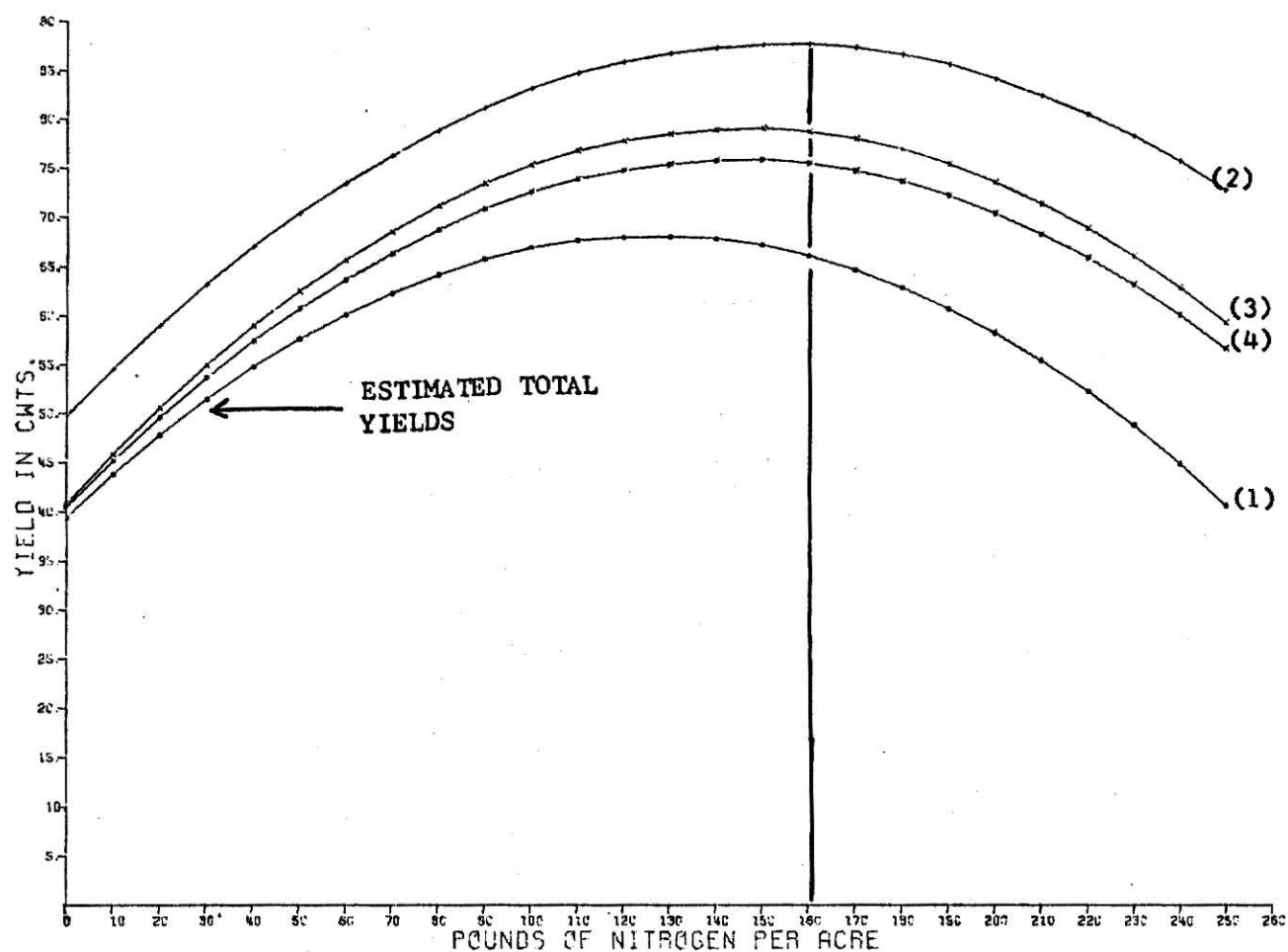


FIG. S1.12 Estimated Total, Marginal and Average Yields of grain sorghum, 1966-1970.

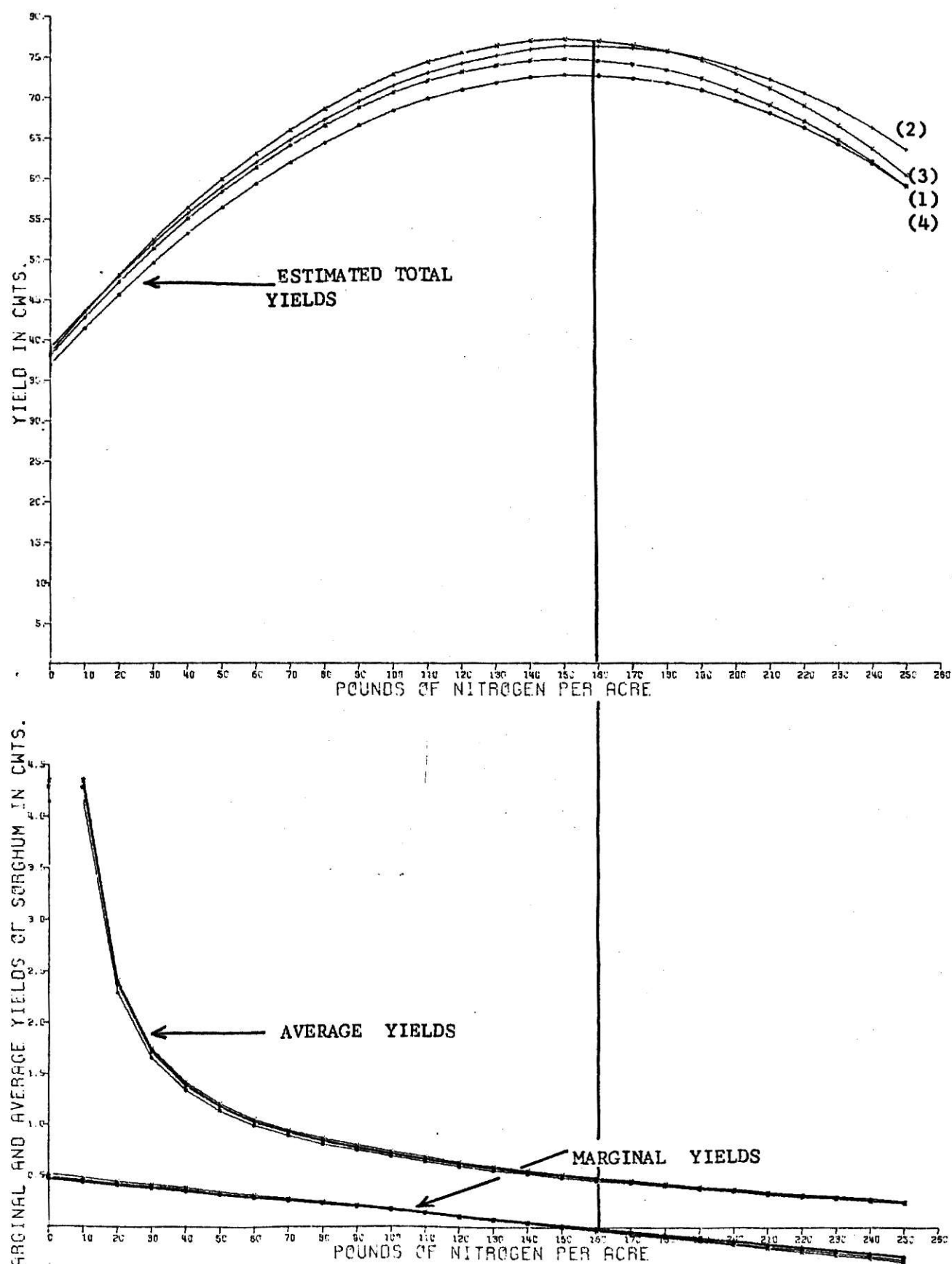


FIG. S1.13 Estimated Total, Marginal and Average Yields of grain sorghum, 1961-1970.

1. Algebraic Solution:

The marginal yield $\frac{dY}{dN}$ is set equal to zero and the corresponding N level is the optimum fertilizer rate. For equation(i)

$$\frac{dY}{dN} = 1.0651 - 2(0.0030)N = 0$$

$$1.0651 = 0.0060N$$

$$N = \frac{1.0651}{0.0060} = 177.52 \text{ lbs/acre}$$

Thus 177.52 lb/acre N gives the optimum yield which can be obtained by substituting this value into the original equation (265).

$$Y = 65.2495 + 1.0651N - 0.0030N^2$$

$$Y = 65.2495 + 1.0651(177.52) - (0.0030)(177.52)^2$$

$$Y = 159.79 \text{ bushels/acre.}$$

In the same way optimal yield levels can be obtained for other equations.

2. Graphical Solution*:

By putting Y on the vertical axis and N on the horizontal axis the same answer can be obtained by plotting the estimated total yield and the marginal yield values. Where the marginal yield curve crosses the x-axis gives the point where total yield is at maximum. Figures C1 and S1 are the graphs obtained using information from Tables 3 and 4 respectively. A line parallel to the y-axis passing through the maximum total yield level meets the x-axis where the marginal yield curve intercept the x-axis or their values are equal to zero.

3. Tabular Solution:

Tables 3 and 4 show for each quadratic equation, the estimated total marginal and average yields. For equation (265) the marginal yield is

*In Figures C1 and S1 (1), (2), (3) & (4) refer to treatments P_0K_0 , P_1K_0 , P_1K_1 and when all nutrients are variable respectively.

0.05 bushels of corn with 170 pounds of N and -0.01 bushels at 180 pounds of N. The estimated total yield at these two levels of N are 159.62 and 159.77 bushels per acre respectively. Thus the maximum total yield lies between 170 and 180 pounds of N and thus a little higher than 159.77. The same observation can be made for all other equation.

E. MAXIMUM PROFIT N APPLICATION-FARMERS' SITUATION

The above analysis gives the nitrogen application rates for situations when the price of nitrogen is assumed to be zero or when nitrogen is considered free.

Usually, at the point when marginal yield equals zero, one of the other inputs becomes limiting and not nitrogen. But usually the farmer will not go so far because nitrogen costs him something.

In order to maximize his profits, the farmer will set the marginal yield of N equal to the ratio of price of corn and nitrogen:

$$MY_N = \frac{dY}{dN} = \frac{P_N}{P_C}$$

where P_N = price of nitrogen

P_C = price of corn

Cross-multiplication yields $dYP_C = dNP_N$ which means that the value of marginal yield of corn is equal to the additional cost of one pound of nitrogen. If the price of corn is \$1.13 per bushel and the cost of nitrogen \$0.086 per pound, the ratio of their prices $\frac{P_N}{P_C} = \frac{0.0865}{1.13} = 0.0765$

For the quadratic equation (265) we have:

$$\frac{dY}{dN} = 1.0651 - 0.0060N = 0.0765$$

$$N = \frac{1.0651 - 0.0765}{0.0060}$$

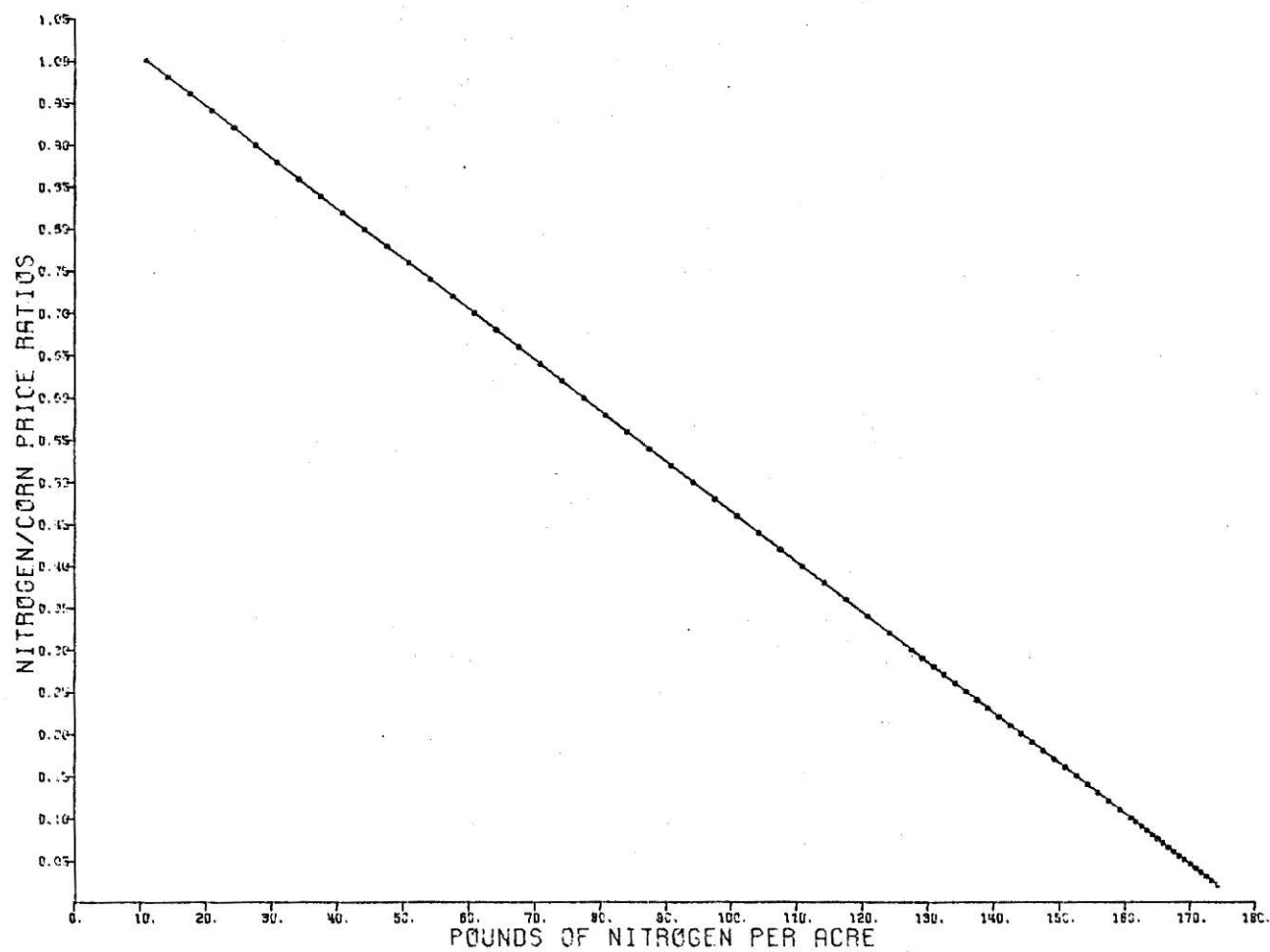


FIG. C2 Derived demand curve for nitrogen on irrigated land in West-Central Kansas.

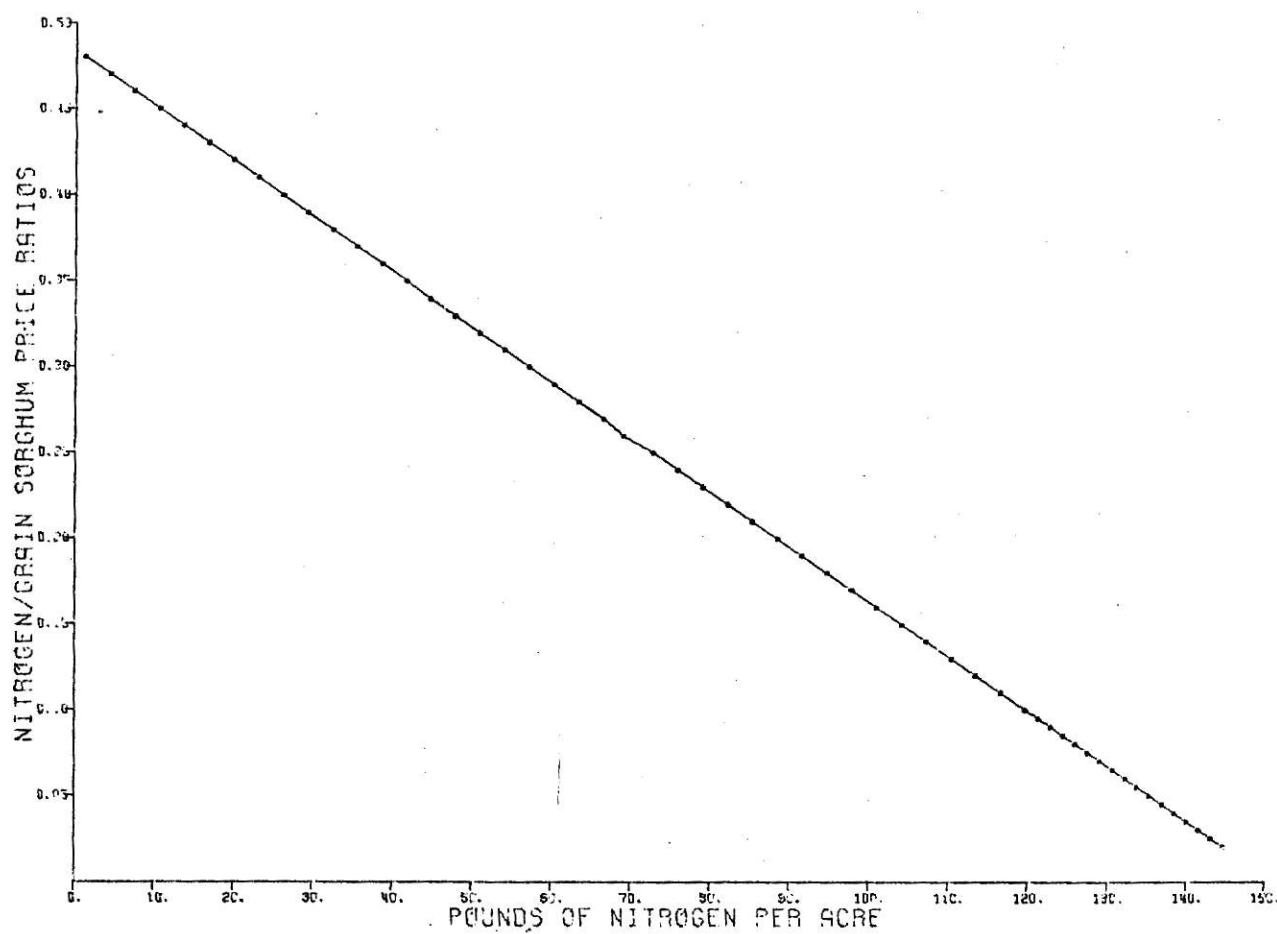


FIG. S2 Derived demand curve for nitrogen on irrigated land of West-Central Kansas.

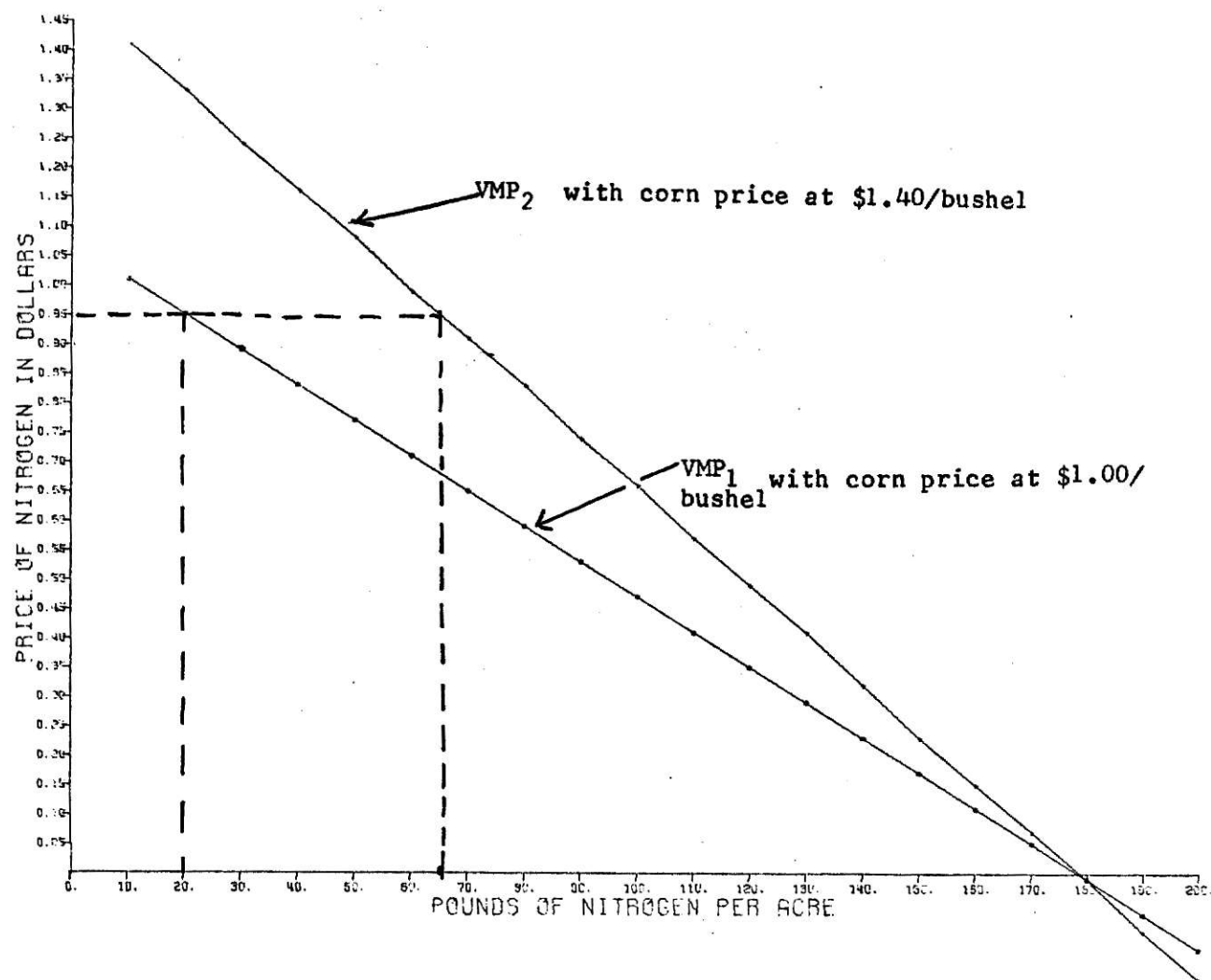


FIG. C3 The value marginal product curves of corn for nitrogen on irrigated land in West-Central Kansas.

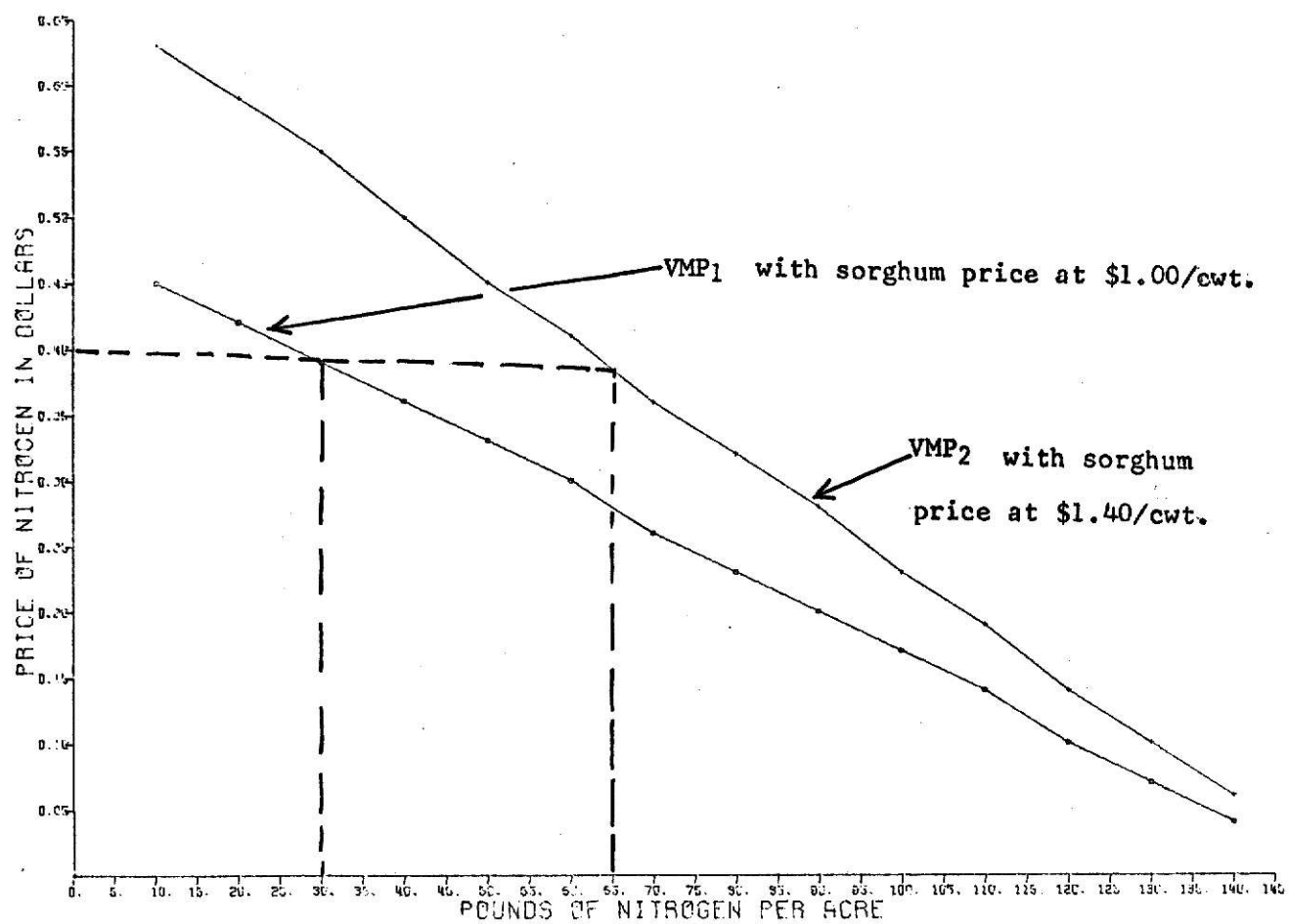


FIG. S3 The value marginal product curves of grain sorghum for nitrogen on irrigated land in West-Central Kansas.

Solving for N we obtain the value of 164.77 pounds per acre.

To obtain the yield at this level, we substitute value of $N = 164.77$ in the original equation (265):

$$Y = 65.2495 + 1.0651(164.77) - (0.0030)(164.77)^2$$

$$Y = 159.30 \text{ bushels/acre.}$$

As a check, going back to Table 3.13 it will be seen that when the level of nitrogen per acre is 170 the marginal yield is 0.05. This gives an estimated total yield of 158.87 bushels per acre. At 180 lbs/acre of N, the estimated total yield is 159.62 bushels/acre while the marginal yield is - 0.01. When the marginal yield is equal to the price ratio of 0.0761, the yield lies between 158.87 and 159.62 bushels per acre.

For sorghum, using equation (572) the maximum profit nitrogen application level given the price of sorghum as \$1.72 per cwt. and price of nitrogen as \$0.0865 per pound can be calculated in a similar way. The price ratio

$$\frac{P_N}{P_S} = \frac{0.0865}{1.72} = 0.0502$$

$$\frac{dY}{dN} = 0.4834 - 0.0032N = 0.0502$$

$$N = 135.38 \text{ pounds per acre.}$$

At this level of N the estimated yield is given by:

$$Y = 38.1239 + 0.4834(135.38) - 0.0016(135.38)^2$$

$$Y = 74.24 \text{ cwt./acre.}$$

F. DERIVED DEMAND FOR NITROGEN

Table 5 shows the prices of nitrogen, phosphate and potash fertilizers paid by Kansas farmers from 1960-1971 and prices they received for corn and sorghum for the same period of time. Price variation from year to year can be observed. The price of nitrogen varied from 6.88 to 9.69 cents per

pound and that of corn from 0.98 to 1.26 dollars per bushel and sorghum from 1.36 to 1.99 dollars per hundredweight.

As a result of this price instability the amount of nitrogen which will maximize profit will differ from year to year. By using different price ratios of nitrogen to corn and sorghum, the most profitable levels of nitrogen can be obtained and tabulated as shown in Table 6 and 7. When these figures are plotted with nitrogen/corn price ratios on the vertical axis and the optimum rate of nitrogen application in pounds on the horizontal axis, one obtains a derived demand for nitrogen. This is shown in Figure C2. Figure S2 shows the derived demand for nitrogen using nitrogen/sorghum price ratios.

The derived demand curves shown in Figures C2 and S2 do not shift but remain permanent in their positions. As the price ratio decreases, more and more nitrogen will be demanded thus the graphs are down-ward sloping to the right.

Another way the derived demand can be obtained is by graphing the value of marginal yields of corn for nitrogen. The price of nitrogen is put on the vertical axis and the pounds per acre of N application on the x-axis. Table 8 Figure C3 and Table 9 Figure S3 show the values and the curves for corn and sorghum respectively. At different corn or sorghum prices, we obtain different VMP curves which shift upwards to the right as the price of corn or sorghum increases. Thus when the price of corn increases from \$1.00/bushel to \$1.40/bushel, the optimum rate of nitrogen application increases from 20 to about 65 lbs/acre at the same nitrogen price of \$0.95 per lb. because in order to maximize profits it will be necessary to increase the yield of corn which can be done through increase in dosage of nitrogen. With price of nitrogen at \$0.40 per pound optimum

nitrogen increases from 30 to 65 lbs/acre when price of sorghum increases from \$1.00 to \$1.40 per cwt.

G. RETURNS AT DIFFERENT LEVELS OF NITROGEN APPLICATION

An analysis of returns to fertilizer is very important for crop production because fertilizer use may increase the yield of the crop to the extent that it not only pays for its own cost but for the other costs of production which might not be met without the fertilizer's use. Table 10 shows the returns at various levels of nitrogen application taking the price of corn at \$1.13 per bushel and price of nitrogen at \$0.0865 per pound. Column 1 shows the level of nitrogen application and columns 2 through 7 show the estimated yields, the increase in yields, the costs of additional unit of nitrogen and net returns per dollar on the last unit of nitrogen, for individual successive ten-pound units of nitrogen. Table 11 is the equivalent of Table 10 for sorghum taking the price of sorghum at \$1.72 per cwt. and nitrogen at \$0.0865. Columns 2 through 6 in Table 12 for corn and Table 13 for sorghum show the cumulative results from increasing rates of nitrogen shown in column 1. The estimated yields are obtained from equation (265) for corn and equation (572) for sorghum. Decreasing returns as more and more nitrogen is applied are observed. The increase in yield, value of increase in yield, return above cost and return per dollar on last unit of nitrogen show large positive numbers which decrease with successive 10-pound increase in nitrogen. For example, for corn the value of the increase in yield from the first unit nitrogen is \$11.37 and the return above the unit cost of nitrogen is \$10.51. By the 20th unit of nitrogen, the return above cost becomes negative with a value of \$-2.06. For sorghum, the value of the increase in yield from the

first unit is \$8.05 and the return above the unit cost of nitrogen is \$9.65 which also becomes negative, \$-3.29 at the 20th unit level of nitrogen. This means that the cost of the additional unit of nitrogen is greater than the value of the additional increase in yield.

The values of the estimated yields of corn in Table 10 and 12 are plotted in Figures C4.1, C4.2 and C4.3 while those of Table 11 and 13 form the source for Figures S4.1, S4.2 and S4.3 for grain sorghum. The value of additional yield of corn equals the cost of additional unit of nitrogen and after the level of N application, the nitrogen cost between 160 and 170 pounds per acre exceeds the value of the increase in yield. Thus if the price of nitrogen is \$0.0865, the profit maximization level of nitrogen application for corn lies between 160 and 170 pounds per acre but if the price of nitrogen is zero, then between 170 and 180 lbs/acre. The average return per dollar spent on nitrogen gives a measure of the profitability of total expenditures of nitrogen at specific rates. At the most profitable level of N application, the average return per dollar spent is \$7.20 which is more profitable when compared with \$4.08 at 250 lbs/acre of N application. Thus the loss per dollar spent increases between 170 and 250 lbs/acre application of nitrogen.

Similarly for grain sorghum, the profit maximization level of nitrogen when price of N is \$0.0865 lies between 140 and 150 lbs/acre. The average return per dollar spent on nitrogen at the most profitable level of application is \$4.84 which is more profitable than at 250 lb of N application which gives \$1.66. Thus the loss per acre increases between 150 and 250 pounds of N application.

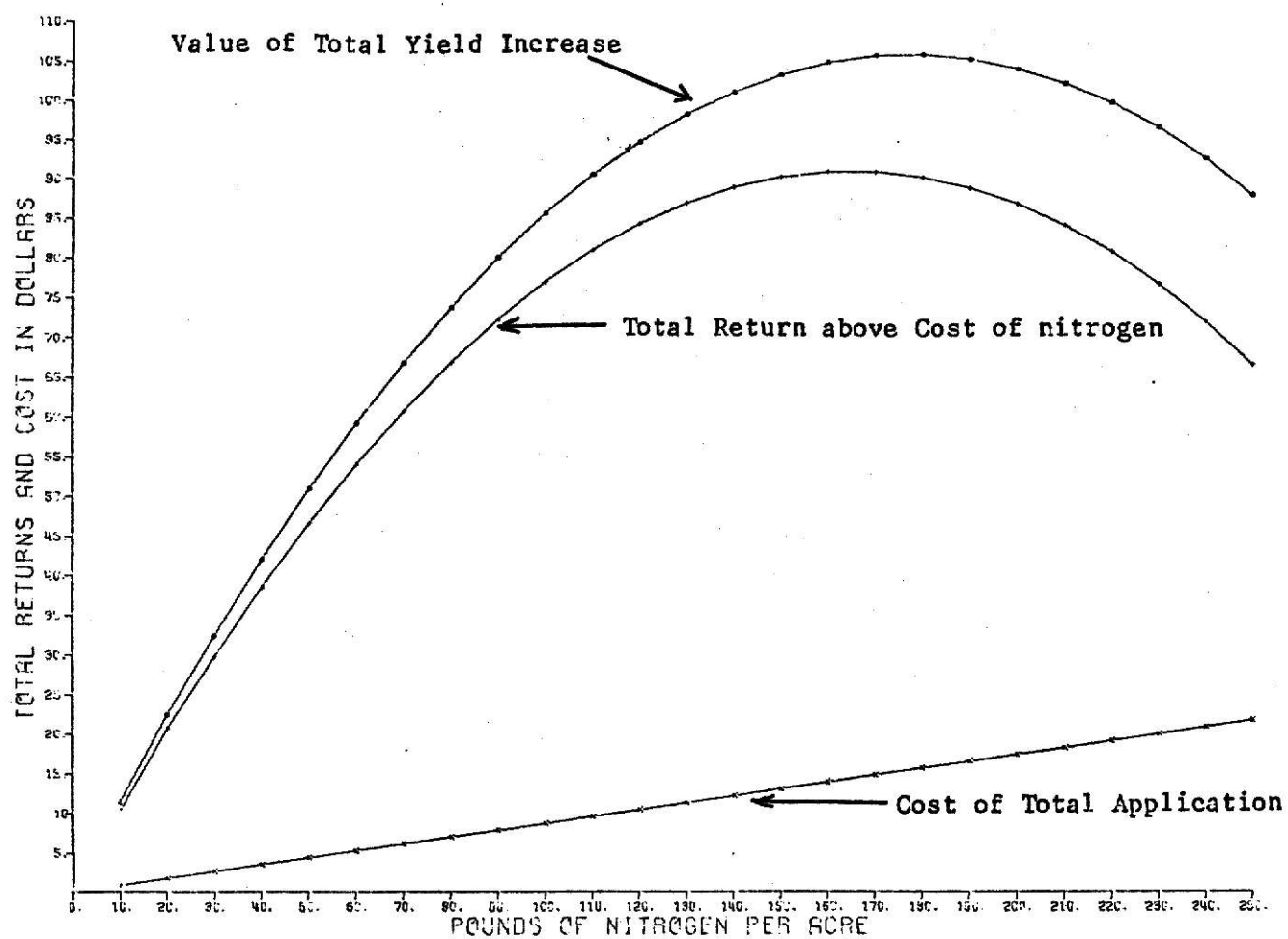


FIG. C4.1 Total Returns and Cost for corn to nitrogen on irrigated land in West-Central Kansas.

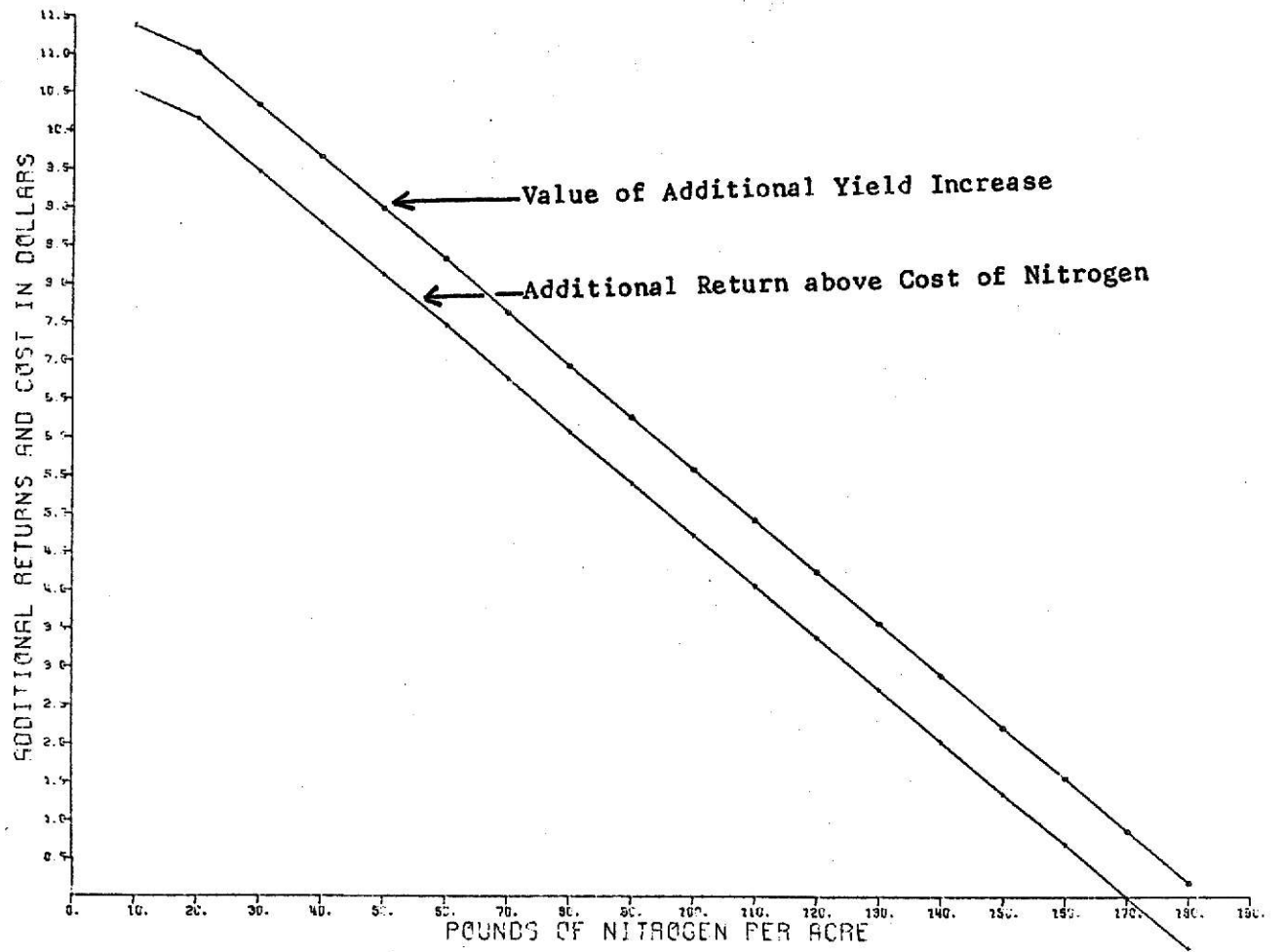


FIG. C4.2 Additional Returns to corn above cost of nitrogen.

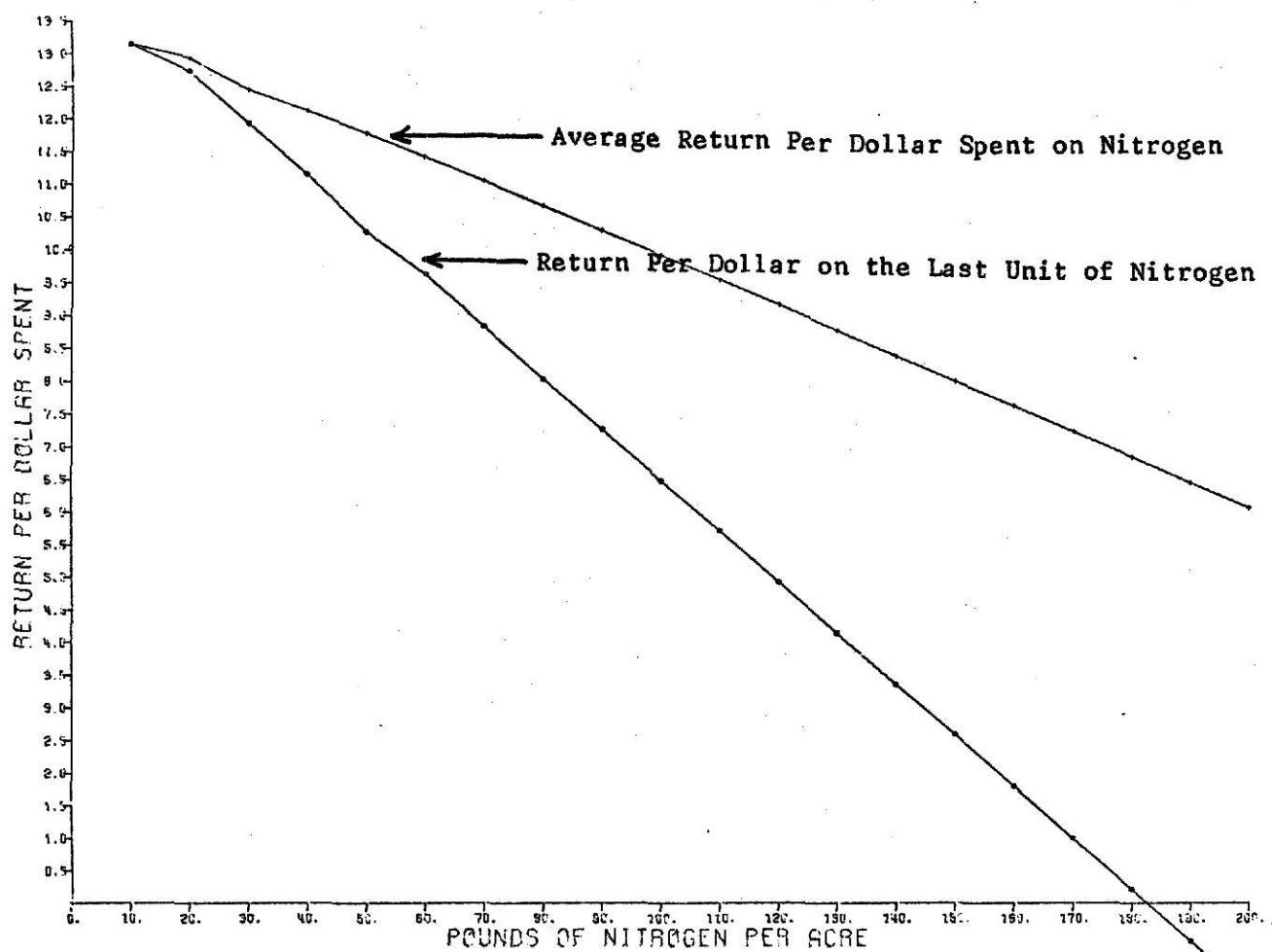


FIG. C4.3 Returns to corn per dollar spent on nitrogen.

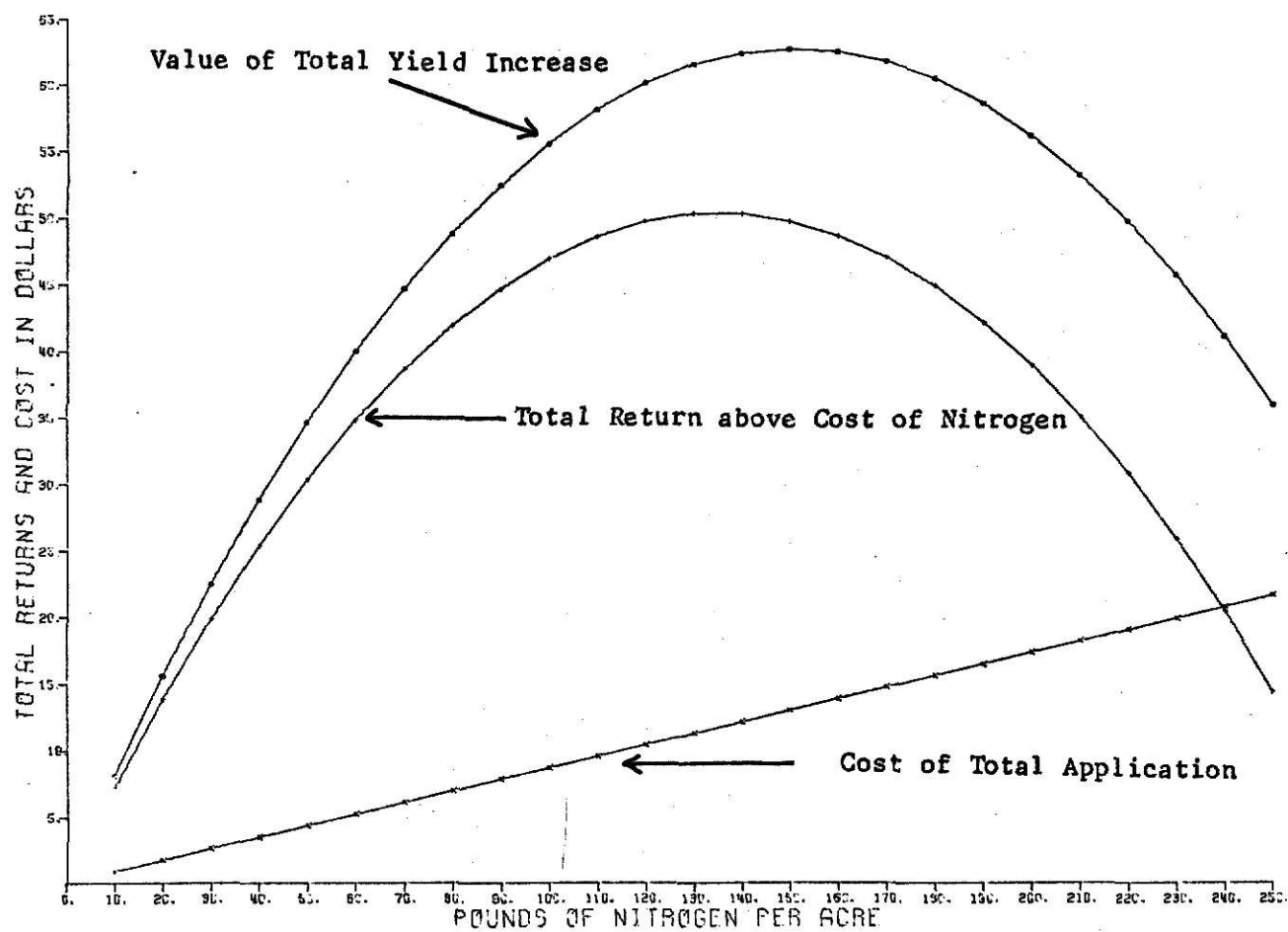


FIG. S4.1 Total Returns and Cost for grain sorghum to nitrogen on irrigated land in West-Central Kansas.

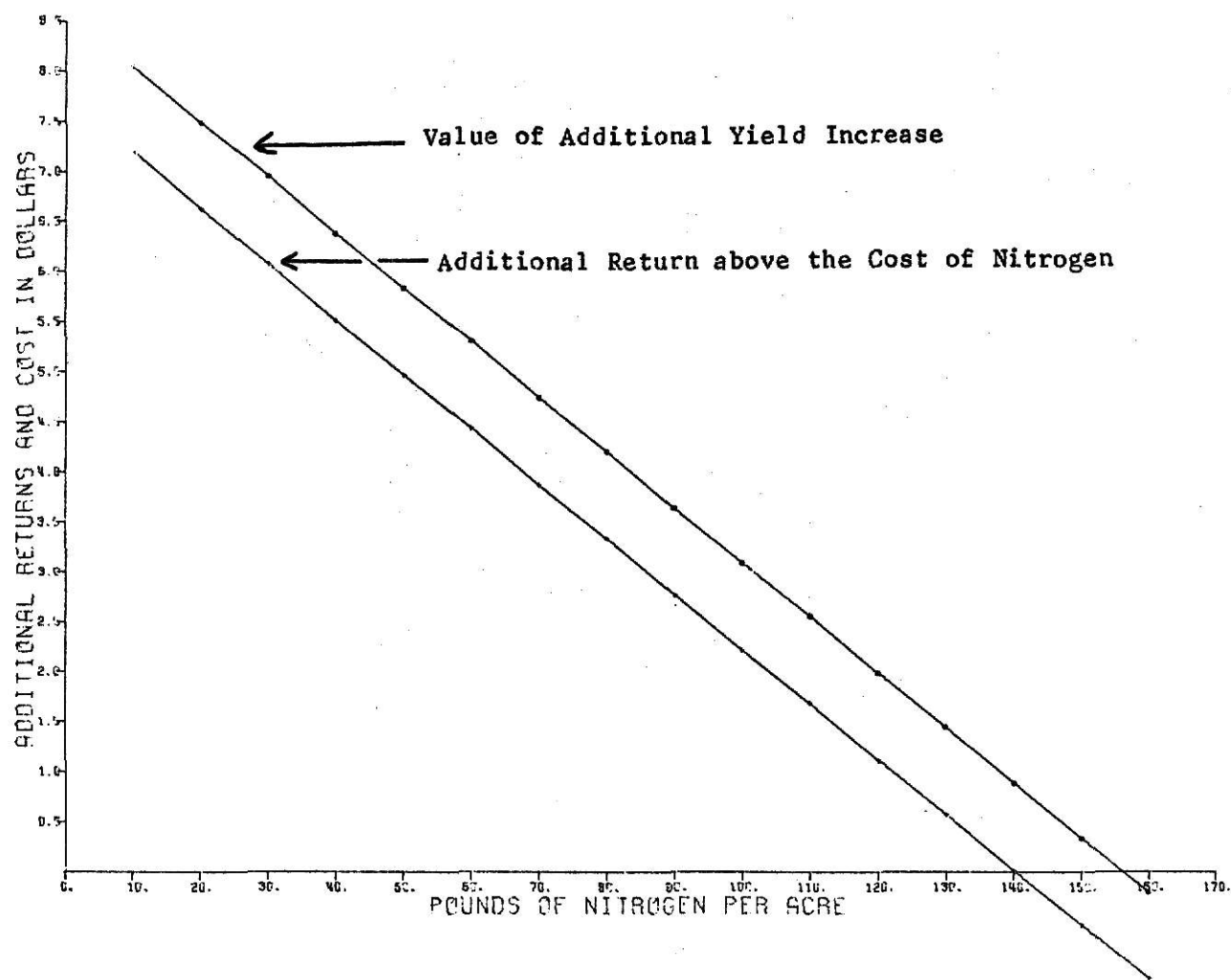


FIG. S4.2 Additional Returns to grain sorghum above cost of nitrogen.

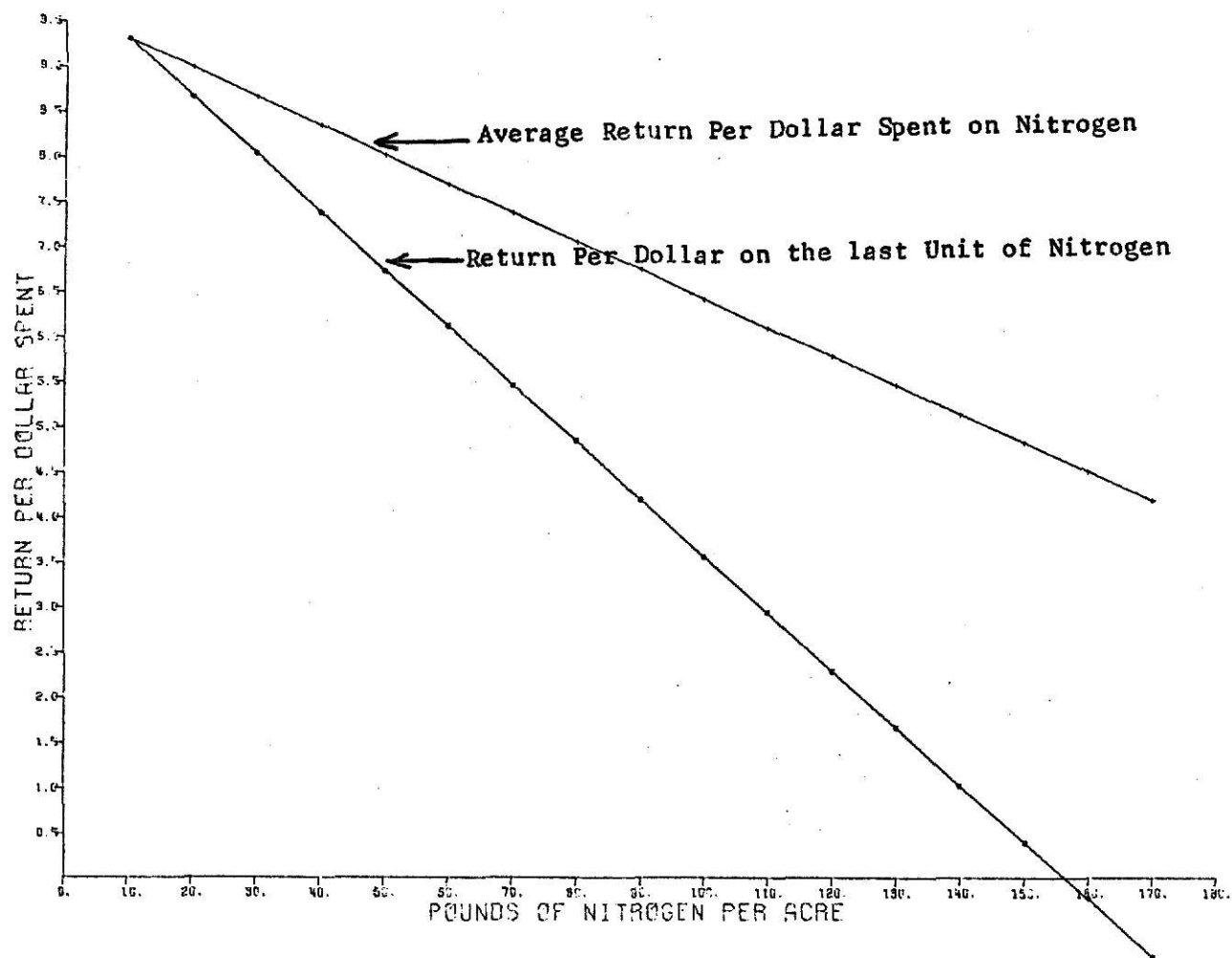


FIG. S4.3 Returns to grain sorghum per dollar spent on nitrogen.

H. EFFECTS OF PRICES OF CORN, SORGHUM AND NITROGEN ON THE MOST PROFITABLE RATE OF NITROGEN APPLICATION AND ON RETURN TO NITROGEN ABOVE ITS COST

There are three elements which determine the most profitable rate of nitrogen application. They are the shape of the response curve of corn or sorghum to nitrogen and the price of nitrogen/lb as well as the price of corn or sorghum. Any change in either of the three will cause a change in the most profitable level of nitrogen application.

(i) Effects of Price of Nitrogen on the most Profitable Level of Nitrogen Application

Table 13 shows the effect of price of nitrogen on the most profitable rate of nitrogen application for corn. The explanation to the columns are as follows:

Column 2: Given the production function

$$Y = 65.2495 + 1.0651N - 0.0030N^2 \dots\dots\dots(265)$$

$$\frac{dY}{dN} = 1.0651 - 0.0060N$$

Equating this to $\frac{P_N}{P_C}$ gives the profit maximization nitrogen application by solving for N.

$$\text{If } P_N = 0.0865, P_C = 1.13 \frac{P_N}{P_C} = 0.0765$$

$$\frac{dY}{dN} = 1.0651 - 0.0060N = 0.0765$$

$$N = 164.77 \text{ lbs/acre.}$$

Column 3: Predicted yield is obtained by substituting $N = 164.77$ in the original equation:

$$Y = 65.2495 + 1.0651(164.77) - 0.0030(164.77)^2$$

$$Y = 159.30 \text{ bushels/acre.}$$

Column 4: Subtract 65.25 from the value in column 3.

Column 5: Multiply price of corn by the value in column 4. This gives $P_c dY$ or the total value of the increased yield. Subtract the product obtained by multiplying the value in Column 2 by the price of nitrogen in Column 1 from $P_c dY$ which gives the (value of the marginal yield) - (cost of producing the increased yield).

Table 14 shows a similar result for sorghum using the production function denoted by equation (572). Table 15 for corn and 16 for sorghum shows the decrease in the most profitable N application and return above cost for every 1 cent increase in price of N. These are obtained from Tables 13 and 14 respectively.

With the price of corn fixed at \$1.13 per bushel, one can expect a decrease of \$1.76 to \$1.49 in return to nitrogen above its costs for every 1 cent increase in the price of nitrogen between \$0.01 and \$0.20 per pound. The lower the price of nitrogen before the 1 cent increase in its price the greater the decrease in the return above cost. With price of sorghum fixed at \$1.72 per cwt., one can expect a decrease of \$1.49 to \$1.15 in return to nitrogen above its costs for every 1 cent increase in the price of nitrogen between \$0.01 and \$0.20 per pound. The higher the price of nitrogen the lower the returns to nitrogen above its cost for both corn and sorghum. Each successive cent increase in nitrogen price decreases the returns to nitrogen above its cost by a smaller amount. This means that an increase in the price of nitrogen at already higher prices results in lower decrease in returns to nitrogen above its cost than when there is an increase in price at lower prices of nitrogen.

For every 1 cent increase in the price of nitrogen between \$0.01 and \$0.20 per pound, the most profitable rate of nitrogen application decreases by 0.75 to 2.20 lbs/acre for corn and 1.81 to 1.85 lbs/acre for sorghum. The lower the price of nitrogen before the 1 cent increase, the lower the decrease in the predicted yield of corn and sorghum under the most profitable N application.

(ii) Effects of Prices of Corn and Sorghum on the Most Profitable Rate of Nitrogen Application and Returns Above Cost.

Tables 18 and 19 show the effect of price of corn and sorghum respectively on the most profitable rate of nitrogen application and returns above cost. Explanations of the columns are the same as those given for Tables 14 and 15. Tables 20 and 21 show the increase in the most profitable N application and return above cost for each 5-cent increase in the price of corn and sorghum respectively.

Contrary to what Yung Liu⁷ found in her thesis with a constant successive unit increase in the price of corn, the most profitable rate of nitrogen application increases at a decreasing rate for both corn and sorghum. The increases in the predicted yields of corn and sorghum also decrease with the constant successive increase in the price of corn.

When the price of corn is \$0.10 per bushel 33.35 lbs/acre of nitrogen is the most profitable rate of nitrogen. If the price of corn increases by 5 cents to \$0.15 per bushel, 81.42 lbs/acre of nitrogen is the most profitable rate of nitrogen application which yields an increase of 66.83 bushels/acre or \$2.98 as return above cost of nitrogen. If, however, when the price of corn increases to \$0.15 33.35 lbs/acre of nitrogen is applied instead of 81.42 lbs/acre (which means that no adjustment is made), the value of the increase in yield will increase by (0.05×32.27) or \$1.61 to

⁷Yung Liu, Ibid., p.80

give \$4.84 instead of \$3.23 (see row 1 of table 17). This makes the return to nitrogen above its cost $\$4.84 - 2.88$ or \$1.96 instead of \$0.35. Thus the increase from \$0.35 to \$1.96 in the return to nitrogen above its cost is caused by the 5 cents increase in corn price alone. However, if the five cents increase in corn price is accompanied by an increase in the rate of nitrogen applied from 33.35 to 81.42 lbs/acre, the return to nitrogen above its cost will be \$2.98 instead of \$1.96. The difference between \$2.98 and \$0.35 (\$2.63) is therefore due to both the price change and the corresponding quantity of nitrogen application. The value of the difference (\$2.63) means that it pays more to change the quantity of nitrogen applied when the price of corn changes. Other values in the last column of Table 19 are even greater than \$2.63 which means that greater gains are obtained at higher prices of corn with the five-cents successive increase in price of corn accompanied by corresponding changes in the quantity of nitrogen to apply. Similar values are obtained for sorghum and shown in Tables 18 and 20.

At planting time, the price of corn and sorghum cannot be exactly estimated or at the time fertilizer is applied. Inaccurate estimates of the price of corn or grain sorghum will produce lower returns to nitrogen when nitrogen rate differs from the most profitable rate. When the price of corn or grain sorghum is over-estimated, larger quantity of nitrogen will be applied which will result in a real reduction in return to nitrogen above its cost. When the price of corn or grain sorghum is under-estimated, a reduction in the potential return will result because a higher rate of nitrogen might have been applied.

I. MOST PROFITABLE RATE OF NITROGEN APPLICATION BY YEAR COMPARED WITH THE EXTENSION SERVICE RECOMMENDATIONS⁸

In order to find whether the most profitable rate of nitrogen application using each years equation falls in line with the recommendations by the extension service, Table 21 has been constructed. The most profitable rate of nitrogen in column 6 has been obtained by taking the price of corn or sorghum for a particular year and the price of nitrogen in that same year and calculating the value of N using the equations whose numbers are specified in column 2. For corn in 1961, 1962, 1966 and 1969 the most profitable level of nitrogen application falls below the recommended quantity of nitrogen. The other years and the groups of years fall within the recommendation. All of the years and groups of years for sorghum fall within the recommendation.

⁸David A. Whitney and Larry S. Murphy, "Lime and Fertilizer Recommendations," Cooperative Extension Service, Kansas State University, Manhattan, Kansas. July 1969.

VI. SUMMARY AND CONCLUSIONS

This study is an economic analysis of experimental data for corn and grain sorghum under irrigation conducted between 1961 and 1970 at Tribune Branch Experiment Station. The yield response to different rates and combinations of fertilizers nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) is the main consideration in this study. Since production functions have been fitted to the data 1961-1965 for corn and 1959-1965 for grain sorghum by Yung Liu, the aim of the present analysis is to update the results to 1970 for both crops. According to Yung Liu's study, yield response to phosphorus and potassium are negligible. An attempt has been made in this study to find out the year when the yield response to phosphorus or/and potassium becomes statistically significant.

The analysis of variance results show that for corn and grain sorghum the most important yield response is to nitrogen for all the years. The yield response to phosphorus, while non-significant from 1961-1965 for corn, is significant from 1966-1970. For grain sorghum, which data went as far back as 1959, the yield response to phosphorus is also statistically significant from 1966-1970. This implies that the farmer need not apply phosphorus to corn until the sixth year and to grain sorghum until the eighth year.

Limitations of the study - A case of no direct application.

The response of corn or grain sorghum to nitrogen and phosphorus vary with soil, climate and other environmental conditions and therefore the interpretation of these results should be applied only to conditions prevailing during the experiment and also because of the following reasons:

1) The experimental plots were small units, each of which is only a minute percentage of the farmer's many acres of land. It is therefore easier to manage efficiently the small experimental plots than is possible under the farmer's conditions.

2) The notion of averages in terms of the ten-year period yield data and prices of nitrogen and corn and grain sorghum is only a matter of convenience. An 'average year' or 'average price' is difficult to come by.

3) It was ensured that soil moisture did not limit the growth of corn and grain sorghum because enough irrigation water was applied at preplant stages and during the growing seasons. These results will not apply to conditions where soil moisture is a limiting factor.

4) One of the objectives assumed in this study is the maximization of returns from a particular acre of corn or grain sorghum. The farmers, however, may have a different objective, such as maximization of income from all their enterprises in their farming businesses which compete for the available scarce resource (capital).

Appraisal of the Study

Despite the direct inapplicability of the analysis of experimental data to any particular farm situation, generalized recommendations can be made and the nature of the response curves can serve a useful guide to all people dealing with fertilizers. Secondly, the massive production functions derived in this study can be used for teaching purposes and may be useful for future research work. Thirdly, the importance of this study to the extension workers cannot be overemphasized as it can assist in deciding the recommendations to be put forward to the farmers. It is noteworthy that the most profitable rate of nitrogen applications obtained

using each year's data, prices of input nitrogen and of outputs corn and grain sorghum are in agreement with the recommendations put forward by the extension service.

Among the different types of functions used, the quadratic form gave consistently statistically significant results at 0.05 level of probability for each treatment under each year's data. The algebraic forms $Y = 65.2495 + 1.0651N - 0.0030N^2$ for corn and $Y = 38.1239 + 0.4834N - 0.0016N^2$ for grain sorghum have been chosen to show the economic applications in this study. The algebraic forms $Y = 59.8987 + 1.0651N - 0.0030N^2 + 0.2007P$ for corn and $Y = 35.4679 + 0.4834N - 0.0016N^2 + 0.0996P$ for grain sorghum are considered as the best functions for describing yield responses to phosphorus with P held constant at 40 pounds per acre.

As a result of the initial soil test which showed that phosphorus and potassium nutrients are not limiting factors for the growth of corn and sorghum, the experiment was designed to contain phosphorus and potassium treatments at only 0 or 40 pounds per acre. This, however, does not allow a more detailed economic analysis. It is not possible, for example, to determine the least-cost combination of P and K with N.

Using the eleven-years (1960-1971) average prices for nitrogen as \$0.0865 per pound and corn as \$1.13 per bushel, the most profitable rate of nitrogen is 164.77 pounds per acre. For the same period using the average price for nitrogen and grain sorghum at \$1.72 per cwt., the most profitable rate of nitrogen application is 135.38 pounds per acre. When nitrogen is applied at the most profitable rate with the above prices, the returns to nitrogen above its cost are \$92.06 per acre for corn and \$50.40 per acre for grain sorghum. Returns to nitrogen above cost change by \$2.63 to \$4.73

per acre with successive 5 cents per bushel change in the price of corn. With the same 5 cents per cwt. Change in the price of grain sorghum, returns to nitrogen above cost change by \$1.57 to \$1.83 per acre. Thus adjusting nitrogen dosage to the most profitable rate of application for each 5 cents change in the price of corn and sorghum gives higher net returns.

APPENDIX A

Table 1.1 Corn yields (bushels) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1961

Pounds P ₂ O ₅	Pounds K ₂ O	Pounds of Nitrogen Per Acre				
		0	40	80	120	160 200
0	0	34.8	93.6	116.1	115.9	127.4 129.3
		33.8	97.9	123.3	129.4	154.5 130.7
		36.2	88.9	123.7	119.7	145.9 129.3
		56.4	91.2	122.3	124.8	140.7 137.3
		44.2	96.0	114.1	116.9	127.0 123.6
40	0	41.1	93.5	119.9	121.3	139.1 130.0
		33.7	65.7	121.5	131.8	126.5 128.9
		48.9	85.4	121.8	134.2	136.5 152.0
		28.5	101.4	102.9	130.4	128.4 134.1
		43.6	81.7	123.3	116.7	141.3 132.2
40	40	53.6	91.8	121.0	122.8	136.5 144.9
		41.7	85.2	118.1	127.2	133.8 138.4
		32.2	84.0	115.6	122.7	127.8 132.2
		46.0	100.4	122.3	125.6	144.0 137.9
		50.6	93.0	107.0	137.7	131.6 133.1
40	40	40.9	72.7	125.5	141.6	126.4 126.5
		48.2	90.1	111.7	146.0	132.6 131.3
		43.6	88.0	116.4	134.7	132.5 132.2

Table 1.2 Corn yields (bushels) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1962

Pounds P ₂ O ₅	Pounds K ₂ O	Pounds of Nitrogen Per Acre				
		0	40	80	120	160 200
0	0	69.4	71.3	135.5	149.1	147.1 154.9
		53.8	105.7	116.0	149.1	164.0 157.5
		60.3	108.2	146.5	150.4	145.2 150.4
		42.1	97.2	144.5	134.2	174.4 164.0
		93.3	110.8	117.3	155.6	145.2 151.0
40	0	63.8	98.6	132.0	147.7	155.2 155.6
		41.5	134.2	145.8	153.6	153.6 167.2
		65.5	112.1	129.6	159.5	151.7 156.2
		68.1	107.6	107.6	148.4	144.5 146.5
		64.2	128.3	153.0	144.5	134.8 150.4
40	40	77.8	132.2	143.9	153.0	156.2 170.5
		63.4	122.9	136.0	151.8	148.2 158.2
		59.6	119.3	135.5	135.5	162.7 147.8
		82.3	110.2	135.5	159.5	149.1 158.2
		75.8	102.4	119.9	169.2	144.5 155.6
40	40	60.3	127.0	138.7	156.2	161.4 144.5
		64.8	90.1	142.0	154.3	158.2 169.8
		68.6	109.8	134.3	154.9	155.2 155.2

Table 1.3 Corn yields (bushels) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1963

Pounds P_2O_5	Pounds K_2O	Pounds of Nitrogen Per Acre					
		0	40	80	120	160	200
0		42.9	61.5	113.6	122.5	147.9	130.8
		51.0	70.4	106.9	112.5	128.5	127.4
	0	42.9	74.9	105.4	109.9	124.8	131.9
		25.3	86.8	112.9	114.7	146.0	135.6
		44.0	76.8	87.2	103.6	111.4	139.3
40		41.2	74.1	105.2	112.6	131.7	133.0
		22.0	96.1	106.9	135.6	119.2	125.5
		74.9	80.8	131.1	114.4	146.0	149.4
	0	57.0	87.9	93.9	112.1	157.2	142.7
		32.4	76.4	114.7	113.6	131.9	149.8
40		32.8	69.7	99.1	121.1	109.9	129.6
		43.8	82.2	109.1	119.4	132.8	139.4
		45.8	73.4	99.5	113.6	137.4	149.4
		39.9	85.7	119.2	132.6	157.2	139.3
	40	60.0	77.8	117.0	138.2	136.7	159.4
40		26.8	89.4	101.3	127.4	127.0	144.5
		47.3	71.2	79.7	117.7	123.0	128.1
		44.0	79.5	103.3	125.9	136.3	144.1

Table 1.4 Corn yields (bushels) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1964

Pounds P ₂ O ₅	Pounds K ₂ O	Pounds of Nitrogen Per Acre					
		0	40	80	120	160	200
0	0	56.7	83.8	128.7	127.1	130.2	139.4
		49.7	82.6	121.0	127.6	131.3	144.7
		61.3	88.0	121.0	139.4	131.3	118.5
		54.3	82.0	125.8	133.5	139.6	130.7
		53.2	83.8	118.0	119.3	126.0	123.7
40	0	55.0	84.0	122.9	129.4	131.7	131.4
		55.0	93.1	135.0	134.6	101.1	142.2
		59.6	85.5	105.4	137.0	135.5	145.7
		59.1	85.5	126.7	131.6	149.7	134.6
		44.4	88.4	104.2	118.9	139.0	138.7
40	40	54.9	99.6	118.4	132.8	136.1	141.6
		54.6	90.4	117.9	131.0	132.3	140.6
		52.6	91.5	120.1	128.7	144.6	160.5
		46.2	69.9	117.1	136.5	145.2	149.8
		58.9	87.0	112.4	144.2	144.6	142.7
40	40	52.6	90.9	115.0	123.4	138.0	132.0
		49.7	83.0	110.1	132.3	131.4	146.2
		52.0	84.5	114.9	133.0	140.8	146.2

Table 1.5 Corn yields (bushels) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1965

Pounds P ₂ O ₅	Pounds K ₂ O	Pounds of Nitrogen Per Acre					
		0	40	80	120	160	200
0	0	43.2	65.3	104.3	129.8	139.5	146.7
		44.1	74.2	114.2	115.7	122.8	140.9
		40.6	84.8	123.3	122.9	146.3	137.7
		56.5	84.5	128.0	123.2	140.9	134.4
		38.6	78.0	104.3	128.1	153.6	118.2
40	0	44.6	77.4	114.8	123.9	140.6	135.6
		42.1	77.4	109.6	151.6	151.6	143.6
		40.0	69.0	123.2	147.1	157.2	161.1
		54.1	78.7	118.8	151.9	158.6	143.5
		48.7	72.0	127.4	132.4	154.7	136.5
40	40	50.4	90.8	124.9	143.6	163.2	142.4
		47.1	77.6	120.8	145.3	157.1	145.4
		53.9	81.1	104.9	138.9	138.6	135.2
		45.5	59.6	118.3	147.9	158.8	160.6
		56.0	88.2	126.0	145.9	136.6	156.0
40	40	40.8	88.2	121.8	140.3	160.6	163.0
		53.9	83.8	127.6	140.6	151.2	139.8
		50.0	80.2	119.7	142.7	149.2	150.9

Table 1.6 Corn yields (bushels) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1966

Pounds P ₂ O ₅	Pounds K ₂ O	Pounds of Nitrogen Per Acre					
		0	40	80	120	160	200
0	0	56.84	75.23	116.94	133.60	120.28	158.84
		63.34	92.50	108.17	129.12	133.25	108.32
		71.02	94.85	145.53	130.70	134.65	125.73
		45.67	83.71	131.08	110.52	130.23	143.53
		67.27	108.71	111.62	99.78	109.26	131.24
		64.62	93.68	116.79	133.60	124.66	143.41
		49.09	106.12	112.89	99.65	124.33	148.59
		67.83	79.03	119.54	136.02	129.74	127.49
		59.22	124.39	136.68	116.69	146.41	115.49
		104.48	116.84	119.19	135.70	110.94	133.74
40	0	64.94	97.51	121.84	122.64	126.38	133.64
		44.94	97.15	92.73	141.20	139.71	125.25
		52.49	90.72	116.76	139.27	147.97	124.19
		51.58	81.49	114.94	142.77	135.37	153.97
		67.94	90.71	119.40	137.60	164.45	149.92
		96.32	95.26	116.03	118.81	113.70	133.05
		44.65	102.07	104.32	136.02	149.15	127.00
		63.17	89.46	144.18	110.53	151.25	114.45
		64.95	82.21	120.84	148.91	136.43	125.89
		71.08	98.92	120.69	120.18	148.19	153.78
40	40	48.65	105.15	126.37	151.05	124.92	158.08
		60.58	93.31	117.63	134.63	141.11	136.56
		61.84	66.45	121.40	134.46	156.24	135.06
		64.83	74.03	122.22	135.61	125.89	117.52
		77.54	97.80	118.27	136.71	140.51	155.71
		79.53	97.91	131.08	130.28	146.45	146.59
		42.85	85.53	145.14	123.64	150.60	170.22
		72.29	95.45	126.02	133.15	154.44	127.19
		53.66	111.23	121.91	140.41	121.91	132.45
		77.18	125.89	138.34	124.00	131.99	142.19
40	40	62.08	107.27	138.10	144.22	110.76	151.21
		60.08	98.06	119.03	132.03	151.73	152.02
		65.19	95.96	128.15	133.45	139.05	143.02

Table 1.7 Corn yields (bushels) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1967

Pounds		Pounds of Nitrogen Per Acre					
P ₂ O ₅	K ₂ O	0	40	80	120	160	200
0	0	35.61	72.66	122.43	121.60	134.77	135.65
		35.92	74.58	106.94	137.16	112.19	135.84
		57.35	119.71	144.41	131.57	145.20	154.47
		36.33	83.78	133.50	144.78	145.32	159.92
		50.51	84.02	93.08	93.04	141.92	134.51
		40.21	66.61	129.61	146.58	143.12	157.69
		40.95	65.18	99.43	154.75	146.67	136.19
		47.24	121.29	143.68	151.48	173.05	171.94
		37.91	107.35	141.96	112.24	123.64	142.49
		68.85	104.66	125.56	118.59	143.12	139.08
40	0	45.09	89.98	124.06	131.18	140.90	146.78
		26.26	79.94	125.86	158.28	166.60	169.25
		33.89	84.87	137.33	181.34	159.42	175.64
		72.29	115.60	101.15	157.84	158.26	137.33
		75.63	91.06	157.96	139.70	159.59	160.76
		75.63	125.25	148.94	145.11	135.57	154.92
		31.73	74.19	118.41	170.91	151.73	147.22
		53.82	96.94	152.02	137.25	175.27	162.62
		73.78	107.90	121.03	172.10	174.54	155.31
		73.34	93.82	148.15	144.97	186.20	158.87
40	40	47.42	103.14	117.72	138.55	143.86	159.27
		56.38	97.27	132.86	154.61	161.10	158.12
		35.08	104.14	121.40	136.51	146.95	134.88
		60.95	96.11	129.19	161.31	163.70	130.85
		56.52	96.48	155.33	130.25	159.43	166.43
		57.35	94.83	135.40	151.04	163.03	182.61
		52.95	90.40	135.19	152.03	155.18	173.94
		37.46	82.91	143.84	139.18	167.68	155.28
		53.26	88.69	133.71	143.61	162.44	142.05
		50.61	78.44	142.10	143.39	121.36	163.40
40	40	61.51	99.18	136.43	132.39	166.71	120.64
		46.97	87.02	119.25	169.28	151.59	156.43
		51.27	91.82	135.18	145.90	155.81	152.65

Table 1.8 Corn yields (bushels) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1968

Pounds P ₂ O ₅	Pounds K ₂ O	Pounds of Nitrogen Per Acre					
		0	40	80	120	160	200
0	0	45.74	82.71	91.48	107.23	142.10	137.29
		34.13	81.12	99.17	108.82	126.98	101.74
		50.82	95.73	115.39	116.02	124.02	121.98
		43.65	69.02	95.84	103.77	140.41	130.55
		55.55	98.34	102.24	112.63	110.89	122.22
		47.65	58.23	123.56	141.90	168.32	178.32
		46.35	76.21	95.61	153.42	136.51	160.65
		50.69	80.19	108.69	107.76	143.78	157.24
		34.64	74.10	131.20	134.02	155.13	151.81
		53.55	78.53	91.13	143.30	132.36	160.65
40	0	46.28	79.42	105.43	122.89	138.05	142.25
		39.41	77.23	119.16	126.32	161.53	155.42
		46.80	74.11	108.50	139.73	153.91	149.85
		50.75	67.31	120.06	165.79	159.26	157.46
		49.89	71.63	128.72	134.69	165.20	171.06
		61.32	90.01	127.81	151.61	158.46	179.93
		40.80	80.70	129.06	146.02	147.22	160.21
		33.21	66.69	128.35	148.95	153.48	186.04
		46.46	92.34	127.49	159.01	183.05	164.43
		52.91	76.49	107.63	136.14	165.03	158.08
40	40	57.16	115.60	139.22	123.79	137.53	166.05
		47.87	81.21	123.60	143.21	158.47	164.85
		30.00	74.11	100.40	113.89	145.15	164.70
		57.94	81.12	106.84	152.71	177.61	171.49
		39.97	90.12	110.50	148.37	170.93	180.89
		54.94	80.91	128.82	147.94	164.42	219.41
		43.54	85.28	96.31	153.48	148.68	149.77
		51.14	62.79	105.05	143.39	153.82	176.61
		57.87	63.78	106.68	140.35	171.30	163.22
		59.01	82.02	126.81	150.40	168.90	176.23
40	40	55.34	82.11	101.15	146.37	177.51	161.64
		48.90	61.84	101.38	145.22	161.39	178.39
		49.87	76.41	108.39	144.21	163.97	174.22

Table 1.9 Corn yields (bushels) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1969

Pounds P ₂ O ₅	Pounds K ₂ O	Pounds of Nitrogen Per Acre					
		0	40	80	120	160	200
0	0	98.61	137.85	158.88	146.28	166.98	152.23
		94.42	139.35	149.70	134.98	158.30	138.84
		100.52	148.20	140.55	140.49	127.00	156.50
		102.39	151.26	153.20	135.33	152.03	159.44
		95.50	130.73	137.68	144.59	146.28	150.85
		94.95	121.55	169.14	172.39	170.00	165.29
		99.82	136.60	155.72	162.33	191.20	183.44
		111.44	157.84	149.29	164.75	159.64	169.56
		76.31	150.60	167.18	159.64	179.89	169.01
		102.39	149.43	159.46	160.44	178.06	179.53
40	0	97.63	142.34	154.08	152.12	162.94	162.45
		92.71	139.46	175.97	166.76	160.54	162.34
		110.95	146.18	168.59	167.61	178.03	174.12
		100.78	156.49	153.57	174.12	183.92	178.63
		97.31	133.80	160.79	164.62	189.59	162.99
		113.44	159.04	151.81	166.35	171.18	181.03
		83.70	154.52	167.95	182.61	151.05	185.19
		91.37	136.37	162.44	167.69	178.39	202.74
		100.45	141.21	169.23	174.66	178.95	172.70
		101.87	116.88	167.43	156.90	169.30	173.56
40	40	103.10	157.09	165.59	162.99	180.51	181.19
		99.57	144.10	164.34	168.43	174.15	177.45
		68.07	128.62	158.61	164.87	172.16	179.75
		104.77	150.61	152.61	183.25	167.84	166.92
		90.45	132.20	163.04	170.63	177.05	167.06
		92.61	139.09	170.43	185.34	194.16	174.53
		113.91	158.24	145.75	143.86	150.07	170.00
		95.06	168.60	156.54	142.10	202.60	185.11
		112.05	161.72	154.75	192.95	178.39	169.65
		108.17	135.80	159.04	158.08	164.01	148.08
40	40	102.26	141.20	152.38	169.51	163.36	161.00
		86.33	141.38	162.07	181.70	151.64	173.64
		97.37	145.69	157.52	169.23	172.13	169.57

Table 1.10 Corn yields (bushels) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1970

Pounds P ₂ O ₅	Pounds K ₂ O	Pounds of Nitrogen Per Acre					
		0	40	80	120	160	200
0	0	63.92	135.02	153.36	140.78	185.48	178.01
		86.55	128.46	168.74	178.75	178.41	156.39
		82.73	152.10	154.56	155.91	172.16	164.01
		86.45	151.24	161.79	160.33	175.27	189.80
		87.48	141.92	148.18	161.31	160.75	182.38
		73.93	120.35	161.39	191.72	208.07	201.06
		81.32	135.19	189.02	189.28	196.49	197.35
		103.39	148.59	182.83	189.70	187.28	201.50
		86.34	153.04	173.41	175.65	211.28	200.24
		102.96	152.91	161.83	184.91	211.28	201.25
		85.51	141.88	165.51	172.83	188.65	187.20
40	0	64.72	134.34	155.28	181.25	213.78	185.05
		87.40	156.04	177.13	201.31	198.09	211.29
		103.91	156.56	161.04	216.11	188.33	209.06
		97.79	158.07	170.00	185.86	199.55	186.89
		82.68	146.40	184.95	200.00	192.69	218.18
		81.69	131.89	155.85	184.16	209.57	202.29
		92.92	135.38	164.25	193.00	186.59	207.04
		86.55	140.04	183.94	186.64	199.47	210.97
		101.26	156.51	185.59	189.75	214.32	203.31
		83.92	159.86	170.29	177.56	204.81	211.32
		88.28	147.51	170.83	191.56	200.72	204.54
40	40	83.13	150.23	179.71	171.76	201.80	206.31
		87.66	143.79	166.05	200.32	203.31	216.85
		101.28	168.69	151.23	182.83	203.06	199.79
		92.91	144.88	167.43	198.05	208.82	182.72
		89.24	169.49	178.39	200.48	197.81	208.29
		74.99	154.61	171.95	198.57	200.28	212.22
		90.24	145.10	168.95	192.34	198.81	213.94
		101.62	150.32	163.04	184.38	196.54	193.53
		96.78	150.11	165.25	192.38	208.06	218.14
		67.40	143.74	175.38	212.35	202.04	181.03
		88.53	152.10	168.74	193.35	202.05	203.28

Table 2.1 Sorghum yields (cwt.) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1961

Pounds P ₂ O ₅	Pounds K ₂ O	Pounds of Nitrogen Per Acre					
		0	40	80	120	160	200
0	0	38.3	49.1	64.5	64.2	67.0	66.4
		29.0	52.9	62.0	68.0	71.2	71.8
		26.9	68.4	65.3	67.6	69.9	72.2
		36.6	52.0	64.5	68.0	72.8	68.5
		27.8	57.1	63.2	70.1	72.0	68.5
		31.7	55.9	63.9	67.6	70.6	69.5
40	0	25.1	55.4	61.4	65.8	69.6	71.9
		34.2	59.2	65.6	65.8	70.0	72.3
		44.7	62.5	64.3	69.2	65.4	71.5
		36.8	53.4	64.7	64.6	69.6	73.5
		37.2	50.1	63.9	67.9	65.4	65.3
		35.6	56.1	63.9	66.7	68.0	70.9
40	40	15.2	54.2	62.6	72.2	69.8	72.1
		52.8	58.4	65.9	73.9	72.7	66.7
		41.8	62.2	66.4	71.8	72.3	71.7
		28.3	54.2	65.5	65.5	72.7	69.6
		28.7	62.6	61.8	70.1	66.1	70.8
		33.4	58.3	64.4	70.7	70.7	70.2

Table 2.2 Sorghum yields (cwts) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1962

Pounds P ₂ O ₅	Pounds K ₂ O	Pounds of Nitrogen Per Acre					
		0	40	80	120	160	200
0	0	46.7	62.1	70.7	72.1	76.8	76.5
		38.6	66.8	73.7	72.5	72.5	80.7
		53.2	71.9	73.7	78.1	74.7	75.2
		48.4	63.8	70.7	79.8	76.0	79.0
		57.4	63.4	73.7	75.1	77.7	77.7
40	0	48.9	65.6	72.5	75.5	75.5	77.8
		43.4	73.4	61.6	78.9	77.4	75.9
		52.5	69.5	76.1	75.0	77.0	74.6
		51.6	70.4	78.3	75.4	77.8	78.0
		56.3	69.5	77.4	72.9	81.3	80.2
40	40	49.9	69.9	75.3	78.4	78.3	80.6
		50.7	70.5	73.7	76.1	78.4	77.9
		47.0	73.3	73.7	76.4	84.8	79.4
		67.7	69.0	79.3	81.5	81.0	82.0
		55.6	72.4	77.6	80.7	82.2	82.0
40	40	42.2	69.0	79.3	76.8	76.2	76.9
		47.0	69.9	67.3	78.1	74.9	76.9
		51.9	70.7	75.4	78.7	79.8	79.4

Table 2.3 Sorghum yields (cwt.s.) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1963

Pounds P ₂ O ₅	Pounds K ₂ O	Pounds of Nitrogen Per Acre					
		0	40	80	120	160	200
0	0	42.3	65.2	69.5	72.9	74.2	79.0
		45.8	66.5	82.0	77.7	77.7	71.6
		47.9	62.2	74.7	78.6	73.8	72.9
		44.5	59.6	80.3	72.9	79.0	77.3
		52.2	53.5	73.8	75.1	73.8	77.7
40	0	46.5	61.4	76.1	75.4	75.7	75.7
		43.2	72.1	69.1	62.6	81.1	76.0
		50.1	63.0	71.6	81.6	79.8	76.8
		60.0	58.7	69.9	77.7	82.0	83.3
		48.8	60.9	73.8	69.1	81.6	75.5
40	40	51.8	71.2	69.1	75.5	80.3	76.8
		50.8	65.2	70.7	73.3	81.0	77.7
		50.9	60.9	82.4	83.3	78.1	82.0
		55.2	67.3	72.5	73.8	69.5	73.8
		50.9	66.5	72.5	76.0	76.8	74.2
40	40	38.4	65.2	68.6	76.0	79.8	80.7
		43.6	65.6	70.4	75.1	87.2	86.3
		47.8	65.1	73.3	76.8	78.3	79.4

Table 2.4 Sorghum yields (cwt.) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1964

Pounds P ₂ O ₅	Pounds K ₂ O	Pounds of Nitrogen Per Acre					
		0	40	80	120	160	200
0	0	37.4	43.1	77.3	60.8	70.7	53.0
		16.5	41.8	57.4	56.0	65.4	81.5
		31.8	57.4	72.9	66.5	67.2	64.8
		23.0	53.0	49.9	74.9	83.7	69.2
		35.2	34.3	59.1	79.3	71.4	83.0
		27.8	51.3	73.8	72.3	72.9	75.4
		23.9	41.4	57.0	62.1	64.5	78.7
		34.8	59.1	75.1	82.8	73.2	77.4
		28.2	51.3	50.8	73.6	80.2	80.0
		28.7	46.6	76.0	71.4	76.2	83.0
40	0	28.7	47.9	64.9	69.9	72.5	74.6
		32.8	60.7	56.5	79.8	79.0	82.1
		27.5	58.9	59.6	78.1	83.8	79.9
		23.2	51.5	61.3	78.9	82.1	80.8
		33.9	60.3	54.8	76.8	82.5	86.9
		52.6	44.4	68.1	75.9	74.7	78.6
		14.4	65.5	78.6	65.8	65.9	67.1
		34.3	48.8	76.0	69.3	66.3	69.7
		33.9	38.3	73.8	64.9	75.1	69.3
		31.0	40.0	81.6	60.1	76.0	80.3
40	40	26.5	54.6	39.9	70.6	68.5	74.1
		31.0	52.3	65.0	72.0	75.4	76.9
		30.0	58.1	79.6	74.8	79.9	72.6
		33.5	60.7	70.5	84.5	85.6	71.3
		45.7	62.4	73.1	85.8	85.6	68.7
		32.2	65.9	77.0	82.3	83.4	70.9
		40.9	56.8	68.3	81.4	84.3	68.7
		23.1	41.9	66.1	61.1	70.8	80.3
		22.3	43.7	60.8	67.7	65.6	73.3
		38.9	41.9	57.7	67.7	69.5	78.2
40	40	28.4	46.3	59.9	73.8	71.2	81.2
		30.1	44.5	53.3	66.4	66.9	86.0
		32.5	52.2	66.6	74.6	76.3	75.1

Table 2.5 Sorghum yields (cwt.s.) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1965

Pounds		Pounds of Nitrogen Per Acre					
P ₂ O ₅	Pounds K ₂ O	0	40	80	120	160	200
0	0	10.1	27.6	57.9	49.3	52.9	52.5
		14.8	35.0	41.0	40.5	56.2	52.5
		14.0	36.6	50.2	54.7	54.6	53.8
		20.6	21.8	42.7	65.6	68.4	64.2
		7.8	25.9	53.5	72.7	57.5	63.8
		34.5	49.0	51.4	57.6	57.5	63.9
		28.3	44.4	51.7	49.3	51.7	61.4
		26.2	49.8	59.6	62.2	62.5	61.0
		35.0	47.3	60.8	68.9	58.8	63.4
		25.8	44.0	56.7	70.2	58.8	65.5
40	0	21.7	38.1	52.6	59.1	57.9	60.2
		28.8	29.5	64.5	58.7	67.7	67.1
		29.2	49.3	60.3	63.2	53.1	56.7
		8.9	52.2	48.0	55.8	63.1	68.8
		7.7	43.9	49.3	52.9	63.1	62.5
		15.9	52.6	60.6	51.6	64.8	67.5
		12.0	51.8	38.8	62.2	63.5	65.4
		21.8	39.9	53.9	68.4	67.3	66.3
		26.7	34.9	55.4	59.7	66.0	62.5
		35.4	37.8	53.3	63.8	64.4	67.9
40	40	12.8	29.9	57.4	60.5	64.8	70.4
		19.9	42.2	54.1	59.7	63.8	65.5
		12.0	30.5	50.0	51.5	63.8	63.4
		16.3	28.9	47.9	61.1	67.0	58.8
		11.3	33.4	42.9	50.7	67.8	58.8
		13.6	33.8	52.9	57.4	69.9	59.7
		8.9	28.4	48.7	64.1	62.4	60.1
		26.5	49.3	65.3	65.9	62.0	61.3
		31.9	44.3	62.8	61.8	59.7	64.2
		33.1	46.8	58.6	70.1	68.0	67.5
40	40	30.2	48.5	61.1	64.7	68.4	62.1
		31.0	49.3	59.0	66.8	60.9	70.0
		21.4	39.3	54.9	61.4	65.0	62.5

Table 2.6 Sorghum yields (cwt.s.) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1966

Pounds P ₂ O ₅	Pounds K ₂ O	Pounds of Nitrogen Per Acre					
		0	40	80	120	160	200
0	0	40.4	52.8	64.5	69.1	74.9	64.4
		26.6	69.1	66.9	66.1	70.2	69.8
		33.0	68.2	69.1	60.8	60.7	60.0
		41.8	54.5	72.7	74.9	73.7	73.3
		34.6	59.6	77.7	74.9	76.3	65.3
		38.4	59.9	70.7	66.0	77.2	71.6
		46.5	61.4	73.1	68.8	56.6	74.3
		45.8	49.9	71.5	61.9	75.9	65.6
		43.0	65.5	77.1	72.6	78.2	61.8
		41.2	55.3	61.2	85.0	73.5	72.7
40	0	39.1	59.6	70.5	70.0	71.7	67.9
		40.4	66.5	69.5	86.0	75.6	76.2
		38.8	64.7	70.8	78.5	74.9	78.2
		41.8	62.5	62.5	65.6	66.7	72.0
		44.0	54.2	70.5	73.7	77.2	77.1
		37.9	62.4	70.9	74.5	78.0	78.8
		26.5	67.6	66.5	69.9	72.1	71.8
		29.9	62.2	64.5	73.8	81.3	79.5
		38.6	56.4	63.8	79.5	60.4	77.5
		40.3	52.0	60.7	75.6	82.9	79.2
40	40	40.0	70.4	83.2	74.1	75.4	87.7
		37.8	61.9	68.3	75.1	74.5	77.8
		37.4	68.1	73.0	71.4	76.4	73.2
		31.8	62.6	73.2	73.9	77.3	65.0
		51.0	71.3	69.4	68.6	66.2	61.3
		41.9	64.3	64.5	68.3	64.1	63.0
		48.0	59.0	74.0	80.4	71.5	77.1
		37.3	65.1	75.7	69.5	68.5	67.1
		36.0	61.3	67.8	75.1	75.0	70.6
		40.2	63.7	73.0	71.9	70.7	72.3
40	40	41.1	64.0	68.5	77.0	70.8	78.7
		32.9	56.6	71.2	79.1	87.7	80.0
		39.8	63.6	71.0	73.5	72.8	70.8

Table 2.7 Sorghum yields (cwt.s.) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1967

Pounds P ₂ O ₅	Pounds K ₂ O	Pounds of Nitrogen Per Acre					
		0	40	80	120	160	200
0	0	37.0	52.7	68.2	63.4	71.0	71.0
		33.6	63.8	76.7	71.9	56.8	68.0
		32.3	59.2	73.2	78.7	77.7	71.5
		38.1	60.0	57.4	82.8	72.3	76.2
		33.8	60.5	94.0	83.8	66.9	76.9
		30.7	56.8	79.6	73.3	71.2	68.9
		42.6	59.7	67.8	52.4	75.6	73.5
		35.6	63.8	52.4	71.8	71.8	66.6
		43.6	70.5	79.3	82.9	79.8	78.0
		45.5	58.1	77.2	80.2	72.5	80.9
40	0	37.3	60.5	72.6	74.1	71.6	73.2
		35.4	68.0	79.8	79.0	78.8	79.7
		32.9	70.8	78.3	82.2	75.8	76.7
		43.3	63.0	73.7	81.6	80.7	87.5
		44.2	74.9	70.6	78.8	79.7	82.8
		46.6	70.0	82.9	85.2	85.1	87.4
		28.3	65.7	67.5	78.8	83.0	75.3
		34.9	65.0	73.2	82.8	84.9	75.6
		44.2	61.8	79.2	80.2	74.9	85.3
		43.6	65.9	74.8	73.9	78.4	70.9
40	40	41.2	66.2	78.3	77.1	83.1	85.1
		39.5	67.1	75.8	80.0	71.6	80.6
		39.0	64.0	79.9	73.7	83.6	76.8
		54.4	66.6	72.5	81.5	77.1	71.2
		36.5	72.4	79.6	82.4	85.2	82.6
		34.9	62.0	76.8	82.6	76.8	77.8
		39.2	68.8	77.0	82.6	86.9	85.8
		45.9	70.7	70.9	76.5	86.6	68.8
		46.8	57.3	77.8	75.2	81.3	84.8
		34.5	56.0	78.8	78.5	86.7	74.3
40	40	41.7	54.3	80.4	81.3	79.3	73.1
		41.9	69.0	76.8	81.0	82.3	85.6
		41.5	64.1	77.1	79.5	82.6	78.1

Table 2.8 Sorghum yields (cwt.s.) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1968

Pounds P ₂ O ₅	Pounds K ₂ O	Pounds of Nitrogen Per Acre					
		0	40	80	120	160	200
0	0	31.08	54.43	65.52	66.81	68.82	77.22
		26.77	60.20	76.94	78.01	75.32	74.98
		29.51	59.42	68.38	82.88	64.68	56.34
		34.16	54.54	52.08	68.15	66.53	71.85
		34.38	56.06	74.65	60.14	58.97	74.93
		30.13	50.85	65.02	62.16	77.11	77.84
		28.84	53.20	73.42	72.30	68.66	77.11
		31.19	57.68	76.94	77.95	69.55	78.01
		34.05	46.59	80.02	65.30	80.42	74.14
		36.23	49.95	71.34	78.79	82.38	76.55
40	0	31.63	54.29	70.43	71.25	71.24	73.90
		29.90	48.22	72.91	69.61	76.83	73.86
		31.30	49.45	69.66	81.70	71.74	65.24
		49.62	61.99	73.25	73.98	85.23	78.96
		32.98	64.46	72.35	88.37	78.74	76.66
		47.43	60.82	76.38	87.36	74.98	69.66
		35.90	48.83	53.20	87.42	87.30	73.75
		28.84	58.41	71.90	79.07	82.38	74.76
		27.66	64.23	71.06	79.35	80.47	84.78
		35.28	64.46	72.69	71.57	81.65	81.59
40	40	29.74	67.26	72.24	66.98	87.47	51.56
		34.86	58.81	70.56	78.54	80.68	73.08
		30.69	65.58	82.66	76.78	75.82	75.60
		38.53	53.20	63.78	81.98	83.16	74.48
		32.26	67.76	74.65	84.67	84.78	85.18
		36.34	60.37	84.00	84.84	81.14	77.56
		26.88	48.78	69.05	86.02	94.14	89.99
		36.34	66.30	77.95	77.00	77.95	73.75
		34.44	60.31	68.94	82.32	76.10	89.66
		45.86	62.50	70.39	75.32	77.50	75.49
40	40	30.97	58.13	71.57	74.82	72.86	78.01
		29.34	52.75	71.29	73.70	89.88	81.70
		34.16	59.57	73.43	79.75	81.33	80.14

Table 2.9 Sorghum yields (cwt.) per acre for different fertilizer treatments on irrigated land of West-Central Kansas 1969

Pounds		Pounds of Nitrogen Per Acre					
P ₂ O ₅	K ₂ O	0	40	80	120	180	200
0	0	39.31	50.85	64.18	57.79	58.97	61.88
		43.96	52.58	51.46	52.02	47.99	60.14
		41.05	58.41	62.44	58.97	60.70	54.32
		43.96	50.29	66.47	72.24	52.02	53.20
		37.58	52.58	63.00	67.03	61.88	57.79
		36.40	49.73	68.77	65.91	61.88	65.30
		32.37	55.50	45.70	47.99	55.50	71.12
		37.58	60.14	66.47	60.14	72.86	57.23
		35.84	54.94	72.86	70.50	61.88	63.62
		40.49	57.79	67.65	69.38	55.50	68.77
40	0	38.85	54.28	62.90	62.20	58.92	61.34
		42.78	63.62	68.77	67.65	64.74	63.62
		52.02	62.44	67.03	68.77	64.18	64.18
		32.93	56.06	64.74	69.38	72.86	67.03
		38.14	53.76	63.62	65.91	67.65	69.94
		40.49	62.44	66.47	64.74	67.65	68.21
		49.11	63.62	60.70	74.59	69.38	69.94
		43.96	68.21	75.71	74.59	74.59	65.91
		30.63	61.26	70.50	69.94	79.18	73.98
		40.49	60.70	71.12	68.77	76.33	75.71
40	40	43.96	64.74	71.12	72.24	78.06	73.98
		41.45	61.69	67.98	69.66	72.46	69.25
		32.37	61.88	72.24	66.47	69.94	63.00
		33.54	61.26	68.77	66.47	65.91	65.30
		40.49	56.06	65.30	66.47	70.50	70.50
		41.05	60.14	65.91	67.65	64.74	62.44
		37.02	54.94	70.50	73.42	69.38	69.38
		38.14	69.38	77.45	69.94	73.42	68.77
		41.05	56.06	73.42	73.42	72.86	78.06
		45.70	61.88	67.65	67.65	74.59	71.68
40	40	34.10	62.44	73.98	75.71	69.38	68.21
		37.02	54.32	63.00	80.36	79.80	79.80
		38.05	59.84	69.82	70.76	71.05	69.71

Table 2. 10 Sorghum yields (cwt) per acre for different fertilizer treatments on irrigated land in West-Central Kansas 1970

Pounds P ₂ O ₅	Pounds K ₂ O	Pounds of Nitrogen Per Acre					
		0	40	80	120	160	200
0	0	36.57	49.84	61.94	60.54	60.87	77.34
		37.02	54.49	57.12	54.71	59.53	65.97
		44.52	56.90	68.54	61.71	62.05	63.06
		44.02	62.05	66.64	69.44	65.13	55.78
		47.54	57.96	71.46	71.85	59.53	66.98
		27.94	58.74	69.89	67.87	66.36	69.27
		37.74	59.14	52.30	58.63	74.76	70.67
		37.74	61.15	71.85	66.92	68.66	81.93
		43.40	56.62	79.07	75.77	78.96	63.78
		41.94	56.34	69.83	83.61	67.14	82.10
40	0	39.84	57.32	66.86	67.11	66.30	69.69
		34.05	59.58	74.37	67.26	73.98	72.41
		39.37	61.26	78.90	71.01	72.07	67.14
		43.29	51.52	65.02	69.16	73.08	73.25
		46.93	53.54	67.42	64.29	67.76	72.02
		47.49	64.40	69.05	68.38	71.90	81.98
		34.22	56.78	68.88	71.74	76.33	77.28
		36.51	63.90	65.52	79.18	85.79	83.89
		43.46	61.77	62.16	76.61	86.41	78.29
		45.25	65.74	77.17	81.65	84.67	87.25
40	40	44.30	57.34	74.42	77.17	89.04	73.19
		41.49	59.58	70.29	72.65	78.10	76.67
		41.22	59.25	69.83	70.06	72.74	83.78
		47.71	73.25	72.41	74.09	74.65	74.59
		38.14	64.79	65.52	72.74	70.45	67.87
		40.21	59.70	69.05	73.02	67.14	74.59
		42.56	59.42	67.14	71.34	74.42	73.70
		34.78	59.70	75.04	76.16	78.90	77.22
		39.98	60.93	78.34	79.46	79.63	81.65
		35.84	54.60	77.62	74.93	82.21	81.26
40	40	35.73	60.09	83.89	76.05	79.41	87.42
		47.38	62.89	72.35	79.46	82.38	83.33
		40.36	61.46	73.12	74.73	76.19	78.54

APPENDIX B

A. PREDICTED EQUATIONS FOR CORN

19611. ($P_2O_5=0$, $K_2O=0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 45.1498 + 1.1771N - 0.0038N^2 \dots\dots\dots(1)$$

$$R = 0.96688, R^2 = 0.93, n = 30$$

Variable	T-value	Probability Level
N	13.7039	0.001
N^2	-9.1923	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 40.0691 - 0.3054N + 11.0628N^{0.5} \dots\dots\dots(2)$$

$$R = 0.96922, R^2 = 0.94, n = 30$$

Variable	T-value	Probability Level
N	-3.8802	0.001
$N^{0.5}$	9.6363	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + \text{Log } N$$

$$\text{Log } Y = \text{Log } 3.6977 + 0.2326 \text{ Log } N \dots\dots\dots(3)$$

$$R = 0.97226, R^2 = 0.95, n = 30$$

Variable	T-value	Probability Level
Log N	21.9971	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Functions

$$Y = a + bN + cN^2$$

$$Y = 44.0791 + 1.1253N - 0.0034N^2 \dots\dots\dots(4)$$

$$R = 0.96317, R^2 = 0.93, n = 30$$

Variable	T-value	Probability Level
N	11.8528	0.001
N^2	7.3537	0.001

b. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b\text{Log } N$$

$$\text{Log } Y = \text{Log } 3.6815 + 0.2358 \text{ Log } N \dots\dots\dots(5)$$

$$R = 0.95326, R^2 = 0.91, n = 30$$

Variable	T-value	Probability Level
Log N	16.6940	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 45.0204 + 1.1802N - 0.0038N^2 \dots\dots\dots (6)$$

$$R = 0.97406, R^2 = 0.95, n = 30$$

Variable	T-value	Probability Level
N	15.4932	0.001
N^2	-10.3487	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 41.6614 - 0.2508N + 10.2956N^{0.5} \dots\dots\dots (7)$$

$$R = 0.96233, R^2 = 0.91, n = 30$$

Variable	T-value	Probability-Level
N	-2.8852	0.01
$N^{0.5}$	8.1186	0.001

c. Cobb-Douglas Function

$$Y = a N^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 3.7455 + 0.2220 \log N \dots\dots\dots (8)$$

$$R = 0.96677, R^2 = 0.93, n = 30$$

Variable	T-value	Probability Level
$\log N$	20.0116	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 44.7498 + 1.1609N - 0.0036N^2 \dots (9)$$

$$R = 0.96705, R^2 = 0.94, n = 90$$

Variable	T-value	Probability Level
N	23.9217	0.001
N^2	-15.6339	0.001

b. Square Root Functions

$$i) Y = a + bN + cN^{0.5}$$

$$Y = 40.6692 - 0.2406N + 10.2794N^{0.5} \dots (10)$$

$$R = 0.96290, R^2 = 0.93, n = 90$$

Variable	T-value	Probability Level
N	-4.9246	0.001
$N^{0.5}$	14.4204	0.001

$$ii) Y = a + bN + cN^2 + dN^{0.5}$$

$$Y = 42.0279 + 0.6074N + 4.3346N^{0.5} - 0.0023N^2 \dots (11)$$

$$R = 0.97015, R^2 = 0.94, n = 90$$

Variable	T-value	Probability Level
N	3.1569	0.005
N^2	-4.5285	0.001
$N^{0.5}$	2.9642	0.005

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 42.7998 + 1.6920N - 0.0003N^{1.5} \dots\dots(12)$$

$$R = 0.97012, R^2 = 0.94, n = 90$$

Variable	T-value	Probability Level
N	22.0746	0.001
N ^{1.5}	-16.6708	0.001

d. Cobb-Douglas Function

$$Y = a N^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 3.6950 + 0.1305 \log N \dots\dots\dots(13)$$

$$R = 0.95066, R^2 = 0.90, n = 90$$

Variable	T-value	Probability Level
Log N	28.7458	0.001

1962

1. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 65.5414 + 1.0965N - 0.0031N^2 \dots\dots(14)$$

$$R = 0.94036, R^2 = 0.88, n = 30$$

Variable	T-value	Probability Level
N	8.5442	0.001
N ²	-4.9639	0.001

b. Cobb-Douglas Function

$$Y = a N^b$$

$$Y = \text{Log } a + b \text{ Log } N$$

$$Y = \text{Log } 4.1119 + 0.1809 \text{ Log } N \dots (15)$$

$$R = 0.9008, R^2 = 0.81, n = 30$$

Variable	T-value	Probability Level
Log N	10.9304	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 73.6175 + 1.1432N - 0.0036N^2 \dots (16)$$

$$R = 0.91743, R^2 = 0.84, n = 30$$

Variable	T-value	Probability Level
N	8.2070	0.001
N^2	-5.4304	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 65.8555 - 0.3600N + 11.8649N^{0.5} \dots (17)$$

$$R = 0.94355, R^2 = 0.89, n = 30$$

Variable	T-value	Probability Level
N	-3.2680	0.005
$N^{0.5}$	7.3836	0.001

c. Cobb-Douglas Function

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.1711 + 0.1763 \text{ Log } N \dots (18)$$

$$R = 0.94041, R^2 = 0.88, n = 30$$

Variable	T-value	Probability Level
Log N	14.6342	0.001

3. ($P_{205} = 40$, $K_{20} = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 72.1679 + 1.0500N - 0.0030N^2 \dots (19)$$

$$R = 0.91883, R^2 = 0.84, n = 30$$

Variable	T-value	Probability Level
N	7.7066	0.001
N^2	-4.6601	0.001

b. Cobb-Douglas Function

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.2265 + 0.1588 \text{ Log } N \dots (20)$$

$$R = 0.90655, R^2 = 0.82, n = 30$$

Variable	T-value	Probability Level
Log N	11.5658	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 70.4423 + 1.1243N - 0.0034N^2 \dots (21)$$

$$R = 0.93429, R^2 = 0.87, n = 90$$

Variable	T-value	Probability Level
N	15.7907	0.001
N^2	-9.9255	0.001

b. Square Root

$$Y = a + bN + cN^{0.5}$$

$$Y = 66.4110 - 0.1878N + 9.6761N^{0.5} \dots (22)$$

$$R = 0.93245, R^2 = 0.87, n = 90$$

Variable	T-value	Probability Level
N	-2.7396	0.01
$N^{0.5}$	9.6771	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 68.5821 + 1.6217N - 0.0003N^{1.5} \dots (23)$$

$$R = 0.93715, R^2 = 0.88, n = 90$$

Variable	T-value	Probability Level
N	14.0409	0.001
$N^{1.5}$	-10.3285	0.001

d. Cobb-Douglas Function

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.1665 + 0.0973 \text{ Log } N \dots\dots (24)$$

$$R = 0.90510, R^2 = 0.82, n = 90$$

Variable	T-value	Probability Level
Log N	19.9888	0.001

19631. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 44.4864 + 0.9212N - 0.0023N^2 \dots\dots (25)$$

$$R = 0.95758, R^2 = 0.92, n = 30$$

Variable	T-value	Probability Level
N	9.2671	0.001
N^2	-4.8104	0.001

b. Cobb-Douglas Function

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6938 + 0.2225 \text{ Log } N \dots\dots (26)$$

$$R = 0.93860, R^2 = 0.88, n = 30$$

Variable	T-value	Probability Level
Log N	14.3950	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 47.5103 + 0.9518N - 0.0024N^2 \dots\dots(27)$$

$$R = 0.92339, R^2 = 0.85, n = 30$$

Variable	T-value	Probability Level
N	6.7144	0.001
N^2	-3.4888	0.005

b. Cobb-Douglas Function

$$Y = a N^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 3.6723 + 0.2370 \log N \dots\dots(28)$$

$$R = 0.89908, R^2 = 0.81, n = 30$$

Variable	T-value	Probability Level
$\log N$	10.8670	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 46.3349 + 0.9600N - 0.0022N^2 \dots\dots(29)$$

$$R = 0.95462, R^2 = 0.91, n = 30$$

Variable	T-value	Probability Level
N	8.3613	0.001
N^2	-3.9871	0.001

b. Cobb-Douglas Function

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.7368 + 0.2273 \text{ Log } N \dots (30)$$

$$R = 0.92712, R^2 = 0.86, n = 30$$

Variable	T-value	Probability Level
Log N	13.0908	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Functions

$$i) Y = a + bN + cN^2$$

$$Y = 46.1105 + 0.9443N - 0.0023N^2 \dots (31)$$

$$R = 0.94075, R^2 = 0.89, n = 90$$

Variable	T-value	Probability Level
N	13.5771	0.001
N^2	- 6.8557	0.001

$$ii) Y = a + bN + cN^2 + dP$$

$$Y = 42.0777 + 0.9443N - 0.0023N^2 + 0.1512P \dots (32)$$

$$R = 0.94396, R^2 = 0.89, n = 90$$

Variable	T-value	Probability Level
N	13.8689	0.001
N^2	- 7.0031	0.001
P	2.1865	0.05

iii) $Y = a + bN + cN^2 + dNP$

$$Y = 46.1105 + 0.9090N - 0.0023N^2 + 0.0013NP \dots (33)$$

$$R = 0.94435, R^2 = 0.89, n = 90$$

Variable	T-value	Probability Level
N	13.0733	0.001
N ²	- 7.0269	0.001
NP	2.3237	0.025

b. Square Root Functions

$$Y = a + bN^{0.5} + cP$$

$$Y = 38.0789 + 7.3412N^{0.5} + 0.1512P \dots (34)$$

$$R = 0.94136, R^2 = 0.89, n = 90$$

Variable	T-value	Probability Level
N ^{0.5}	25.9339	0.001
P	2.1512	0.05

c. 1.5 Power Function

i) $Y = a + bN + cN^{1.5}$

$$Y = 44.9200 + 1.2761N - 0.0002N^{1.5} \dots (35)$$

$$R = 0.94165, R^2 = 0.89, n = 90$$

Variable	T-value	Probability Level
N	11.1523	0.001
N ^{1.5}	- 7.0004	0.001

$$\text{iii)} \quad Y = a + bN + cN^{1.5} + dP$$

$$Y = 40.8871 + 1.2761N - 0.0002N^{1.5} + 0.1512P \dots (36)$$

$$R = 0.94486, R^2 = 0.89, n = 90$$

Variable	T-value	Probability Level
N	11.3968	0.001
$N^{1.5}$	- 7.1539	0.001
NP	2.2037	0.05

$$\text{iii)} \quad Y = a + bN + cN^{1.5} + dNP$$

$$Y = 44.9200 + 1.2408N - 0.0002N^{1.5} + 0.0013NP \dots (37)$$

$$R = 0.94525, R^2 = 0.89, n = 90$$

Variable	T-value	Probability Level
N	11.0202	0.001
$N^{1.5}$	- 7.1786	0.001
NP	2.3421	0.025

d. Cobb-Douglas Function

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.7013 + 0.1279 \text{ Log } N \dots (38)$$

$$R = 0.89278, R^2 = 0.80, n = 90$$

Variable	T-value	Probability Level
Log N	18.5912	0.001

1964

1. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 55.6425 + 1.0672N - 0.0034N^2 \dots \dots \dots (39)$$

$$R = 0.97143, R^2 = 0.94, n = 30$$

Variable	T-value	Probability Level
N	14.4896	0.001
N^2	- 9.5423	0.001

b. Square Root Function

$$Y = a + bN^2 + cN^{0.5}$$

$$Y = 53.1581 - 0.0006N^2 + 7.7790N^{0.5} \dots \dots \dots (40)$$

$$R = 0.95139, R^2 = 0.91, n = 30 \dots$$

Variable	T-value	Probability Level
N^2	-2.6149	0.025
$N^{0.5}$	10.9063	0.01

c. Cobb-Douglas Function

$$Y = a N^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 4.0057 + 0.1733 \log N \dots \dots \dots (41)$$

$$R = 0.95189, R^2 = 0.91, n = 30$$

Variable	T-value	Probability Level
$\log N$	16.4368	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 58.0597 + 0.9807N - 0.0028N^2 \dots \dots \dots (42)$$

$$R = 0.94909, R^2 = 0.90, n = 30$$

Variable	T-value	Probability Level
N	9.5422	0.001
N^2	-5.6792	0.001

b. Cobb-Douglas Function

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.9984 + 0.1793 \text{ Log } N \dots \dots \dots (43)$$

$$R = 0.95082, R^2 = 0.90, n = 30$$

Variable	T-value	Probability Level
Log N	16.2434	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 53.2559 + 1.0117N - 0.0026N^2 \dots \dots \dots (44)$$

$$R = 0.98066, R^2 = 0.96, n = 30$$

Variable	T-value	Probability Level
N	14.4835	0.001
N^2	- 7.8350	0.001

b. Cobb-Douglas Function

$$Y = a N^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 3.9304 + 0.1963 \log N \dots \dots \dots (45)$$

$$R = 0.95481, R^2 = 0.91, n = 30$$

Variable	T-value	Probability Level
Log N	16.9995	0.001

4. (N, P, K variable)

a. Quadratic Functions

$$i) Y = a + bN + cN^2$$

$$Y = 55.6527 + 1.0199N - 0.0029N^2 \dots \dots \dots (46)$$

$$R = 0.96298, R^2 = 0.93, n = 90$$

Variable	T-value	Level of Probability
N	20.4563	0.001
N ²	-12.2605	0.001

$$ii) Y = a + bN + cNP + dN^2$$

$$Y = 55.6527 + 0.9953N - 0.0029N^2 + 0.0009NP \dots \dots \dots (47)$$

$$R = 0.96510, R^2 = 0.93, n = 90$$

Variable	T-value	Level of Probability
N	19.9357	0.001
N ²	-12.5469	0.001
NP	2.2610	0.050

$$\text{iii) } Y = a + bN + cN^2 + dNK$$

$$Y = 55.6527 + 1.0070N - 0.0029N^2 + 0.0010 NK \dots\dots\dots(48)$$

$$R = 0.96529, R^2 = 0.93, n = 90$$

Variable	T-value	Level of Probability
N	20.5971	0.001
N ²	-12.5805	0.001
NK	2.3665	0.025

b. Square Root Function

$$Y = a + bN^{0.5} + cN^2$$

$$Y = 52.8150 + 7.5312N^{0.5} - 0.0003N^2 \dots\dots\dots(49)$$

$$R = 0.95277, R^2 = 0.91, n = 90$$

Variable	T-value	Level of Probability
N ^{0.5}	17.6420	0.001
N ²	- 2.3036	0.025

c. The 1.5 Power Function

$$\text{i) } Y = a + bN + cN^{1.5}$$

$$Y = 54.3768 + 1.4304N - 0.0003N^{1.5} \dots\dots\dots(50)$$

$$R = 0.96282, R^2 = 0.93, n = 90$$

Variable	T-value	Level of Probability
N	17.2745	0.001
N ^{1.5}	-12.2199	0.001

$$\text{ii) } Y = a + bN + cN^{1.5} + dNP$$

$$Y = 54.3768 + 1.4058N - 0.003N^{1.5} + 0.0009NP \dots (51)$$

$$R = 0.96494, R^2 = 0.93, n = 90$$

Variable	T-value	Level of Probability
N	17.2153	0.001
$N^{1.5}$	-12.5038	0.001
NP	2.2559	0.05

$$\text{iii) } Y = a + bN + cN^{1.5} + dNK$$

$$Y = 54.3768 + 1.4176N - 0.0003N^{1.5} + 0.0010NK \dots (52)$$

$$R = 0.96513, R^2 = 0.93, n = 90$$

Variable	T-value	Level of Probability
N	17.5237	0.001
$N^{1.5}$	-12.5371	0.001
NK	2.3612	0.025

d. Cobb-Douglas Functions

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.9801 + 0.1020 \text{ Log } N \dots (53)$$

$$R = 0.92238, R^2 = 0.85, n = 90$$

Variable	T-value	Level of Probability
Log N	22.3999	0.001

1965

1. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Functions

$$Y = a + bN + cN^2$$

$$Y = 44.6654 + 1.1262N - 0.0032N^2 \dots \dots \dots (54)$$

$$R = 0.96495, R^2 = 0.93, n = 30$$

Variable	T-value	Probability Level
N	11.6377	0.001
N^2	- 6.9225	0.001

b. Cobb-Douglas Function

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.7723 + 0.2201 \text{ Log } N \dots \dots \dots (55)$$

$$R = 0.94888, R^2 = 0.90, n = 90$$

Variable	T-value	Probability Level
Log N	15.9073	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + BN + cN^2$$

$$Y = 42.9344 + 1.3395N - 0.0039N^2 \dots \dots \dots (56)$$

$$R = 0.97821, R^2 = 0.96, n = 90$$

Variable	T-value	Probability Level
N	15.2369	0.001
N^2	- 9.2519	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5} + dN^2$$

$$Y = 48.5990 + 2.4913N - 0.0067N^2 - 9.0209N^{0.5} \dots\dots(57)$$

$$R = 0.98686, R^2 = 0.97, n = 30$$

Variable	T-value	Probability Level
N	8.6329	0.001
N ²	-8.8314	0.001
N ^{0.5}	-4.1130	0.001

c. Cobb-Douglas

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.8096 + 0.2296 \text{ Log } N \dots\dots\dots(58)$$

$$R = 0.93948, R^2 = 0.88, n = 30$$

Variable	T-value	Probability Level
Log N	14.5097	0.001

3. (P₂O₅ = 40, K₂O = 40, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 48.7853 + 1.1369N - 0.0029N^2 \dots\dots\dots(59)$$

$$R = 0.97496, R^2 = 0.95, n = 30$$

Variable	T-value	Probability Level
N	12.2929	0.001
N ²	- 6.4212	0.001

b. Cobb-Douglas Function

$$Y = a N^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 3.8685 + 0.2182 \log N \dots \dots \dots (60)$$

$$R = 0.9317, R^2 = 0.87, n = 30$$

Variable	T-value	Probability Level
Log N	13.5755	0.001

4. (N, P₂O₅, K₂O, Variable)

a. Quadratic Function

$$i) Y = a + bN + cN^2$$

$$Y = 45.4617 + 1.2009N - 0.0033N^2 \dots \dots \dots (61)$$

$$R = 0.96360, R^2 = 0.93, n = 90$$

Variable	T-value	Probability Level
N	19.8475	0.001
N ²	-11.4432	0.001

$$ii) Y = a + bN + cN^2 + dP$$

$$Y = 38.7805 + 1.2009N - 0.0033N^2 + 0.2505P \dots \dots (62)$$

$$R = 0.97066, R^2 = 0.94, n = 90$$

Variable	T-value	Probability Level
N	21.9391	0.001
N ²	-12.6491	0.001
P	4.5059	0.001

$$\text{iii) } Y = a + bN + cN^2 + dNP$$

$$Y = 45.4617 + 1.1384N - 0.0033N^2 + 0.0023NP \dots (63)$$

$$R = 0.97263, R^2 = 0.95, n = 90$$

Variable	T-value	Probability Level
N	21.0063	0.001
N ²	-13.0914	0.001
NP	5.2788	0.001

b. Square Root Function

$$\text{i) } Y = a + bN^{0.5} + cP$$

$$Y = 38.2364 + 8.1368N^{0.5} + 0.2505P \dots (64)$$

$$R = 0.94960, R^2 = 0.90, n = 90$$

Variable	T-value	Probability Level
N ^{0.5}	28.0399	0.001
P	3.4766	0.001

$$\text{ii) } Y = a + bN^{0.5} + cNP$$

$$Y = 46.3343 + 7.2840N^{0.5} + 0.0023NP \dots (65)$$

$$R = 0.95174, R^2 = 0.91, n = 90$$

Variable	T-value	Probability Level
N ^{0.5}	20.5903	0.001
NP	4.0462	0.001

$$\text{iii) } Y = a + bN + cN^{0.5} + dN^2$$

$$Y = 48.7378 + 1.8670N - 5.2173N^{0.5} - 0.0049N^2 \dots\dots (66)$$

$$R = 0.96680, R^2 = 0.93, n = 90$$

Variable	T-value	Probability Level
N	7.7555	0.001
N ^{0.5}	-2.8516	0.01
N ²	-7.8041	0.001

$$\text{iv) } Y = a + bN + cN^2 + dN^{0.5} + eP$$

$$Y = 42.0566 + 1.8670N - 5.2173N^{0.5} - 0.0049N^2 +$$

$$0.2505P \dots\dots\dots (67)$$

$$R = 0.97383, R^2 = 0.95, n = 90$$

Variable	T-value	Probability Level
N	8.6695	0.001
N ^{0.5}	-3.1877	0.05
N ²	-8.7238	0.001
P	4.7398	0.001

$$\text{v) } Y = a + bN + cN^2 + dN^{0.5} + eNP$$

$$Y = 48.7378 + 1.8046N - 5.2173N^{0.5} - 0.0049N^2 +$$

$$0.0023NP \dots\dots\dots (68)$$

$$R = 0.97580, R^2 = 0.95, n = 90$$

Variable	T-value	Probability Level
N	8.6969	0.001
N ²	-3.3132	0.001
N ^{0.5}	-9.0675	0.001
NP	5.5766	0.001

c. 1.5 Power Function

i) $Y = a + bN + cN^{1.5}$

$$Y = 44.6500 + 1.6286N - 0.00003N^{1.5} \dots\dots\dots(69)$$

$$R = 0.95983, R^2 = 0.92, n = 90$$

Variable	T-value	Probability Level
N	15.4754	0.001
$N^{1.5}$	-10.5312	0.001

ii) $Y = a + bN + cN^{1.5} + dP$

$$Y = 37.9687 + 1.6286N - 0.0003N^{1.5} + 0.2505P \dots\dots(70)$$

$$R = 0.96692, R^2 = 0.93, n = 90$$

Variable	T-value	Probability Level
N	16.9235	0.001
$N^{1.5}$	-11.5167	0.001
P	4.2478	0.001

iii) $Y = a + bN + cN^{1.5} + dNP$

$$Y = 44.6500 + 1.5661N - 0.0003N^{1.5} +$$

$$0.0023NP \dots\dots\dots(71)$$

$$R = 0.96890, R^2 = 0.94, n = 90$$

Variable	T-value	Probability Level
N	16.6266	0.001
$N^{1.5}$	-11.8725	0.001
NP	4.9570	0.001

d. Cobb-Douglas Function

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.8254 + 0.1231 \text{ Log } N \dots \dots \dots (72)$$

$$R = 0.90092, R^2 = 0.82, n = 90$$

Variable	T-value	Probability Level
Log N	19.4743	0.001

19661. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 67.9413 + 0.7742N - 0.0023N^2 \dots \dots \dots (73)$$

$$R = 0.84654, R^2 = 0.72, n = 60$$

Variable	T-value	Probability Level
N	7.7432	0.001
N^2	-4.8596	0.001

b. Cobb-Douglas Function

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.1334 + 0.1392 \text{ Log } N \dots \dots \dots (74)$$

$$R = 0.86941, R^2 = 0.76, n = 60$$

Variable	T-value	Probability Level
Log N	13.4006	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 60.0318 + 0.9614N - 0.0029N^2 \dots \dots \dots (75)$$

$$R = 0.91061, R^2 = 0.83, n = 60$$

Variable	T-value	Probability Level
N	10.6528	0.001
N^2	- 6.6427	0.001

b. Cobb-Douglas Function

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.0445 + 0.1656 \text{ Log } N \dots \dots \dots (76)$$

$$R = 0.89937, R^2 = 0.81, n = 60$$

Variable	T-value	Probability Level
Log N	15.6669	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 65.7532 + 0.9106N - 0.0027N^2 \dots \dots \dots (77)$$

$$R = 0.90433, R^2 = 0.82, n = 60$$

Variable	T-value	Probability Level
N	10.0707	0.001
N^2	- 6.1818	0.001

b. Cobb-Douglas Function

$$Y = a N^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 4.1288 + 0.1532 \log N \dots \dots \dots (78)$$

$$R = 0.88883, R^2 = 0.79, n = 60$$

Variable	T-value	Probability Level
Log N	14.7718	0.001

4. (N, P, K variable)

a. Quadratic Function

$$i) Y = a + bN + cN^2$$

$$Y = 64.5754 + 0.8821N - 0.0026N^2 \dots \dots \dots (79)$$

$$R = 0.88386, R^2 = 0.78, n = 180$$

Variable	T-value	Probability Level
N	16.0371	0.001
N ²	- 9.9655	0.001

$$ii) Y = a + bN + cN^2 + dP$$

$$Y = 61.5333 + 0.8821N - 0.0026N^2 + 0.1141P \dots \dots (80)$$

$$R = 0.88677, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	16.1835	0.001
N ²	-10.0564	0.001
P	2.0605	0.05

$$\text{iii) } Y = a + bN + cN^2 + dNP$$

$$Y = 64.5754 + 0.8460N - 0.0026N^2 + 0.0014NP \dots (81)$$

$$R = 0.88984, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	15.3452	0.001
N ²	-10.1876	0.001
NP	2.9965	0.005

$$\text{iv) } Y = a + bN + cN^2 + dK$$

$$Y = 62.9403 + 0.8821N - 0.0026N^2 + 0.1226K \dots (82)$$

$$R = 0.88722, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	16.2140	0.001
N ²	-10.0754	0.001
K	2.2192	0.05

b. Square Root Function

$$\text{i) } Y = a + bN + cN^{0.5}$$

$$Y = 62.1697 - 0.1149N + 7.1893N^{0.5} \dots (83)$$

$$R = 0.87660, R^2 = 0.77, n = 180$$

Variable	T-value	Probability Level
N	-2.1382	0.05
N ^{0.5}	9.1685	0.001

$$\text{ii) } Y = a + bN + cN^{0.5} + dP$$

$$Y = 59.1275 - 0.1149N + 7.1893N^{0.5} + 0.1144P \dots (84)$$

$$R = 0.87953, R^2 = 0.77, n = 180$$

Variable	T-value	Probability Level
N	-2.1563	0.05
$N^{0.5}$	9.2461	0.001
P	2.0015	0.05

$$\text{iii) } Y = a + bN + cN^{0.5} + dNP$$

$$Y = 62.1697 - 0.1510N + 7.1893N^{0.5} + 0.0014NP \dots (85)$$

$$R = 0.88263, R^2 = 0.78, n = 180$$

Variable	T-value	Probability Level
N	-2.7914	0.010
$N^{0.5}$	9.3598	0.001
NP	2.9086	0.005

$$\text{iv) } Y = a + bN + cN^{0.5} + dK$$

$$Y = 60.5345 - 0.1149N + 7.1893N^{0.5} + 0.1226K \dots (86)$$

$$R = 0.87999, R^2 = 0.77, n = 180$$

Variable	T-value	Probability Level
N	-2.1601	0.05
$N^{0.5}$	9.2625	0.001
K	2.1554	0.05

$$v) Y = a + bN^{0.5} + cN^2$$

$$Y = 61.6292 + 6.6166N^{0.5} - 0.0004N^2 \dots \dots \dots (87)$$

$$R = 0.87920, R^2 = 0.77, n = 180$$

Variable	T-value	Probability Level
$N^{0.5}$	15.5397	0.001
N^2	- 2.8681	0.005

$$vi) Y = a + bN^{0.5} + cN^2 + dNP$$

$$Y = 61.7327 + 6.3377N^{0.5} - 0.0005N^2 + 0.0014NP \dots \dots \dots (88)$$

$$R = 0.88583, R^2 = 0.78, n = 180$$

Variable	T-value	Probability Level
$N^{0.5}$	14.8952	0.001
N^2	- 3.5530	0.001
NP	3.0944	0.005

c. 1.5 Power Function

$$i) Y = a + bN + cN^{1.5}$$

$$Y = 63.2602 + 1.2603N - 0.0002N^{1.5} \dots \dots \dots (89)$$

$$R = 0.88526, R^2 = 0.78, n = 180$$

Variable	T-value	Probability Level
N	13.9041	0.001
$N^{1.5}$	-10.1231	0.001

$$\text{ii) } Y = a + bN + cN^{1.5} + dP$$

$$Y = 60.2181 + 1.2603N - 0.0002N^{1.5} + 0.1141P \dots (90)$$

$$R = 0.88816, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	14.0329	0.001
$N^{1.5}$	-10.2169	0.001
P	2.0725	0.05

$$\text{iii) } Y = a + bN + cN^{1.5} + dK$$

$$Y = 61.6251 + 1.2603N - 0.0002N^{1.5} + 0.1226K \dots (91)$$

$$R = 0.88861, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	14.0597	0.001
$N^{1.5}$	-10.2364	0.001
K	2.2322	0.05

$$\text{iv) } Y = a + bN + cN^{1.5} + dNP$$

$$Y = 63.2602 + 1.2242N - 0.0002N^{1.5} +$$

$$0.0014NP \dots \dots \dots (92)$$

$$R = 0.89124, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	13.6873	0.001
$N^{1.5}$	-10.3518	0.001
NP	3.0145	0.005

d. Cobb-Douglas Function

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.1011 + 0.0855 \text{ Log } N \dots \dots \dots (93)$$

$$R = 0.86031, R^2 = 0.74, n = 180$$

Variable	T-value	Probability Level
Log N	22.5157	0.001

19671. ($P_2O_5 = 0, K_2O, 0, N$ variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 47.8499 + 1.1303N - 0.0033N^2 \dots \dots \dots (94)$$

$$R = 0.90261, R^2 = 0.81, n = 60$$

Variable	T-value	Probability Level
N	9.7602	0.001
N ²	-5.8737	0.001

b. Cobb-Douglas Function

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.7560 + 0.2287 \text{ Log } N \dots \dots \dots (95)$$

$$R =$$

Variable	T-value	Probability Level
Log N	18.1582	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 55.1707 + 1.2651N - 0.0037N^2 \dots \dots \dots (96)$$

$$R = 0.92584, R^2 = 0.86, n = 60$$

Variable	T-value	Probability Level
N	11.7118	0.001
N^2	- 7.2277	0.001

b. Cobb-Douglas Function

$$Y = a N^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 3.9239 + 0.2164 \log N \dots \dots \dots (97)$$

$$R = 0.88517, R^2 = 0.78, n = 60$$

Variable	T-value	Probability Level
Log N	14.4890	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 50.4441 + 1.2934N - 0.0039N^2 \dots \dots \dots (98)$$

$$R = 0.94816, R^2 = 0.90, n = 60$$

Variable	T-value	Probability Level
N	14.6793	0.001
N^2	- 9.2999	0.001

b. Cobb-Douglas Function

$$Y = a N^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 3.8852 + 0.2179 \log N \dots \dots \dots (99)$$

$$R = 0.94181, R^2 = 0.89, n = 60$$

Variable	T-value	Probability Level
Log N	21.3375	0.001

4. (N, P, K variable)

a. Quadratic Functions

$$i) Y = a + bN + cN^2$$

$$Y = 51.1549 + 1.2296N - 0.0036N^2 \dots \dots \dots (100)$$

$$R = 0.91612, R^2 = 0.84, n = 180$$

Variable	T-value	Probability Level
N	19.2859	0.001
N ²	-11.9223	0.001

$$ii) Y = a + bN + cN^2 + dP$$

$$Y = 43.5447 + 1.2296N - 0.0036N^2 + 0.2854P \dots \dots (101)$$

$$R = 0.92569, R^2 = 0.86, n = 180$$

Variable	T-value	Probability Level
N	20.3817	0.001
N ²	-12.5997	0.001
P	4.6567	0.001

b. Square Root Functions

i) $Y = a + bN + cN^{0.5}$

$$Y = 48.6826 - 0.1283N + 9.5921N^{0.5} \dots\dots\dots (102)$$

$$R = 0.90401, R^2 = 0.82, n = 180$$

Variable	T-value	Probability Level
N	-1.9862	0.05
$N^{0.5}$	10.1813	0.001

ii) $Y = a + bN + cN^{0.5} + dP$

$$Y = 41.0724 - 0.1283N + 9.5921N^{0.5} +$$

$$0.2854P \dots\dots\dots (103)$$

$$R = 0.91371, R^2 = 0.83, n = 180$$

Variable	T-value	Probability Level
N	-2.0837	0.001
$N^{0.5}$	10.6807	0.001
P	4.3349	0.001

iii) $Y = a + bN^2 + cN^{0.5}$

$$Y = 47.5938 + 9.1090N^{0.5} - 0.0005N^2 \dots\dots\dots (104)$$

$$R = 0.90688, R^2 = 0.82, n = 180$$

Variable	T-value	Probability Level
N^2	17.8852	0.001
$N^{0.5}$	- 3.0398	0.005

$$\text{iv) } Y = a + bN^{0.5} + cN^2 + dP$$

$$Y = 39.9836 + 9.1090N^{0.5} - 0.0005N^2 +$$

$$0.2854P \dots \dots \dots (105)$$

$$R = 0.91655, R^2 = 0.84, n = 180$$

Variable	T-value	Probability Level
$N^{0.5}$	18.7919	0.001
N^2	- 3.1939	0.005
P	4.4047	0.001

c. 1.5 Power Function

$$\text{i) } Y = a + bN + cN^{1.5}$$

$$Y = 49.5588 + 1.7407N - 0.0003N^{1.5} \dots \dots \dots (106)$$

$$R = 0.91601, R^2 = 0.84, n = 180$$

Variable	T-value	Probability Level
N	16.4628	0.001
$N^{1.5}$	-11.9059	0.001

$$\text{ii) } Y = a + bN + cN^{1.5} + dP$$

$$Y = 41.9486 + 1.7407N - 0.0003N^{1.5} +$$

$$4.6535P \dots \dots \dots (107)$$

$$R = 0.92559, R^2 = 0.86, n = 180$$

Variable	T-value	Probability Level
N	17.3969	0.001
$N^{1.5}$	-12.5814	0.001
P	4.6535	0.001

d. Cobb-Douglas Function

i) $Y = a N^b$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.8516 + 0.1240 \text{ Log } N \dots \dots \dots (108)$$

$$R = 0.88782, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
Log N	25.7398	0.001

ii) $Y = a N^b P^c$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 3.7825 + 0.1240 \text{ Log } N + 0.0141 \text{ Log } P \dots \dots (109)$$

$$R = 0.89476, R^2 = 0.80, n = 180$$

Variable	T-value	Probability Level
Log N	26.4510	0.001
Log P	3.3124	0.005

19681. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 46,4346 + 0.9008N - 0.0021N^2 \dots \dots \dots (110)$$

$$R = 0.91298, R^2 = 0.83, n = 60$$

Variable	T-value	Probability Level
N	8.5984	0.001
N^2	-4.1760	0.001

b. Cobb-Douglas Function

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.7661 + 0.2108 \text{ Log } N \dots\dots\dots(111)$$

$$R = 0.91581, R^2 = 0.84, n = 60$$

Variable	T-value	Probability Level
Log N	17.3663	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 45.6525 + 1.1404N - 0.0027N^2 \dots\dots\dots(112)$$

$$R = 0.96390, R^2 = 0.93, n = 60$$

Variable	T-value	Probability Level
N	14.1398	0.001
N^2	- 7.0146	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 45.4748 + 0.1774N + 6.4119N^{0.5} \dots\dots\dots(113)$$

$$R = 0.95333, R^2 = 0.91, n = 60$$

Variable	T-value	Probability Level
N	2.0419	0.05
$N^{0.5}$	5.0595	0.001

c. Cobb-Douglas Function

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.7794 + 0.2362 \text{ Log } N \dots \dots \dots (114)$$

$$R = 0.92921, R^2 = 0.86, n = 60$$

Variable	T-value	Probability Level
Log N	19.1487	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 46.0182 + 0.9483N - 0.0015N^2 \dots \dots \dots (115)$$

$$R = 0.96391, R^2 = 0.93, n = 60$$

Variable	T-value	Probability Level
N	10.9645	0.001
N^2	- 3.5037	0.001

b. Square Root Function

$$Y = a + bN + cN^2 + dN^{0.5}$$

$$Y = 50.0080 + 1.7595N - 0.0034N^2 - 6.3538N^{0.5} \dots \dots (116)$$

$$R = 0.96742, R^2 = 0.94, n = 60$$

Variable	T-value	Probability Level
N	5.1240	0.001
N^2	-3.7946	0.001
$N^{0.5}$	-2.4346	0.025

c. Cobb-Douglas Function

$$Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.7851 + 0.2323 \text{ Log } N \dots \dots \dots (117)$$

$$R = 0.89678, R^2 = 0.80, n = 60$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
Log N	15.4355	0.001

4. (N, P₂O₅, K₂O variable)

a. Quadratic Functions

$$i) Y = a + bN + cN^2$$

$$Y = 46.0351 + 0.9965N - 0.0021N^2 \dots \dots \dots (118)$$

$$R = 0.93201, R^2 = 0.87, n = 180$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
N	16.1678	0.001
N ²	- 7.0645	0.001

$$ii) Y = a + bN + cN^2 + dP$$

$$Y = 36.7198 + 0.9965N - 0.0021N^2 + 0.3493P \dots \dots (119)$$

$$R = 0.94433, R^2 = 0.89, n = 180$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
N	17.7593	0.001
N ²	- 7.7599	0.001
P	6.1286	0.001

$$\text{iii) } Y = a + bN + cN^2 + dNP$$

$$Y = 46.0351 + 0.9019N - 0.0021N^2 + 0.0035NP \dots (120)$$

$$R = 0.95057, R^2 = 0.90, n = 180$$

Variable	T-value	Probability Level
N	16.6208	0.001
N ²	- 8.2224	0.001
NP	7.9861	0.001

b. Square Root Functions

$$\text{i) } Y = a + bN + cN^{0.5}$$

$$Y = 46.1811 + 0.2634N + 4.8112N^{0.5} \dots (121)$$

$$R = 0.92475, R^2 = 0.86, n = 180$$

Variable	T-value	Probability Level
N	4.2846	0.001
N ^{0.5}	5.3645	0.001

$$\text{ii) } Y = a + bN + cN^{0.5} + dP$$

$$Y = 36.8657 + 0.2634N + 4.8112N^{0.5} + 0.3493P \dots (122)$$

$$R = 0.93716, R^2 = 0.95, n = 180$$

Variable	T-value	Probability Level
N	4.6602	0.001
N ^{0.5}	5.8348	0.001
P	5.7792	0.001

$$\text{iii) } Y = a + bN + cN^{0.5} + dNP$$

$$Y = 46.1811 + 0.1688N + 4.8112N^{0.5} + 0.0035P \dots (123)$$

$$R = 0.94345, R^2 = 0.89, n = 180$$

Variable	T-value	Probability Level
N	3.0598	0.005
$N^{0.5}$	6.1410	0.001
NP	7.4801	0.001

c. 1.5 Power Functions

$$\text{i) } Y = a + bN + cN^{1.5}$$

$$Y = 45.5231 + 1.2655N - 0.0002N^{1.5} \dots (124)$$

$$R = 0.93068, R^2 = 0.87, n = 180$$

Variable	T-value	Probability Level
N	12.2734	0.001
$N^{1.5}$	- 6.7600	0.001

$$\text{ii) } Y = a + bN + cN^{1.5} + dP$$

$$Y = 36.2078 + 1.2655N - 0.0002N^{1.5} + 0.3493P \dots (125)$$

$$R = 0.94301, R^2 = 0.89, n = 180$$

Variable	T-value	Probability Level
N	13.4548	0.001
$N^{1.5}$	- 7.4108	0.001
P	6.0595	0.001

$$\text{iii) } Y = a + bN + cN^{1.5} + dNP$$

$$Y = 45.5231 + 1.1709N - 0.0002N^{1.5} + 0.0035NP \dots (126)$$

$$R = 0.94927, R^2 = 0.90, n = 180$$

Variable	T-value	Probability Level
N	13.0547	0.001
$N^{1.5}$	- 7.8417	0.001
NP	7.8853	0.001

d. Cobb-Douglas Functions

$$\text{i) } Y = a N^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.7918 + 0.1244 \text{ Log } N \dots \dots \dots (127)$$

$$R = 0.86678, R^2 = 0.75, n = 180$$

Variable	T-value	Probability Level
Log N	23.1890	0.001

$$\text{ii) } Y = a N^b P^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 3.7203 + 0.1244 \text{ Log } N + 0.0145 \text{ Log } P \dots (128)$$

$$R = 0.87396, R^2 = 0.76, n = 180$$

Variable	T-value	Probability Level
Log N	23.7281	0.001
Log P	3.0615	0.005

1969

1. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 104.1707 + 0.7867N - 0.0026N^2 \dots \dots \dots (129)$$

$$R = 0.83452, R^2 = 0.70, n = 60$$

Variable	T-value	Probability Level
N	8.0727	0.001
N^2	-5.4779	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 98.0242 - 0.2938N + 8.6658N^{0.5} \dots \dots \dots (130)$$

$$R = 0.86943, R^2 = 0.76, n = 60$$

Variable	T-value	Probability Level
N	-3.5331	0.001
$N^{0.5}$	7.1561	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 4.5824 + 0.0974 \log N \dots \dots \dots (131)$$

$$R = 0.89548, R^2 = 0.80, n = 60$$

Variable	T-value	Probability Level
$\log N$	15.3219	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 104.3995 + 0.9353N - 0.0029N^2 \dots\dots\dots (132)$$

$$R = 0.92335, R^2 = 0.85, n = 60$$

Variable	T-value	Probability Level
N	12.3339	0.001
N^2	- 8.1033	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 99.1415 - 0.2558N + 9.1798N^{0.5} \dots\dots\dots (133)$$

$$R = 0.93815, R^2 = 0.88, n = 60$$

Variable	T-value	Probability Level
N	-3.9381	0.001
$N^{0.5}$	9.6881	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 4.5910 + 0.1107 \log N \dots\dots\dots (134)$$

$$R = 0.94510, R^2 = 0.89, n = 60$$

Variable	T-value	Probability Level
Log N	22.0269	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 102.4085 + 0.9685N - 0.0032N^2 \dots \dots \dots (135)$$

$$R = 0.87984, R^2 = 0.77, n = 60$$

Variable	T-value	Probability Level
N	10.1690	0.001
N^2	- 7.0725	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 97.0018 - 0.3269N + 9.9068N^{0.5} \dots \dots \dots (136)$$

$$R = 0.89397, R^2 = 0.80, n = 60$$

Variable	T-value	Probability Level
N	-3.8324	0.001
$N^{0.5}$	7.9609	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.5699 + 0.1110 \text{ Log } N \dots \dots \dots (137)$$

$$R = 0.90536, R^2 = 0.83, n = 60$$

Variable	T-value	Probability Level
Log N	16.2372	0.001

4. (N, P₂O₅, K₂O variable)

a. Quadratic Functions

i) $Y = a + bN + cN^2$

$$Y = 103.6595 + 0.8968N - 0.0029N^2 \dots\dots\dots(138)$$

$$R = 0.87043, R^2 = 0.76, n = 180$$

Variable	T-value	Probability Level
N	16.5651	0.001
N ²	-11.2173	0.001

ii) $Y = a + bN + cN^2 + dP$

$$Y = 98.3304 + 0.8968N - 0.0029N^2 + 0.1998P \dots\dots(139)$$

$$R = 0.88076, R^2 = 0.78, n = 180$$

Variable	T-value	Probability Level
N	17.1711	0.001
N ²	-11.6277	0.001
P	3.7666	0.001

iii) $Y = a + bN + cN^2 + dNP$

$$Y = 103.6595 + 0.8479N - 0.0029N^2 + 0.0018NP \dots\dots(140)$$

$$R = 0.88318, R^2 = 0.78, n = 180$$

Variable	T-value	Probability Level
N	15.9960	0.001
N ²	-11.7402	0.001
NP	4.2293	0.001

b. Square Root Function

i) $Y = a + bN + cN^{0.5}$

$$Y = 98.0558 - 0.2920N + 9.2508N^{0.5} \dots\dots\dots(141)$$

$$R = 0.89081, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	-6.1514	0.001
$N^{0.5}$	13.3592	0.001

ii) $Y = a + bN + cN^{0.5} + dP$

$$Y = 92.7267 - 0.2920N + 9.2508N^{0.5} + 0.1998P \dots\dots(142)$$

$$R = 0.90090, R^2 = 0.81, n = 180$$

Variable	T-value	Probability Level
N	-6.4216	0.001
$N^{0.5}$	13.9459	0.001
P	4.1098	0.001

iii) $Y = a + bN + cN^{0.5} + dNP$

$$Y = 98.0558 - 0.3409N + 9.2508N^{0.5} + 0.0018NP \dots\dots(143)$$

$$R = 0.90327, R^2 = 0.82, n = 180$$

Variable	T-value	Probability Level
N	-7.3825	0.001
$N^{0.5}$	14.1071	0.001
NP	4.6232	0.001

c. 1.5 Power Functions

i) $Y = a + bN + cN^{1.5}$

$$Y = 101.5767 + 1.3527N - 0.0003N^{1.5} \dots\dots\dots(144)$$

$$Y = 0.87995, R^2 = 0.77, n = 180$$

Variable	T-value	Probability Level
N	15.6219	0.001
$N^{1.5}$	-12.1725	0.001

ii) $Y = a + bN + cN^{1.5} + dP$

$$Y = 96.2476 + 1.3527N - 0.0003N^{1.5} + 0.1998P \dots\dots(145)$$

$$R = 0.89016, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	16.2417	0.001
$N^{1.5}$	-12.6555	0.001
P	3.9148	0.001

iii) $Y = a + bN + cN^{1.5} + dNP$

$$Y = 101.5767 + 1.3038N - 0.0003N^{1.5} +$$

$$0.0018NP \dots\dots\dots(146)$$

$$R = 0.89256, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	15.6759	0.001
$N^{1.5}$	-12.7879	0.001
NP	4.3990	0.001

d. Cobb-Douglas Function

i) $Y = aN^b$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 4.5724 + 0.0607 \log N \dots \dots \dots (147)$$

$$R = 0.90164, R^2 = 0.81, n = 180$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
Log N	27.8138	0.001

ii) $Y = aN^bP^c$

$$\log Y = \log a + b \log N + c \log P$$

$$\log Y = \log 4.5389 + 0.0607 \log N + 0.0068 \log P \dots (148)$$

$$R = 0.90851, R^2 = 0.83, n = 180$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
Log N	28.7062	0.001
Log P	3.5504	0.001

19701. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 93.1042 + 1.2889N - 0.0037N^2 \dots \dots \dots (149)$$

$$R = 0.96116, R^2 = 0.92, n = 60$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
N	16.2375	0.001
N^2	- 9.7873	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 87.5487 - 0.1857N + 11.1288N^{0.5} \dots\dots\dots(150)$$

$$R = 0.96571, R^2 = 0.93, n = 60$$

Variable	T-value	Probability Level
N	-2.6182	0.025
N ^{0.5}	10.7550	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.4545 + 0.1611 \text{ Log } N \dots\dots\dots(151)$$

$$R = 0.96324, R^2 = 0.93, n = 60$$

Variable	T-value	Probability Level
Log N	27.3075	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 90.9971 + 1.1838N - 0.0036N^2 \dots\dots\dots(152)$$

$$R = 0.91648, R^2 = 0.84, n = 60$$

Variable	T-value	Probability Level
N	11.1881	0.001
N ²	- 7.0415	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 85.0108 - 0.2492N + 10.9602N^{0.5} \dots\dots\dots(153)$$

$$R = 0.92607, R^2 = 0.86, n = 60$$

Variable	T-value	Probability Level
N	-2.6291	0.025
$N^{0.5}$	7.9258	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.4298 + 0.1516 \text{ Log } N \dots\dots\dots(154)$$

$$R = 0.94107, R^2 = 0.89, n = 60$$

Variable	T-value	Probability Level
Log N	21.1910	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 93.7774 + 1.3010N - 0.0038N^2 \dots\dots\dots(155)$$

$$R = 0.96203, R^2 = 0.93, n = 60$$

Variable	T-value	Probability Level
N	16.6238	0.001
N^2	-10.1676	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 88.0888 - 0.2268N + 11.6162N^{0.5} \dots\dots\dots(156)$$

$$R = 0.96842, R^2 = 0.94, n = 60$$

Variable	T-value	Probability Level
N	-3.2959	0.05
$N^{0.5}$	11.6186	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 4.4637 + 0.1603 \log N \dots\dots\dots(157)$$

$$R = 0.96836, R^2 = 0.94, n = 60$$

Variable	T-value	Probability Level
$\log N$	29.2966	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Functions

$$i) Y = a + bN + cN^2$$

$$Y = 92.7377 + 1.2579N - 0.0037N^2 \dots\dots\dots(158)$$

$$R = 0.93908, R^2 = 0.88, n = 180$$

Variable	T-value	Probability Level
N	22.9272	0.001
N^2	-14.0984	0.001

ii) $Y = a + bN + cN^2 + dP$

$$Y = 85.5868 + 1.2579N - 0.0037N^2 + 0.2682P \dots (159)$$

$$R = 0.94727, R^2 = 0.90, n = 180$$

Variable	T-value	Probability Level
N	24.5221	0.001
N ²	-15.0791	0.001
P	5.1460	0.001

iii) $Y = a + bN + cN^2 + dNP$

$$Y = 92.7377 + 1.1943N - 0.0037N^2 + 0.0024NP \dots (160)$$

$$R = 0.94859, R^2 = 0.90, n = 180$$

Variable	T-value	Probability Level
N	23.0019	0.001
N ²	-15.2663	0.001
NP	5.6160	0.001

b. Square Root Function

i) $Y = a + bN + cN^{0.5}$

$$Y = 86.8750 - 0.2198N + 11.2252N^{0.5} \dots (161)$$

$$R = 0.94588, R^2 = 0.89, n = 180$$

Variable	T-value	Probability Level
N	-4.4661	0.001
N ^{0.5}	15.6370	0.001

$$\text{ii) } Y = a + bN + cN^{0.5} + dP$$

$$Y = 79.7240 - 0.2198N + 11.2252N^{0.5} + 0.2682P \dots (162)$$

$$R = 0.95401, R^2 = 0.91, n = 180$$

Variable	T-value	Probability Level
N	-4.8211	0.001
$N^{0.5}$	16.8800	0.001
P	5.5009	0.001

$$\text{iii) } Y = a + bN^{0.5} + cN^2 + dP$$

$$Y = 79.8447 + 9.7591N^{0.5} - 0.0006N^2 + 0.2682P \dots (163)$$

$$R = 0.95501, R^2 = 0.91, n = 180$$

Variable	T-value	Probability Level
$N^{0.5}$	27.0477	0.001
N^2	- 5.2517	0.001
P	5.5604	0.001

c. 1.5 Power Functions

$$\text{i) } Y = a + bN + cN^{1.5}$$

$$Y = 90.4295 + 1.8183N - 0.0004N^{1.5} \dots (164)$$

$$R = 0.94353, R^2 = 0.89, n = 180$$

Variable	T-value	Probability Level
N	20.7462	0.001
$N^{1.5}$	-15.0828	0.001

$$\text{ii) } Y = a + bN + cN^{1.5} + dP$$

$$Y = 83.2786 + 1.8183N - 0.0004N^2 + 0.2682P \dots (165)$$

$$R = 0.95168, R^2 = 0.91, n = 180$$

Variable	T-value	Probability Level
N	22.3180	0.001
N ²	-16.2255	0.001
P	5.3700	0.001

$$\text{iii) } Y = a + bN + cN^{1.5} + dNP$$

$$Y = 90,4295 + 1.7547 - 0.0004N^{1.5} + 0.0024NP \dots (166)$$

$$R = 0.95300, R^2 = 0.91, n = 180$$

Variable	T-value	Probability Level
N	21.6323	0.001
N ^{1.5}	-16.4452	0.001
NP	5.8670	0.001

d. Cobb-Douglas Functions

$$\text{i) } Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.4420 + 0.0891 \text{ Log } N \dots (167)$$

$$R = 0.93685, R^2 = 0.88, n = 180$$

Variable	T-value	Probability Level
Log N	35.7400	0.001

$$\text{ii) } Y = a N^b P^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 4.3993 + 0.0891 \text{ Log } N + 0.0087 \text{ Log } P \dots (168)$$

$$R = 0.94226, R^2 = 0.89, n = 180$$

Variable	T-value	Probability Level
Log N	37.2203	0.001
Log P	4.0063	0.001

$$\text{iii) } Y = a N^b K^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } K$$

$$\text{Log } Y = \text{Log } 4.4301 + 0.0891 \text{ Log } N + 0.0049 \text{ Log } K \dots (169)$$

$$R = 0.93855, R^2 = 0.88, n = 180$$

Variable	T-value	Probability Level
Log N	36.1122	0.001
Log K	2.1740	0.05

1961, 1965, 1968 - SOIL TEST YEARS

1. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 45.6711 + 1.0262N - 0.0028N^2 \dots (170)$$

$$R = 0.93228, R^2 = 0.87, n = 120$$

Variable	T-value	Probability Level
N	16.2415	0.001
N^2	- 9.2365	0.001

b. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 44.5135 + 1.4363N - 0.0673N^{1.5} \dots\dots\dots(172)$$

$$R = 0.93240, R^2 = 0.87, n = 120$$

Variable	T-value	Probability Level
N	13.5085	0.001
N ^{1.5}	- 9.2546	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.7506 + 0.2186 \text{ Log } N \dots\dots\dots(172)$$

$$R = 0.93763, R^2 = 0.88, n = 120$$

Variable	T-value	Probability Level
Log N	29.2999	0.001

2. ($P_{205} = 40$, $K_{20} = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 44.5796 + 1.1864N - 0.0032N^2 \dots\dots\dots(173)$$

$$R = 0.95363, R^2 = 0.91, n = 120$$

Variable	T-value	Probability Level
N	19.5748	0.001
N ²	-10.9019	0.001

b. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 43.6509 + 1.6276N - 0.0746N^{1.5} \dots\dots\dots(174)$$

$$R = 0.95173, R^2 = 0.91, n = 120$$

Variable	T-value	Probability Level
N	15.6367	0.001
$N^{1.5}$	-10.4783	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.7625 + 0.2344 \text{ Log } N \dots\dots\dots(175)$$

$$R = 0.93316, R^2 = 0.87, n = 120$$

Variable	T-value	Probability Level
Log N	28.2008	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 46.4606 + 1.0534N - 0.0024N^2 \dots\dots\dots(176)$$

$$R = 0.94389, R^2 = 0.89, n = 120$$

Variable	T-value	Probability Level
N	15.4011	0.001
N^2	- 7.2670	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 46.6917 + 0.2184N + 5.4641N^{0.5} \dots\dots\dots(177)$$

$$R = 0.93418, R^2 = 0.87, n = 120$$

Variable	T-value	Probability Level
N	3.1114	0.005
$N^{0.5}$	5.3357	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 45.9628 + 1.3732N - 0.0553N^{1.5} \dots\dots\dots(178)$$

$$R = 0.94212, R^2 = 0.89, n = 120$$

Variable	T-value	Probability Level
N	11.7428	0.001
$N^{1.5}$	- 6.9112	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.7960 + 0.2262 \text{ Log } N \dots\dots\dots(179)$$

$$R = 0.91630, R^2 = 0.84, n = 120$$

Variable	T-value	Probability Level
Log N	24.8537	0.001

4. ($P_2O_5 = K_2O$, N variable)

a. Quadratic Functions

i) $Y = a + bN + cN^2$

$$Y = 45.5704 + 1.0887N - 0.0028N^2 \dots \dots \dots (180)$$

$$R = 0.93456, R^2 = 0.87, n = 360$$

Variable	T-value	Probability Level
N	27.2549	0.001
N^2	-14.5320	0.001

ii) $Y = a + bN + cN^2 + dP$

$$Y = 39.2048 + 1.0887N - 0.0028N^2 + 0.2387P \dots \dots (181)$$

$$R = 0.94110, R^2 = 0.89, n = 360$$

Variable	T-value	Probability Level
N	28.6404	0.001
N^2	-15.2707	0.001
P	6.1820	0.001

iii) $Y = a + bN + cN^2 + dNP$

$$Y = 45.5704 + 1.0244N - 0.0028N^2 + 0.0024NP \dots \dots (182)$$

$$R = 0.94432, R^2 = 0.89, n = 360$$

Variable	T-value	Probability Level
N	27.0261	0.001
N^2	-15.6919	0.001
NP	7.7629	0.001

b. Square Root Functions

i) $Y = a + bN + cN^{0.5}$

$$Y = 44.7099 + 0.0812N + 6.8756N^{0.5} \dots\dots\dots(183)$$

$$R = 0.92371, R^2 = 0.85, n = 360$$

Variable	T-value	Probability Level
N	1.9866	0.05
$N^{0.5}$	11.5363	0.001

ii) $Y = a + bN + cN^{0.5} + dP$

$$Y = 38.3443 + 0.0812N + 6.8756N^{0.5} + 0.2387P \dots\dots(184)$$

$$R = 0.93032, R^2 = 0.87, n = 360$$

Variable	T-value	Probability Level
N	2.0723	0.05
$N^{0.5}$	12.0342	0.001
P	5.6996	0.001

iii) $Y = a + bN^{0.5} + cNP$

$$Y = 44.3385 + 7.0992N^{0.5} + 0.0024NP \dots\dots\dots(185)$$

$$R = 0.93354, R^2 = 0.87, n = 360$$

Variable	T-value	Probability Level
$N^{0.5}$	34.6349	0.001
NP	7.4321	0.001

c. 1.5 Power Functions

i) $Y = a + bN + cN^{1.5}$

$$Y = 44.6240 + 1.4629N - 0.0003N^{1.5} \dots\dots\dots(186)$$

$$R = 0.93315, R^2 = 0.87, n = 360$$

Variable	T-value	Probability Level
N	21.8715	0.001
$N^{1.5}$	-14.1289	0.001

ii) $Y = a + bN + cN^{1.5} + dP$

$$Y = 38.2584 + 1.4629N - 0.0003N^{1.5} + 0.2387P \dots\dots(187)$$

$$R = 0.93971, R^2 = 0.88, n = 360$$

Variable	T-value	Probability Level
N	22.9582	0.001
$N^{1.5}$	-14.8310	0.001
P	6.1121	0.001

iii) $Y = a + bN + cN^{1.5} + dNP$

$$Y = 44.6240 + 1.3987N - 0.0003N^{1.5} + 0.0024NP \dots\dots(188)$$

$$R = 0.94292, R^2 = 0.89, n = 360$$

Variable	T-value	Probability Level
N	22.3389	0.001
$N^{1.5}$	-15.2305	0.001
NP	7.6704	0.001

d. Cobb-Douglas Functions

i) $Y = aN^b$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 3.7760 + 0.1256 \log N \dots \dots \dots (189)$$

$$R = 0.89346, R^2 = 0.80, n = 360$$

Variable	T-value	Probability Level
Log N	37.6383	0.001

ii) $Y = aN^bP^c$

$$\log Y = \log a + b \log N + c \log P$$

$$\log Y = \log 3.7265 + 0.1256 \log N + 0.0101 \log P \dots \dots (190)$$

$$R = 0.89695, R^2 = 0.80, n = 360$$

Variable	T-value	Probability Level
Log N	38.1825	0.001
Log P	3.3805	0.001

1962, 1963, 1964, 1966, 1967, 1969 & 1970, NON-SOIL TEST YEARS

1. ($P_{205} = 0, K_{20} = 0, N$ variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 71.5989 + 0.9850N - 0.0029N^2 \dots \dots \dots (191)$$

$$R = 0.76854, R^2 = 0.59, n = 330$$

Variable	T-value	Probability Level
N	13.8016	0.001
N^2	- 8.5447	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 67.4950 - 0.1651N + 8.6229N^{0.5} \dots\dots\dots(192)$$

$$R = 0.77098, R^2 = 0.59, n = 330$$

Variable	T-value	Probability Level
N	-2.4471	0.025
N ^{0.5}	8.7595	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 69.9314 + 1.4410N - 0.0722N^{1.5} \dots\dots\dots(193)$$

$$R = 0.77195, R^2 = 0.60, n = 330$$

Variable	T-value	Probability Level
N	12.0675	0.001
N ^{1.5}	- 8.8444	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } Y$$

$$\text{Log } Y = \text{Log } 4.1468 + 0.1646 \text{ Log } N \dots\dots\dots(194)$$

$$R = 0.79552, R^2 = 0.63, n = 330$$

Variable	T-value	Probability Level
Log N	23.7773	0.001

2. $P_{205} = 40$, $R_{20} = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 73.1454 + 1.0888N - 0.0032N^2 \dots\dots\dots (195)$$

$$R = 0.79120, R^2 = 0.63, n = 330$$

Variable	T-value	Probability Level
N	14.7844	0.001
N^2	- 9.1072	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 69.4101 - 0.1539N + 9.1436N^{0.5} \dots\dots\dots (196)$$

$$R = 0.78927, R^2 = 0.62, n = 330$$

Variable	T-value	Probability Level
N	-2.1903	0.05
$N^{0.5}$	8.9230	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 71.5309 + 1.5772N - 0.0785N^{1.5} \dots\dots\dots (197)$$

$$R = 0.79320, R^2 = 0.63, n = 330$$

Variable	T-value	Probability Level
N	12.7703	0.001
$N^{1.5}$	- 9.2969	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.1699 + 0.1728 \text{ Log } N \dots\dots\dots (198)$$

$$R = 0.80302, R^2 = 0.64, n = 330$$

Variable	T-value	Probability Level
Log N	24.4037	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 72.4722 + 1.0957N - 0.0032N^2 \dots\dots\dots (199)$$

$$R = 0.80327, R^2 = 0.65, n = 330$$

Variable	T-value	Probability Level
N	15.4310	0.001
N^2	- 9.5168	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 69.1321 - 0.1442N + 9.0268N^{0.5} \dots\dots\dots (200)$$

$$R = 0.79883, R^2 = 0.64, n = 330$$

Variable	T-value	Probability Level
N	-2.1170	0.05
$N^{0.5}$	9.0856	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 70.9421 + 1.5819N - 0.0787N^{1.5} \dots\dots\dots(201)$$

$$R = 0.80466, R^2 = 0.65, n = 330$$

Variable	T-value	Probability Level
N	13.2706	0.001
$N^{1.5}$	- 9.6551	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.1812 + 0.1700 \text{ Log } N \dots\dots\dots(202)$$

$$R = 0.82004, R^2 = 0.67, n = 330$$

Variable	T-value	Probability Level
Log N	25.9500	0.001

4. ($P_{205} = 40$, $K_{20} = 40$, N variable)

a. Quadratic Functions

$$i) Y = a + bN + cN^2$$

$$Y = 72.4055 + 1.0565N - 0.0031N^2 \dots\dots\dots(203)$$

$$R = 0.78470, R^2 = 0.62, n = 990$$

Variable	T-value	Probability Level
N	25.1857	0.001
N^2	-15.5451	0.001

ii) $Y = a + bN + cN^2 + dP$

$$Y = 67.4238 + 1.0565N - 0.0031N^2 + 0.1868P \dots (204)$$

$$R = 0.78945, R^2 = 0.62, n = 990$$

Variable	T-value	Probability Level
N	25.4217	0.001
N^2	-15.6908	0.001
P	4.4252	0.001

iii) $Y = a + bN + cN^2 + dNP$

$$Y = 72.4055 + 1.0127N - 0.0031N^2 + 0.0016NP \dots (205)$$

$$R = 0.79008, R^2 = 0.62, n = 990$$

Variable	T-value	Probability Level
N	23.8117	0.001
N^2	-15.7117	0.001
NP	4.7189	0.001

b. Square Root Functions

i) $Y = a + bN + cN^{0.5}$

$$Y = 68.6790 - 0.1544N + 8.9311N^{0.5} \dots (206)$$

$$R = 0.78331, R^2 = 0.61, n = 990$$

Variable	T-value	Probability Level
N	-3.8636	0.001
$N^{0.5}$	15.3208	0.001

$$\text{ii) } Y = a + bN + cN^{0.5} + dP$$

$$Y = 63.6973 - 0.1544N + 8.9311N^{0.5} + 0.1868P \dots (207)$$

$$R = 0.78807, R^2 = 0.62, n = 990$$

Variable	T-value	Probability Level
N	-3.8996	0.001
$N^{0.5}$	15.4635	0.001
P	4.4124	0.001

$$\text{iii) } Y = a + bN + cN^{0.5} + dN^2$$

$$Y = 69.7558 + 0.5177N + 4.2197N^{0.5} - 0.0018N^2 \dots (208)$$

$$R = 0.78723, R^2 = 0.62, n = 990$$

Variable	T-value	Probability Level
N	2.9962	0.005
$N^{0.5}$	3.2132	0.005
N^2	-3.9965	0.001

$$\text{iv) } Y = a + bN + cN^2 + dN^{0.5} + eNP$$

$$Y = 64.7741 + 0.5177N + 4.2197N^{0.5} + 0.0018N^2 + 0.1868P \dots (209)$$

$$R = 0.79197, R^2 = 0.63, n = 990$$

Variable	T-value	Probability Level
N	3.0246	0.005
$N^{0.5}$	3.2437	0.005
N^2	-4.0343	0.001
NP	4.4465	0.001

c. 1.5 Power Functions

i) $Y = a + bN + cN^{1.5}$

$$Y = 70.6845 + 1.5157N - 0.0003N^{1.5} \dots\dots\dots(210)$$

$$R = 0.78695, R^2 = 0.62, n = 990$$

Variable	T-value	Probability Level
N	21.9019	0.001
$N^{1.5}$	-15.9094	0.001

ii) $Y = a + bN + cN^{1.5} + dP$

$$Y = 65.7027 + 1.5157N - 0.0003N^{1.5} + 0.1868P \dots(211)$$

$$R = 0.79169, R^2 = 0.63, n = 990$$

Variable	T-value	Probability Level
N	22.1092	0.001
$N^{1.5}$	-16.0600	0.001
P	4.4462	0.001

iii) $Y = a + bN + cN^{1.5} + dNP$

$$Y = 70.6845 + 1.4718N - 0.0003N^{1.5} + 0.0016NP \dots(212)$$

$$R = 0.79233, R^2 = 0.63, n = 990$$

Variable	T-value	Probability Level
N	21.3059	0.001
$N^{1.5}$	-16.0816	0.001
NP	4.7414	0.001

d. Cobb-Douglas Functions

i) $Y = aN^b$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.1620 + 0.0951 \text{ Log } N \dots \dots \dots (213)$$

$$R = 0.78664, R^2 = 0.62, n = 990$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
Log N	40.0472	0.001

ii) $Y = aN^bP^c$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 4.1254 + 0.0951 \text{ Log } N + 0.0075 \text{ Log } P \dots (214)$$

$$R = 0.78958, R^2 = 0.62, n = 990$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
Log N	40.2727	0.001
Log P	3.4867	0.001

1961-1965*1. ($P_{205} = 0, K_{20} = 0, N$ variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 51.0971 + 1.0776N - 0.0031N^2 \dots \dots \dots (215)$$

$$R = 0.92148, R^2 = 0.85, n = 150$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
N	17.9340	0.001
N ²	-10.9088	0.001

*The results obtained here are agreement with those obtained by Yung Liu.

b. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 49.7936 + 1.5384N - 0.0756 \dots \dots \dots (216)$$

$$R = 0.92166, R^2 = 0.85, n = 150$$

Variable	T-value	Probability Level
N	15.2181	0.001
$N^{1.5}$	-10.9348	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 3.8563 + 0.2059 \log N \dots \dots \dots (217)$$

$$R = 0.91576, R^2 = 0.84, n = 150$$

Variable	T-value	Probability Level
$\log N$	27.7326	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 53.2402 + 1.1081N - 0.0032N^2 \dots \dots \dots (218)$$

$$R = 0.90838, R^2 = 0.83, n = 150$$

Variable	T-value	Probability Level
N	16.2996	0.001
N^2	- 9.8441	0.001

b. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 51.7144 + 1.5903N - 0.0780N^{1.5} \dots\dots\dots(219)$$

$$R = 0.90990, R^2 = 0.83, n = 150$$

Variable	T-value	Probability Level
N	14.0006	0.001
$N^{1.5}$	-10.0406	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.8666 + 0.2116 \text{ Log } N \dots\dots\dots(220)$$

$$R = 0.90216, R^2 = 0.81, n = 150$$

Variable	T-value	Probability Level
Log N	25.4408	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 53.1129 + 1.0844N - 0.0030N^2 \dots\dots\dots(221)$$

$$R = 0.93043, R^2 = 0.87, n = 150$$

Variable	T-value	Probability Level
N	18.1042	0.001
N^2	-10.3973	0.001

b. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 52.0082 + 1.5141N - 0.0713N^{1.5} \dots\dots\dots(222)$$

$$R = 0.92974, R^2 = 0.86, n = 150$$

Variable	T-value	Probability Level
N	14.9387	0.001
$N^{1.5}$	-10.2811	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.9028 + 0.2050 \text{ Log } N \dots\dots\dots(223)$$

$$R = 0.91409, R^2 = 0.84, n = 150$$

Variable	T-value	Probability Level
Log N	27.4234	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Functions

$$i) Y = a + bN + cN^2$$

$$Y = 52.4834 + 1.0901N - 0.0031N^2 \dots\dots\dots(224)$$

$$R = 0.91804, R^2 = 0.84, n = 450$$

Variable	T-value	Probability Level
N	29.8569	0.001
N^2	-17.7811	0.001

$$\text{ii) } Y = a + bN + cN^2 + dP$$

$$Y = 49.4101 + 1.0901N - 0.0031N^2 + 0.1152P \dots (225)$$

$$R = 0.91989, R^2 = 0.85, n = 450$$

Variable	T-value	Probability Level
N	30.1510	0.001
N ²	-17.9562	0.001
P	3.1380	0.005

$$\text{iii) } Y = a + bN + cN^2 + dNP$$

$$Y = 52.4834 + 1.0632N - 0.0031N^2 + 0.0010NP \dots (226)$$

$$R = 0.92011, R^2 = 0.85, n = 450$$

Variable	T-value	Probability Level
N	28.7370	0.001
N ²	-17.9797	0.001
NP	3.3230	0.001

b. Square Root Functions

$$\text{i) } Y = a + bN + cN^{0.5}$$

$$Y = 50.0761 - 0.0781N + 8.3215N^{0.5} \dots (227)$$

$$R = 0.90926, R^2 = 0.83, n = 450$$

Variable	T-value	Probability Level
N	-2.1451	0.05
N ^{0.5}	15.6675	0.001

$$\text{ii) } Y = a + bN + cN^{0.5} + dP$$

$$Y = 47.0029 - 0.0781N + 8.3215N^{0.5} + 0.1152P \dots (228)$$

$$R = 0.91112, R^2 = 0.83, n = 450$$

Variable	T-value	Probability Level
N	-2.1640	0.05
$N^{0.5}$	15.8057	0.001
P	2.9861	0.005

c. 1.5 Power Functions

$$\text{i) } Y = a + bN + cN^{1.5}$$

$$Y = 51.0657 + 1.5297N - 0.0003N^{1.5} \dots (229)$$

$$R = 0.91832, R^2 = 0.84, n = 450$$

Variable	T-value	Probability Level
N	25.3215	0.001
$N^{1.5}$	-17.8500	0.001

$$\text{ii) } Y = a + bN + cN^{1.5} + dP$$

$$Y = 47.9925 + 1.5297N - 0.0003N^{1.5} + 0.1152P \dots (230)$$

$$R = 0.92016, R^2 = 0.85, n = 450$$

Variable	T-value	Probability Level
N	25.5718	0.001
$N^{1.5}$	-18.0264	0.001
P	3.1432	0.005

$$\text{iii) } Y = a + bN + cN^{1.5} + dNP$$

$$Y = 51.0657 + 1.5029N - 0.0003N^{1.5} + 0.0010NP \dots (231)$$

$$R = 0.92038, R^2 = 0.85, n = 450$$

Variable	T-value	Probability Level
N	24.9302	0.001
$N^{1.5}$	-18.0501	0.001
NP	3.3284	0.001

d. Cobb-Douglas Function

$$\text{i) } Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.8737 + 0.1162 \text{ Log } N \dots (232)$$

$$R = 0.88602, R^2 = 0.79, n = 450$$

Variable	T-value	Probability Level
Log N	40.4473	0.001

$$\text{ii) } Y = aN^bP^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 3.8485 + 0.1162 \text{ Log } N + 0.0051 \text{ Log } P \dots (233)$$

$$R = 0.88706, R^2 = 0.79, n = 450$$

Variable	T-value	Probability Level
Log N	40.5773	0.001
Log P	1.9709	0.05

1966-1970

1. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 71.4787 + 0.9551N - 0.0028N^2 \dots \dots \dots (234)$$

$$R = 0.74549, R^2 = 0.56, n = 300$$

Variable	T-value	Probability Level
N	11.9201	0.001
N^2	- 7.1945	0.001

b. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 69.8331 + 1.3905N - 0.0686N^{1.5} \dots \dots \dots (235)$$

$$R = 0.74893, R^2 = 0.56, n = 300$$

Variable	T-value	Probability Level
N	10.3640	0.001
$N^{1.5}$	- 7.4735	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } Y$$

$$\text{Log } Y = \text{Log } 4.1335 + 0.1656 \text{ Log } N \dots \dots \dots (236)$$

$$R = 0.77869, R^2 = 0.61, n = 300$$

Variable	T-value	Probability Level
Log N	21.4252	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 71.6717 + 1.1182N - 0.0032N^2 \dots\dots\dots (237)$$

$$R = 0.81111, R^2 = 0.66, n = 300$$

Variable	T-value	Probability Level
N	14.6101	0.001
N^2	- 8.7209	0.001

b. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 70.2872 + 1.5908N - 0.0772N^{1.5} \dots\dots\dots (238)$$

$$R = 0.81159, R^2 = 0.66, n = 300$$

Variable	T-value	Probability Level
N	12.3559	0.001
$N^{1.5}$	- 8.7695	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.1586 + 0.1780 \text{ Log } N \dots\dots\dots (239)$$

$$R = 0.80816, R^2 = 0.65, n = 300$$

Variable	T-value	Probability Level
Log N	23.6874	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 71.7472 + 1.0844N - 0.0030N^2 \dots \dots \dots (240)$$

$$R = 0.80564, R^2 = 0.65, n = 300$$

Variable	T-value	Probability Level
N	13.9574	0.001
N^2	- 8.1183	0.001

b. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 70.4173 + 1.5323N - 0.0731N^{1.5} \dots \dots \dots (241)$$

$$R = 0.80618, R^2 = 0.65, n = 300$$

Variable	T-value	Probability Level
N	11.7257	0.001
$N^{1.5}$	- 8.1746	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 4.1664 + 0.1749 \log N \dots \dots \dots (242)$$

$$R = 0.80884, R^2 = 0.65, n = 300$$

Variable	T-value	Probability Level
$\log N$	23.7450	0.001

4. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Functions

i) $Y = a + bN + cN^2$

$$Y = 71.6326 + 1.0526N - 0.0030N^2 \dots \dots \dots (243)$$

$$R = 0.78325, R^2 = 0.61, n = 900$$

Variable	T-value	Probability Level
N	22.9388	0.001
N^2	-13.6183	0.001

ii) $Y = a + bN + cN^2 + dP$

$$Y = 65.1430 + 1.0526N - 0.0030N^2 + 0.2434P \dots \dots (244)$$

$$R = 0.79071, R^2 = 0.63, n = 900$$

Variable	T-value	Probability Level
N	23.2824	0.001
N^2	-13.8223	0.001
P	5.2990	0.001

iii) $Y = a + bN + cN^2 + dNP$

$$Y = 71.6326 + 0.9921N - 0.0030N^2 + 0.0023NP \dots \dots (245)$$

$$R = 0.79273, R^2 = 0.63, n = 900$$

Variable	T-value	Probability Level
N	21.5081	0.001
N^2	-13.8819	0.001
NP	6.0049	0.001

b. Square Root Function

i) $Y = a + bN + cN^{0.5}$

$$Y = 68.3928 - 0.0983N + 8.4137N^{0.5} \dots (246)$$

$$R = 0.78039, R^2 = 0.61, n = 900$$

Variable	T-value	Probability Level
N	-2.2425	0.025
$N^{0.5}$	13.1559	0.001

ii) $Y = a + bN + cN^{0.5} + dP$

$$Y = 61.9033 - 0.0983N + 8.4137N^{0.5} + 0.2434P \dots (247)$$

$$R = 0.78788, R^2 = 0.62, n = 900$$

Variable	T-value	Probability Level
N	-2.2757	0.025
$N^{0.5}$	13.3506	0.001
P	5.2677	0.001

iii) $Y = a + bN + cN^2 + dN^{0.5}$

$$Y = 69.5623 + 0.6316N + 3.2969N^2 - 0.0020N^{0.5} \dots (248)$$

$$R = 0.78468, R^2 = 0.62, n = 900$$

Variable	T-value	Probability Level
N	3.3339	0.001
N^2	2.2897	0.025
$N^{0.5}$	-3.9585	0.001

$$\text{iv) } Y = a + bN + cN^2 + dN^{0.5} + eP$$

$$Y = 63.0727 + 0.6316N + 3.2969N^{0.5} - 0.0020N^2 +$$

$$0.2434P \dots \dots \dots (249)$$

$$R = 0.79213, R^2 = 0.63, n = 900$$

Variable	T-value	Probability Level
N	3.3841	0.001
$N^{0.5}$	2.3242	0.025
N^2	-4.0182	0.001
P	5.3120	0.001

c. 1.5 Power Function

$$\text{i) } Y = a + bN + cN^{1.5}$$

$$Y = 70.0697 + 1.4875N - 0.0003N^{1.5} \dots \dots \dots (250)$$

$$R = 0.78465, R^2 = 0.62, n = 900$$

Variable	T-value	Probability Level
N	19.6152	0.001
$N^{1.5}$	-13.8445	0.001

$$\text{ii) } Y = a + bN + cN^{1.5} + dP$$

$$Y = 63.5801 + 1.4875N - 0.0003N^{1.5} + 0.2434P \dots (251)$$

$$R = 0.79210, R^2 = 0.63, n = 900$$

Variable	T-value	Probability Level
N	19.9109	0.001
$N^{1.5}$	-14.0532	0.001
P	5.3147	0.001

$$\text{iii) } Y = a + bN + cN^{1.5} + dNP$$

$$Y = 70.0697 + 1.4270N - 0.0003N^{1.5} + 0.0023NP \dots (252)$$

$$R = 0.79413, R^2 = 0.63, n = 900$$

Variable	T-value	Probability Level
N	19.0120	0.001
$N^{1.5}$	-14.1141	0.001
NP	6.0228	0.001

d. Cobb-Douglas Functions

$$\text{i) } Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.1518 + 0.0967 \text{ Log } N \dots (253)$$

$$R = 0.77492, R^2 = 0.60, n = 900$$

Variable	T-value	Probability Level
Log N	36.7404	0.001

$$\text{ii) } Y = aN^bP^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 4.1042 + 0.0967 \text{ Log } N + 0.0097 \text{ Log } P \dots (254)$$

$$R = 0.77963, R^2 = 0.61, n = 900$$

Variable	T-value	Probability Level
Log N	37.0611	0.001
Log P	4.0921	0.001

1961-701. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 64.6849 + 0.9960N - 0.0029N^2 \dots\dots\dots(255)$$

$$R = 0.78845, R^2 = 0.62, n = 450$$

Variable	T-value	Probability Level
N	16.8091	0.001
N^2	-10.1739	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 61.0897 - 0.1277N + 8.3221N^{0.5} \dots\dots\dots(256)$$

$$R = 0.78803, R^2 = 0.62, n = 450$$

Variable	T-value	Probability Level
N	-2.2673	0.025
$N^{0.5}$	10.1266	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 63.1533 + 1.4398N - 0.0709N^{1.5} \dots\dots\dots(257)$$

$$R = 0.79085, R^2 = 0.63, n = 450$$

Variable	T-value	Probability Level
N	14.5010	0.001
$N^{1.5}$	-10.4434	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.0411 + 0.1790 \text{ Log } N \dots \dots \dots (258)$$

$$R = 0.81726, R^2 = 0.67, n = 450$$

Variable	T-value	Probability Level
Log N	30.0174	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 65.5279 + 1.1148N - 0.0032N^2 \dots \dots \dots (259)$$

$$R = 0.81906, R^2 = 0.67, n = 450$$

Variable	T-value	Probability Level
N	18.5269	0.001
N^2	-11.1020	0.001

b. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 64.0962 + 1.5906N - 0.0032N^2 \dots \dots \dots (260)$$

$$R = 0.81983, R^2 = 0.67, n = 450$$

Variable	T-value	Probability Level
N	15.7261	0.001
$N^{1.5}$	-11.2003	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 4.0613 + 0.1892 \log N \dots \dots \dots (261)$$

$$R = 0.82610, R^2 = 0.68, n = 450$$

Variable	T-value	Probability Level
Log N	31.0282	0.001

3. ($P_2O_4 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 65.5358 + 1.0844N - 0.0030N^2 \dots \dots \dots (262)$$

$$R = 0.82499, R^2 = 0.68, n = 450$$

Variable	T-value	Probability Level
N	18.3037	0.001
N^2	-10.6015	0.001

b. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 64.2810 + 1.5262N - 0.0725N^{1.5} \dots \dots \dots (263)$$

$$R = 0.82515, R^2 = 0.68, n = 450$$

Variable	T-value	Probability Level
N	15.3031	0.001
$N^{1.5}$	-10.6234	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.0785 + 0.1850 \text{ Log } N \dots \dots \dots (264)$$

$$R = 0.83204, R^2 = 0.69, n = 450$$

Variable	T-value	Probability Level
Log N	31.7480	0.001

4. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Functions

$$i) Y = a + bN + cN^2$$

$$Y = 65.2495 + 1.0651N - 0.0030N^2 \dots \dots \dots (265)$$

$$R = 0.80737, R^2 = 0.65, n = 1350$$

Variable	T-value	Probability Level
N	30.5635	0.001
N^2	-18.1644	0.001

$$ii) Y = a + bN + cN^2 + dP$$

$$Y = 59.8987 + 1.0651N - 0.0030N^2 + 0.2007P \dots \dots (266)$$

$$R = 0.81249, R^2 = 0.66, n = 1350$$

Variable	T-value	Probability Level
N	30.9232	0.001
N^2	-18.3781	0.001
P	5.7350	0.001

$$\text{iii)} \quad Y = a + bN + cN^2 + dNP$$

$$Y = 65.2495 + 1.0158N - 0.0030N^2 + 0.0018NP \dots (267)$$

$$R = 0.81373, R^2 = 0.66, n = 1350$$

Variable	T-value	Probability Level
N	28.8677	0.001
N ²	-18.4329	0.001
NP	6.4123	0.001

b. Square Root Function

$$\text{i)} \quad Y = a + bN + cN^{0.5}$$

$$Y = 62.2873 - 0.0916N + 8.3830N^{0.5} \dots (268)$$

$$R = 0.80278, R^2 = 0.64, n = 1350$$

Variable	T-value	Probability Level
N	-2.7375	0.01
N ^{0.5}	17.1781	0.001

$$\text{ii)} \quad Y = a + bN + cN^{0.5} + dP$$

$$Y = 56.9365 - 0.0916N + 8.3830N^{0.5} + 0.2007P \dots (269)$$

$$R = 0.80793, R^2 = 0.65, n = 1350$$

Variable	T-value	Probability Level
N	-2.7690	0.01
N ^{0.5}	17.3759	0.001
P	5.6736	0.001

$$\text{iii) } Y = a + bN + cN^2 + dN^{0.5}$$

$$Y = 63.6045 + 0.7306N + 2.6198N^{0.5} - 0.0022N^2 \dots (270)$$

$$R = 0.80828, R^2 = 0.65, n = 1350$$

Variable	T-value	Probability Level
N	5.0746	0.001
N ²	2.3943	0.025
N ^{0.5}	-5.8674	0.001

$$\text{iv) } Y = a + bN + cN^{0.5} + dN^2 + eP$$

$$Y = 58.2537 + 0.7306N + 2.6198N^{0.5} - 0.0022N^2 + 0.2007P \dots (271)$$

$$R = 0.81340, R^2 = 0.66, n = 1350$$

Variable	T-value	Probability Level
N	5.1346	0.001
N ^{0.5}	2.4226	0.025
N ²	-5.9367	0.001
P	5.7453	0.001

c. 1.5 Power Function

$$\text{i) } Y = a + bN + cN^{1.5}$$

$$Y = 63.7350 + 1.5016N - 0.0003N^{1.5} \dots (272)$$

$$R = 0.80840, R^2 = 0.65, n = 1350$$

Variable	T-value	Probability Level
N	26.0616	0.001
N ^{1.5}	-18.3867	0.001

$$\text{ii) } Y = a + bN + cN^{1.5} + dP$$

$$Y = 58.3842 + 1.5016N - 0.0003N^{1.5} + 0.2007P \dots (273)$$

$$R = 0.81352, R^2 = 0.66, n = 1350$$

Variable	T-value	Probability Level
N	26.3699	0.001
$N^{1.5}$	-18.6042	0.001
P	5.7492	0.001

$$\text{iii) } Y = a + bN + cN^{1.5} + dNP$$

$$Y = 63.7350 + 1.4523N - 0.0003N^{1.5} + 0.0018NP \dots (274)$$

$$R = 0.81476, R^2 = 0.66, n = 1350$$

Variable	T-value	Probability Level
N	25.3514	0.001
$N^{1.5}$	-18.6599	0.001
NP	6.4283	0.001

d. Cobb-Douglas Function

$$\text{i) } Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 4.0591 + 0.1032 \text{ Log } N \dots (275)$$

$$R = 0.80162, R^2 = 0.64, n = 1350$$

Variable	T-value	Probability Level
Log N	49.2310	0.001

$$\text{ii) } Y = aN^bP^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 4.0190 + 0.1032 \text{ Log } N + 0.0082 \text{ Log } P \dots (276)$$

$$R = 0.80467, R^2 = 0.65, n = 1350$$

Variable	T-value	Probability Level
Log N	49.5528	0.001
Log P	4.3216	0.001

$$\text{iii) } Y = aN^bK^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } K$$

$$\text{Log } Y = \text{Log } 4.0489 + 0.1032 \text{ Log } N + 0.0041 \text{ Log } K \dots (277)$$

$$R = 0.80241, R^2 = 0.64, n = 1350$$

Variable	T-value	Probability Level
Log N	49.3000	0.001
Log K	2.1858	0.05

A. PREDICTED EQUATIONS FOR GRAIN SORGHUM

1961

1. ($P_{205} = 0, K_{20} = 0, N$ variable)

$$\text{a. } Y = a + bN + cN^2$$

$$Y = 34.2514 + 0.4957N - 0.0016N^2 \dots (278)$$

$$R = 0.94802, R^2 = 0.90, n = 30$$

Variable	T-value	Probability Level
N	11.0889	0.001
N^2	- 7.6153	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 31.5029 - 0.1595N + 5.0140N^{0.5} \dots\dots\dots(279)$$

$$R = 0.96277, R^2 = 0.93, n = 30$$

Variable	T-value	Probability Level
N	-4.4198	0.001
$N^{0.5}$	9.5271	0.01

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.4482 + 0.1563 \text{ Log } N \dots\dots\dots(280)$$

$$R = 0.96061, R^2 = 0.92, n = 30$$

Variable	T-value	Probability Level
Log N	18.2902	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 38.0693 + 0.4083N - 0.0013N^2 \dots\dots\dots(281)$$

$$R = 0.93614, R^2 = 0.88, n = 30$$

Variable	T-value	Probability Level
N	9.2863	0.001
N^2	-6.0387	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 35.5275 - 0.1141N + 4.0847N^{0.5} \dots\dots\dots(282)$$

$$R = 0.95664, R^2 = 0.92, n = 30$$

Variable	T-value	Probability Level
N	-3.2977	0.005
N ^{0.5}	8.0935	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.5524 + 0.1332 \text{ Log } N \dots\dots\dots(283)$$

$$R = 0.93950, R^2 = 0.88, n = 30$$

Variable	T-value	Probability Level
Log N	14.5126	0.001

3. (P₂O₅ = 40, K₂O = 40, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 35.9907 + 0.5016N - 0.0017N^2 \dots\dots\dots(284)$$

$$R = 0.89870, R^2 = 0.81, n = 30$$

Variable	T-value	Probability Level
N	7.8681	0.001
N ²	-5.5408	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 33.1535 - 0.1778N + 5.1960N^{0.5} \dots \dots \dots (285)$$

$$R = 0.91400, R^2 = 0.84, n = 30$$

Variable	T-value	Probability Level
N	-3.1732	0.005
$N^{0.5}$	6.3577	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 3.4358 + 0.1634 \log N \dots \dots \dots (286)$$

$$R = 0.85531, R^2 = 0.73, n = 30$$

Variable	T-value	Probability Level
$\log N$	8.7351	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 36.1038 + 0.4685N - 0.0015N^2 \dots \dots \dots (287)$$

$$R = 0.92350, R^2 = 0.85, n = 90$$

Variable	T-value	Probability Level
N	15.9602	0.001
N^2	-10.8911	0.001

b. Square Root Function

$$Y = a + bN + N^{0.5}$$

$$Y = 33.3946 - 0.1504N + 4.7649N^{0.5} \dots\dots\dots(288)$$

$$R = 0.94035, R^2 = 0.88, n = 90$$

Variable	T-value	Probability Level
N	-6.0826	0.001
$N^{0.5}$	13.2065	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 35.0643 + 0.7052N - 0.0001N^{1.5} \dots\dots\dots(289)$$

$$R = 0.93249, R^2 = 0.87, n = 90$$

Variable	T-value	Probability Level
N	15.3931	0.001
$N^{0.5}$	-12.0384	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.4650 + 0.0863 \text{ Log } N \dots\dots\dots(290)$$

$$R = 0.90265, R^2 = 0.81, n = 90$$

Variable	T-value	Probability Level
Log N	19.6744	0.001

19621. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. $Y = a + bN + cN^2$

$$Y = 50.6764 + 0.3497N - 0.0011N^2 \dots\dots\dots(291)$$

$$R = 0.92680, R^2 = 0.86, n = 30$$

Variable	T-value	Probability Level
N	8.8175	0.001
N^2	-5.8529	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 48.6950 - 0.1001N + 3.4657N^{0.5} \dots\dots\dots(292)$$

$$R = 0.94220, R^2 = 0.89, n = 30$$

Variable	T-value	Probability Level
N	-2.9782	0.01
$N^{0.5}$	7.0682	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.8753 + 0.0900 \text{ Log } N \dots\dots\dots(293)$$

$$R = 0.92887, R^2 = 0.86, n = 30$$

Variable	T-value	Probability Level
Log N	13.2691	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 53.4250 + 0.3504N - 0.0012N^2 \dots \dots \dots (294)$$

$$R = 0.90484, R^2 = 0.82, n = 30$$

Variable	T-value	Probability Level
N	8.0848	0.001
N^2	-5.6512	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 50.8590 - 0.1378N + 3.8649N^{0.5} \dots \dots \dots (295)$$

$$R = 0.93928, R^2 = 0.88, n = 30$$

Variable	T-value	Probability Level
N	-4.1528	0.001
$N^{0.5}$	7.9833	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 3.9283 + 0.0839 \log N \dots \dots \dots (296)$$

$$R = 0.93895, R^2 = 0.88, n = 30$$

Variable	T-value	Probability Level
$\log N$	14.4409	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 54.0800 + 0.3666N - 0.0012N^2 \dots \dots \dots (297)$$

$$R = 0.88321, R^2 = 0.78, n = 30$$

Variable	T-value	Probability Level
N	7.1805	0.001
N^2	-5.0283	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 51.8224 - 0.1328N + 3.8620N^{0.5} \dots \dots \dots (298)$$

$$R = 0.90377, R^2 = 0.82, n = 30$$

Variable	T-value	Probability Level
N	-2.9993	0.01
$N^{0.5}$	5.9810	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.9377 + 0.0862 \text{ Log } N \dots \dots \dots (299)$$

$$R = 0.89514, R^2 = 0.80, n = 30$$

Variable	T-value	Probability Level
Log N	10.6252	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Functions

i) $Y = a + bN + cN^2$

$$Y = 52.7271 + 0.3556N - 0.0012N^2 \dots\dots\dots (300)$$

$$R = 0.89628, R^2 = 0.80, n = 90$$

Variable	T-value	Probability Level
N	13.5305	0.001
N^2	- 9.3075	0.001

ii) $Y = a + bN + cN^2 + dP$

$$Y = 50.9660 + 0.3556N - 0.0012N^2 + 0.0660P \dots\dots (301)$$

$$R = 0.90396, R^2 = 0.82, n = 90$$

Variable	T-value	Probability Level
N	13.9521	0.001
N^2	- 9.5975	0.001
P	2.5509	0.025

b. Square Root Functions

i) $Y = a + bN + cN^{0.5}$

$$Y = 50.4590 - 0.1236N + 3.7309N^{0.5} \dots\dots\dots (302)$$

$$R = 0.91909, R^2 = 0.84, n = 90$$

Variable	T-value	Probability Level
N	-5.5705	0.001
$N^{0.5}$	11.5300	0.001

ii) $Y = a + bN + cN^{0.5} + dP$

$$Y = 48.6979 - 0.1236N + 3.7309N^{0.5} + 0.0660P \dots (303)$$

$$R = 0.92659, R^2 = 0.86, n = 90$$

Variable	T-value	Probability Level
N	-5.8029	0.001
$N^{0.5}$	12.0112	0.001
P	2.9004	0.01

c. 1.5 Power Function

i) $Y = a + bN + cN^{1.5}$

$$Y = 51.8873 + 0.5393N - 0.0001N^{1.5} \dots (304)$$

$$R = 0.90681, R^2 = 0.82, n = 90$$

Variable	T-value	Probability Level
N	13.0255	0.001
$N^{1.5}$	-10.2557	0.001

ii) $Y = a + bN + cN^{1.5} + dP$

$$Y = 50.1262 + 0.5393N - 0.0001N^{1.5} + 0.0660P \dots (305)$$

$$R = 0.91440, R^2 = 0.84, n = 90$$

Variable	T-value	Probability Level
N	13.4860	0.001
$N^{1.5}$	-10.6183	0.001
P	2.6946	0.01

d. Cobb-Douglas Functions

i) $Y = aN^b$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.9064 + 0.0495 \text{ Log } N \dots \dots \dots (306)$$

$$R = 0.90828, R^2 = 0.82, n = 90$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
Log N	20.3662	0.001

ii) $Y = aN^bP^c$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 3.8807 + 0.0495 \text{ Log } N + 0.0052 \text{ Log } P \dots \dots (307)$$

$$R = 0.91440, R^2 = 0.84, n = 90$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
Log N	20.9275	0.001
Log P	2.4327	0.025

19631. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 47.1879 + 0.4288N - 0.0015N^2 \dots \dots \dots (308)$$

$$R = 0.93562, R^2 = 0.86, n = 30$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
N	10.3803	0.001
N ²	- 7.4257	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 45.7304 - 0.1323N + 4.0718N^{0.5} \dots\dots\dots(309)$$

$$R = 0.92436, R^2 = 0.85, n = 30$$

Variable	T-value	Probability Level
N	-3.1207	0.005
N ^{0.5}	6.5818	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.8284 + 0.0982 \text{ Log } N \dots\dots\dots(310)$$

$$R = 0.92876, R^2 = 0.86, n = 30$$

Variable	T-value	Probability Level
Log N	13.2580	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 51.8400 + 0.3100N - 0.0009N^2 \dots\dots\dots(311)$$

$$R = 0.89636, R^2 = 0.80, n = 30$$

Variable	T-value	Probability Level
N	6.4460	0.001
N ²	-3.8611	0.005

b. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.9068 + 0.0837 \text{ Log } N \dots \dots \dots (312)$$

$$R = 0.89636, R^2 = 0.80, n = 30$$

Variable	T-value	Probability Level
Log N	10.4158	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 49.3321 + 0.3844N - 0.0012N^2 \dots \dots \dots (313)$$

$$R = 0.91191, R^2 = 0.83, n = 30$$

Variable	T-value	Probability Level
N	7.7811	0.001
N^2	-5.0771	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 47.5093 - 0.0925N + 3.6057N^{0.5} \dots \dots \dots (314)$$

$$R = 0.91859, R^2 = 0.84, n = 30$$

Variable	T-value	Probability Level
N	-2.0472	0.05
$N^{0.5}$	5.4695	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.8499 + 0.0987 \text{ Log } N \dots \dots \dots (315)$$

$$R = 0.91937, R^2 = 0.85, n = 30$$

Variable	T-value	Probability Level
Log N	12.3663	0.001

4. (P₂O₅, K₂O, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 49.4533 + 0.3744N - 0.0012N^2 \dots \dots \dots (316)$$

$$R = 0.90964, R^2 = 0.83, n = 90$$

Variable	T-value	Probability Level
N	13.9934	0.001
N ²	- 9.2599	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 47.9538 - 0.0881N + 3.4297N^{0.5} \dots \dots \dots (317)$$

$$R = 0.90946, R^2 = 0.83, n = 90$$

Variable	T-value	Probability Level
N	-3.4615	0.005
N ^{0.5}	9.2422	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 48.7768 + 0.5502N - 0.0001N^{1.5} \dots\dots\dots(318)$$

$$R = 0.91379, R^2 = 0.84, n = 90$$

Variable	T-value	Probability Level
N	12.6884	0.001
$N^{1.5}$	- 9.6780	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.8588 + 0.0527 \text{ Log } N \dots\dots\dots(319)$$

$$R = 0.89285, R^2 = 0.80, n = 90$$

Variable	T-value	Probability Level
Log N	18.5982	0.001

1964

1. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 29.2361 + 0.5399N - 0.0016N^2 \dots\dots\dots(320)$$

$$R = 0.89420, R^2 = 0.80, n = 60$$

Variable	T-value	Probability Level
N	9.5409	0.001
N^2	-5.8833	0.001

b. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.3012 + 0.1876 \text{ Log } N \dots \dots \dots (321)$$

$$R = 0.89561, R^2 = 0.80, n = 60$$

Variable	T-value	Probability Level
Log N	15.3331	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 32.1543 + 0.5228N - 0.0015N^2 \dots \dots \dots (322)$$

$$R = 0.88109, R^2 = 0.77, n = 60$$

Variable	T-value	Probability Level
N	8.7729	0.001
N^2	-5.3230	0.001

b. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.3617 + 0.1822 \text{ Log } N \dots \dots \dots (323)$$

$$R = 0.87088, R^2 = 0.76, n = 60$$

Variable	T-value	Probability Level
Log N	13.4947	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 32.7154 + 0.5555N - 0.0017N^2 \dots \dots \dots (324)$$

$$R = 0.89903, R^2 = 0.81, n = 30$$

Variable	T-value	Probability Level
N	10.3837	0.001
N	- 6.7402	0.001

b. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.4309 + 0.1698 \text{ Log } N \dots \dots \dots (325)$$

$$R = 0.89406, R^2 = 0.80, n = 60$$

Variable	T-value	Probability Level
Log N	15.2001	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Function

$$i) Y = a + bN + cN^2$$

$$Y = 31.3686 + 0.5394N - 0.0016N^2 \dots \dots \dots (326)$$

$$R = 0.88878, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	16.5507	0.001
N ²	-10.3375	0.001

ii) $Y = a + bN + cN^2 + dP$

$$Y = 29.5669 + 0.5394N - 0.0016N^2 + 0.0676P \dots (327)$$

$$R = 0.89156, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	16.7015	0.001
N ²	-10.4317	0.001
P	2.0593	0.05

b. Square Root Function

i) $Y = a + bN + cN^{0.5}$

$$Y = 29.9247 - 0.0724N + 4.4038N^{0.5} \dots (328)$$

$$R = 0.88088, R^2 = 0.78, n = 180$$

Variable	T-value	Probability Level
N	-2.2650	0.05
N ^{0.5}	9.4415	0.001

ii) $Y = a + bN + N^{0.5} + dP$

$$Y = 28.1231 - 0.0724N + 4.4038N^{0.5} + 0.0676P \dots (329)$$

$$R = 0.88368, R^2 = 0.78, n = 180$$

Variable	T-value	Probability Level
N	-2.2839	0.025
N ^{0.5}	9.5204	0.001
P	1.9925	0.05

c. 1.5 Power Functions

i) $Y = a + bN + cN^{1.5}$

$$Y = 30.5839 + 0.7705N - 0.0002N^{1.5} \dots\dots\dots(330)$$

$$R = 0.88986, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	14.3293	0.001
$N^{1.5}$	-10.4628	0.001

ii) $Y = a + bN + cN^{1.5} + dP$

$$Y = 28.7822 + 0.7705N - 0.0002N^{1.5} + 0.0676P \dots\dots(331)$$

$$R = 0.89263, R^2 = 0.80, n = 180$$

Variable	T-value	Probability Level
N	14.4615	0.001
$N^{1.5}$	-10.5593	0.001
P	2.0690	0.05

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.3618 + 0.1009 \text{ Log } N \dots\dots\dots(332)$$

$$R = 0.86271, R^2 = 0.74, n = 60$$

Variable	T-value	Probability Level
Log N	22.7610	0.001

19651. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 21.8971 + 0.4815N - 0.0015N^2 \dots \dots \dots (333)$$

$$R = 0.86740, R^2 = 0.75, n = 60$$

Variable	T-value	Probability Level
N	8.7165	0.001
N^2	-5.6020	0.001

b. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 2.9394 + 0.2191 \text{ Log } N \dots \dots \dots (334)$$

$$R = 0.83361, R^2 = 0.69, n = 60$$

Variable	T-value	Probability Level
Log N	11.4939	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 20.9342 + 0.5240N - 0.0015N^2 \dots \dots \dots (335)$$

$$R = 0.91646, R^2 = 0.84, n = 60$$

Variable	T-value	Probability Level
N	10.8226	0.001
N^2	- 6.6932	0.001

b. Square Root Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 2.8035 + 0.2626 \text{ Log } N \dots \dots \dots (336)$$

$$R = 0.89249, R^2 = 0.80, n = 60$$

Variable	T-value	Probability Level
Log N	14.9384	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN$$

$$Y = 21.8173 + 0.5300N - 0.0016N^2 \dots \dots \dots (337)$$

$$R = 0.91707, R^2 = 0.84, n = 60$$

Variable	T-value	Probability Level
N	11.3870	0.001
N^2	- 7.1756	0.001

b. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 2.9644 + 0.2266 \text{ Log } N \dots \dots \dots (338)$$

$$R = 0.86325, R^2 = 0.75, n = 60$$

Variable	T-value	Probability Level
Log N	13.0244	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Function

i) $Y = a + bN + cN^2$

$$Y = 21.5768 + 0.5112N - 0.0015N^2 \dots\dots\dots(339)$$

$$R = 0.89828, R^2 = 0.81, n = 180$$

Variable	T-value	Probability Level
N	17.6606	0.001
N^2	-11.1529	0.001

ii) $Y = a + bN + cN^2 + dP$

$$Y = 19.8685 + 0.5112N - 0.0015N^2 + 0.0641P \dots\dots(340)$$

$$R = 0.90116, R^2 = 0.81, n = 180$$

Variable	T-value	Probability Level
N	17.8516	0.001
N^2	-11.2735	0.001
P	2.2022	0.05

iii) $Y = a + bN + cN^2 + dNP$

$$Y = 21.5768 + 0.4942N - 0.0015N^2 + 0.0006NP \dots\dots(341)$$

$$R = 0.90246, R^2 = 0.81, n = 180$$

Variable	T-value	Probability Level
N	16.9479	0.001
N^2	-11.3448	0.001
NP	2.6729	0.01

b. Square Root Function

i) $Y = a + bN + cN^{0.5}$

$$Y = 20,2291 - 0.0740N + 4.2042N^{0.5} \dots\dots\dots (342)$$

$$R = 0.88941, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	-2.5880	0.025
$N^{0.5}$	10.0752	0.001

ii) $Y = a + bN + cN^{0.5} + dP$

$$Y = 18.5207 - 0.0740N + 4.2042N^{0.5} + 0.0641P \dots\dots (343)$$

$$R = 0.89231, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	-2.6133	0.01
$N^{0.5}$	10.1736	0.001
P	2.1147	0.05

iii) $Y = a + bN + cN^2 + dNP$

$$Y = 20.2291 - 0.0910N + 4.2042N^{0.5} + 0.0006NP \dots\dots (344)$$

$$R = 0.89363, R^2 = 0.80, n = 180$$

Variable	T-value	Probability Level
N	-3.1466	0.001
$N^{0.5}$	10.2329	0.001
NP	2.5655	0.01

c. 1.5 Power Functions

i) $Y = a + bN + cN^{1.5}$

$$Y = 20.8326 + 0.7322N - 0.0001N^{1.5} \dots\dots\dots(345)$$

$$R = 0.89928, R^2 = 0.81, n = 180$$

Variable	T-value	Probability Level
N	15.3335	0.001
$N^{1.5}$	-11.2795	0.001

ii) $Y = a + bN + cN^{1.5} + dP$

$$Y = 19.1243 + 0.7322N - 0.0001N^{1.5} + 0.0641P \dots\dots(346)$$

$$R = 0.90216, R^2 = 0.81, n = 180$$

Variable	T-value	Probability Level
N	15.5013	0.001
$N^{1.5}$	-11.4033	0.001
P	2.2128	0.05

iii) $Y = a + bN + cN^2 + dNP$

$$Y = 20.8326 - 0.0001N^{1.5} + 0.0006NP \dots\dots\dots(347)$$

$$R = 0.90346, R^2 = 0.82, n = 180$$

Variable	T-value	Probability Level
N	15.1009	0.001
$N^{1.5}$	-11.4762	0.001
NP	2.6860	0.01

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 2.8987 + 0.1326 \log N \dots \dots \dots (348)$$

$$R = 0.84584, R^2 = 0.72, n = 180$$

Variable	T-value	Probability Level
Log N	21.1554	0.001

19661. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 40.8932 + 0.4813N - 0.0018N^2 \dots \dots \dots (349)$$

$$R = 0.87055, R^2 = 0.76, n = 60$$

Variable	T-value	Probability Level
N	10.9510	0.001
N^2	- 8.3674	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 38.5539 - 0.2084N + 5.1405N^{0.5} \dots \dots \dots (350)$$

$$R = 0.87356, R^2 = 0.76, n = 60$$

Variable	T-value	Probability Level
N	-5.0466	0.001
$N^{0.5}$	8.5338	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6638 + 0.1174 \text{ Log } N \dots \dots \dots (351)$$

$$R = 0.88064, R^2 = 0.78, n = 60$$

Variable	T-value	Probability Level
Log N	14.1554	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 40.5871 + 0.4690N - 0.0015N^2 \dots \dots \dots (352)$$

$$R = 0.90632, R^2 = 0.82, n = 60$$

Variable	T-value	Probability Level
N	10.9409	0.001
N^2	- 7.1550	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 37.7555 - 0.1314N + 4.6723N^{0.5} \dots \dots \dots (353)$$

$$R = 0.92461, R^2 = 0.85, n = 60$$

Variable	T-value	Probability Level
N	-3.5812	0.001
$N^{0.5}$	8.7266	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6199 + 0.1382 \text{ Log } N \dots \dots \dots (354)$$

$$R = 0.93292, R^2 = 0.87, n = 60$$

Variable	T-value	Probability Level
Log N	19.7310	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 42.3868 + 0.4934N - 0.0018N^2 \dots \dots \dots (355)$$

$$R = 0.89608, R^2 = 0.80, n = 60$$

Variable	T-value	Probability Level
N	12.4521	0.001
N^2	- 9.4886	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 39.4462 - 0.2274N + 5.4956N^{0.5} \dots \dots \dots (356)$$

$$R = 0.91545, R^2 = 0.84, n = 60$$

Variable	T-value	Probability Level
N	-6.6653	0.001
$N^{0.5}$	11.0402	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6883 + 0.1199 \text{ Log } N \dots \dots \dots (357)$$

$$R = 0.91726, R^2 = 0.84, n = 60$$

Variable	T-value	Probability Level
Log N	17.5396	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Function

$$i) Y = a + bN + cN^2$$

$$Y = 41.2890 + 0.4812N - 0.0017N^2 \dots \dots \dots (358)$$

$$R = 0.88176, R^2 = 0.78, n = 60$$

Variable	T-value	Probability Level
N	19.1520	0.001
N^2	-13.9350	0.001

$$ii) Y = a + bN + cN^2 + dP$$

$$Y = 39.6607 + 0.4812N - 0.0017N^2 + 0.0611P \dots \dots (359)$$

$$R = 0.88583, R^2 = 0.78, n = 180$$

Variable	T-value	Probability Level
N	19.4143	0.001
N^2	-14.1258	0.001
P	2.4252	0.025

$$\text{iii) } Y = a + bN + cN^2 + dNP$$

$$Y = 41.2890 + 0.4647N - 0.0017N^2 + 0.0006NP \dots (360)$$

$$R = 0.88785, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	18.4524	0.001
N ²	-14.2449	0.001
NP	2.9935	0.005

b. Square Root Functions

$$\text{i) } Y = a + bN + cN^{0.5}$$

$$Y = 38.5852 - 0.1891N + 5.1028N^{0.5} \dots (361)$$

$$R = 0.89633, R^2 = 0.80, n = 180$$

Variable	T-value	Probability Level
N	-8.4285	0.001
N ^{0.5}	15.5919	0.001

$$\text{ii) } Y = a + bN + cN^{0.5} + dP$$

$$Y = 36.9569 - 0.1891N + 5.1028N^{0.5} + 0.0611P \dots (362)$$

$$R = 0.90034, R^2 = 0.81, n = 180$$

Variable	T-value	Probability Level
N	-8.5628	0.001
N ^{0.5}	15.8404	0.001
P	2.5858	0.01

$$\text{iii) } Y = a + bN + cN^{0.5} + dNP$$

$$Y = 38.5852 - 0.2055N + 5.1028N^{0.5} + 0.0006NP \dots (363)$$

$$R = 0.90233, R^2 = 0.81, n = 180$$

Variable	T-value	Probability Level
N	-9.1472	0.001
$N^{0.5}$	13.9925	0.001
NP	3.1954	0.005

c. 1.5 Power Functions

$$\text{i) } Y = a + bN + cN^{1.5}$$

$$Y = 40.2034 + 0.7373N - 0.0002N^{1.5} \dots (364)$$

$$R = 0.89166, R^2 = 0.80, n = 180$$

Variable	T-value	Probability Level
N	18.4476	0.001
$N^{1.5}$	-15.0330	0.001

$$\text{ii) } Y = a + bN + cN^{1.5} + dP$$

$$Y = 38.5751 + 0.7373N - 0.0002N^{1.5} + 0.0611P \dots (365)$$

$$R = 0.89569, R^2 = 0.80, n = 180$$

Variable	T-value	Probability Level
N	18.7271	0.001
$N^{1.5}$	-15.2608	0.001
P	2.5306	0.025

$$\text{iii) } Y = a + bN + cN^{1.5} + dNP$$

$$Y = 40.2034 + 0.7208N - 0.0002N^{1.5} + 0.0006NP \dots (366)$$

$$R = 0.89769, R^2 = 0.80, n = 180$$

Variable	T-value	Probability Level
N	18.3113	0.001
$N^{1.5}$	-15.4010	0.001
NP	3.1260	0.005

d. Cobb-Douglas Functions

$$\text{i) } Y = aN^b$$

$$\text{Log } Y = \text{Log } a + \text{Log } N$$

$$\text{Log } Y = \text{Log } 3.6440 + 0.0719 \text{ Log } N \dots (367)$$

$$R = 0.90668, R^2 = 0.82, n = 180$$

Variable	T-value	Probability Level
Log N	28.6765	0.001

$$\text{ii) } Y = aN^bP^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 3.6202 + 0.0719 \text{ Log } N + 0.0048 \text{ Log } P \dots (368)$$

$$R = 0.90918, R^2 = 0.83, n = 180$$

Variable	T-value	Probability Level
Log N	28.9681	0.001
Log P	2.1537	0.05

1967

1. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 39.6543 + 0.5250N - 0.0019N^2 \dots \dots \dots (369)$$

$$R = 0.85239, R^2 = 0.73, n = 60$$

Variable	T-value	Probability Level
N	9.6582	0.001
N^2	-7.1319	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 36.7685 - 0.2141N + 5.6031N^{0.5} \dots \dots \dots (370)$$

$$R = 0.86485, R^2 = 0.75, n = 60$$

Variable	T-value	Probability Level
N	-4.3184	0.001
$N^{0.5}$	7.7473	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 3.6180 + 0.1343 \log N \dots \dots \dots (371)$$

$$R = 0.89596, R^2 = 0.80, n = 60$$

Variable	T-value	Probability Level
$\log N$	15.3634	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 42.5886 + 0.5586N - 0.0019N^2 \dots\dots\dots(372)$$

$$R = 0.93601, R^2 = 0.88, n = 60$$

Variable	T-value	Probability Level
N	14.9591	0.001
N^2	-10.6041	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 39.2353 - 0.2079N + 5.9003N^{0.5} \dots\dots\dots(373)$$

$$R = 0.95619, R^2 = 0.91, n = 60$$

Variable	T-value	Probability Level
N	-7.0479	0.001
$N^{0.5}$	13.7089	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 3.6717 + 0.1426 \log N \dots\dots\dots(374)$$

$$R = 0.95115, R^2 = 0.90, n = 60$$

Variable	T-value	Probability Level
Log N	23.4637	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 53.2700 + 0.5627N - 0.0020N^2 \dots\dots\dots(375)$$

$$R = 0.93996, R^2 = 0.88, n = 60$$

Variable	T-value	Probability Level
N	15.9027	0.001
N^2	-11.5078	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 40.6956 - 0.1884N + 5.5002N^{0.5} \dots\dots\dots(376)$$

$$R = 0.93275, R^2 = 0.87, n = 60$$

Variable	T-value	Probability Level
N	-5.3054	0.001
$N^{0.5}$	10.6180	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.7137 + 0.1320 \text{ Log } N \dots\dots\dots(377)$$

$$R = 0.93531, R^2 = 0.87, n = 60$$

Variable	T-value	Probability Level
Log N	20.1307	0.001

4. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Functions

i) $Y = a + bN + cN^2$

$$Y = 41.6965 + 0.5488N - 0.0019N^2 \dots\dots\dots(378)$$

$$R = 0.89550, R^2 = 0.80, n = 180$$

Variable	T-value	Probability Level
N	20.4613	0.001
N^2	-14.8006	0.001

ii) $Y = a + bN + cN^2 + dP$

$$Y = 37.9310 + 0.5488N - 0.0019N^2 + 0.1412P \dots\dots(379)$$

$$R = 0.91213, R^2 = 0.83, n = 180$$

Variable	T-value	Probability Level
N	22.1536	0.001
N^2	-16.0247	0.001
P	5.6115	0.001

b. Square Root Functions

i) $Y = a + bN + cN^{0.5}$

$$Y = 38.8998 - 0.2035N + 5.6679N^{0.5} \dots\dots\dots(380)$$

$$R = 0.90390, R^2 = 0.82, n = 180$$

Variable	T-value	Probability Level
N	-8.3097	0.001
$N^{0.5}$	15.8672	0.001

$$\text{ii) } Y = a + bN + cN^{0.5} + dP$$

$$Y = 35.1343 - 0.2035 + 5.6679N^{0.5} + 0.1412P \dots (381)$$

$$R = 0.92038, R^2 = 0.85, n = 180$$

Variable	T-value	Probability Level
N	-9.0642	0.001
$N^{0.5}$	17.3079	0.001
P	5.8822	0.001

$$\text{iii) } Y = a + bN^{0.5} + cN^2 + dP$$

$$Y = 35.3821 + 4.2667N^{0.5} - 0.0006N^2 + 0.1412P \dots (382)$$

$$R = 0.92400, R^2 = 0.85, n = 180$$

Variable	T-value	Probability Level
$N^{0.5}$	24.2929	0.001
N^2	- 9.6928	0.001
P	6.0151	0.001

c. 1.5 Power Function

$$\text{i) } Y = a + bN + cN^{1.5}$$

$$Y = 40.5177 + 0.8360N - 0.0002N^{1.5} \dots (383)$$

$$R = 0.90397, R^2 = 0.82, n = 180$$

Variable	T-value	Probability Level
N	19.5758	0.001
$N^{1.5}$	-15.8768	0.001

$$ii) Y = a + bN + cN^{1.5} + dP$$

$$Y = 36.7521 + 0.8360N - 0.0002N^{1.5} + 0.1412P....(384)$$

$$R = 0.92045, R^2 = 0.85, n = 180$$

Variable	T-value	Probability Level
N	21.3546	0.001
$N^{1.5}$	-17.3195	0.001
P	5.8847	0.001

d. Cobb-Douglas Function

$$i) Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6548 + 0.0780 \text{ Log } N.....(385)$$

$$R = 0.91288, R^2 = 0.83, n = 180$$

Variable	T-value	Probability Level
Log N	29.8355	0.001

$$ii) Y = aN^bP^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 3.5973 + 0.0780 \text{ Log } N + 0.0117 \text{ Log } P....(386)$$

$$R = 0.92529, R^2 = 0.91, n = 180$$

Variable	T-value	Probability Level
Log N	32.0233	0.001
Log P	5.2974	0.001

$$\text{iii) } Y = aN^bK^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } K$$

$$\text{Log } Y = \text{Log } 3.6402 + 0.0780 \text{ Log } N + 0.0060 \text{ Log } K \dots (387)$$

$$R = 0.91612, R^2 = 0.84, n = 180$$

Variable	T-value	Probability Level
Log N	30.2945	0.001
Log K	2.5532	0.025

1968

1. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 33.5419 + 0.5553N + 0.0018N^2 \dots (388)$$

$$R = 0.90742, R^2 = 0.82, n = 60$$

Variable	T-value	Probability Level
N	11.7326	0.001
N^2	- 8.0879	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 30.9638 - 0.1667N + 5.4134N^{0.5} \dots (389)$$

$$R = 0.91205, R^2 = 0.83, n = 60$$

Variable	T-value	Probability Level
N	-3.7998	0.001
$N^{0.5}$	8.4585	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.4454 + 0.1648 \text{ Log } N \dots \dots \dots (390)$$

$$R = 0.94079, R^2 = 0.89, n = 60$$

Variable	T-value	Probability Level
Log N	21.1360	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 35.9377 + 0.5966N - 0.0020N^2 \dots \dots \dots (391)$$

$$R = 0.92058, R^2 = 0.85, n = 60$$

Variable	T-value	Probability Level
N	12.7473	0.001
N^2	- 8.7539	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 34.0377 - 0.1515N + 5.4182N^{0.5} \dots \dots \dots (392)$$

$$R = 0.91059, R^2 = 0.83, n = 60$$

Variable	T-value	Probability Level
N	-3.2210	0.005
$N^{0.5}$	7.8945	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.5219 + 0.1635 \text{ Log } N \dots \dots \dots (393)$$

$$R = 0.92176, R^2 = 0.85, n = 60$$

Variable	T-value	Probability Level
Log N	18.1039	0.001

3. $P_2O_5 = 40$, $K_2O = 40$, N variable

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 35.6912 + 0.6217N - 0.0020N^2 \dots \dots \dots (394)$$

$$R = 0.94319, R^2 = 0.89, n = 60$$

Variable	T-value	Probability Level
N	15.1943	0.001
N^2	-10.3464	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 33.3781 - 0.1614N + 5.7500N^{0.5} \dots \dots \dots (395)$$

$$R = 0.93882, R^2 = 0.88, n = 60$$

Variable	T-value	Probability Level
N	-4.0084	0.001
$N^{0.5}$	9.7939	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.5113 + 0.1710 \text{ Log } N \dots \dots \dots (396)$$

$$R = 0.95025, R^2 = 0.90, n = 60$$

Variable	T-value	Probability Level
Log N	23.2341	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Functions

$$i) Y = a + bN + cN^2$$

$$Y = 35.0570 + 0.5912N - 0.0019N^2 \dots \dots \dots (397)$$

$$R = 0.91357, R^2 = 0.83, n = 180$$

Variable	T-value	Probability Level
N	21.3610	0.001
N^2	-14.6433	0.001

$$ii) Y = a + bN + cN^2 + dP$$

$$Y = 31.5330 + 0.5912N - 0.0019N^2 + 0.1321P \dots \dots (398)$$

$$R = 0.92480, R^2 = 0.86, n = 180$$

Variable	T-value	Probability Level
N	22.7689	0.001
N^2	-15.6085	0.001
P	5.0101	0.001

b. Square Root Functions

i) $Y = a + bN + cN^{0.5}$

$$Y = 32.7932 - 0.1599N + 5.5279N^{0.5} \dots\dots\dots(399)$$

$$R = 0.91014, R^2 = 0.83, n = 180$$

Variable	T-value	Probability Level
N	-5.9696	0.001
$N^{0.5}$	14.1485	0.001

ii) $Y = a + dN + cN^{0.5} + dP$

$$Y = 29.2692 - 0.1599N + 5.5279N^{0.5} + 0.1321P \dots\dots(400)$$

$$R = 0.92141, R^2 = 0.85, n = 180$$

Variable	T-value	Probability Level
N	-6.3463	0.001
$N^{0.5}$	15.0420	0.001
P	4.9054	0.001

iii) $Y = a + bN + cN^{0.5} + dN^2$

$$Y = 33.4841 + 0.2714N + 2.5048N^{0.5} - 0.0012N^2 \dots\dots(401)$$

$$R = 0.91779, R^2 = 0.84, n = 180$$

Variable	T-value	Probability Level
N	2.4199	0.025
$N^{0.5}$	2.9387	0.005
N^2	-3.9510	0.001

$$\text{iv) } Y = a + bN + cN^2 + dN^{0.5} + eP$$

$$Y = 29.9602 + 0.2714N + 2.5048N^{0.5} - 0.0012N^2 + 0.1321P \dots \dots \dots (402)$$

$$R = 0.92897, R^2 = 0.86, n = 180$$

Variable	T-value	Probability Level
N	2.5885	0.025
$N^{0.5}$	3.1434	0.005
N^2	-4.2262	0.001
P	5.1349	0.001

$$\text{v) } Y = a + bN + cN^{0.5} + dN^2 + eNP$$

$$Y = 33.4841 + 0.2428N + 2.5048N^{0.5} - 0.0012N^2 + 0.0011NP \dots \dots \dots (403)$$

$$R = 0.92858, R^2 = 0.86, n = 180$$

Variable	T-value	Probability Level
N	2.3064	0.025
$N^{0.5}$	3.1351	0.005
N^2	-4.2151	0.001
NP	5.0314	0.001

c. 1.5 Power Functions

$$\text{i) } Y = a + bN + cN^{1.5}$$

$$Y = 33.9923 + 0.8762N - 0.0002N^{1.5} \dots \dots \dots (404)$$

$$R = 0.91758, R^2 = 0.84, n = 180$$

Variable	T-value	Probability Level
N	19.5410	0.001
$N^{1.5}$	-15.2520	0.001

$$\text{ii) } Y = a + bN + cN^{1.5} + dP$$

$$Y = 30.4693 + 0.8762N - 0.0002N^{1.5} + 0.1321P \dots (405)$$

$$R = 0.92876, R^2 = 0.86, n = 180$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
N	20.8993	0.001
$N^{1.5}$	-16.3114	0.001
P	5.1423	0.001

d. Cobb-Douglas Functions

$$\text{i) } Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.4827 + 0.0945 \text{ Log } N \dots \dots \dots (406)$$

$$R = 0.91930, R^2 = 0.85, n = 180$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
Log N	31.1645	0.001

$$\text{ii) } Y = aN^bP^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 3.4290 + 0.0945 \text{ Log } N + 0.0109 \text{ Log } P \dots (407)$$

$$R = 0.92678, R^2 = 0.86, n = 180$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
Log N	32.5627	0.001
Log P	4.1629	0.01

$$\text{iii) } Y = aN^bK^c$$

$$\log Y = \log a + b \log N + c \log K$$

$$\log Y = \log 3.4647 + 0.0945 \log N + 0.0073 \log K \dots (408)$$

$$R = 0.92266, R^2 = 0.85, n = 180$$

Variable	T-value	Probability Level
Log N	31.7177	0.001
Log K	2.7157	0.01

1969

1. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 40.7371 + 0.3411N - 0.0013N^2 \dots (409)$$

$$R = 0.76875, R^2 = 0.59, n = 60$$

Variable	T-value	Probability Level
N	7.4864	0.001
N^2	-5.7478	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 38.5505 - 0.1650N + 3.8890N^{0.5} \dots (410)$$

$$R = 0.79125, R^2 = 0.62, n = 60$$

Variable	T-value	Probability Level
N	-3.9864	0.001
$N^{0.5}$	6.4414	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6665 + 0.0896 \text{ Log } N \dots \dots \dots (411)$$

$$R = 0.81986, R^2 = 0.67, n = 60$$

Variable	T-value	Probability Level
Log N	10.9053	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 43.6882 + 0.4120N - 0.0015N^2 \dots \dots \dots (412)$$

$$R = 0.89430, R^2 = 0.80, n = 60$$

Variable	T-value	Probability Level
N	11.7657	0.001
N^2	- 8.6449	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 41.2492 - 0.1704N + 4.4565N^{0.5} \dots \dots \dots (413)$$

$$R = 0.91295, R^2 = 0.83, n = 60$$

Variable	T-value	Probability Level
N	-5.6186	0.001
$N^{0.5}$	10.0702	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.7211 + 0.1060 \text{ Log } N \dots\dots\dots (414)$$

$$R = 0.90951, R^2 = 0.83, n = 60$$

Variable	T-value	Probability Level
Log N	16.6630	0.001

3. $(P_2O_5 = 40, K_2O = 40, N \text{ variable})$

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 40.2354 + 0.4824N - 0.0017N^2 \dots\dots\dots (415)$$

$$R = 0.91730, R^2 = 0.84, n = 60$$

Variable	T-value	Probability Level
N	13.7863	0.001
N^2	-10.2601	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 37.6155 - 0.2005N + 5.1658N^{0.5} \dots\dots\dots (416)$$

$$R = 0.92968, R^2 = 0.86, n = 60$$

Variable	T-value	Probability Level
N	-6.5215	0.001
$N^{0.5}$	11.5156	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6423 + 0.1234 \text{ Log } N \dots \dots \dots (417)$$

$$R = 0.93930, R^2 = 0.88, n = 60$$

Variable	T-value	Probability Level
Log N	20.8498	0.001

4. (P₂O₅, K₂O, N variable)

a. Quadratic Functions

$$i) Y = a + bN + cN^2$$

$$Y = 41.5536 + 0.4119N - 0.0015N^2 \dots \dots \dots (418)$$

$$R = 0.82818, R^2 = 0.69, n = 180$$

Variable	T-value	Probability Level
N	15.6733	0.001
N ²	-11.7169	0.001

$$ii) Y = a + bN + cN^2 + dP$$

$$Y = 36.9015 + 0.4119N - 0.0015N^2 + 0.1745P \dots \dots (419)$$

$$R = 0.87275, R^2 = 0.76, n = 180$$

Variable	T-value	Probability Level
N	17.9430	0.001
N ²	-13.4136	0.001
P	7.4817	0.001

$$\text{iii) } Y = a + bN + cN^2 + dNP$$

$$Y = 41.5536 + 0.3717N - 0.0015N^2 + 0.0015NP \dots (420)$$

$$R = 0.87682, R^2 = 0.77, n = 180$$

Variable	T-value	Probability Level
N	16.0438	0.001
N ²	-13.6188	0.001
NP	7.9452	0.001

b. Square Root Functions

$$\text{i) } Y = a + bN + cN^{0.5}$$

$$Y = 39.1784 - 0.1787N + 4.5038N^{0.5} \dots (421)$$

$$R = 0.84482, R^2 = 0.71, n = 180$$

Variable	T-value	Probability Level
N	-7.4970	0.001
N ^{0.5}	12.9552	0.001

$$\text{ii) } Y = a + bN + cN^{0.5} + dP$$

$$Y = 34.4863 - 0.1787N + 4.5038N^{0.5} + 0.1745P \dots (422)$$

$$R = 0.88855, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	-8.7185	0.001
N ^{0.5}	15.0660	0.001
P	7.9609	0.001

$$\text{iii)} \quad Y = a + bN + cN^{0.5} + dNP$$

$$Y = 39.1384 - 0.2188N + 4.5038N^{0.5} + 0.0015NP \dots (423)$$

$$R = 0.89255, R^2 = 0.80, n = 180$$

Variable	T-value	Probability Level
N	-10.5754	0.001
$N^{0.5}$	15.3278	0.001
NP	8.4715	0.001

$$\text{iv)} \quad Y = a + bN + cN^{0.5} + dN + eNP$$

$$Y = 37.1452 - 0.2052N + 4.5038N^{0.5} + 0.0747P + 0.0010NP \dots (424)$$

$$R = 0.89502, R^2 = 0.80, n = 180$$

Variable	T-value	Probability Level
N	-9.4805	0.001
$N^{0.5}$	15.4533	0.001
P	1.9735	0.05
NP	3.1881	0.001

$$\text{v)} \quad Y = a + bN^{0.5} + cN^2 + dP$$

$$Y = 34.8079 + 3.2400N^{0.5} - 0.0005N^2 + 0.1745P \dots (425)$$

$$R = 0.89040, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
$N^{0.5}$	19.9191	0.001
N^2	- 8.9457	0.001
P	8.0241	0.001

$$\text{vi)} \quad Y = a + bN^{0.5} + cN^2 + dNP$$

$$Y = 39.5695 + 2.9452N^{0.5} - 0.0006N^2 + 0.0015NP \dots (426)$$

$$R = 0.89405, R^2 = 0.80, n = 180$$

Variable	T-value	Probability Level
$N^{0.5}$	17.9808	0.001
N^2	-10.7559	0.001
NP	8.4962	0.001

c. 1.5 Power Function

$$\text{i)} \quad Y = a + bN + cN^{1.5}$$

$$Y = 40.5740 + 0.6385N - 0.0001N^{1.5} \dots (427)$$

$$R = 0.83958, R^2 = 0.70, n = 180$$

Variable	T-value	Probability Level
N	15.1251	0.001
$N^{1.5}$	-12.5506	0.001

$$\text{ii)} \quad Y = a + bN + cN^{1.5} + dP$$

$$Y = 35.9219 + 0.6385N - 0.0001N^{1.5} + 0.1745P \dots (428)$$

$$R = 0.88356, R^2 = 0.78, n = 180$$

Variable	T-value	Probability Level
N	17.4954	0.001
$N^{1.5}$	-14.5175	0.001
P	7.7990	0.001

$$\text{iii) } Y = a + bN + cN^{1.5} + dNP$$

$$Y = 40.5740 + 0.5983 - 0.0001N^{1.5} + 0.0015NP \dots (429)$$

$$R = 0.88759, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	16.5178	0.001
$N^{1.5}$	-14.7593	0.001
NP	8.2933	0.001

d. Cobb-Douglas Functions

$$\text{i) } Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6641 + 0.0612 \text{ Log } N \dots (430)$$

$$R = 0.86611, R^2 = 0.75, n = 180$$

Variable	T-value	Probability Level
Log N	23.1172	0.001

$$\text{ii) } Y = aN^bP^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 3.5890 + 0.0612 \text{ Log } N + 0.0153 \text{ Log } P \dots (431)$$

$$R = 0.89834, R^2 = 0.81, n = 180$$

Variable	T-value	Probability Level
Log N	26.2301	0.001
Log P	7.2226	0.001

$$\text{iii) } Y = aN^bK^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } K$$

$$\text{Log } Y = \text{Log } 3.6482 + 0.0612 \text{ Log } N + 0.0065 \text{ Log } K \dots (432)$$

$$R = 0.87200, R^2 = 0.76, n = 180$$

Variable	T-value	Probability Level
Log N	23.5398	0.001
Log K	2.7509	0.01

1970

1. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 41.9301 + 0.3756N - 0.0012N^2 \dots (433)$$

$$R = 0.81150, R^2 = 0.66, n = 60$$

Variable	T-value	Probability Level
N	7.5858	0.001
N^2	-5.2521	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 39.6157 - 0.1310N + 3.9244N^{0.5} \dots (434)$$

$$R = 0.83018, R^2 = 0.69, n = 180$$

Variable	T-value	Probability Level
N	-2.9198	0.005
$N^{0.5}$	5.9943	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6758 + 0.1069 \text{ Log } N \dots \dots \dots (435)$$

$$R = 0.86157, R^2 = 0.74, n = 60$$

Variable	T-value	Probability Level
Log N	12.9256	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 42.6989 + 0.4319N - 0.0013N^2 \dots \dots \dots (436)$$

$$R = 0.90767, R^2 = 0.82, n = 60$$

Variable	T-value	Probability Level
N	10.7422	0.001
N^2	- 6.8629	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 41.0417 - 0.0828N + 3.8140N^{0.5} \dots \dots \dots (437)$$

$$R = 0.90728, R^2 = 0.82, n = 180$$

Variable	T-value	Probability Level
N	-2.1633	0.05
$N^{0.5}$	6.8325	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 3.7031 + 0.1205 \log N \dots \dots \dots (438)$$

$$R = 0.91951, R^2 = 0.85, n = 180$$

Variable	T-value	Probability Level
Log N	17.8153	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 42.4801 + 0.4695N - 0.0015N^2 \dots \dots \dots (439)$$

$$R = 0.92486, R^2 = 0.86, n = 60$$

Variable	T-value	Probability Level
N	12.6868	0.001
N^2	- 8.4566	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 40.0006 - 0.1313N + 4.5858N^{0.5} \dots \dots \dots (440)$$

$$R = 0.93638, R^2 = 0.88, n = 60$$

Variable	T-value	Probability Level
N	-4.0459	0.001
$N^{0.5}$	9.6899	0.001

c. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6859 + 0.1283 \text{ Log } N \dots\dots\dots(441)$$

$$R = 0.94765, R^2 = 0.89, n = 60$$

Variable	T-value	Probability Level
Log N	22.6018	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Functions

$$i) Y = a + bN + cN^2$$

$$Y = 42.3697 + 0.4257N - 0.0014N^2 \dots\dots\dots(442)$$

$$R = 0.86440, R^2 = 0.75, n = 180$$

Variable	T-value	Probability Level
N	15.7547	0.001
N^2	-10.4736	0.001

$$ii) Y = a + bN + cN^2 + dP$$

$$Y = 38.5399 + 0.4257N - 0.0014N^2 + 0.1436P \dots\dots(443)$$

$$R = 0.88673, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
N	17.0873	0.001
N^2	-11.3595	0.001
P	5.6753	0.001

$$\text{iii) } Y = a + bN + cN^2 + dNP$$

$$Y = 42.3697 + 0.3906N - 0.0014N^2 + 0.0013NP \dots (444)$$

$$R = 0.89173, R^2 = 0.80, n = 180$$

Variable	T-value	Probability Level
N	15.6314	0.001
N ²	-11.6035	0.001
NP	6.4225	0.001

b. Square Root Functions

$$\text{i) } Y = a + bN + cN^{0.5}$$

$$Y = 40.2214 - 0.1150N + 4.1081N^{0.5} \dots (445)$$

$$R = 0.87319, R^2 = 0.76, n = 180$$

Variable	T-value	Probability Level
N	-4.6235	0.001
N ^{0.5}	11.3196	0.001

$$\text{ii) } Y = a + bN + cN^2 + dP$$

$$Y = 36.3916 - 0.1150N + 4.1081N^{0.5} + 0.1436P \dots (446)$$

$$R = 0.89530, R^2 = 0.80, n = 180$$

Variable	T-value	Probability Level
N	-5.0444	0.001
N ^{0.5}	12.3499	0.001
P	5.8897	0.001

$$\text{iii)} \quad Y = a + dN^{0.5} + dN^2 + dP$$

$$Y = 36.5316 + 3.3160N^{0.5} - 0.0003N^2 + 0.1436P \dots (447)$$

$$R = 0.89680, R^2 = 0.80, n = 180$$

Variable	T-value	Probability Level
$N^{0.5}$	18.3008	0.001
N^2	- 5.3115	0.001
P	5.9300	0.001

c. 1.5 Power Function

$$\text{i)} \quad Y = a + bN + cN^{1.5}$$

$$Y = 41.4790 + 0.6334N - 0.0001N^{1.5} \dots (448)$$

$$R = 0.87121, R^2 = 0.76, n = 180$$

Variable	T-value	Probability Level
N	14.4876	0.001
$N^{1.5}$	-11.1247	0.001

$$\text{ii)} \quad Y = a + bN + cN^{1.5} + dP$$

$$Y = 37.6492 + 0.6334N - 0.0001N^{1.5} + 0.1436P \dots (449)$$

$$R = 0.89337, R^2 = 0.80, n = 180$$

Variable	T-value	Probability Level
N	15.7840	0.001
$N^{1.5}$	-12.1201	0.001
P	5.8390	0.001

$$\text{iii) } Y = a + bN + bN + cN^{1.5} + dNP$$

$$Y = 41.4790 + 0.5984N - 0.0001N^{1.5} + 0.0013P \dots (450)$$

$$R = 0.89834, R^2 = 0.81, n = 180$$

Variable	T-value	Probability Level
N	15.1136	0.001
$N^{1.5}$	12.3962	0.001
NP	6.6163	0.001

d. Cobb-Douglas Function

$$\text{i) } Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6816 + 0.0672 \text{ Log } N \dots (451)$$

$$R = 0.88459, R^2 = 0.78, n = 180$$

Variable	T-value	Probability Level
Log N	25.3059	0.001

$$\text{ii) } Y = aN^bP^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 3.6238 + 0.0672 \text{ Log } N + 0.0117 \text{ Log } P \dots (452)$$

$$R = 0.90089, R^2 = 0.81, n = 180$$

Variable	T-value	Probability Level
Log N	27.1141	0.001
Log P	5.2293	0.001

$$\text{iii) } Y = aN^bK^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } K$$

$$\text{Log } Y = \text{Log } 3.6640 + 0.0672 \text{ Log } N + 0.0072 \text{ Log } K \dots (453)$$

$$R = 0.89071, R^2 = 0.79, n = 180$$

Variable	T-value	Probability Level
Log N	25.8892	0.001
Log K	3.0497	0.005

SOIL TEST YEARS 1961, 1965 & 1968

1. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 29.0259 + 0.5139N - 0.0017N^2 \dots (454)$$

$$R = 0.82903, R^2 = 0.69, n = 150$$

Variable	T-value	Probability Level
N	12.5271	0.001
N^2	- 8.4102	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 27.0058 - 0.1281N + 4.7463N^{0.5} \dots (455)$$

$$R = 0.82773, R^2 = 0.69, n = 150$$

Variable	T-value	Probability Level
N	-3.2774	0.005
$N^{0.5}$	8.3210	0.001

c. 1.5 Power Function

$$Y = a + bN + N^{1.5}$$

$$Y = 28.1375 + 0.7685N - 0.0406N^{1.5} \dots\dots\dots(456)$$

$$R = 0.83317, R^2 = 0.69, n = 150$$

Variable	T-value	Probability Level
N	11.2495	0.001
$N^{1.5}$	- 8.6965	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.2436 + 0.1848 \text{ Log } N \dots\dots\dots(457)$$

$$R = 0.81687, R^2 = 0.67, n = 150$$

Variable	T-value	Probability Level
Log N	17.2284	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 30.6830 + 0.5242N - 0.0016N^2 \dots\dots\dots(458)$$

$$R = 0.83447, R^2 = 0.70, n = 150$$

Variable	T-value	Probability Level
N	12.3142	0.001
N^2	- 8.0374	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 28.5063 - 0.1137N + 4.7487N^{0.5} \dots\dots\dots (459)$$

$$R = 0.83480, R^2 = 0.70, n = 150$$

Variable	T-value	Probability Level
N	-2.8301	0.005
$N^{0.5}$	8.0608	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 29.7893 + 0.7757N - 0.0401N^{1.5} \dots\dots\dots (460)$$

$$R = 0.83791, R^2 = 0.70, n = 150$$

Variable	T-value	Probability Level
N	10.9279	0.001
$N^{1.5}$	- 8.2861	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.2576 + 0.1935 \text{ Log } N \dots\dots\dots (461)$$

$$R = 0.81338, R^2 = 0.66, n = 150$$

Variable	T-value	Probability Level
Log N	16.9525	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 29.6561 + 0.5706N - 0.0018N^2 \dots \dots \dots (462)$$

$$R = 0.83995, R^2 = 0.71, n = 150$$

Variable	T-value	Probability Level
N	13.0903	0.001
N^2	- 8.7948	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 27.7586 - 0.1329N + 5.1224N^{0.5} \dots \dots \dots (463)$$

$$R = 0.83343, R^2 = 0.69, n = 150$$

Variable	T-value	Probability Level
N	-3.1511	0.005
$N^{0.5}$	8.3273	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 28.7873 + 0.8465N - 0.0447N^{1.5} \dots \dots \dots (464)$$

$$R = 0.84205, R^2 = 0.71, n = 150$$

Variable	T-value	Probability Level
N	11.6010	0.001
$N^{1.5}$	- 8.9490	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.2519 + 0.1971 \text{ Log } N \dots \dots \dots (465)$$

$$R = 0.82475, R^2 = 0.68, n = 150$$

Variable	T-value	Probability Level
Log N	17.7431	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Functions

$$i) Y = a + bN + cN^2$$

$$Y = 29.8743 + 0.5347N - 0.0017N^2 \dots \dots \dots (466)$$

$$R = 0.83098, R^2 = 0.69, n = 450$$

Variable	T-value	Probability Level
N	21.7359	0.001
N^2	-14.4395	0.001

$$ii) Y = a + bN + cN^2 + dP$$

$$Y = 27.6629 + 0.5347N - 0.0017N^2 + 0.0829P \dots \dots (467)$$

$$R = 0.83556, R^2 = 0.70, n = 450$$

Variable	T-value	Probability Level
N	21.9841	0.001
N^2	-14.6043	0.001
P	3.3565	0.001

iii) $Y = a + bN + cN^2 + dNP$

$$Y = 29.8743 + 0.5161N - 0.0017N^2 + 0.0007NP \dots (468)$$

$$R = 0.83572, R^2 = 0.70, n = 450$$

Variable	T-value	Probability Level
N	20.7176	0.001
N^2	-14.6109	0.001
NP	3.4174	0.001

b. Square Root Functions

i) $Y = a + bN + cN^{0.5}$

$$Y = 27.8878 - 0.1237N + 4.8458N^{0.5} \dots (469)$$

$$R = 0.82830, R^2 = 0.69, n = 450$$

Variable	T-value	Probability Level
N	-5.2540	0.001
$N^{0.5}$	14.1148	0.001

ii) $Y = a + bN + cN^{0.5} + dP$

$$Y = 25.6765 - 0.1237N + 4.8458N^{0.5} + 0.0829P \dots (470)$$

$$R = 0.83289, R^2 = 0.69, n = 450$$

Variable	T-value	Probability Level
N	-5.3131	0.001
$N^{0.5}$	14.2734	0.001
P	3.3320	0.001

$$\text{iii)} \quad Y = a + bN + cN^{0.5} + dNP$$

$$Y = 27.8878 - 0.1422N + 4.8458N^{0.5} + 0.0007NP \dots (471)$$

$$R = 0.83306, R^2 = 0.69, n = 450$$

Variable	T-value	Probability Level
N	-5.9515	0.001
$N^{0.5}$	14.2798	0.001
NP	3.3925	0.001

$$\text{iv)} \quad Y = a + bN + cN^2 + dN^{0.5}$$

$$Y = 28.4924 + 0.2537N + 2.2007N^{0.5} - 0.0010N^2 \dots (472)$$

$$R = 0.83434, R^2 = 0.70, n = 450$$

Variable	T-value	Probability Level
N	2.5120	0.01
N^2	-3.8389	0.001
$N^{0.5}$	2.8672	0.005

$$\text{v)} \quad Y = a + bN + cN^{0.5} + dN^2 + eP$$

$$Y = 26.2810 + 0.2537N + 2.2007N^{0.5} - 0.0010N^2 + 0.0829P \dots (473)$$

$$R = 0.83890, R^2 = 0.70, n = 450$$

Variable	T-value	Probability Level
N	2.5413	0.025
$N^{0.5}$	2.9006	0.005
N^2	-3.8836	0.001
P	3.3842	0.001

$$\text{vi) } Y = a + bN + cN^{0.5} + dN^2 + eNP$$

$$Y = 28.4924 + 0.2351N + 2.2007N^{0.5} - 0.0010N^2 +$$

$$0.0007NP \dots \dots \dots (474)$$

$$R = 0.83906, R^2 = 0.70, n = 450$$

Variable	T-value	Probability Level
N	2.3528	0.025
$N^{0.5}$	2.9019	0.005
N^2	-3.8854	0.001
NP	3.4457	0.001

c. 1.5 Power Functions

$$\text{i) } Y = a + bN + cN^{1.5}$$

$$Y = 28.9432 + 0.7844N - 0.0002N^{1.5} \dots \dots \dots (475)$$

$$R = 0.83414, R^2 = 0.70, n = 450$$

Variable	T-value	Probability Level
N	19.4055	0.001
$N^{1.5}$	-14.8265	0.001

$$\text{ii) } Y = a + bN + cN^{1.5} + dP$$

$$Y = 26.7319 + 0.7844N - 0.0002N^{1.5} + 0.0829P \dots \dots (476)$$

$$R = 0.83870, R^2 = 0.70, n = 450$$

Variable	T-value	Probability Level
N	19.6314	0.001
$N^{1.5}$	-14.9991	0.001
P	3.3861	0.001

$$\text{iii) } Y = a + bN + cN^{1.5} + dNP$$

$$Y = 28.9432 + 0.7658N - 0.002N^{1.5} + 0.0007NP \dots (477)$$

$$R = 0.83886, R^2 = 0.70, n = 450$$

Variable	T-value	Probability Level
N	19.0028	0.001
$N^{1.5}$	-15.0060	0.001
NP	3.4476	0.001

d. Cobb-Douglas Function

$$\text{i) } Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.2456 + 0.1081 \text{ Log } N \dots (478)$$

$$R = 0.80443, R^2 = 0.65, n = 450$$

Variable	T-value	Probability Level
Log N	28.6622	0.001

$$\text{ii) } Y = aN^bP^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 3.2102 + 0.1081 \text{ Log } N + 0.0072 \text{ Log } P \dots (479)$$

$$R = 0.80660, R^2 = 0.65, n = 450$$

Variable	T-value	Probability Level
Log N	28.7729	0.001
Log P	2.1134	0.05

NON-SOIL TEST YEARS - 1962, 1963, 1964, 1966, 1967, 1969, 1970.

1. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 40,2305 + 0.4420N - 0.0015N^2 \dots\dots\dots(480)$$

$$R = 0.80391, R^2 = 0.65, n = 360$$

Variable	T-value	Probability Level
N	19.0247	0.001
N^2	-13.4838	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 38.0898 - 0.1498N + 4.4442N^{0.5} \dots\dots\dots(481)$$

$$R = 0.80926, R^2 = 0.65, n = 360$$

Variable	T-value	Probability Level
N	-6.8698	0.001
$N^{0.5}$	13.9741	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 39.3500 + 0.6778N - 0.0372N^{1.5} \dots\dots\dots(482)$$

$$R = 0.81097, R^2 = 0.66, n = 360$$

Variable	T-value	Probability Level
N	17.6069	0.001
$N^{1.5}$	-14.1333	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6295 + 0.1216 \text{ Log } N \dots\dots\dots (483)$$

$$R = 0.82544, R^2 = 0.68, n = 360$$

Variable	T-value	Probability Level
Log N	27.6676	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 42.3916 + 0.4541N - 0.0015N^2 \dots\dots\dots (484)$$

$$R = 0.86467, R^2 = 0.75, n = 360$$

Variable	T-value	Probability Level
N	22.4408	0.001
N^2	- 14.9402	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 40.0735 - 0.1242N + 4.3987N^{0.5} \dots\dots\dots (485)$$

$$R = 0.87397, R^2 = 0.76, n = 360$$

Variable	T-value	Probability Level
N	-6.6794	0.001
$N^{0.5}$	16.2159	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 41.5256 + 0.6825N - 0.0360N^{1.5} \dots\dots\dots(486)$$

$$R = 0.87079, R^2 = 0.76, n = 360$$

Variable	T-value	Probability Level
N	20.4645	0.001
$N^{1.5}$	-15.7704	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\log Y = \log a + b \log N$$

$$\log Y = \log 3.6659 + 0.1289 \log N \dots\dots\dots(487)$$

$$R = 0.86404, R^2 = 0.75, n = 360$$

Variable	T-value	Probability Level
Log N	32.4749	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 42.0617 + 0.4898N - 0.0017N^2 \dots\dots\dots(488)$$

$$R = 0.87608, R^2 = 0.77, n = 360$$

Variable	T-value	Probability Level
N	25.3650	0.001
N^2	-17.8607	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 39.8247 - 0.1583N + 4.8404N^{0.5} \dots\dots\dots(489)$$

$$R = 0.87910, R^2 = 0.77, n = 360$$

Variable	T-value	Probability Level
N	-8.7276	0.001
$N^{0.5}$	18.2975	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 41.1511 + 0.7458N - 0.0407N^{1.5} \dots\dots\dots(490)$$

$$R = 0.88205, R^2 = 0.79, n = 360$$

Variable	T-value	Probability Level
N	23.4688	0.001
$N^{1.5}$	-18.7347	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6758 + 0.1276 \text{ Log } N \dots\dots\dots(491)$$

$$R = 0.88416, R^2 = 0.78, n = 360$$

Variable	T-value	Probability Level
Log N	35.8089	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Functions

i) $Y = a + bN + cN^2$

$$Y = 41.5613 + 0.4620N - 0.0015N^2 \dots\dots\dots(492)$$

$$R = 0.83986, R^2 = 0.71, n = 1080$$

Variable	T-value	Probability Level
N	36.7834	0.001
N^2	-25.4924	0.001

ii) $Y = a + bN + cN^2 + dP$

$$Y = 38.7200 + 0.4620N - 0.0015N^2 + 0.1065P \dots\dots(493)$$

$$R = 0.85114, R^2 = 0.72, n = 1080$$

Variable	T-value	Probability Level
N	38.0178	0.001
N^2	-26.3479	0.001
P	8.6313	0.001

iii) $Y = a + bN + cN^2 + dNP$

$$Y = 41.5613 + 0.4384N - 0.0015N^2 + 0.0009NP \dots\dots(494)$$

$$R = 0.85129, R^2 = 0.72, n = 1080$$

Variable	T-value	Probability Level
N	35.2207	0.001
N^2	-26.3601	0.001
NP	8.6932	0.001

$$\text{iv) } Y = a + bN + cN^2 + dP + eNP$$

$$Y = 40.0545 + 0.4486N - 0.0015N^2 + 0.0565P + 0.0005NP \dots (495)$$

$$R = 0.85230, R^2 = 0.73, n = 1080$$

Variable	T-value	Probability Level
N	34.4267	0.001
N ²	-26.4300	0.001
P	2.5900	0.01
NP	2.7780	0.01

b. Square Root Functions

$$\text{i) } Y = a + bN + cN^{0.5}$$

$$Y = 39.3293 - 0.1441N + 4.5611N^{0.5} \dots (496)$$

$$R = 0.84585, R^2 = 0.72, n = 1080$$

Variable	T-value	Probability Level
N	-12.2888	0.001
N ^{0.5}	26.6677	0.001

$$\text{ii) } Y = a + bN + cN^{0.5} + dP$$

$$Y = 36.4881 - 0.1441N + 4.5611N^{0.5} + 0.1065P \dots (497)$$

$$R = 0.85706, R^2 = 0.73, n = 1080$$

Variable	T-value	Probability Level
N	-12.7168	0.001
N ^{0.5}	27.5965	0.001
P	8.7940	0.001

$$\text{iii) } Y = a + bN + cN^{0.5} + dNP$$

$$Y = 39.3293 - 0.1677 + 4.5611N^{0.5} + 0.0009NP \dots (498)$$

$$R = 0.85721, R^2 = 0.73, n = 1080$$

Variable	T-value	Probability Level
N	-14.4144	0.001
$N^{0.5}$	27.6099	0.001
NP	8.8573	0.001

$$\text{iv) } Y = a + bN + cN^{0.5} + dP + eNP$$

$$Y = 37.8226 - 0.1574N + 4.5611N^{0.5} + 0.0565P + 0.0005NP \dots (499)$$

$$R = 0.85820, R^2 = 0.74, n = 1080$$

Variable	T-value	Probability Level
N	-12.8640	0.001
$N^{0.5}$	27.6863	0.001
P	2.6392	0.01
NP	2.8308	0.005

$$\text{v) } Y = a + bN^{0.5} + cN^2 + dP$$

$$Y = 36.6261 + 3.5809N^{0.5} - 0.0004N^2 + 0.1065P \dots (500)$$

$$R = 0.85984, R^2 = 0.74, n = 1080$$

Variable	T-value	Probability Level
$N^{0.5}$	39.8650	0.001
N^2	-13.5787	0.001
P	8.8741	0.001

$$\text{vi)} \quad Y = a + bN^{0.5} + cN^2 + dNP$$

$$Y = 39.5325 + 3.4055N - 0.0005N^2 + 0.0009NP \dots (501)$$

$$R = 0.86018, R^2 = 0.74, n = 1080$$

Variable	T-value	Probability Level
$N^{0.5}$	37.0939	0.001
N^2	-15.2640	0.001
NP	9.0210	0.001

$$\text{vii)} \quad Y = a + bN^{0.5} + cN^2 + dP + eNP$$

$$Y = 38.0610 + 3.4779N - 0.0004N^2 + 0.0542P + 0.0005NP \dots (502)$$

$$R = 0.86110, R^2 = 0.74, n = 1080$$

Variable	T-value	Probability Level
$N^{0.5}$	36.2913	0.001
N^2	-13.7616	0.001
P	2.5625	0.025
NP	3.0048	0.005

c. 1.5 Power Functions

$$\text{i)} \quad Y = a + bN + cN^{1.5}$$

$$Y = 40.6150 + 0.6934N - 0.0001N^{1.5} \dots (503)$$

$$R = 0.84630, R^2 = 0.72, n = 1080$$

Variable	T-value	Probability Level
N	33.9426	0.001
$N^{1.5}$	-26.7578	0.001

$$\text{ii) } Y = a + bN + cN^{1.5} + dP$$

$$Y = 37.7738 + 0.6934N - 0.0001N^{1.5} + 0.1065P \dots (504)$$

$$R = 0.85750, R^2 = 0.74, n = 1080$$

Variable	T-value	Probability Level
N	35.1283	0.001
$N^{1.5}$	-27.6925	0.001
P	8.8067	0.001

$$\text{iii) } Y = a + bN + cN^{1.5} + dNP$$

$$Y = 40.6150 + 0.6698N - 0.0001N^{1.5} + 0.0009NP \dots (505)$$

$$R = 0.85765, R^2 = 0.74, n = 1080$$

Variable	T-value	Probability Level
N	33.6432	0.001
$N^{1.5}$	-27.7060	0.001
NP	8.8700	0.001

$$\text{iv) } Y = a + bN + cN^{1.5} + dP + eNP$$

$$Y = 39.1082 + 0.6801N - 0.0001N^{1.5} + 0.0565P + 0.0005NP \dots (506)$$

$$R = 0.85865, R^2 = 0.74, n = 1080$$

Variable	T-value	Probability Level
N	33.6159	0.001
$N^{1.5}$	-27.7829	0.001
P	2.6430	0.01
NP	2.8349	0.005

d. Cobb-Douglas Functions

i) $Y = aN^b$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6481 + 0.0717 \text{ Log } N \dots\dots\dots(507)$$

$$R = 0.84320, R^2 = 0.71, n = 1080$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
Log N	51.4970	0.001

ii) $Y = aN^bP^c$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 3.6035 + 0.0717 \text{ Log } N + 0.0091 \text{ Log } P \dots\dots(508)$$

$$R = 0.85140, R^2 = 0.72, n = 1080$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
Log N	52.7576	0.001
Log P	7.3772	0.001

iii) $Y = aN^bK^c$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } K$$

$$\text{Log } Y = \text{Log } 3.6357 + 0.0717 \text{ Log } N + 0.0051 \text{ Log } K \dots\dots(509)$$

$$R = 0.84575, R^2 = 0.72, n = 1080$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
Log N	51.8614	0.001
Log K	4.0385	0.001

1961-1965

1. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 33.4832 + 0.4739N - 0.0015N^2 \dots \dots \dots (510)$$

$$R = 0.78639, R^2 = 0.62, n = 210$$

Variable	T-value	Probability Level
N	12.3418	0.001
N^2	- 8.0520	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 31.8859 - 0.0954N + 4.1602N^{0.5} \dots \dots \dots (511)$$

$$R = 0.78204, R^2 = 0.61, n = 210$$

Variable	T-value	Probability Level
N	-2.5916	0.001
$N^{0.5}$	7.7500	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 32.7387 + 0.6990N - 0.0362N^{1.5} \dots \dots \dots (512)$$

$$R = 0.78892, R^2 = 0.62, n = 210$$

Variable	T-value	Probability Level
N	10.8668	0.001
$N^{1.5}$	- 8.2282	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.3762 + 0.1654 \text{ Log } N \dots \dots \dots (513)$$

$$R = 0.76250, R^2 = 0.58, n = 210$$

Variable	T-value	Probability Level
Log N	16.9969	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 35.9980 + 0.4454N - 0.0013N^2 \dots \dots \dots (514)$$

$$R = 0.78752, R^2 = 0.62, n = 210$$

Variable	T-value	Probability Level
N	11.7188	0.001
N^2	- 7.3015	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 33.9781 - 0.0801N + 3.9695N^{0.5} \dots \dots \dots (515)$$

$$R = 0.79163, R^2 = 0.63, n = 210$$

Variable	T-value	Probability Level
N	-2.2448	0.025
$N^{0.5}$	7.6037	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 35.2185 + 0.6531N - 0.0328N^{1.5} \dots\dots\dots(516)$$

$$R = 0.79118, R^2 = 0.63, n = 210$$

Variable	T-value	Probability Level
N	10.2841	0.001
$N^{1.5}$	- 7.5711	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.4043 + 0.1667 \text{ Log } N \dots\dots\dots(517)$$

$$R = 0.75496, R^2 = 0.57, n = 210$$

Variable	T-value	Probability Level
Log N	16.5638	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 35.3365 + 0.4918N - 0.0016N^2 \dots\dots\dots(518)$$

$$R = 0.79387, R^2 = 0.63, n = 210$$

Variable	T-value	Probability Level
N	12.8541	0.001
N^2	- 8.4980	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 33.7616 - 0.1038N + 4.3294N^{0.5} \dots\dots\dots(519)$$

$$R = 0.78761, R^2 = 0.62, n = 210$$

Variable	T-value	Probability Level
N	-2.8196	0.005
$N^{0.5}$	8.0583	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 34.6081 + 0.7253N - 0.0378N^{1.5} \dots\dots\dots(520)$$

$$R = 0.79558, R^2 = 0.63, n = 210$$

Variable	T-value	Probability Level
N	11.2974	0.001
$N^{1.5}$	- 8.6184	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.4202 + 0.1652 \text{ Log } N \dots\dots\dots(521)$$

$$R = 0.76245, R^2 = 0.58, n = 210$$

Variable	T-value	Probability Level
Log N	16.9945	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Functions

i) $Y = a + bN + cN^2$

$$Y = 34.8821 + 0.4714N - 0.0015N^2 \dots\dots\dots (522)$$

$$R = 0.78865, R^2 = 0.62, n = 630$$

Variable	T-value	Probability Level
N	21.3966	0.001
N^2	-13.8217	0.001

ii) $Y = a + bN + cN^2 + dP$

$$Y = 33.4033 + 0.4714N - 0.0015N^2 + 0.0555P \dots\dots (523)$$

$$R = 0.79099, R^2 = 0.63, n = 630$$

Variable	T-value	Probability Level
N	21.4850	0.001
N^2	-13.8788	0.001
P	2.4882	0.025

iii) $Y = a + bN + cN^2 + dNP$

$$Y = 33.4033 + 0.4714N - 0.0015N^2 + 0.0555NP \dots\dots (524)$$

$$R = 0.79099, R^2 = 0.63, n = 630$$

Variable	T-value	Probability Level
N	21.4850	0.001
N^2	-13.8788	0.001
NP	2.4882	0.025

b. Square Root Functions

i) $Y = a + bN + cN^{0.5}$

$$Y = 33.1593 - 0.0936N + 4.1631N^{0.5} \dots\dots\dots(525)$$

$$R = 0.78669, R^2 = 0.62, n = 630$$

Variable	T-value	Probability Level
N	-4.4527	0.001
$N^{0.5}$	13.5809	0.001

ii) $Y = a + bN + cN^{0.5} + dP$

$$Y = 31.6804 - 0.0936N + 4.1631N^{0.5} + 0.0555P \dots\dots(526)$$

$$R = 0.78904, R^2 = 0.62, n = 630$$

Variable	T-value	Probability Level
N	-4.4709	0.001
$N^{0.5}$	13.6364	0.001
P	2.4781	0.025

iii) $Y = a + bN + cN^{0.5} + dN^2$

$$Y = 33.6693 + 0.2248N + 1.9314N^{0.5} - 0.0009N^2 \dots\dots(527)$$

$$R = 0.79161, R^2 = 0.63, n = 630$$

Variable	T-value	Probability Level
N	2.4788	0.025
$N^{0.5}$	2.8024	0.01
N^2	-3.6069	0.001

$$\text{iv)} \quad Y = a + bN + cN^{0.5} + dN^2 + dP$$

$$Y = 32.1904 + 0.2248N + 1.9314N^{0.5} - 0.0009N^2 + 0.0555P \dots \dots \dots (528)$$

$$R = 0.79395, R^2 = 0.63, n = 630$$

Variable	T-value	Probability Level
N	2.4892	0.025
$N^{0.5}$	2.8142	0.005
N^2	-3.6220	0.001
P	2.5019	0.025

c. 1.5 Power Functions

$$\text{i)} \quad Y = a + bN + cN^{1.5}$$

$$Y = 34.0802 + 0.6857N - 0.0001N^{1.5} \dots \dots \dots (529)$$

$$R = 0.79137, R^2 = 0.63, n = 630$$

Variable	T-value	Probability Level
N	18.8869	0.001
$N^{1.5}$	-14.1580	0.001

$$\text{ii)} \quad Y = a + bN + cN^{1.5} + dP$$

$$Y = 32.6013 + 0.6857N - 0.0001N^{1.5} + 0.0555P \dots \dots (530)$$

$$R = 0.79370, R^2 = 0.63, n = 630$$

Variable	T-value	Probability Level
N	18.9660	0.001
$N^{1.5}$	-14.2173	0.001
P	2.5026	0.025

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.3930 + 0.0936 \text{ Log } N \dots\dots\dots (531)$$

$$R = 0.74721, R^2 = 0.59, n = 630$$

Variable	T-value	Probability Level
Log N	28.1757	0.001

1966-19701. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 39.3513 + 0.4557N - 0.0018N^2 \dots\dots\dots (532)$$

$$R = 0.81863, R^2 = 0.67, n = 300$$

Variable	T-value	Probability Level
N	18.9531	0.001
N^2	-13.8108	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 36.8905 - 0.1770N + 4.7941N^{0.5} \dots\dots\dots (533)$$

$$R = 0.82963, R^2 = 0.69, n = 300$$

Variable	T-value	Probability Level
N	-7.9742	0.001
$N^{0.5}$	14.8021	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 38.3717 + 0.7083N - 0.0396N^{1.5} \dots\dots\dots(534)$$

$$R = 0.82812, R^2 = 0.69, n = 300$$

Variable	T-value	Probability Level
N	17.9234	0.001
$N^{1.5}$	-14.6626	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6139 + 0.1226 \text{ Log } N \dots\dots\dots(535)$$

$$R = 0.86247, R^2 = 0.74, n = 300$$

Variable	T-value	Probability Level
Log N	29.4184	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 49.7569 + 0.4936N - 0.0016N^2 \dots\dots\dots(536)$$

$$R = 0.89391, R^2 = 0.80, n = 300$$

Variable	T-value	Probability Level
N	24.5491	0.001
N^2	-16.8201	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 38.6639 - 0.1488N + 4.8523N^{0.5} \dots\dots\dots(537)$$

$$R = 0.90158, R^2 = 0.81, n = 300$$

Variable	T-value	Probability Level
N	-8.0737	0.001
$N^{0.5}$	18.0441	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 40.1670 + 0.7470N - 0.0401N^{1.5} \dots\dots\dots(538)$$

$$R = 0.90025, R^2 = 0.81, n = 300$$

Variable	T-value	Probability Level
N	22.7130	0.001
$N^{1.5}$	-17.8243	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6476 + 0.1342 \text{ Log } N \dots\dots\dots(539)$$

$$R = 0.91241, R^2 = 0.83, n = 300$$

Variable	T-value	Probability Level
Log N	38.4840	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 40.7281 + 0.5259N - 0.0018N^2 \dots\dots\dots(540)$$

$$R = 0.90335, R^2 = 0.82, n = 300$$

Variable	T-value	Probability Level
N	27.3070	0.001
N^2	-19.5062	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 38.2284 - 0.1818N + 5.2999N^{0.5} \dots\dots\dots(541)$$

$$R = 0.90807, R^2 = 0.82, n = 300$$

Variable	T-value	Probability Level
N	-10.1759	0.001
$N^{0.5}$	20.3353	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 39.7203 + 0.8057N - 0.0444N^{1.5} \dots\dots\dots(542)$$

$$R = 0.91033, R^2 = 0.83, n = 300$$

Variable	T-value	Probability Level
N	25.7412	0.001
$N^{1.5}$	-20.7493	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6483 + 0.1349 \text{ Log } N \dots \dots \dots (543)$$

$$R = 0.92313, R^2 = 0.85, n = 300$$

Variable	T-value	Probability Level
Log N	41.4470	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Functions

$$i) Y = a + bN + cN^2$$

$$Y = 40.3932 + 0.4917N - 0.0017N^2 \dots \dots \dots (544)$$

$$R = 0.85986, R^2 = 0.74, n = 900$$

Variable	T-value	Probability Level
N	37.5934	0.001
N^2	-26.6538	0.001

$$ii) Y = a + bN + cN^2 + dP$$

$$Y = 36.9132 + 0.4917N - 0.0017N^2 + 0.1305P \dots \dots (545)$$

$$R = 0.87601, R^2 = 0.77, n = 900$$

Variable	T-value	Probability Level
N	36.6547	0.001
N^2	-28.3688	0.001
P	10.9612	0.001

$$\text{iii) } Y = a + bN + cN^2 + dP + eNP$$

$$Y = 38.9263 + 0.4716N - 0.0017N^2 + 0.0550P +$$

$$0.0008NP \dots \dots \dots (546)$$

$$R = 0.87850, R^2 = 0.77, n = 900$$

Variable	T-value	Probability Level
N	35.7756	0.001
N^2	-28.4512	0.001
P	2.4927	0.025
NP	4.1426	0.001

b. Square Root Functions

$$\text{i) } Y = a + bN + cN^{0.5}$$

$$Y = 37.9276 - 0.1692N + 4.9821N^{0.5} \dots \dots \dots (547)$$

$$R = 0.86744, R^2 = 0.75, n = 900$$

Variable	T-value	Probability Level
N	-13.9741	0.001
$N^{0.5}$	28.2020	0.001

$$\text{ii) } Y = a + bN + cN^{0.5} + dP$$

$$Y = 34.4477 - 0.1692N + 4.9821N^{0.5} + 0.1305P \dots \dots (548)$$

$$R = 0.88344, R^2 = 0.78, n = 900$$

Variable	T-value	Probability Level
N	-14.8311	0.001
$N^{0.5}$	29.9314	0.001
P	10.6950	0.001

$$\text{iii) } Y = a + bN + cN^{0.5} + dNP$$

$$Y = 37.9276 - 0.1994N + 4.9821N^{0.5} + 0.0011NP \dots (549)$$

$$R = 0.88502, R^2 = 0.78, n = 900$$

Variable	T-value	Probability Level
N	-17.1159	0.001
$N^{0.5}$	30.1236	0.001
NP	11.2871	0.001

$$\text{iv) } Y = a + bN + cN^{0.5} + dP + eNP$$

$$Y = 36.4607 - 0.1894N + 4.9821N^{0.5} + 0.0550P + 0.0008NP \dots (550)$$

$$R = 0.88592, R^2 = 0.78, n = 900$$

Variable	T-value	Probability Level
N	-15.4609	0.001
$N^{0.5}$	30.2174	0.001
P	2.5673	0.025
NP	4.2667	0.001

$$\text{v) } Y = a + bN^2 + cN^{0.5} + dP$$

$$Y = 34.6421 + 3.8205N^{0.5} - 0.0005N^2 + 0.1305P \dots (551)$$

$$R = 0.88650, R^2 = 0.79, n = 900$$

Variable	T-value	Probability Level
N^2	-15.7538	0.001
$N^{0.5}$	42.3768	0.001
P	10.8294	0.001

$$\text{vi) } Y = a + bN^2 + cN^{0.5} + dP + eNP$$

$$Y = 36.7545 + 3.6688N^{0.5} - 0.0005N^2 + 0.0534P +$$

$$0.0008NP \dots \dots \dots (552)$$

$$R = 0.88910, R^2 = 0.79, n = 900$$

Variable	T-value	Probability Level
N^2	-16.4196	0.001
$N^{0.5}$	38.3965	0.001
P	2.5331	0.025
NP	4.4367	0.001

c. 1.5 Power Functions

$$\text{i) } Y = a + bN + cN^{1.5}$$

$$Y = 39.3535 + 0.7443N - 0.0002N^{1.5} \dots \dots \dots (553)$$

$$R = 0.86740, R^2 = 0.75, n = 900$$

Variable	T-value	Probability Level
N	35.2226	0.001
$N^{1.5}$	-28.1953	0.001

$$\text{ii) } Y = a + bN + cN^{1.5} + dP$$

$$Y = 35.8735 + 0.7443N - 0.0002N^{1.5} + 0.1305P \dots \dots (554)$$

$$R = 0.88341, R^2 = 0.78, n = 900$$

Variable	T-value	Probability Level
N	37.3819	0.001
$N^{1.5}$	-29.9238	0.001
P	10.6936	0.001

$$\text{iii) } Y = a + bN + cN^{1.5} + dNP$$

$$Y = 39.3535 + 0.7142N - 0.0002N^{1.5} + 0.0011NP \dots (555)$$

$$R = 0.88499, R^2 = 0.78, n = 900$$

Variable	T-value	Probability Level
N	35.7744	0.001
$N^{1.5}$	-30.1159	0.001
NP	11.2856	0.001

$$\text{iv) } Y = a + bN + cN^{1.5} + dP + eNP$$

$$Y = 37.8866 + 0.7242N - 0.0002N^{1.5} + 0.0550P + 0.0008NP \dots (556)$$

$$R = 0.88589, R^2 = 0.78, n = 900$$

Variable	T-value	Probability Level
N	35.7104	0.001
$N^{1.5}$	-30.2097	0.001
P	2.5670	0.025
NP	4.2662	0.001

d. Cobb-Douglas Functions

$$\text{i) } Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.6254 + 0.0746 \text{ Log } N \dots (557)$$

$$R = 0.88479, R^2 = 0.78, n = 900$$

Variable	T-value	Probability Level
Log N	56.8983	0.001

$$\text{ii) } Y = aN^bP^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 3.5719 + 0.0746 \text{ Log } N + 0.0109 \text{ Log } P \dots (558)$$

$$R = 0.89623, R^2 = 0.80, n = 900$$

Variable	T-value	Probability Level
Log N	59.7389	0.001
Log P	9.6385	0.001

$$\text{iii) } Y = aN^bK^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } K$$

$$\text{Log } Y = \text{Log } 3.6111 + 0.0746 \text{ Log } N + 0.0058 \text{ Log } K \dots (559)$$

$$R = 0.88806, R^2 = 0.79, n = 900$$

Variable	T-value	Probability Level
Log N	57.6417	0.001
Log K	4.9615	0.001

1961 - 1970

1. ($P_2O_5 = 0$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 36.9350 + 0.4632N - 0.0015N^2 \dots (560)$$

$$R = 0.79462, R^2 = 0.63, n = 510$$

Variable	T-value	Probability Level
N	21.4832	0.001
N^2	-14.9642	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 34.8298 - 0.1434N + 4.5331N^{0.5} \dots\dots\dots(561)$$

$$R = 0.79750, R^2 = 0.64, n = 510$$

Variable	T-value	Probability Level
N	-7.0463	0.001
$N^{0.5}$	15.2680	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 36.0522 + 0.7045N - 0.0382N^{1.5} \dots\dots\dots(562)$$

$$R = 0.80051, R^2 = 0.64, n = 510$$

Variable	T-value	Probability Level
N	19.6547	0.001
$N^{1.5}$	-15.5900	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.5160 + 0.1402 \text{ Log } N \dots\dots\dots(563)$$

$$R = 0.78832, R^2 = 0.62, n = 510$$

Variable	T-value	Probability Level
Log N	28.8782	0.001

2. ($P_2O_5 = 40$, $K_2O = 0$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 39.0285 + 0.4732N - 0.0015N^2 \dots\dots\dots(564)$$

$$R = 0.83096, R^2 = 0.69, n = 510$$

Variable	T-value	Probability Level
N	22.9790	0.001
N^2	-15.1903	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 36.7666 - 0.1202N + 4.4822N^{0.5} \dots\dots\dots(565)$$

$$R = 0.83683, R^2 = 0.70, n = 510$$

Variable	T-value	Probability Level
N	-6.2531	0.001
$N^{0.5}$	15.9620	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 38.1595 + 0.7075N - 0.0371N^{1.5} \dots\dots\dots(566)$$

$$R = 0.83597, R^2 = 0.70, n = 510$$

Variable	T-value	Probability Level
N	20.6819	0.001
$N^{1.5}$	-15.8477	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.5490 + 0.1472 \text{ Log } N \dots \dots \dots (567)$$

$$R = 0.80302, R^2 = 0.64, n = 510$$

Variable	T-value	Probability Level
Log N	30.4505	0.001

3. ($P_2O_5 = 40$, $K_2O = 40$, N variable)

a. Quadratic Function

$$Y = a + bN + cN^2$$

$$Y = 38.4674 + 0.5126N - 0.0017N^2 \dots \dots \dots (568)$$

$$R = 0.83959, R^2 = 0.70, n = 510$$

Variable	T-value	Probability Level
N	25.2264	0.001
N^2	17.4923	0.001

b. Square Root Function

$$Y = a + bN + cN^{0.5}$$

$$Y = 36.3407 - 0.1502N + 4.9101N^{0.5} \dots \dots \dots (569)$$

$$R = 0.83891, R^2 = 0.70, n = 510$$

Variable	T-value	Probability Level
N	-7.7646	0.001
$N^{0.5}$	17.4035	0.001

c. 1.5 Power Function

$$Y = a + bN + cN^{1.5}$$

$$Y = 37.5723 + 0.7738N - 0.0418N^2 \dots \dots \dots (570)$$

$$R = 0.84398, R^2 = 0.71, n = 510$$

Variable	T-value	Probability Level
N	22.9000	0.001
$N^{1.5}$	-18.0794	0.001

d. Cobb-Douglas Function

$$Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.5529 + 0.1477 \text{ Log } N \dots \dots \dots (571)$$

$$R = 0.81414, R^2 = 0.66, n = 510$$

Variable	T-value	Probability Level
Log N	31.6008	0.001

4. (P_2O_5 , K_2O , N variable)

a. Quadratic Functions

$$i) Y = a + bN + cN^2$$

$$Y = 38.1239 + 0.4834N - 0.0016N^2 \dots \dots \dots (572)$$

$$R = 0.81625, R^2 = 0.67, n = 1530$$

Variable	T-value	Probability Level
N	39.3364	0.001
N^2	-26.8941	0.001

ii) $Y = a + bN + cN^2 + dP$

$$Y = 35.4679 + 0.4834N - 0.0016N^2 + 0.0996P \dots (573)$$

$$R = 0.82473, R^2 = 0.70, n = 1530$$

Variable	T-value	Probability Level
N	40.1698	0.001
N^2	-27.4639	0.001
P	8.1481	0.001

iii) $Y = a + bN + cN^2 + dNP$

$$Y = 38.1239 + 0.4612N - 0.0016N^2 + 0.0008NP \dots (574)$$

$$R = 0.82489, R^2 = 0.68, n = 1530$$

Variable	T-value	Probability Level
N	37.4211	0.001
N^2	-27.4752	0.001
NP	8.2281	0.001

iv) $Y = a + bN + cN^2 + dP + eNP$

$$Y = 36.7340 + 0.4707N - 0.0016N^2 + 0.0521P + 0.0005NP \dots (575)$$

$$R = 0.82563, R^2 = 0.68, n = 1530$$

Variable	T-value	Probability Level
N	36.4352	0.001
N^2	-27.5184	0.001
P	2.4101	0.05
NP	2.6585	0.01

b. Square Root Functions

i) $Y = a + bN + cN^{0.5}$

$$Y = 35.9642 - 0.1381N + 4.6448N^{0.5} \dots\dots\dots(576)$$

$$R = 0.81903, R^2 = 0.67, n = 1530$$

Variable	T-value	Probability Level
N	-11.9098	0.001
$N^{0.5}$	27.4651	0.001

ii) $Y = a + bN + cN^{0.5} + dP$

$$Y = 33.3082 - 0.1381N + 4.6448N^{0.5} + 0.0996P \dots\dots(577)$$

$$R = 0.82748, R^2 = 0.68, n = 1530$$

Variable	T-value	Probability Level
N	-12.1658	0.001
$N^{0.5}$	28.0554	0.001
P	8.2066	0.001

iii) $Y = a + bN + cN^{0.5} + dNP$

$$Y = 35.9642 - 0.1602N + 4.6448N^{0.5} + 0.0008NP \dots\dots(578)$$

$$R = 0.82764, R^2 = 0.68, n = 1530$$

Variable	T-value	Probability Level
N	-13.7463	0.001
$N^{0.5}$	28.0671	0.001
NP	8.2872	0.001

$$\text{iv) } Y = a + bN + cN^{0.5} + dP + eNP$$

$$Y = 34.5742 - 0.1507N + 4.6448N + 0.0521P +$$

$$0.0005NP, \dots (579)$$

$$R = 0.82837, R^2 = 0.69, n = 1530$$

Variable	T-value	Probability Level
N	-12.2810	0.001
$N^{0.5}$	28.1120	0.001
P	2.4275	0.025
NP	2.6777	0.01

$$\text{v) } Y = a + bN + cN^{0.5} + dN^2$$

$$Y = 36.3973 + 0.1323N + 2.7496N^{0.5} - 0.0007N^2, \dots (580)$$

$$R = 0.82300, R^2 = 0.67, n = 1530$$

Variable	T-value	Probability Level
N	2.6447	0.01
$N^{0.5}$	7.2327	0.001
N^2	-5.5533	0.001

$$\text{vi) } Y = a + bN + cN^{0.5} + dN^2 + eP$$

$$Y = 33.7413 + 0.1323 + 2.7496N^{0.5} - 0.0007N^2 +$$

$$0.0996P, \dots (581)$$

$$R = 0.83141, R^2 = 0.69, n = 1530$$

Variable	T-value	Probability Level
N	2.7028	0.01
$N^{0.5}$	7.3915	0.001
N^2	-5.6752	0.001
P	8.2901	0.001

$$\text{vii) } Y = a + bN + cN^{0.5} + dN^2 + eP + fNP$$

$$Y = 35.0074 + 0.1196N + 2.7496N^{0.5} - 0.0007N^2 +$$

$$0.0521P + 0.0005NP \dots \dots \dots (582)$$

$$R = 0.83230, R^2 = 0.69, n = 1530$$

Variable	T-value	Probability Level
N	2.4380	0.025
$N^{0.5}$	7.4068	0.001
N^2	-5.6869	0.001
P	2.4523	0.025
NP	2.7050	0.01

c. 1.5 Power Functions

$$\text{i) } Y = a + bN + cN^{1.5}$$

$$Y = 37.1821 + 0.7202N - 0.0002N^{1.5} \dots \dots \dots (583)$$

$$R = 0.82140, R^2 = 0.67, n = 1530$$

Variable	T-value	Probability Level
N	35.8162	0.001
$N^{1.5}$	-27.9562	0.001

$$\text{ii) } Y = a + bN + cN^{1.5} + dP$$

$$Y = 34.5261 + 0.7202N - 0.0002N^{1.5} + 0.0996P \dots \dots (584)$$

$$R = 0.82140, R^2 = 0.67, n = 1530$$

Variable	T-value	Probability Level
N	36.5957	0.001
$N^{1.5}$	-28.5646	0.001
P	8.2576	0.001

$$\text{iii) } Y = a + bN + cN^{1.5} + dNP$$

$$Y = 37.1821 + 0.6980N - 0.0002N^{1.5} + 0.0008NP \dots (585)$$

$$R = 0.82998, R^2 = 0.69, n = 1530$$

Variable	T-value	Probability Level
N	35.1670	0.001
$N^{1.5}$	-28.5766	0.001
NP	8.3387	0.001

$$\text{iv) } Y = a + bN + cN^{1.5} + dP + eNP$$

$$Y = 35.7922 + 0.7075N - 0.0002N^{1.5} + 0.0521P +$$

$$0.0005NP \dots \dots \dots (586)$$

$$R = 0.83071, R^2 = 0.69, n = 1530$$

Variable	T-value	Probability Level
N	35.0372	0.001
$N^{1.5}$	-28.6231	0.001
P	2.4426	0.025
NP	2.6944	0.01

d. Cobb-Douglas Functions

$$\text{i) } Y = aN^b$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N$$

$$\text{Log } Y = \text{Log } 3.5297 + 0.0824 \text{ Log } N \dots \dots \dots (587)$$

$$R = 0.78986, R^2 = 0.62, n = 1530$$

Variable	T-value	Probability Level
Log N	50.3444	0.001

$$\text{ii) } Y = aN^bP^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } P$$

$$\text{Log } Y = \text{Log } 3.4878 + 0.0824 \text{ Log } N + 0.0085 \text{ Log } P \dots (588)$$

$$R = 0.79500, R^2 = 0.63, n = 1530$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
Log N	50.8815	0.001
Log P	5.8121	0.001

$$\text{iii) } Y = aN^bK^c$$

$$\text{Log } Y = \text{Log } a + b \text{ Log } N + c \text{ Log } K$$

$$\text{Log } Y = \text{Log } 3.5177 + 0.0824 \text{ Log } N + 0.0049 \text{ Log } K \dots (589)$$

$$R = 0.79157, R^2 = 0.63, n = 1530$$

<u>Variable</u>	<u>T-value</u>	<u>Probability Level</u>
Log N	50.5096	0.001
Log K	3.3233	0.001

APPENDIX C

TABLE 3.1 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF CORN,
ASSOCIATED WITH INCREASED NITROGEN LEVELS ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1961

LBS. OF N PER ACRE	1 YIELDS IN BUSHEL/ACRE WITH P, K = 0			4 YIELDS IN BUSHEL/ACRE WITH P = 40, K = 0			6 YIELDS IN BUSHEL/ACRE WITH P = 40, K = 40			9 YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE		
	TOTAL	AVER- : AGE	MARG- : INAL	TOTAL	AVER- : AGE	MARG- : INAL	TOTAL	AVER- : AGE	MARG- : INAL	TOTAL	AVER- : AGE	MARG- : INAL
0	45.15		1.18	44.08		1.13	45.02		1.18	44.75		1.16
10	56.55	5.66	1.10	54.99	5.50	1.06	56.44	5.64	1.10	56.00	5.60	1.09
20	67.21	3.36	1.03	65.23	3.26	0.99	67.10	3.36	1.03	66.53	3.33	1.02
30	77.13	2.57	0.96	74.78	2.49	0.92	77.01	2.57	0.95	76.34	2.54	0.94
40	86.31	2.16	0.88	83.65	2.09	0.85	86.15	2.15	0.88	85.43	2.14	0.87
50	94.75	1.90	0.81	91.84	1.84	0.79	94.53	1.89	0.80	93.79	1.88	0.80
60	102.46	1.71	0.73	99.36	1.66	0.72	102.15	1.70	0.72	101.44	1.69	0.73
70	109.42	1.56	0.66	106.19	1.52	0.65	109.01	1.56	0.65	108.37	1.55	0.66
80	115.64	1.45	0.59	112.34	1.40	0.58	115.12	1.44	0.57	114.58	1.43	0.58
90	121.12	1.35	0.51	117.82	1.31	0.51	120.46	1.34	0.50	120.07	1.33	0.51
100	125.86	1.26	0.44	122.61	1.23	0.45	125.04	1.25	0.42	124.84	1.25	0.44
110	129.86	1.18	0.36	126.72	1.15	0.38	128.86	1.17	0.34	128.89	1.17	0.37
120	133.12	1.11	0.29	130.16	1.08	0.31	131.92	1.10	0.27	132.22	1.10	0.30
130	135.64	1.04	0.22	132.91	1.02	0.24	134.23	1.03	0.19	134.83	1.04	0.22
140	137.42	0.98	0.14	134.98	0.96	0.17	135.77	0.97	0.12	136.72	0.98	0.15
150	138.46	0.92	0.07	136.37	0.91	0.11	136.55	0.91	0.04	137.88	0.92	0.08
160	138.77	0.87	-0.01	137.09	0.86	0.04	136.57	0.85	-0.04	138.33	0.86	0.01
170	138.33	0.81	-0.08	137.12	0.81	-0.03	135.83	0.80	-0.11	138.06	0.81	-0.06
180	137.15	0.76	-0.15	136.47	0.76	-0.10	134.34	0.75	-0.19	137.07	0.76	-0.14
190	135.23	0.71	-0.23	135.15	0.71	-0.17	132.08	0.70	-0.26	135.36	0.71	-0.21
200	132.57	0.66	-0.30	133.14	0.67	-0.23	129.06	0.65	-0.34	132.93	0.66	-0.28
210	129.17	0.62	-0.38	130.45	0.62	-0.30	125.28	0.60	-0.42	129.78	0.62	-0.35
220	125.03	0.57	-0.45	127.08	0.58	-0.37	120.74	0.55	-0.49	125.91	0.57	-0.42
230	120.15	0.52	-0.52	123.04	0.53	-0.44	115.45	0.50	-0.57	121.32	0.53	-0.50
240	114.53	0.48	-0.60	118.31	0.49	-0.51	109.39	0.46	-0.64	116.01	0.48	-0.57
250	108.17	0.43	-0.67	112.90	0.45	-0.57	102.57	0.41	-0.72	109.97	0.44	-0.64

TABLE 3.2 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF CORN,
ASSOCIATED WITH INCREASED NITROGEN LEVELS ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1962

LBS. OF N PER ACRE	14				16				19				21			
	YIELDS IN BUSHEL/ACRE WITH P, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 40				YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE			
	TOTAL	AVER-	MARG-	INAL	TOTAL	AVER-	MARG-	INAL	TOTAL	AVER-	MARG-	INAL	TOTAL	AVER-	MARG-	INAL
0	65.54	7.62	1.10	1.03	73.62	8.47	1.14	1.07	72.17	8.24	1.05	1.05	70.44	8.13	1.12	1.06
10	76.20	4.31	0.97	0.97	84.69	4.75	1.00	1.00	82.37	4.60	0.99	0.99	81.35	4.58	0.99	0.99
20	86.23	3.19	0.91	0.91	95.04	3.49	0.93	0.93	91.97	3.37	0.93	0.93	91.57	3.37	0.92	0.92
30	95.65	2.61	0.85	0.85	104.67	2.84	0.86	0.86	100.97	2.73	0.87	0.87	101.11	2.75	0.85	0.85
40	104.44	2.25	0.79	0.79	113.59	2.44	0.78	0.78	109.37	2.34	0.81	0.81	109.97	2.36	0.78	0.78
50	112.62	2.00	0.72	0.72	121.78	2.15	0.71	0.71	117.17	2.07	0.75	0.75	118.16	2.09	0.72	0.72
60	120.17	1.82	0.66	0.66	129.25	1.94	0.64	0.64	124.37	1.87	0.69	0.69	125.66	1.89	0.65	0.65
70	127.11	1.67	0.60	0.60	136.00	1.78	0.57	0.57	130.97	1.71	0.63	0.63	132.48	1.73	0.58	0.58
80	133.42	1.55	0.54	0.54	142.03	1.64	0.50	0.50	136.97	1.58	0.57	0.57	138.63	1.60	0.51	0.51
90	139.12	1.44	0.48	0.48	147.35	1.52	0.42	0.42	142.37	1.47	0.45	0.45	144.09	1.49	0.44	0.44
100	144.19	1.35	0.41	0.41	151.94	1.42	0.35	0.35	147.17	1.38	0.39	0.39	148.87	1.39	0.38	0.38
110	148.65	1.27	0.35	0.35	155.81	1.32	0.28	0.28	151.37	1.29	0.33	0.33	152.98	1.30	0.31	0.31
120	152.48	1.20	0.29	0.29	158.96	1.24	0.21	0.21	154.97	1.22	0.27	0.27	156.40	1.22	0.24	0.24
130	155.70	1.13	0.23	0.23	161.39	1.17	0.14	0.14	157.97	1.15	0.21	0.21	159.14	1.15	0.17	0.17
140	158.29	1.07	0.17	0.17	163.11	1.09	0.06	0.06	160.37	1.08	0.15	0.15	161.20	1.08	0.10	0.10
150	160.27	1.01	0.10	0.10	164.10	1.03	-0.01	-0.01	162.17	1.02	0.09	0.09	162.59	1.02	0.04	0.04
160	161.62	0.96	0.04	0.04	164.37	0.96	-0.08	-0.08	163.37	0.96	0.03	0.03	163.29	0.96	-0.03	-0.03
170	162.36	0.90	-0.02	-0.02	163.92	0.90	-0.15	-0.15	163.97	0.91	-0.03	-0.03	163.31	0.90	-0.10	-0.10
180	162.47	0.85	-0.08	-0.08	162.75	0.85	-0.22	-0.22	163.97	0.86	-0.09	-0.09	162.66	0.85	-0.17	-0.17
190	161.97	0.80	-0.14	-0.14	160.87	0.79	-0.30	-0.30	163.37	0.81	-0.15	-0.15	161.32	0.80	-0.24	-0.24
200	160.84	0.76	-0.21	-0.21	158.26	0.74	-0.37	-0.37	162.17	0.76	-0.21	-0.21	159.30	0.75	-0.30	-0.30
210	159.10	0.71	-0.27	-0.27	154.93	0.69	-0.44	-0.44	160.37	0.72	-0.27	-0.27	156.60	0.70	-0.37	-0.37
220	156.73	0.67	-0.33	-0.33	150.88	0.64	-0.51	-0.51	157.97	0.67	-0.33	-0.33	153.23	0.65	-0.44	-0.44
230	153.75	0.63	-0.39	-0.39	146.11	0.59	-0.58	-0.58	154.97	0.63	-0.39	-0.39	149.17	0.60	-0.51	-0.51
240	150.14	0.58	-0.45	-0.45	140.63	0.54	-0.66	-0.66	151.37	0.59	-0.45	-0.45	144.43	0.56	-0.58	-0.58
250	145.92				134.42				147.17				139.02			

TABLE 3.3 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF CORN,
ASSOCIATED WITH INCREASED NITROGEN LEVELS ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1963

LBS. OF N PER ACRE	25				27				29				31			
	YIELDS IN BUSHEL/ACRE WITH P, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 40				YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE			
	TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-	
		AGE	INAL			AGE	INAL			AGE	INAL			AGE	INAL	
0	44.49		0.92	47.51		0.95	46.33		0.96		0.94	46.11		0.94		
10	53.47	5.35	0.88	56.79	5.68	0.90	55.71	5.57	0.92	5.53	0.90	55.32	5.53	0.90		
20	61.99	3.10	0.83	65.59	3.28	0.86	64.65	3.23	0.87	3.20	0.85	64.08	3.20	0.85		
30	70.05	2.34	0.78	73.90	2.46	0.81	73.15	2.44	0.83	2.41	0.81	72.37	2.41	0.81		
40	77.65	1.94	0.74	81.74	2.04	0.76	81.21	2.03	0.78	2.01	0.76	80.20	2.01	0.76		
50	84.80	1.70	0.69	89.10	1.78	0.71	88.83	1.78	0.74	1.75	0.71	87.58	1.75	0.71		
60	91.48	1.52	0.65	95.98	1.60	0.66	96.01	1.60	0.70	1.57	0.67	94.49	1.57	0.67		
70	97.70	1.40	0.60	102.38	1.46	0.62	102.75	1.47	0.65	1.44	0.62	100.94	1.44	0.62		
80	103.46	1.29	0.55	108.29	1.35	0.57	109.05	1.36	0.61	1.34	0.58	106.93	1.34	0.58		
90	108.76	1.21	0.51	113.73	1.26	0.52	114.91	1.28	0.56	1.25	0.53	112.47	1.25	0.53		
100	113.61	1.14	0.46	118.69	1.19	0.47	120.33	1.20	0.52	1.18	0.48	117.54	1.18	0.48		
110	117.99	1.07	0.42	123.17	1.12	0.42	125.31	1.14	0.48	1.11	0.44	122.15	1.11	0.44		
120	121.91	1.02	0.37	127.17	1.06	0.38	129.85	1.08	0.43	1.05	0.39	126.31	1.05	0.39		
130	125.37	0.96	0.32	130.68	1.01	0.33	133.95	1.03	0.39	1.00	0.35	130.00	1.00	0.35		
140	128.37	0.92	0.28	133.72	0.96	0.28	137.61	0.98	0.34	0.95	0.30	133.23	0.95	0.30		
150	130.92	0.87	0.23	136.28	0.91	0.23	140.83	0.94	0.30	0.91	0.25	136.01	0.91	0.25		
160	133.00	0.83	0.19	138.36	0.86	0.18	143.61	0.90	0.26	0.86	0.21	138.32	0.86	0.21		
170	134.62	0.79	0.14	139.96	0.82	0.14	145.95	0.86	0.21	0.82	0.16	140.17	0.82	0.16		
180	135.78	0.75	0.09	141.07	0.78	0.09	147.85	0.82	0.17	0.79	0.12	141.56	0.79	0.12		
190	136.48	0.72	0.05	141.71	0.75	0.04	149.31	0.79	0.12	0.75	0.07	142.50	0.75	0.07		
200	136.73	0.68	0.00	141.87	0.71	-0.01	150.33	0.75	0.08	0.71	0.02	142.97	0.71	0.02		
210	136.51	0.65	-0.04	141.55	0.67	-0.06	150.91	0.72	0.04	0.68	-0.02	142.98	0.68	-0.02		
220	135.83	0.62	-0.09	140.75	0.64	-0.10	151.05	0.69	-0.01	0.65	-0.07	142.54	0.65	-0.07		
230	134.69	0.59	-0.14	139.46	0.61	-0.15	150.75	0.66	-0.05	0.62	-0.11	141.63	0.62	-0.11		
240	133.09	0.55	-0.18	137.70	0.57	-0.20	150.01	0.63	-0.10	0.58	-0.16	140.26	0.58	-0.16		
250	131.04	0.52	-0.23	135.46	0.54	-0.25	148.83	0.60	-0.14	0.55	-0.21	138.44	0.55	-0.21		

TABLE 3.4 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF CORN,
ASSOCIATED WITH INCREASED NITROGEN LEVELS ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1964

LBS. OF N PER ACRE	39				42				44				46			
	YIELDS IN BUSHEL/ACRE WITH P, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 40				YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE			
	TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-	
		AGE	: INAL			AGE	: INAL			AGE	: INAL			AGE	: INAL	
0	55.64	6.60	1.07	58.06	6.76	0.98	53.26	6.31	1.01	0.96	55.65	6.56	1.02	0.96	6.56	1.02
10	65.97	3.78	0.93	67.59	3.83	0.92	63.11	3.62	0.96	0.91	65.56	3.74	0.96	0.91	3.74	0.96
20	75.63	2.82	0.86	76.55	2.83	0.87	72.45	2.71	0.86	0.86	74.89	2.79	0.86	0.86	2.79	0.86
30	84.60	2.32	0.80	84.96	2.32	0.81	81.27	2.24	0.80	0.80	83.64	2.30	0.80	0.80	2.30	0.80
40	92.89	2.01	0.73	92.81	2.00	0.76	89.56	1.95	0.75	0.75	91.81	1.99	0.75	0.75	1.99	0.75
50	100.50	1.79	0.66	100.09	1.78	0.70	97.34	1.74	0.70	0.70	99.40	1.77	0.70	0.70	1.77	0.70
60	107.43	1.62	0.59	106.82	1.61	0.64	104.60	1.59	0.65	0.65	106.41	1.61	0.65	0.65	1.61	0.65
70	113.69	1.49	0.52	112.99	1.48	0.53	111.33	1.47	0.60	0.60	112.84	1.48	0.60	0.60	1.48	0.60
80	119.26	1.38	0.46	118.60	1.37	0.48	117.55	1.37	0.54	0.54	118.68	1.38	0.54	0.54	1.38	0.54
90	124.15	1.28	0.39	123.64	1.28	0.42	123.25	1.28	0.49	0.49	123.95	1.29	0.49	0.49	1.29	0.49
100	128.36	1.20	0.32	128.13	1.20	0.42	128.43	1.21	0.44	0.44	128.64	1.21	0.44	0.44	1.21	0.44
110	131.89	1.12	0.25	132.06	1.13	0.36	133.08	1.14	0.39	0.39	132.75	1.14	0.39	0.39	1.14	0.39
120	134.75	1.05	0.18	135.42	1.06	0.31	137.22	1.08	0.34	0.34	136.28	1.07	0.34	0.34	1.07	0.34
130	136.92	0.99	0.12	138.23	1.00	0.25	140.84	1.03	0.28	0.28	139.23	1.01	0.28	0.28	1.01	0.28
140	138.41	0.93	0.05	140.48	0.95	0.20	143.93	0.98	0.23	0.23	141.60	0.96	0.23	0.23	0.96	0.23
150	139.22	0.87	-0.02	142.16	0.90	0.14	146.51	0.93	0.18	0.18	143.39	0.90	0.18	0.18	0.90	0.18
160	139.35	0.82	-0.09	143.29	0.85	0.08	148.57	0.88	0.13	0.13	144.60	0.85	0.13	0.13	0.85	0.13
170	138.81	0.76	-0.16	143.86	0.80	0.03	150.10	0.84	0.08	0.08	145.23	0.81	0.08	0.08	0.81	0.08
180	137.58	0.71	-0.22	143.31	0.75	-0.03	151.12	0.80	0.02	0.02	145.27	0.76	0.02	0.02	0.76	0.02
190	135.67	0.67	-0.29	143.31	0.71	-0.08	151.62	0.76	-0.03	-0.03	144.74	0.72	-0.03	-0.03	0.72	-0.03
200	133.08	0.62	-0.36	142.20	0.67	-0.14	151.60	0.72	-0.08	-0.08	143.63	0.68	-0.08	-0.08	0.68	-0.08
210	129.81	0.57	-0.43	140.53	0.63	-0.20	151.05	0.68	-0.13	-0.13	141.94	0.63	-0.13	-0.13	0.63	-0.13
220	125.87	0.53	-0.50	138.29	0.59	-0.25	149.99	0.65	-0.18	-0.18	139.67	0.59	-0.18	-0.18	0.59	-0.18
230	121.24	0.48	-0.56	135.50	0.55	-0.31	148.41	0.61	-0.24	-0.24	136.82	0.56	-0.24	-0.24	0.56	-0.24
240	115.93	0.44	-0.63	132.15	0.51	-0.36	146.30	0.57	-0.29	-0.29	133.39	0.52	-0.29	-0.29	0.52	-0.29
250	109.94			128.23		-0.42	143.68				129.38					

TABLE 3.5 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF CORN,
ASSOCIATED WITH INCREASED NITROGEN LEVELS ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1965

LBS. OF N PER ACRE	54				56				59				61			
	YIELDS IN BUSHEL/ACRE WITH P, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 40				YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE			
	TOTAL	AVER- : AGE	MARG- : INAL		TOTAL	AVER- : AGE	MARG- : INAL		TOTAL	AVER- : AGE	MARG- : INAL		TOTAL	AVER- : AGE	MARG- : INAL	
0	44.67		1.13	42.93	1.34		1.34	48.79	1.14		1.14	45.46				1.20
10	55.61	5.56	1.06	55.94	5.59		1.26	59.86	1.08	5.99	1.08	57.14	5.71			1.13
20	65.91	3.30	1.00	68.16	3.41		1.18	70.36	1.02	3.52	1.02	68.16	3.41			1.07
30	75.57	2.52	0.93	79.61	2.65		1.11	80.28	0.96	2.68	0.96	78.52	2.62			1.00
40	84.59	2.11	0.87	90.27	2.26		1.03	89.62	0.90	2.24	0.90	88.22	2.21			0.94
50	92.98	1.86	0.81	100.16	2.00		0.95	98.38	0.85	1.97	0.85	97.26	1.95			0.87
60	100.72	1.68	0.74	109.26	1.82		0.87	106.56	0.79	1.78	0.79	105.64	1.76			0.80
70	107.82	1.54	0.68	117.59	1.68		0.79	114.16	0.73	1.63	0.73	113.35	1.62			0.74
80	114.28	1.43	0.61	125.13	1.56		0.72	121.18	0.67	1.51	0.67	120.41	1.51			0.67
90	120.10	1.33	0.55	131.90	1.47		0.64	127.62	0.61	1.42	0.61	126.81	1.41			0.61
100	125.29	1.25	0.49	137.88	1.38		0.56	133.48	0.56	1.33	0.56	132.55	1.33			0.54
110	129.83	1.18	0.42	143.09	1.30		0.48	138.75	0.50	1.26	0.50	137.63	1.25			0.47
120	133.73	1.11	0.36	147.51	1.23		0.40	143.45	0.44	1.20	0.44	142.05	1.18			0.41
130	136.99	1.05	0.29	151.16	1.16		0.33	147.57	0.38	1.14	0.38	145.81	1.12			0.34
140	139.61	1.00	0.23	154.02	1.10		0.25	151.11	0.32	1.08	0.32	148.91	1.06			0.28
150	141.60	0.94	0.17	156.11	1.04		0.17	154.07	0.27	1.03	0.27	151.35	1.01			0.21
160	142.94	0.89	0.10	157.41	0.98		0.09	156.45	0.21	0.98	0.21	153.13	0.96			0.14
170	143.64	0.84	0.04	157.94	0.93		0.01	158.25	0.15	0.93	0.15	154.24	0.91			0.08
180	143.70	0.80	-0.03	157.68	0.88		-0.06	159.47	0.09	0.89	0.09	154.70	0.86			0.01
190	143.12	0.75	-0.09	156.65	0.82		-0.14	160.11	0.03	0.84	0.03	154.50	0.81			-0.05
200	141.91	0.71	-0.15	154.83	0.77		-0.22	160.17	-0.02	0.80	-0.02	153.64	0.77			-0.12
210	140.05	0.67	-0.22	152.24	0.72		-0.30	159.64	-0.08	0.76	-0.08	152.12	0.72			-0.19
220	137.55	0.63	-0.28	148.86	0.68		-0.38	158.54	-0.14	0.72	-0.14	149.94	0.68			-0.25
230	134.41	0.58	-0.35	144.71	0.63		-0.45	156.86	-0.20	0.68	-0.20	147.10	0.64			-0.32
240	130.63	0.54	-0.41	139.77	0.58		-0.53	154.60	-0.26	0.64	-0.26	143.60	0.60			-0.38
250	126.22	0.50	-0.47	134.06	0.54		-0.61	151.76	-0.31	0.61	-0.31	139.44	0.56			-0.45

TABLE 3.6 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF CORN, ASSOCIATED WITH INCREASED NITROGEN LEVELS ON IRRIGATED LAND OF WEST-CENTRAL KANSAS, 1966

LBS. OF N PER ACRE	73				75				77				79			
	YIELDS IN BUSHEL/ACRE WITH P, K = 0		YIELDS IN BUSHEL/ACRE WITH P = 40, K = 0		YIELDS IN BUSHEL/ACRE WITH P = 40, K = 0		YIELDS IN BUSHEL/ACRE WITH P = 40, K = 0		YIELDS IN BUSHEL/ACRE WITH P = 40, K = 40		YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE		YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE		YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE	
	TOTAL	MARG- : AGE	TOTAL	MARG- : AGE	TOTAL	MARG- : AGE	TOTAL	MARG- : AGE	TOTAL	MARG- : AGE	TOTAL	MARG- : AGE	TOTAL	MARG- : AGE	TOTAL	MARG- : AGE
0	67.94	0.77	60.03	0.96	65.75	0.91	64.58	0.88	73.14	0.86	73.14	0.83	73.14	0.83	73.14	0.83
10	75.45	7.55	69.36	0.90	74.59	0.86	73.14	0.83	81.18	0.80	81.18	0.78	81.18	0.78	81.18	0.78
20	82.51	4.13	78.10	0.85	82.89	0.80	81.18	0.78	88.70	0.75	88.70	0.73	88.70	0.73	88.70	0.73
30	89.10	2.97	86.26	0.79	90.64	0.75	88.70	0.73	95.70	0.69	95.70	0.67	95.70	0.67	95.70	0.67
40	95.23	2.38	93.85	0.73	97.86	0.67	95.70	0.67	102.18	0.64	102.18	0.62	102.18	0.62	102.18	0.62
50	100.90	2.02	100.85	0.67	104.53	0.61	102.18	0.61	108.14	0.59	108.14	0.57	108.14	0.57	108.14	0.57
60	106.11	1.77	107.28	0.61	110.67	0.56	108.14	0.56	113.58	0.53	113.58	0.52	113.58	0.52	113.58	0.52
70	110.87	1.58	113.12	0.56	116.27	0.50	113.58	0.50	118.50	0.48	118.50	0.47	118.50	0.47	118.50	0.47
80	115.16	1.44	118.38	0.44	121.32	0.44	118.50	0.44	122.90	0.42	122.90	0.41	122.90	0.41	122.90	0.41
90	118.99	1.32	123.07	0.38	125.84	0.38	122.90	0.38	126.79	0.37	126.79	0.36	126.79	0.36	126.79	0.36
100	122.36	1.22	127.17	0.32	129.81	0.32	126.79	0.32	130.15	0.32	130.15	0.31	130.15	0.31	130.15	0.31
110	125.27	1.14	130.70	0.27	133.25	0.27	130.15	0.27	132.99	0.26	132.99	0.26	132.99	0.26	132.99	0.26
120	127.73	1.06	133.64	0.21	136.15	0.21	132.99	0.21	135.31	0.21	135.31	0.21	135.31	0.21	135.31	0.21
130	129.72	1.00	136.00	0.15	138.50	0.15	135.31	0.15	137.11	0.15	137.11	0.15	137.11	0.15	137.11	0.15
140	131.25	0.94	137.79	0.09	140.32	0.09	137.11	0.09	138.39	0.10	138.39	0.10	138.39	0.10	138.39	0.10
150	132.32	0.88	138.99	0.03	141.59	0.03	138.39	0.03	139.15	0.05	139.15	0.05	139.15	0.05	139.15	0.05
160	132.93	0.83	139.62	-0.02	142.33	-0.02	139.15	-0.02	139.39	-0.01	139.39	-0.01	139.39	-0.01	139.39	-0.01
170	133.09	0.78	139.66	-0.05	142.53	-0.05	139.39	-0.05	139.11	-0.06	139.11	-0.06	139.11	-0.06	139.11	-0.06
180	132.78	0.74	139.12	-0.10	142.18	-0.10	139.11	-0.10	138.31	-0.12	138.31	-0.12	138.31	-0.12	138.31	-0.12
190	132.01	0.69	138.01	-0.15	141.30	-0.15	138.31	-0.15	137.00	-0.17	137.00	-0.17	137.00	-0.17	137.00	-0.17
200	130.78	0.65	136.31	-0.19	139.87	-0.19	137.00	-0.19	135.16	-0.22	135.16	-0.22	135.16	-0.22	135.16	-0.22
210	129.09	0.61	134.04	-0.24	137.91	-0.24	135.16	-0.24	132.80	-0.28	132.80	-0.28	132.80	-0.28	132.80	-0.28
220	126.95	0.58	131.18	-0.28	135.40	-0.28	132.80	-0.28	129.92	-0.33	129.92	-0.33	129.92	-0.33	129.92	-0.33
230	124.34	0.54	127.74	-0.33	132.36	-0.33	129.92	-0.33	126.52	-0.44	126.52	-0.44	126.52	-0.44	126.52	-0.44
240	121.27	0.51	123.73	-0.38	128.78	-0.38	126.52	-0.38	122.60	-0.50	122.60	-0.50	122.60	-0.50	122.60	-0.50
250	117.74	0.47	119.13	-0.48	124.65	-0.48	122.60	-0.48								

TABLE 3.7 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF CORN,
ASSOCIATED WITH INCREASED NITROGEN LEVELS ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1967

LBS. OF N PER ACRE	94				96				98				100			
	YIELDS IN BUSHEL/ACRE WITH P, K = 0		YIELDS IN BUSHEL/ACRE WITH P = 40, K = 0		YIELDS IN BUSHEL/ACRE WITH P = 40, K = 0		YIELDS IN BUSHEL/ACRE WITH P = 40, K = 40		YIELDS IN BUSHEL/ACRE WITH P = 40, K = 40		YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE		YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE		YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE	
	TOTAL	MARG- : AVER- : AGE	TOTAL	MARG- : AVER- : AGE	TOTAL	MARG- : AVER- : AGE	TOTAL	MARG- : AVER- : AGE	TOTAL	MARG- : AVER- : AGE	TOTAL	MARG- : AVER- : AGE	TOTAL	MARG- : AVER- : AGE	TOTAL	MARG- : AVER- : AGE
0	47.85	1.13	55.17	1.27	50.44	1.29	51.15	1.23	50.44	1.27	50.44	1.23	51.15	1.29	51.15	1.23
10	58.82	1.06	67.45	1.19	62.99	1.22	63.09	1.16	62.99	1.19	62.99	1.16	63.09	1.22	63.09	1.16
20	69.14	1.00	78.99	1.12	74.75	1.14	74.31	1.09	74.75	1.12	74.75	1.09	74.31	1.14	74.31	1.09
30	78.79	0.93	89.79	1.04	85.74	1.06	84.80	1.01	85.74	1.04	85.74	1.01	84.80	1.06	84.80	1.01
40	87.78	0.87	99.85	0.97	95.94	0.98	94.58	0.94	95.94	0.97	95.94	0.94	94.58	0.98	94.58	0.94
50	96.11	1.92	109.18	0.90	105.36	0.90	103.63	0.87	105.36	0.90	105.36	0.87	103.63	0.90	103.63	0.87
60	103.79	1.73	117.76	0.82	114.01	0.83	111.97	0.80	114.01	0.82	114.01	0.80	111.97	0.83	111.97	0.80
70	110.80	1.58	125.60	0.75	121.87	0.75	119.59	0.73	121.87	0.75	121.87	0.73	119.59	0.75	119.59	0.73
80	117.15	1.46	132.70	0.67	128.96	0.67	126.48	0.65	128.96	0.67	128.96	0.65	126.48	0.67	126.48	0.65
90	122.85	1.36	139.06	0.60	135.26	0.60	132.66	0.58	135.26	0.60	135.26	0.58	132.66	0.60	132.66	0.58
100	127.88	1.28	144.68	0.53	140.78	0.53	138.11	0.51	140.78	0.53	140.78	0.51	138.11	0.53	138.11	0.51
110	132.25	1.20	149.56	0.45	145.53	0.45	142.85	0.44	145.53	0.45	145.53	0.44	142.85	0.45	142.85	0.44
120	135.97	1.13	153.70	0.38	149.49	0.38	146.87	0.37	149.49	0.38	149.49	0.37	146.87	0.38	146.87	0.37
130	139.02	1.07	157.10	0.30	152.68	0.30	150.16	0.29	152.68	0.30	152.68	0.29	150.16	0.30	150.16	0.29
140	141.41	1.01	159.76	0.23	155.08	0.23	152.74	0.22	155.08	0.23	155.08	0.22	152.74	0.23	152.74	0.22
150	143.14	0.95	161.69	0.16	156.70	0.16	154.59	0.15	156.70	0.16	156.70	0.15	154.59	0.16	154.59	0.15
160	144.22	0.90	162.87	0.08	157.55	0.08	155.73	0.08	157.55	0.08	157.55	0.08	155.73	0.08	155.73	0.08
170	144.63	0.85	163.31	0.01	157.61	0.01	156.15	0.01	157.61	0.01	157.61	0.01	156.15	0.01	156.15	0.01
180	144.38	0.80	163.01	-0.07	156.90	-0.07	155.84	-0.07	156.90	-0.07	156.90	-0.07	155.84	-0.07	155.84	-0.07
190	143.48	0.76	161.97	-0.14	155.40	-0.14	154.82	-0.14	155.40	-0.14	155.40	-0.14	154.82	-0.14	154.82	-0.14
200	141.91	0.71	160.19	-0.21	153.12	-0.21	153.07	-0.21	153.12	-0.21	153.12	-0.21	153.07	-0.21	153.07	-0.21
210	139.68	0.67	157.67	-0.29	150.07	-0.29	150.61	-0.29	150.07	-0.29	150.07	-0.29	150.61	-0.29	150.61	-0.29
220	136.80	0.62	154.41	-0.36	146.23	-0.36	147.43	-0.36	146.23	-0.36	146.23	-0.36	147.43	-0.36	147.43	-0.36
230	133.25	0.58	150.41	-0.44	141.62	-0.44	143.52	-0.44	141.62	-0.44	141.62	-0.44	143.52	-0.44	143.52	-0.44
240	129.04	0.54	145.67	-0.51	136.22	-0.51	138.90	-0.51	136.22	-0.51	136.22	-0.51	138.90	-0.51	138.90	-0.51
250	124.17	0.50	140.20	-0.58	130.04	-0.58	133.55	-0.58	130.04	-0.58	130.04	-0.58	133.55	-0.58	133.55	-0.58

TABLE 3.8 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF CORN,
ASSOCIATED WITH INCREASED NITROGEN LEVELS ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1968

LBS. OF N PER ACRE	110				112				115				118			
	YIELDS IN BUSHEL/ACRE WITH P, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 40				YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE			
	TOTAL	AVER- : AGE	MARG- : INAL		TOTAL	AVER- : AGE	MARG- : INAL		TOTAL	AVER- : AGE	MARG- : INAL		TOTAL	AVER- : AGE	MARG- : INAL	
0	46.43		0.90		45.65		1.14		46.02		0.95		46.04		1.00	
10	55.23	5.52	0.86		56.79	5.68	1.09		55.35	5.54	0.92		55.79	5.58	0.95	
20	63.61	3.18	0.82		67.38	3.37	1.03		64.38	3.22	0.89		65.13	3.26	0.91	
30	71.57	2.39	0.77		77.43	2.58	0.98		73.12	2.44	0.86		74.04	2.47	0.87	
40	79.11	1.98	0.73		86.95	2.17	0.92		81.55	2.04	0.83		82.54	2.06	0.83	
50	86.22	1.72	0.69		95.92	1.92	0.87		89.68	1.79	0.80		90.61	1.81	0.79	
60	92.92	1.55	0.65		104.36	1.74	0.82		97.52	1.63	0.77		98.27	1.64	0.74	
70	99.20	1.42	0.61		112.25	1.60	0.76		105.05	1.50	0.74		105.50	1.51	0.70	
80	105.06	1.31	0.56		119.60	1.50	0.71		112.28	1.40	0.71		112.32	1.40	0.66	
90	110.50	1.23	0.52		126.42	1.40	0.65		119.22	1.32	0.68		118.71	1.32	0.62	
100	115.51	1.16	0.48		132.69	1.33	0.60		125.85	1.26	0.65		124.69	1.25	0.58	
110	120.11	1.09	0.44		138.43	1.26	0.55		132.18	1.20	0.62		130.24	1.18	0.53	
120	124.29	1.04	0.40		143.62	1.20	0.49		138.21	1.15	0.59		135.38	1.13	0.49	
130	128.05	0.98	0.35		148.27	1.14	0.44		143.95	1.11	0.56		140.09	1.08	0.45	
140	131.39	0.94	0.31		152.39	1.09	0.38		149.38	1.07	0.53		144.39	1.03	0.41	
150	134.30	0.90	0.27		155.96	1.04	0.33		154.51	1.03	0.50		148.26	0.99	0.37	
160	136.80	0.86	0.23		159.00	0.99	0.28		159.35	1.00	0.47		151.72	0.95	0.32	
170	138.88	0.82	0.19		161.49	0.95	0.22		163.88	0.96	0.44		154.75	0.91	0.28	
180	140.54	0.78	0.14		163.44	0.91	0.17		168.11	0.93	0.41		157.37	0.87	0.24	
190	141.78	0.75	0.10		164.86	0.87	0.11		172.05	0.91	0.38		159.56	0.84	0.20	
200	142.59	0.71	0.06		165.73	0.83	0.06		175.68	0.88	0.35		161.34	0.81	0.16	
210	142.99	0.68	0.02		166.07	0.79	0.01		179.01	0.85	0.32		162.69	0.77	0.11	
220	142.97	0.65	-0.02		165.86	0.75	-0.05		182.04	0.83	0.29		163.62	0.74	0.07	
230	142.53	0.62	-0.07		165.11	0.72	-0.10		184.78	0.80	0.26		164.14	0.71	0.03	
240	141.67	0.59	-0.11		163.83	0.68	-0.16		187.21	0.78	0.23		164.24	0.68	-0.01	
250	140.38	0.56	-0.15		162.00	0.65	-0.21		189.34	0.76	0.20		163.91	0.66	-0.05	

TABLE 3.9 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF CORN,
ASSOCIATED WITH INCREASED NITROGEN LEVELS ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1969

LBS. OF N PER ACRE	129				132				135				138			
	YIELDS IN BUSHEL/ACRE WITH P, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 40				YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE			
	TOTAL	AVER- : AGE	MARG- : INAL		TOTAL	AVER- : AGE	MARG- : INAL		TOTAL	AVER- : AGE	MARG- : INAL		TOTAL	AVER- : AGE	MARG- : INAL	
0	104.17		0.79	104.40		11.35	0.94	102.41		11.18	0.97	103.66		11.23	0.90	0.90
10	111.78	11.18	0.73	113.46		6.10	0.88	111.77		6.02	0.90	112.34		6.02	0.84	0.84
20	118.86	5.94	0.68	121.95		4.33	0.82	120.50		4.29	0.84	120.44		4.27	0.78	0.78
30	125.43	4.18	0.63	129.85		3.43	0.76	128.58		3.40	0.78	127.95		3.37	0.71	0.72
40	131.48	3.29	0.58	137.17		2.88	0.70	136.03		2.86	0.65	134.89		2.82	0.65	0.66
50	137.01	2.74	0.53	143.91		2.50	0.65	142.83		2.48	0.58	141.25		2.45	0.58	0.61
60	142.01	2.37	0.47	150.08		2.22	0.59	149.00		2.21	0.52	147.03		2.17	0.52	0.55
70	146.50	2.09	0.42	155.66		2.01	0.53	154.52		1.99	0.46	152.23		1.96	0.46	0.49
80	150.47	1.88	0.37	160.66		1.83	0.47	159.41		1.82	0.39	156.84		1.79	0.39	0.43
90	153.91	1.71	0.32	165.09		1.69	0.41	163.65		1.67	0.33	160.88		1.64	0.33	0.37
100	156.84	1.57	0.27	168.93		1.57	0.36	167.26		1.55	0.26	164.34		1.52	0.26	0.32
110	159.25	1.45	0.21	172.19		1.46	0.30	170.22		1.44	0.20	167.22		1.41	0.20	0.26
120	161.13	1.34	0.16	174.88		1.36	0.24	172.55		1.34	0.14	169.52		1.32	0.14	0.20
130	162.50	1.25	0.11	176.98		1.28	0.18	174.23		1.25	0.07	171.23		1.23	0.07	0.14
140	163.35	1.17	0.06	178.50		1.20	0.12	175.28		1.17	0.01	172.37		1.15	0.01	0.08
150	163.68	1.09	0.01	179.44		1.12	0.07	175.68		1.10	-0.06	172.93		1.08	-0.06	0.03
160	163.48	1.02	-0.05	179.81		1.06	0.01	175.45		1.03	-0.12	172.91		1.01	-0.12	-0.03
170	162.77	0.96	-0.10	179.59		0.99	-0.05	174.57		0.96	-0.18	172.31		0.95	-0.18	-0.09
180	161.54	0.90	-0.15	178.79		0.93	-0.11	173.06		0.90	-0.25	171.12		0.89	-0.25	-0.15
190	159.78	0.84	-0.20	177.42		0.88	-0.17	170.90		0.84	-0.31	169.36		0.84	-0.31	-0.21
200	157.51	0.79	-0.25	175.46		0.82	-0.22	168.11		0.78	-0.38	167.02		0.78	-0.38	-0.26
210	154.72	0.74	-0.31	172.92		0.77	-0.28	164.67		0.73	-0.44	164.10		0.73	-0.44	-0.32
220	151.40	0.69	-0.36	169.81		0.72	-0.34	160.60		0.68	-0.50	160.60		0.68	-0.50	-0.38
230	147.57	0.64	-0.41	166.11		0.67	-0.40	155.88		0.63	-0.57	156.51		0.63	-0.57	-0.44
240	143.22	0.60	-0.46	161.83		0.63	-0.46	150.53		0.58	-0.63	151.85		0.59	-0.63	-0.50
250	138.35	0.55	-0.51	156.97		0.63	-0.51	144.53		0.58	-0.63	146.61		0.59	-0.63	-0.55

TABLE 3.10 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF CORN,
ASSOCIATED WITH INCREASED NITROGEN LEVELS ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1970

LBS. OF N PER ACRE	149				152				155				158			
	YIELDS IN BUSHEL/ACRE WITH P, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 40				YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE			
	TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-	
		: AGE	: INAL			: AGE	: INAL			: AGE	: INAL			: AGE	: INAL	
0	93.10	1	1.29	91.00	1.18	10.25	1.18	93.78	1.30	10.64	1.30	92.74	1.30	10.49	1.26	
10	105.62	10.56	1.21	102.48	1.11	5.66	1.11	106.41	1.22	5.91	1.22	104.95	1.22	5.82	1.18	
20	117.40	5.87	1.14	113.23	1.04	4.11	1.04	118.28	1.15	4.31	1.15	116.42	1.15	4.24	1.11	
30	128.44	4.28	1.07	123.27	0.97	3.31	0.97	129.39	1.07	3.49	1.07	127.14	1.07	3.43	1.04	
40	138.74	3.47	0.99	132.59	0.90	2.82	0.90	139.74	1.00	2.99	1.00	137.13	1.00	2.93	0.96	
50	148.30	2.97	0.92	141.19	0.82	2.48	0.82	149.33	0.92	2.64	0.92	146.38	0.92	2.58	0.89	
60	157.12	2.62	0.84	149.07	0.75	2.23	0.75	158.16	0.84	2.37	0.84	154.89	0.84	2.32	0.81	
70	165.20	2.36	0.77	156.22	0.68	2.03	0.68	166.23	0.77	2.17	0.77	162.66	0.77	2.12	0.74	
80	172.54	2.16	0.70	162.66	0.61	1.87	0.61	173.54	0.69	2.00	0.69	169.69	0.69	1.96	0.67	
90	179.14	1.99	0.62	168.38	0.54	1.73	0.54	180.09	0.62	1.86	0.62	175.98	0.62	1.82	0.59	
100	184.99	1.85	0.55	173.38	0.46	1.62	0.46	185.88	0.54	1.74	0.54	181.53	0.54	1.69	0.52	
110	190.11	1.73	0.47	177.66	0.39	1.51	0.39	190.91	0.46	1.63	0.46	186.34	0.46	1.59	0.44	
120	194.49	1.62	0.40	181.21	0.32	1.42	0.32	195.18	0.39	1.53	0.39	190.41	0.39	1.49	0.37	
130	198.13	1.52	0.33	184.05	0.25	1.33	0.25	198.69	0.31	1.44	0.31	193.73	0.31	1.40	0.30	
140	201.03	1.44	0.25	186.17	0.18	1.25	0.18	201.44	0.24	1.36	0.24	196.32	0.24	1.32	0.22	
150	203.19	1.35	0.18	187.57	0.10	1.18	0.10	203.43	0.16	1.28	0.16	198.17	0.16	1.25	0.15	
160	204.61	1.28	0.10	188.25	0.03	1.11	0.03	204.66	0.09	1.21	0.09	199.28	0.09	1.17	0.07	
170	205.29	1.21	0.03	188.20	-0.04	1.04	-0.04	205.13	0.01	1.14	0.01	199.65	0.01	1.11	-0.00	
180	205.23	1.14	-0.04	187.44	-0.11	0.98	-0.11	204.84	-0.07	1.07	-0.07	199.28	-0.07	1.04	-0.07	
190	204.42	1.08	-0.12	185.96	-0.18	0.92	-0.18	203.79	-0.14	1.01	-0.14	198.17	-0.14	0.98	-0.15	
200	202.88	1.01	-0.19	183.76	-0.26	0.86	-0.26	201.98	-0.22	0.95	-0.22	196.32	-0.22	0.92	-0.22	
210	200.60	0.96	-0.27	180.83	-0.33	0.81	-0.33	199.41	-0.29	0.89	-0.29	193.73	-0.29	0.87	-0.30	
220	197.58	0.90	-0.34	177.19	-0.40	0.75	-0.40	196.08	-0.37	0.83	-0.37	190.40	-0.37	0.81	-0.37	
230	193.82	0.84	-0.41	172.83	-0.47	0.70	-0.47	191.99	-0.45	0.78	-0.45	186.32	-0.45	0.76	-0.44	
240	189.32	0.79	-0.49	167.75	-0.54	0.65	-0.54	187.14	-0.52	0.73	-0.52	181.51	-0.52	0.70	-0.52	
250	184.08	0.74	-0.56	161.95	-0.62	0.65	-0.62	181.53	-0.60	0.73	-0.60	175.96	-0.60	0.70	-0.59	

TABLE 3.11 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF CORN,
ASSOCIATED WITH INCREASED NITROGEN LEVELS ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1961-1965

LBS. OF N PER ACRE	215				218				221				224			
	YIELDS IN BUSHEL/ACRE WITH P, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 40				YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE			
	TOTAL	AVER-	MARG-	INAL	TOTAL	AVER-	MARG-	INAL	TOTAL	AVER-	MARG-	INAL	TOTAL	AVER-	MARG-	INAL
0	51.10		1.08		53.24		1.11		53.11		1.08		52.48		1.09	
10	61.56	6.16	1.02		64.00	6.40	1.04		63.66	6.37	1.02		63.07	6.31	1.03	
20	71.41	3.57	0.95		74.12	3.71	0.98		73.60	3.68	0.96		73.05	3.65	0.97	
30	80.64	2.69	0.89		83.60	2.79	0.92		82.94	2.76	0.90		82.40	2.75	0.90	
40	89.24	2.23	0.83		92.44	2.31	0.85		91.69	2.29	0.84		91.13	2.28	0.84	
50	97.23	1.94	0.77		100.65	2.01	0.79		99.83	2.00	0.78		99.24	1.98	0.78	
60	104.59	1.74	0.71		108.21	1.80	0.72		107.38	1.79	0.72		106.73	1.78	0.72	
70	111.34	1.59	0.64		115.13	1.64	0.66		114.32	1.63	0.66		113.60	1.62	0.66	
80	117.47	1.47	0.58		121.41	1.52	0.60		120.66	1.51	0.60		119.85	1.50	0.59	
90	122.97	1.37	0.52		127.05	1.41	0.53		126.41	1.40	0.54		125.48	1.39	0.53	
100	127.86	1.28	0.46		132.05	1.32	0.47		131.55	1.32	0.48		130.49	1.30	0.47	
110	132.12	1.20	0.40		136.41	1.24	0.40		136.10	1.24	0.42		134.88	1.23	0.41	
120	135.77	1.13	0.33		140.13	1.17	0.34		140.04	1.17	0.36		138.66	1.16	0.35	
130	138.80	1.07	0.27		143.21	1.10	0.28		143.38	1.10	0.30		141.81	1.09	0.28	
140	141.20	1.01	0.21		145.65	1.04	0.21		146.13	1.04	0.24		144.34	1.03	0.22	
150	142.99	0.95	0.15		147.46	0.98	0.15		148.27	0.99	0.18		146.25	0.97	0.16	
160	144.15	0.90	0.09		148.62	0.93	0.08		149.82	0.94	0.12		147.54	0.92	0.10	
170	144.70	0.85	0.02		149.14	0.88	0.02		150.76	0.89	0.06		148.21	0.87	0.04	
180	144.63	0.80	-0.04		149.02	0.83	-0.04		151.10	0.84	0.00		148.26	0.82	-0.03	
190	143.93	0.76	-0.10		148.26	0.78	-0.11		150.85	0.79	-0.06		147.69	0.78	-0.09	
200	142.62	0.71	-0.16		146.86	0.73	-0.17		149.99	0.75	-0.12		146.50	0.73	-0.15	
210	140.68	0.67	-0.22		144.82	0.69	-0.24		148.54	0.71	-0.18		144.69	0.69	-0.21	
220	138.13	0.63	-0.29		142.14	0.65	-0.30		146.48	0.67	-0.24		142.27	0.65	-0.27	
230	134.95	0.59	-0.35		138.82	0.60	-0.36		143.82	0.63	-0.30		139.22	0.61	-0.34	
240	131.16	0.55	-0.41		134.86	0.56	-0.43		140.57	0.59	-0.36		135.55	0.56	-0.40	
250	126.75	0.51	-0.47		130.26	0.52	-0.49		136.71	0.55	-0.42		131.26	0.53	-0.46	

TABLE 3.12 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF CORN,
ASSOCIATED WITH INCREASED NITROGEN LEVELS ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1966-1970

LBS. OF N PER ACRE	234				237				240				243			
	YIELDS IN BUSHEL/ACRE WITH P, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 40				YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE			
	TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-	
		AGE	INAL			AGE	INAL			AGE	INAL			AGE	INAL	
0	71.48		0.96	71.67	1.12	8.25	1.05	71.75	1.08	8.23	1.02	71.63			1.05	
10	80.75	8.07	0.90	82.53	1.05	4.64	0.99	82.29	1.02	4.61	0.96	81.86	8.19		0.99	
20	89.46	4.47	0.84	92.76	0.99	3.41	0.93	92.24	0.96	3.39	0.90	91.48	4.57		0.93	
30	97.61	3.25	0.79	102.34	0.93	2.78	0.86	101.58	0.90	2.76	0.84	100.51	3.35		0.87	
40	105.20	2.63	0.73	111.28	0.86	2.39	0.80	110.32	0.84	2.37	0.78	108.94	2.72		0.81	
50	112.23	2.24	0.68	119.58	0.80	2.12	0.73	118.47	0.78	2.10	0.72	116.76	2.34		0.75	
60	118.70	1.98	0.62	127.24	0.73	1.92	0.67	126.01	0.72	1.90	0.66	123.99	2.07		0.69	
70	124.62	1.78	0.56	134.27	0.67	1.76	0.61	132.96	0.66	1.74	0.60	130.61	1.87		0.63	
80	129.97	1.62	0.51	140.65	0.61	1.63	0.54	139.30	0.60	1.61	0.54	136.64	1.71		0.57	
90	134.76	1.50	0.45	146.39	0.54	1.51	0.48	145.04	0.54	1.50	0.48	142.07	1.58		0.51	
100	138.99	1.39	0.40	151.49	0.48	1.42	0.41	150.19	0.48	1.41	0.42	146.89	1.47		0.45	
110	142.66	1.30	0.34	155.95	0.41	1.33	0.35	154.73	0.42	1.32	0.36	151.12	1.37		0.39	
120	145.77	1.21	0.28	159.78	0.35	1.25	0.29	158.68	0.36	1.25	0.30	154.74	1.29		0.33	
130	148.32	1.14	0.23	162.96	0.29	1.18	0.22	162.02	0.30	1.18	0.24	157.77	1.21		0.27	
140	150.31	1.07	0.17	165.50	0.22	1.12	0.16	164.76	0.24	1.11	0.18	160.20	1.14		0.21	
150	151.74	1.01	0.12	167.40	0.16	1.05	0.09	166.91	0.18	1.05	0.12	162.02	1.08		0.15	
160	152.61	0.95	0.06	168.66	0.09	1.00	0.03	168.45	0.12	1.00	0.06	163.25	1.02		0.09	
170	152.93	0.90	0.00	169.29	0.03	0.94	-0.03	169.39	0.06	0.94	0.00	163.87	0.96		0.03	
180	152.68	0.85	-0.05	169.27	-0.03	0.89	-0.10	169.74	0.00	0.89	-0.06	163.90	0.91		-0.03	
190	151.87	0.80	-0.11	168.61	-0.10	0.84	-0.16	169.48	-0.06	0.84	-0.12	163.33	0.86		-0.09	
200	150.50	0.75	-0.16	167.31	-0.16	0.79	-0.23	168.63	-0.12	0.80	-0.18	162.15	0.81		-0.15	
210	148.57	0.71	-0.22	165.37	-0.23	0.74	-0.29	167.17	-0.18	0.75	-0.24	160.38	0.76		-0.21	
220	146.08	0.66	-0.28	162.80	-0.29	0.69	-0.35	165.11	-0.24	0.71	-0.30	158.00	0.72		-0.27	
230	143.03	0.62	-0.33	159.58	-0.35	0.65	-0.42	162.46	-0.30	0.66	-0.36	155.03	0.67		-0.33	
240	139.42	0.58	-0.39	155.72	-0.42	0.60	-0.48	159.20	-0.36	0.62	-0.42	151.46	0.63		-0.39	
250	135.25	0.54	-0.44	151.22	-0.48	0.60		155.35	-0.42	0.62		147.28	0.59		-0.45	

TABLE 3.13 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF CORN,
ASSOCIATED WITH INCREASED NITROGEN LEVELS ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1961-1970

LBS. OF N PER ACRE	255				259				262				265			
	YIELDS IN BUSHEL/ACRE WITH P, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 0				YIELDS IN BUSHEL/ACRE WITH P = 40, K = 40				YIELDS IN BUSHEL/ACRE WITH P AND K VARIABLE			
	TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-	
	: AGE	: AGE	: INAL		: AGE	: AGE	: INAL		: AGE	: AGE	: INAL		: AGE	: AGE	: INAL	
0	64.68	7.44	1.00	65.53	7.64	1.11	65.54	7.61	1.08	65.25	1.07	7.56	1.01			
10	74.35	4.17	0.94	76.36	4.33	1.05	76.08	4.30	1.02	75.60	1.01	4.27	1.01			
20	83.44	3.07	0.88	86.54	3.20	0.99	86.02	3.18	0.96	85.35	0.95	3.15	0.95			
30	91.95	2.50	0.82	96.09	2.62	0.92	95.37	2.60	0.90	94.50	0.89	2.58	0.89			
40	99.88	2.14	0.76	105.00	2.27	0.86	104.11	2.25	0.84	103.05	0.83	2.22	0.83			
50	107.23	1.90	0.71	113.27	2.01	0.79	112.26	2.00	0.78	111.00	0.77	2.22	0.77			
60	114.00	1.72	0.65	120.90	1.83	0.73	119.80	1.81	0.72	118.36	0.71	1.97	0.71			
70	120.19	1.57	0.59	127.88	1.68	0.67	126.74	1.66	0.66	125.11	0.65	1.79	0.65			
80	125.80	1.45	0.53	134.23	1.55	0.60	133.09	1.54	0.60	131.26	0.59	1.64	0.59			
90	130.83	1.35	0.47	139.94	1.45	0.54	138.83	1.44	0.54	136.81	0.53	1.52	0.53			
100	135.28	1.27	0.42	145.01	1.36	0.47	143.98	1.35	0.48	141.76	0.47	1.42	0.47			
110	139.15	1.19	0.36	149.44	1.28	0.41	148.52	1.27	0.42	146.11	0.41	1.33	0.41			
120	142.44	1.12	0.30	153.22	1.20	0.35	152.46	1.20	0.36	149.86	0.35	1.25	0.35			
130	145.15	1.05	0.24	156.37	1.13	0.28	155.81	1.13	0.30	153.01	0.29	1.18	0.29			
140	147.28	0.99	0.18	158.88	1.07	0.22	158.55	1.07	0.24	155.56	0.23	1.11	0.23			
150	148.83	0.94	0.13	160.75	1.01	0.15	160.70	1.01	0.18	157.51	0.17	1.05	0.17			
160	149.80	0.88	0.07	161.98	0.96	0.09	162.24	0.96	0.12	158.87	0.11	0.99	0.11			
170	150.19	0.83	0.01	162.56	0.90	0.03	163.18	0.96	0.06	159.62	0.05	0.94	0.05			
180	150.00	0.79	-0.05	162.51	0.85	-0.04	163.53	0.91	0.00	159.77	-0.01	0.89	-0.01			
190	149.23	0.74	-0.11	161.82	0.80	-0.10	163.27	0.86	-0.06	159.32	-0.07	0.84	-0.07			
200	147.88	0.70	-0.16	160.49	0.75	-0.17	162.42	0.81	-0.12	158.27	-0.13	0.79	-0.13			
210	145.95	0.65	-0.22	158.52	0.71	-0.23	160.96	0.77	-0.18	156.62	-0.19	0.75	-0.19			
220	143.44	0.61	-0.28	155.90	0.66	-0.29	158.90	0.72	-0.24	154.37	-0.25	0.70	-0.25			
230	140.35	0.57	-0.34	152.65	0.62	-0.36	156.25	0.68	-0.30	151.52	-0.31	0.66	-0.31			
240	136.68	0.53	-0.40	148.76	0.58	-0.42	152.99	0.64	-0.36	148.07	-0.37	0.62	-0.37			
250	132.43		-0.45	144.23	0.53	-0.49	149.14	0.60	-0.42	144.02	-0.43	0.58	-0.43			

TABLE 4.1 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF GRAIN SORGHUM, ASSOCIATED WITH INCREASED NITROGEN LEVELS, ON IRRIGATED LAND OF WEST-CENTRAL KANSAS, 1961

LBS. OF N PER ACRE	278			281			284			287		
	YIELDS IN CWT/ACRE WITH P, K = 0			YIELDS IN CWT/ACRE WITH P = 40, K = 0			YIELDS IN CWT/ACRE WITH P = 40, K = 40			YIELDS IN CWT/ACRE WITH P AND K VARIABLE		
	TOTAL	AVER- : AGE	MARG- : INAL	TOTAL	AVER- : AGE	MARG- : INAL	TOTAL	AVER- : AGE	MARG- : INAL	TOTAL	AVER- : AGE	MARG- : INAL
0	34.25		0.50	38.07	4.20	0.41	35.99	4.08	0.50	36.10		0.47
10	39.05	3.90	0.46	42.02	2.29	0.38	40.84		0.47	40.64	4.06	0.44
20	43.53	2.18	0.43	45.72	1.64	0.36	45.34	2.27	0.43	44.87	2.24	0.41
30	47.68	1.59	0.40	49.15	1.31	0.33	49.51	1.65	0.40	48.81	1.63	0.38
40	51.52	1.29	0.37	52.32	1.10	0.30	53.33	1.33	0.37	52.44	1.31	0.35
50	55.04	1.10	0.34	55.23	0.96	0.28	56.82	1.14	0.33	55.78	1.12	0.32
60	58.23	0.97	0.30	57.89	0.86	0.25	59.97	1.00	0.30	58.81	0.98	0.29
70	61.11	0.87	0.27	60.28	0.78	0.23	62.77	0.90	0.26	61.55	0.88	0.26
80	63.67	0.80	0.24	62.41	0.71	0.20	65.24	0.82	0.23	63.98	0.80	0.23
90	65.90	0.73	0.21	64.29	0.66	0.17	67.36	0.75	0.20	66.12	0.73	0.20
100	67.82	0.68	0.18	65.90	0.61	0.15	69.15	0.69	0.16	67.95	0.68	0.17
110	69.42	0.63	0.14	67.25	0.57	0.12	70.60	0.64	0.13	69.49	0.63	0.14
120	70.70	0.59	0.11	68.35	0.53	0.10	71.70	0.60	0.09	70.72	0.59	0.11
130	71.65	0.55	0.08	69.18	0.50	0.07	72.47	0.56	0.06	71.66	0.55	0.08
140	72.29	0.52	0.05	69.75	0.47	0.04	72.89	0.52	0.03	72.29	0.52	0.05
150	72.61	0.48	0.02	70.06	0.44	0.02	72.98	0.49	-0.01	72.63	0.48	0.02
160	72.60	0.45	-0.02	70.12	0.41	-0.01	72.73	0.45	-0.04	72.66	0.45	-0.01
170	72.28	0.43	-0.05	69.91	0.39	-0.03	72.13	0.42	-0.08	72.40	0.43	-0.04
180	71.64	0.40	-0.08	69.44	0.36	-0.06	71.20	0.40	-0.11	71.83	0.40	-0.07
190	70.67	0.37	-0.11	68.72	0.34	-0.09	69.92	0.37	-0.14	70.97	0.37	-0.10
200	69.39	0.35	-0.14	67.73	0.32	-0.11	68.31	0.34	-0.18	69.80	0.35	-0.13
210	67.79	0.32	-0.18	66.48	0.30	-0.14	66.36	0.32	-0.21	68.34	0.33	-0.16
220	65.87	0.30	-0.21	64.98	0.27	-0.16	64.06	0.29	-0.25	66.57	0.30	-0.19
230	63.62	0.28	-0.24	63.21	0.25	-0.19	61.43	0.27	-0.28	64.51	0.28	-0.22
240	61.06	0.25	-0.27	61.18	0.24	-0.22	58.45	0.24	-0.31	62.14	0.26	-0.25
250	58.18	0.23	-0.30	58.89	0.24	-0.24	55.14	0.22	-0.35	59.48	0.24	-0.28

TABLE 4.2 ESTIMATED TOTAL, MARGINAL AND AVERAGEPER ACRE YIELDS OF GRAIN SORGHUM, ASSOCIATED WITH INCREASED NITROGEN LEVELS, ON IRRIGATED LAND OF WEST-CENTRAL KANSAS, 1962

LBS. OF N PER ACRE	291				294				297				300			
	YIELDS IN CWT/ACRE WITH P, K = 0				YIELDS IN CWT/ACRE WITH P = 40, K = 0				YIELDS IN CWT/ACRE WITH P = 40, K = 40				YIELDS IN CWT/ACRE WITH P AND K VARIABLE			
	TOTAL	: AVER-	: MARG-		TOTAL	: AVER-	: MARG-		TOTAL	: AVER-	: MARG-		TOTAL	: AVER-	: MARG-	
		: AGE	: INAL			: AGE	: INAL			: AGE	: INAL			: AGE	: INAL	
0	50.68		0.35		53.42		0.35		54.08		0.37		52.73		0.36	
10	54.06	5.41	0.33		56.81	5.68	0.33		57.63	5.76	0.34		56.16	5.62	0.33	
20	57.23	2.86	0.31		59.95	3.00	0.30		60.93	3.05	0.32		59.36	2.97	0.31	
30	60.18	2.01	0.28		62.86	2.10	0.28		64.00	2.13	0.29		62.32	2.08	0.28	
40	62.90	1.57	0.26		65.52	1.64	0.25		66.82	1.67	0.27		65.03	1.63	0.26	
50	65.41	1.31	0.24		67.94	1.36	0.23		69.41	1.39	0.25		67.51	1.35	0.24	
60	67.70	1.13	0.22		70.13	1.17	0.21		71.76	1.20	0.22		69.74	1.16	0.21	
70	69.77	1.00	0.20		72.07	1.03	0.18		73.86	1.06	0.20		71.74	1.02	0.19	
80	71.61	0.90	0.17		73.78	0.92	0.16		75.73	0.95	0.17		73.50	0.92	0.16	
90	73.24	0.81	0.15		75.24	0.84	0.13		77.35	0.86	0.15		75.01	0.83	0.14	
100	74.65	0.75	0.13		76.46	0.76	0.11		78.74	0.79	0.13		76.29	0.76	0.12	
110	75.83	0.69	0.11		77.45	0.70	0.09		79.89	0.73	0.10		77.32	0.70	0.09	
120	76.80	0.64	0.09		78.19	0.65	0.06		80.79	0.67	0.08		78.12	0.65	0.07	
130	77.55	0.60	0.06		78.70	0.61	0.04		81.46	0.63	0.05		78.68	0.61	0.04	
140	78.07	0.56	0.04		78.96	0.56	0.01		81.88	0.58	0.03		78.99	0.56	0.02	
150	78.38	0.52	0.02		78.98	0.53	-0.01		82.07	0.55	0.01		79.07	0.53	-0.00	
160	78.47	0.49	-0.00		78.77	0.49	-0.03		82.02	0.51	-0.02		78.90	0.49	-0.03	
170	78.34	0.46	-0.02		78.31	0.46	-0.06		81.72	0.48	-0.04		78.50	0.46	-0.05	
180	77.98	0.43	-0.05		77.62	0.43	-0.08		81.19	0.45	-0.07		77.86	0.43	-0.08	
190	77.41	0.41	-0.07		76.68	0.40	-0.11		80.41	0.42	-0.09		76.97	0.41	-0.10	
200	76.62	0.38	-0.09		75.50	0.38	-0.13		79.40	0.40	-0.11		75.85	0.38	-0.12	
210	75.60	0.36	-0.11		74.09	0.35	-0.15		78.15	0.37	-0.14		74.48	0.35	-0.15	
220	74.37	0.34	-0.13		72.43	0.33	-0.18		76.65	0.35	-0.16		72.88	0.33	-0.17	
230	72.92	0.32	-0.16		70.54	0.31	-0.20		74.92	0.33	-0.19		71.04	0.31	-0.20	
240	71.24	0.30	-0.18		68.40	0.29	-0.23		72.94	0.30	-0.21		68.95	0.29	-0.22	
250	69.35	0.28	-0.20		66.02	0.26	-0.25		70.73	0.28	-0.23		66.63	0.27	-0.24	

TABLE 4.3 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF GRAIN SORGHUM, ASSOCIATED WITH INCREASED NITROGEN LEVELS, ON IRRIGATED LAND OF WEST-CENTRAL KANSAS, 1963

LBS. OF N PER ACRE	308			311			313			316		
	YIELDS IN CWT/ACRE WITH P, K = 0			YIELDS IN CWT/ACRE WITH P = 40, K = 0			YIELDS IN CWT/ACRE WITH P = 40, K = 40			YIELDS IN CWT/ACRE WITH P AND K VARIABLE		
	TOTAL	AVER-	MARG-	TOTAL	AVER-	MARG-	TOTAL	AVER-	MARG-	TOTAL	AVER-	MARG-
	: AGE	: AGE	: INAL	: AGE	: AGE	: INAL	: AGE	: AGE	: INAL	: AGE	: AGE	: INAL
0	47.19		0.43	51.84		0.31	49.33		0.38	49.45		0.37
10	51.33	5.13	0.40	54.85	5.48	0.29	53.06	5.31	0.36	53.08	5.31	0.35
20	55.16	2.76	0.37	57.68	2.88	0.27	56.54	2.83	0.34	56.46	2.82	0.33
30	58.70	1.96	0.34	60.33	2.01	0.26	59.78	1.99	0.31	59.61	1.99	0.30
40	61.94	1.55	0.31	62.80	1.57	0.24	62.79	1.57	0.29	62.51	1.56	0.28
50	64.88	1.30	0.28	65.09	1.30	0.22	65.55	1.31	0.26	65.17	1.30	0.25
60	67.52	1.13	0.25	67.20	1.12	0.20	68.08	1.13	0.24	67.60	1.13	0.23
70	69.85	1.00	0.22	69.13	0.99	0.18	70.36	1.01	0.22	69.78	1.00	0.21
80	71.89	0.90	0.19	70.88	0.89	0.17	72.40	0.91	0.19	71.73	0.90	0.18
90	73.63	0.82	0.16	72.45	0.80	0.15	74.21	0.82	0.17	73.43	0.82	0.16
100	75.07	0.75	0.13	73.84	0.74	0.13	75.77	0.76	0.14	74.89	0.75	0.13
110	76.21	0.69	0.10	75.05	0.68	0.11	77.10	0.70	0.12	76.12	0.69	0.11
120	77.04	0.64	0.07	76.08	0.63	0.09	78.18	0.65	0.10	77.10	0.64	0.09
130	77.58	0.60	0.04	76.93	0.59	0.08	79.02	0.61	0.07	77.85	0.60	0.06
140	77.82	0.56	0.01	77.60	0.55	0.06	79.63	0.57	0.05	78.35	0.56	0.04
150	77.76	0.52	-0.02	78.09	0.52	0.04	79.99	0.53	0.02	78.61	0.52	0.01
160	77.40	0.48	-0.05	78.40	0.49	0.02	80.12	0.50	0.00	78.64	0.49	-0.01
170	76.73	0.45	-0.08	78.53	0.46	0.00	80.00	0.47	-0.02	78.42	0.46	-0.03
180	75.77	0.42	-0.11	78.48	0.44	-0.01	79.64	0.44	-0.05	77.97	0.43	-0.06
190	74.51	0.39	-0.14	78.25	0.41	-0.03	79.05	0.42	-0.07	77.27	0.41	-0.08
200	72.95	0.36	-0.17	77.84	0.39	-0.05	78.21	0.39	-0.10	76.33	0.38	-0.11
210	71.09	0.34	-0.20	77.25	0.37	-0.07	77.14	0.37	-0.12	75.16	0.36	-0.13
220	68.92	0.31	-0.23	76.48	0.35	-0.09	75.82	0.34	-0.14	73.74	0.34	-0.15
230	66.46	0.29	-0.26	75.53	0.33	-0.10	74.26	0.32	-0.17	72.09	0.31	-0.18
240	63.70	0.27	-0.29	74.40	0.31	-0.12	72.47	0.30	-0.19	70.19	0.29	-0.20
250	60.64	0.24	-0.32	73.09	0.29	-0.14	70.43	0.28	-0.22	68.05	0.27	-0.23

TABLE 4.4 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF GRAIN SORGHUM, ASSOCIATED WITH INCREASED NITROGEN LEVELS, ON IRRIGATED LAND OF WEST-CENTRAL KANSAS, 1964

LBS. OF N PER ACRE	320			322			324			326		
	YIELDS IN CWT/ACRE			YIELDS IN CWT/ACRE			YIELDS IN CWT/ACRE			YIELDS IN CWT/ACRE		
	WITH P, K = 0			WITH P = 40, K = 0			WITH P = 40, K = 40			WITH P AND K VARIABLE		
	TOTAL	AVER-	MARG-	TOTAL	AVER-	MARG-	TOTAL	AVER-	MARG-	TOTAL	AVER-	MARG-
		AGE	INAL		AGE	INAL		AGE	INAL		AGE	INAL
0	29.24	3.45	0.54	32.15	3.72	0.52	32.72	3.81	0.56	31.37	3.66	0.54
10	34.48	1.97	0.51	37.23	2.10	0.49	38.10	2.16	0.52	36.60	2.08	0.51
20	39.39	1.47	0.48	42.01	1.55	0.46	43.15	1.60	0.49	41.52	1.54	0.48
30	43.99	1.21	0.44	46.49	1.27	0.43	47.85	1.31	0.45	46.11	1.26	0.44
40	48.27	1.04	0.41	50.67	1.09	0.40	52.22	1.12	0.42	50.38	1.09	0.41
50	52.23	0.93	0.38	54.54	0.97	0.37	56.24	1.00	0.39	54.34	0.97	0.38
60	55.87	0.85	0.35	58.12	0.88	0.34	59.93	0.90	0.35	57.97	0.88	0.35
70	59.19	0.78	0.32	61.40	0.80	0.31	63.27	0.83	0.32	61.29	0.80	0.32
80	62.19	0.72	0.28	64.38	0.75	0.28	66.28	0.77	0.28	64.28	0.74	0.28
90	64.87	0.67	0.25	67.06	0.69	0.25	68.94	0.71	0.25	66.95	0.69	0.25
100	67.23	0.63	0.22	69.43	0.65	0.22	71.27	0.67	0.22	69.31	0.65	0.22
110	69.27	0.59	0.19	71.51	0.61	0.19	73.25	0.62	0.18	71.34	0.61	0.19
120	70.98	0.56	0.16	73.29	0.58	0.16	74.90	0.59	0.15	73.06	0.57	0.16
130	72.38	0.52	0.12	74.77	0.54	0.13	76.20	0.55	0.11	74.45	0.54	0.12
140	73.46	0.49	0.09	75.95	0.51	0.10	77.17	0.52	0.08	75.52	0.51	0.09
150	74.22	0.47	0.06	76.82	0.48	0.07	77.79	0.52	0.05	76.28	0.48	0.06
160	74.66	0.44	0.03	77.40	0.46	0.04	78.08	0.49	0.01	76.71	0.45	0.03
170	74.78	0.41	-0.00	77.68	0.43	0.01	78.02	0.46	-0.02	76.83	0.43	-0.00
180	74.58	0.39	-0.04	77.66	0.41	-0.02	77.63	0.43	-0.06	76.62	0.40	-0.04
190	74.06	0.37	-0.07	77.34	0.38	-0.05	76.89	0.40	-0.09	76.09	0.38	-0.07
200	73.22	0.34	-0.10	76.71	0.36	-0.08	75.82	0.38	-0.12	75.25	0.35	-0.10
210	72.06	0.32	-0.13	75.79	0.34	-0.11	74.40	0.35	-0.16	74.08	0.33	-0.13
220	70.57	0.30	-0.16	74.57	0.32	-0.14	72.65	0.33	-0.19	72.60	0.31	-0.16
230	68.77	0.28	-0.20	73.05	0.30	-0.17	70.55	0.31	-0.23	70.79	0.29	-0.20
240	66.65	0.26	-0.23	71.23	0.28	-0.20	68.12	0.28	-0.26	68.66	0.26	-0.23
250	64.21	0.26	-0.26	69.10	0.28	-0.23	65.34	0.26	-0.29	66.22	0.26	-0.26

TABLE 4.5 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF GRAIN SORGHUM,
ASSOCIATED WITH INCREASED NITROGEN LEVELS, ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1965

LBS. OF N PER ACRE	333			335			337			339		
	YIELDS IN CWT/ACRE WITH P, K = 0			YIELDS IN CWT/ACRE WITH P = 40, K = 0			YIELDS IN CWT/ACRE WITH P = 40, K = 40			YIELDS IN CWT/ACRE WITH P AND K VARIABLE		
	TOTAL	: AVER- : AGE	: MARG- : INAL	TOTAL	: AVER- : AGE	: MARG- : INAL	TOTAL	: AVER- : AGE	: MARG- : INAL	TOTAL	: AVER- : AGE	: MARG- : INAL
0	21.90		0.48	20.93		0.52	21.82		0.53	21.58		0.51
10	26.56	2.66	0.45	26.02	2.60	0.49	26.96	2.70	0.50	26.54	2.65	0.48
20	30.93	1.55	0.42	30.81	1.54	0.46	31.78	1.59	0.47	31.20	1.56	0.45
30	34.99	1.17	0.39	35.30	1.18	0.43	36.28	1.21	0.43	35.56	1.19	0.42
40	38.76	0.97	0.36	39.49	0.99	0.40	40.46	1.01	0.40	39.62	0.99	0.39
50	42.22	0.84	0.33	43.38	0.87	0.37	44.32	0.89	0.37	43.39	0.87	0.36
60	45.39	0.76	0.30	46.97	0.78	0.34	47.86	0.80	0.34	46.85	0.78	0.33
70	48.25	0.69	0.27	50.26	0.72	0.31	51.08	0.73	0.31	50.01	0.71	0.30
80	50.82	0.64	0.24	53.25	0.67	0.28	53.98	0.67	0.27	52.87	0.66	0.27
90	53.08	0.59	0.21	55.94	0.62	0.25	56.56	0.63	0.24	55.43	0.62	0.24
100	55.05	0.55	0.18	58.33	0.58	0.22	58.82	0.59	0.21	57.70	0.58	0.21
110	56.71	0.52	0.15	60.42	0.55	0.19	60.76	0.55	0.18	59.66	0.54	0.18
120	58.08	0.48	0.12	62.21	0.52	0.16	62.38	0.52	0.15	61.32	0.51	0.15
130	59.14	0.45	0.09	63.70	0.49	0.13	63.68	0.49	0.11	62.68	0.48	0.12
140	59.91	0.43	0.06	64.89	0.46	0.10	64.66	0.46	0.08	63.74	0.46	0.09
150	60.37	0.40	0.03	65.78	0.44	0.07	65.32	0.44	0.05	64.51	0.43	0.06
160	60.54	0.38	0.00	66.37	0.41	0.04	65.66	0.41	0.02	64.97	0.41	0.03
170	60.40	0.36	-0.03	66.66	0.39	0.01	65.68	0.39	-0.01	65.13	0.38	0.00
180	59.97	0.33	-0.06	66.65	0.37	-0.02	65.38	0.36	-0.05	64.99	0.36	-0.03
190	59.23	0.31	-0.09	66.34	0.35	-0.05	64.76	0.34	-0.08	64.55	0.34	-0.06
200	58.20	0.29	-0.12	65.73	0.33	-0.08	63.82	0.32	-0.11	63.82	0.32	-0.09
210	56.86	0.27	-0.15	64.82	0.31	-0.11	62.56	0.30	-0.14	62.78	0.30	-0.12
220	55.23	0.25	-0.18	63.61	0.29	-0.14	60.98	0.28	-0.17	61.44	0.28	-0.15
230	53.29	0.23	-0.21	62.10	0.27	-0.17	59.08	0.26	-0.21	59.80	0.26	-0.18
240	51.06	0.21	-0.24	60.29	0.25	-0.20	56.86	0.24	-0.24	57.86	0.24	-0.21
250	48.52	0.19	-0.27	58.18	0.23	-0.23	54.32	0.22	-0.27	55.63	0.22	-0.24

TABLE 4.6 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF GRAIN SORGHUM, ASSOCIATED WITH INCREASED NITROGEN LEVELS, ON IRRIGATED LAND OF WEST-CENTRAL KANSAS, 1966

LBS. OF N PER ACRE	349			352			355			358		
	YIELDS IN CWT/ACRE WITH P, K = 0			YIELDS IN CWT/ACRE WITH P = 40, K = 0			YIELDS IN CWT/ACRE WITH P = 40, K = 40			YIELDS IN CWT/ACRE WITH P AND K VARIABLE		
	TOTAL	AVER-	MARG-	TOTAL	AVER-	MARG-	TOTAL	AVER-	MARG-	TOTAL	AVER-	MARG-
		AGE	INAL		AGE	INAL		AGE	INAL		AGE	INAL
0	40.89	4.55	0.48	40.59	4.51	0.47	42.39	4.71	0.49	41.29		0.48
10	45.53	2.49	0.45	45.13	2.47	0.44	47.14	2.58	0.46	45.93	4.59	0.45
20	49.80	1.79	0.41	49.37	1.78	0.41	51.53	1.85	0.42	50.23	2.51	0.41
30	53.71	1.43	0.37	53.31	1.42	0.38	55.57	1.48	0.39	54.19	1.81	0.38
40	57.27	1.21	0.34	56.95	1.21	0.35	59.24	1.25	0.35	57.82	1.45	0.35
50	60.46	1.05	0.30	60.29	1.06	0.32	62.56	1.09	0.31	61.10	1.22	0.31
60	63.29	0.94	0.27	63.33	0.94	0.29	65.51	0.97	0.28	64.04	1.07	0.28
70	65.76	0.85	0.23	66.07	0.86	0.26	68.10	0.88	0.24	66.64	0.95	0.24
80	67.88	0.77	0.19	68.51	0.78	0.23	70.34	0.80	0.21	68.90	0.86	0.21
90	69.63	0.71	0.16	70.65	0.72	0.20	72.21	0.74	0.17	70.83	0.79	0.18
100	71.02	0.66	0.12	72.49	0.67	0.17	73.73	0.68	0.13	72.41	0.72	0.14
110	72.06	0.61	0.09	74.03	0.63	0.14	74.88	0.63	0.10	73.65	0.67	0.11
120	72.73	0.56	0.05	75.27	0.59	0.11	75.67	0.59	0.06	74.55	0.62	0.07
130	73.04	0.52	0.01	76.21	0.55	0.08	76.11	0.54	0.03	75.11	0.58	0.04
140	73.00	0.48	-0.02	76.85	0.51	0.05	76.18	0.51	-0.01	75.34	0.54	0.01
150	72.59	0.45	-0.06	77.19	0.48	0.02	75.90	0.47	-0.05	75.22	0.50	-0.03
160	71.82	0.42	-0.09	77.23	0.45	-0.01	75.25	0.44	-0.08	74.76	0.47	-0.06
170	70.69	0.38	-0.13	76.97	0.42	-0.04	74.24	0.40	-0.12	73.96	0.44	-0.10
180	69.21	0.35	-0.17	76.41	0.40	-0.07	72.88	0.37	-0.15	72.82	0.40	-0.13
190	67.36	0.33	-0.20	75.55	0.37	-0.10	71.15	0.35	-0.19	71.35	0.38	-0.16
200	65.15	0.30	-0.24	74.39	0.35	-0.13	69.07	0.32	-0.23	69.53	0.35	-0.20
210	62.59	0.27	-0.27	72.93	0.32	-0.16	66.62	0.29	-0.26	67.37	0.32	-0.23
220	59.66	0.25	-0.31	71.17	0.30	-0.19	63.81	0.26	-0.30	64.87	0.29	-0.27
230	56.37	0.22	-0.35	69.11	0.28	-0.22	60.65	0.24	-0.33	62.03	0.27	-0.30
240	52.73	0.19	-0.38	66.75	0.26	-0.25	57.12	0.21	-0.37	58.86	0.25	-0.33
250	48.72		-0.42	64.09	0.26	-0.28	53.24	0.21	-0.41	55.34	0.22	-0.37

TABLE 4.7 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF GRAIN SORGHUM,
ASSOCIATED WITH INCREASED NITROGEN LEVELS, ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1967

LBS. OF N PER ACRE	369				372				375				378			
	YIELDS IN CWT/ACRE WITH P, K = 0				YIELDS IN CWT/ACRE WITH P = 40, K = 0				YIELDS IN CWT/ACRE WITH P = 40, K = 40				YIELDS IN CWT/ACRE WITH P AND K VARIABLE			
	TOTAL	: AVER-	: MARG-		TOTAL	: AVER-	: MARG-		TOTAL	: AVER-	: MARG-		TOTAL	: AVER-	: MARG-	
		: AGE	: INAL			: AGE	: INAL			: AGE	: INAL			: AGE	: INAL	
0	39.65	4.47	0.52	42.59	4.80	0.56	53.27	5.87	41.70	0.56	0.56	41.70	4.70	0.55		
10	44.71	2.47	0.49	47.98	2.65	0.52	58.70	3.19	46.99	0.52	0.52	46.99	2.60	0.51		
20	49.39	1.79	0.45	53.00	1.92	0.48	63.72	2.28	51.91	0.48	0.48	51.91	1.88	0.47		
30	53.69	1.44	0.41	57.64	1.55	0.44	68.35	1.81	56.45	0.44	0.44	56.45	1.52	0.43		
40	57.61	1.22	0.37	61.89	1.32	0.41	72.58	1.53	60.61	0.40	0.40	60.61	1.29	0.40		
50	61.15	1.07	0.34	65.77	1.15	0.37	76.40	1.33	64.39	0.36	0.36	64.39	1.13	0.36		
60	64.31	0.96	0.30	69.26	1.03	0.33	79.83	1.18	67.78	0.32	0.32	67.78	1.01	0.32		
70	67.09	0.87	0.26	72.38	0.94	0.29	82.86	1.07	70.80	0.28	0.28	70.80	0.92	0.28		
80	69.49	0.79	0.22	75.12	0.86	0.25	85.49	0.97	73.44	0.24	0.24	73.44	0.84	0.24		
90	71.51	0.73	0.18	77.47	0.79	0.22	87.71	0.90	75.70	0.20	0.20	75.70	0.78	0.21		
100	73.15	0.68	0.15	79.45	0.74	0.18	89.54	0.83	77.58	0.16	0.16	77.58	0.72	0.17		
110	74.41	0.63	0.11	81.04	0.69	0.14	90.97	0.77	79.07	0.12	0.12	79.07	0.67	0.13		
120	75.29	0.58	0.07	82.26	0.64	0.10	91.99	0.71	80.19	0.08	0.08	80.19	0.62	0.09		
130	75.79	0.54	0.03	83.10	0.60	0.06	92.62	0.66	80.93	0.04	0.04	80.93	0.58	0.05		
140	75.91	0.50	-0.01	83.55	0.56	0.03	92.85	0.62	81.29	0.00	0.00	81.29	0.54	0.02		
150	75.65	0.47	-0.04	83.63	0.52	-0.01	92.67	0.58	81.27	-0.04	-0.04	81.27	0.51	-0.02		
160	75.01	0.44	-0.08	83.32	0.49	-0.05	92.10	0.54	80.86	-0.08	-0.08	80.86	0.47	-0.06		
170	73.99	0.40	-0.12	82.64	0.45	-0.09	91.13	0.50	80.08	-0.12	-0.12	80.08	0.44	-0.10		
180	72.59	0.37	-0.16	81.58	0.42	-0.13	89.76	0.46	78.92	-0.16	-0.16	78.92	0.41	-0.14		
190	70.81	0.34	-0.20	80.13	0.39	-0.16	87.98	0.43	77.38	-0.20	-0.20	77.38	0.38	-0.17		
200	68.65	0.31	-0.23	78.31	0.36	-0.20	85.81	0.40	75.46	-0.24	-0.24	75.46	0.35	-0.21		
210	66.11	0.29	-0.27	76.10	0.33	-0.24	83.24	0.36	73.15	-0.28	-0.28	73.15	0.32	-0.25		
220	63.19	0.26	-0.31	73.52	0.31	-0.28	80.26	0.33	70.47	-0.32	-0.32	70.47	0.29	-0.29		
230	59.89	0.23	-0.35	70.56	0.28	-0.32	76.89	0.30	67.41	-0.36	-0.36	67.41	0.27	-0.33		
240	56.21	0.21	-0.39	67.21	0.25	-0.35	73.12	0.28	63.97	-0.40	-0.40	63.97	0.24	-0.36		
250	52.15		-0.42	63.49		-0.39	68.94		60.15	-0.44	-0.44	60.15		-0.40		

TABLE 4.8 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF GRAIN SORGHUM,
ASSOCIATED WITH INCREASED NITROGEN LEVELS, ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1968

LBS. OF N PER ACRE	388				391				394				397			
	YIELDS IN CWT/ACRE WITH P, K = 0				YIELDS IN CWT/ACRE WITH P = 40, K = 0				YIELDS IN CWT/ACRE WITH P = 40, K = 40				YIELDS IN CWT/ACRE WITH P AND K VARIABLE			
	TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-	
		AGE	INAL			AGE	INAL			AGE	INAL			AGE	INAL	
0	33.54		0.56		35.94		0.60		35.69		0.62		35.06		0.59	
10	38.91	3.89	0.52	4.17	41.70	4.17	0.56	4.17	41.71	4.17	0.58	4.17	40.78	4.08	0.55	4.08
20	43.93	2.20	0.48	2.35	47.07	2.35	0.52	2.35	47.33	2.37	0.54	2.37	46.12	2.31	0.52	2.31
30	48.58	1.62	0.45	1.73	52.04	1.73	0.48	1.73	52.54	1.75	0.50	1.75	51.08	1.70	0.48	1.70
40	52.87	1.32	0.41	1.42	56.60	1.42	0.44	1.42	57.36	1.43	0.46	1.43	55.66	1.39	0.44	1.39
50	56.81	1.14	0.38	1.22	60.77	1.22	0.40	1.22	61.78	1.24	0.42	1.24	59.87	1.20	0.40	1.20
60	60.38	1.01	0.34	1.08	64.53	1.08	0.36	1.08	65.79	1.10	0.38	1.10	63.69	1.06	0.36	1.06
70	63.59	0.91	0.30	0.97	67.90	0.97	0.32	0.97	69.41	0.99	0.34	0.99	67.13	0.96	0.33	0.96
80	66.45	0.83	0.27	0.89	70.87	0.89	0.28	0.89	72.63	0.91	0.30	0.91	70.19	0.88	0.29	0.88
90	68.94	0.77	0.23	0.82	73.43	0.82	0.24	0.82	75.44	0.84	0.26	0.84	72.87	0.81	0.25	0.81
100	71.07	0.71	0.20	0.76	75.60	0.76	0.20	0.76	77.86	0.78	0.22	0.78	75.18	0.75	0.21	0.75
110	72.84	0.66	0.16	0.70	77.36	0.70	0.16	0.70	79.88	0.73	0.18	0.73	77.10	0.70	0.17	0.70
120	74.26	0.62	0.12	0.66	78.73	0.66	0.12	0.66	81.50	0.68	0.14	0.68	78.64	0.66	0.14	0.66
130	75.31	0.58	0.09	0.61	79.70	0.61	0.08	0.61	82.71	0.64	0.10	0.64	79.80	0.61	0.10	0.61
140	76.00	0.54	0.05	0.57	80.26	0.57	0.04	0.57	83.53	0.60	0.06	0.60	80.58	0.58	0.06	0.58
150	76.34	0.51	0.02	0.54	80.43	0.54	-0.00	0.54	83.95	0.56	0.02	0.56	80.99	0.54	0.02	0.54
160	76.31	0.48	-0.02	0.50	80.19	0.50	-0.04	0.50	83.96	0.52	-0.02	0.52	81.01	0.51	-0.02	0.51
170	75.92	0.45	-0.06	0.47	79.56	0.47	-0.08	0.47	83.58	0.49	-0.06	0.49	80.65	0.47	-0.05	0.47
180	75.18	0.42	-0.09	0.44	78.53	0.44	-0.12	0.44	82.80	0.46	-0.10	0.46	79.91	0.44	-0.09	0.44
190	74.07	0.39	-0.13	0.41	77.09	0.41	-0.16	0.41	81.61	0.43	-0.14	0.43	78.79	0.41	-0.13	0.41
200	72.60	0.36	-0.16	0.38	75.26	0.38	-0.20	0.38	80.03	0.40	-0.18	0.40	77.30	0.39	-0.17	0.39
210	70.77	0.34	-0.20	0.35	73.02	0.35	-0.24	0.35	78.05	0.37	-0.22	0.37	75.42	0.36	-0.21	0.36
220	68.59	0.31	-0.24	0.32	70.39	0.32	-0.28	0.32	75.67	0.34	-0.26	0.34	73.16	0.33	-0.24	0.33
230	66.04	0.29	-0.27	0.29	67.36	0.29	-0.32	0.29	72.88	0.32	-0.30	0.32	70.52	0.31	-0.28	0.31
240	63.13	0.26	-0.31	0.27	63.92	0.27	-0.36	0.27	69.70	0.29	-0.34	0.29	67.50	0.28	-0.32	0.28
250	59.87	0.24	-0.34	0.24	60.09	0.24	-0.40	0.24	66.12	0.26	-0.38	0.26	64.11	0.26	-0.36	0.26

TABLE 4.9 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF GRAIN SORGHUM, ASSOCIATED WITH INCREASED NITROGEN LEVELS, ON IRRIGATED LAND OF WEST-CENTRAL KANSAS, 1969

LBS. OF N PER ACRE	409				412				415				418			
	YIELDS IN CWT/ACRE WITH P, K = 0				YIELDS IN CWT/ACRE WITH P = 40, K = 0				YIELDS IN CWT/ACRE WITH P = 40, K = 40				YIELDS IN CWT/ACRE WITH P AND K VARIABLE			
	TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-	
		AGE	INAL			AGE	INAL			AGE	INAL			AGE	INAL	
0	40.74		0.34	43.69	4.77	0.41	0.48	41.55	4.49	0.45	0.48	41.55	4.55	0.41	0.41	0.41
10	44.02	4.40	0.32	47.66	2.57	0.38	0.45	45.52	2.46	0.41	0.45	45.52	2.46	0.41	0.38	0.38
20	47.04	2.35	0.29	51.33	1.82	0.35	0.38	49.19	1.77	0.38	0.38	49.19	1.75	0.35	0.35	0.35
30	49.80	1.66	0.26	54.70	1.44	0.32	0.35	52.56	1.42	0.35	0.35	52.56	1.39	0.32	0.32	0.32
40	52.30	1.31	0.24	57.77	1.21	0.29	0.31	55.63	1.20	0.31	0.31	55.63	1.17	0.29	0.29	0.29
50	54.54	1.09	0.21	60.54	1.05	0.26	0.28	58.40	1.05	0.28	0.28	58.40	1.01	0.26	0.26	0.26
60	56.52	0.94	0.19	63.01	0.93	0.23	0.24	60.87	0.94	0.24	0.24	60.87	0.90	0.23	0.23	0.23
70	58.24	0.83	0.16	65.18	0.84	0.20	0.21	63.04	0.85	0.21	0.21	63.04	0.81	0.20	0.20	0.20
80	59.71	0.75	0.13	67.05	0.76	0.17	0.18	64.91	0.78	0.18	0.18	64.91	0.74	0.17	0.17	0.17
90	60.91	0.68	0.11	68.62	0.70	0.14	0.14	66.47	0.71	0.14	0.14	66.47	0.68	0.14	0.14	0.14
100	61.85	0.62	0.08	69.89	0.64	0.11	0.11	67.74	0.66	0.11	0.11	67.74	0.62	0.11	0.11	0.11
110	62.53	0.57	0.06	70.86	0.60	0.08	0.07	68.71	0.61	0.07	0.07	68.71	0.58	0.08	0.08	0.08
120	62.95	0.52	0.03	71.53	0.55	0.05	0.04	69.38	0.57	0.04	0.04	69.38	0.54	0.05	0.05	0.05
130	63.11	0.49	0.00	71.90	0.51	0.02	0.01	69.75	0.53	0.01	0.01	69.75	0.50	0.02	0.02	0.02
140	63.01	0.45	-0.02	71.97	0.48	-0.01	-0.03	69.82	0.50	-0.03	-0.03	69.82	0.46	-0.01	-0.01	-0.01
150	62.65	0.42	-0.05	71.74	0.45	-0.04	-0.06	69.59	0.46	-0.06	-0.06	69.59	0.43	-0.04	-0.04	-0.04
160	62.03	0.39	-0.07	71.21	0.41	-0.07	-0.10	69.06	0.43	-0.10	-0.10	69.06	0.40	-0.07	-0.07	-0.07
170	61.15	0.36	-0.10	70.38	0.38	-0.10	-0.13	68.23	0.40	-0.13	-0.13	68.23	0.37	-0.10	-0.10	-0.10
180	60.02	0.33	-0.13	69.25	0.36	-0.13	-0.16	67.10	0.37	-0.16	-0.16	67.10	0.35	-0.13	-0.13	-0.13
190	58.62	0.31	-0.15	67.82	0.33	-0.16	-0.20	65.66	0.34	-0.20	-0.20	65.66	0.32	-0.16	-0.16	-0.16
200	56.96	0.28	-0.18	66.09	0.31	-0.19	-0.23	63.93	0.32	-0.23	-0.23	63.93	0.29	-0.19	-0.19	-0.19
210	55.04	0.26	-0.20	64.06	0.28	-0.22	-0.27	61.90	0.29	-0.27	-0.27	61.90	0.27	-0.22	-0.22	-0.22
220	52.86	0.24	-0.23	61.73	0.26	-0.25	-0.30	59.57	0.27	-0.30	-0.30	59.57	0.25	-0.25	-0.25	-0.25
230	50.42	0.22	-0.26	59.10	0.23	-0.28	-0.33	56.94	0.24	-0.33	-0.33	56.94	0.23	-0.28	-0.28	-0.28
240	47.72	0.20	-0.28	56.17	0.21	-0.31	-0.37	54.01	0.22	-0.37	-0.37	54.01	0.20	-0.31	-0.31	-0.31
250	44.76	0.18	-0.31	52.94	0.21	-0.34	-0.37	50.78	0.22	-0.37	-0.37	50.78	0.20	-0.34	-0.34	-0.34

TABLE 4.10 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF GRAIN SORGHUM,
ASSOCIATED WITH INCREASED NITROGEN LEVELS, ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1970

LBS. OF N PER ACRE	433				436				439				442			
	YIELDS IN CWT/ACRE WITH P, K = 0				YIELDS IN CWT/ACRE WITH P = 40, K = 0				YIELDS IN CWT/ACRE WITH P = 40, K = 40				YIELDS IN CWT/ACRE WITH P AND K VARIABLE			
	TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-	
		AGE	INAL			AGE	INAL			AGE	INAL			AGE	INAL	
0	41.93		0.38		42.70		0.43		42.48		0.47		42.37		0.43	
10	45.57	4.56	0.35		46.89	4.69	0.41		47.03	4.70	0.44		46.49	4.65	0.40	
20	48.96	2.45	0.33		50.82	2.54	0.38		51.27	2.56	0.41		50.32	2.52	0.37	
30	52.12	1.74	0.30		54.49	1.82	0.35		55.22	1.84	0.38		53.88	1.80	0.34	
40	55.03	1.38	0.28		57.89	1.45	0.33		58.86	1.47	0.35		57.16	1.43	0.31	
50	57.71	1.15	0.26		61.04	1.22	0.30		62.21	1.24	0.32		60.15	1.20	0.29	
60	60.15	1.00	0.23		63.93	1.07	0.28		65.25	1.09	0.29		62.87	1.05	0.26	
70	62.34	0.89	0.21		66.56	0.95	0.25		68.00	0.97	0.26		65.31	0.93	0.23	
80	64.30	0.80	0.18		68.93	0.86	0.22		70.44	0.88	0.23		67.47	0.84	0.20	
90	66.01	0.73	0.16		71.04	0.79	0.20		72.59	0.81	0.20		69.34	0.77	0.17	
100	67.49	0.67	0.14		72.89	0.73	0.17		74.43	0.74	0.17		70.94	0.71	0.15	
110	68.73	0.62	0.11		74.48	0.68	0.15		75.98	0.69	0.14		72.26	0.66	0.12	
120	69.72	0.58	0.09		75.81	0.63	0.12		77.22	0.64	0.11		73.29	0.61	0.09	
130	70.48	0.54	0.06		76.88	0.59	0.09		78.17	0.60	0.08		74.05	0.57	0.06	
140	70.99	0.51	0.04		77.68	0.55	0.07		78.81	0.56	0.05		74.53	0.53	0.03	
150	71.27	0.48	0.02		78.23	0.52	0.04		79.16	0.53	0.02		74.72	0.50	0.01	
160	71.31	0.45	-0.01		78.52	0.49	0.02		79.20	0.50	-0.01		74.64	0.47	-0.02	
170	71.10	0.42	-0.03		78.55	0.46	-0.01		78.95	0.46	-0.04		74.28	0.44	-0.05	
180	70.66	0.39	-0.06		78.32	0.44	-0.04		78.39	0.44	-0.07		73.64	0.41	-0.08	
190	69.97	0.37	-0.08		77.83	0.41	-0.06		77.54	0.41	-0.10		72.71	0.38	-0.11	
200	69.05	0.35	-0.10		77.08	0.39	-0.09		76.38	0.38	-0.13		71.51	0.36	-0.13	
210	67.89	0.32	-0.13		76.07	0.36	-0.11		74.93	0.36	-0.16		70.03	0.33	-0.16	
220	66.48	0.30	-0.15		74.80	0.34	-0.14		73.17	0.33	-0.19		68.26	0.31	-0.19	
230	64.84	0.28	-0.18		73.27	0.32	-0.17		71.12	0.31	-0.22		66.22	0.29	-0.22	
240	62.95	0.26	-0.20		71.47	0.30	-0.19		68.76	0.29	-0.25		63.90	0.27	-0.25	
250	60.83	0.24	-0.22		69.42	0.28	-0.22		66.11	0.26	-0.28		61.29	0.25	-0.27	

TABLE 4.11 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF GRAIN SORGHUM,
ASSOCIATED WITH INCREASED NITROGEN LEVELS, ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1961-1965

LBS. OF N PER ACRE	510				514				518				522			
	YIELDS IN CWT/ACRE WITH P, K = 0				YIELDS IN CWT/ACRE WITH P = 40, K = 0				YIELDS IN CWT/ACRE WITH P = 40, K = 40				YIELDS IN CWT/ACRE WITH P AND K VARIABLE			
	TOTAL	: AVER-	: MARG-	: INAL	TOTAL	: AVER-	: MARG-	: INAL	TOTAL	: AVER-	: MARG-	: INAL	TOTAL	: AVER-	: MARG-	: INAL
0	33.48	3.81	0.47	0.47	36.00	4.03	0.45	0.45	35.34	4.01	0.49	0.49	34.88	3.94	0.47	0.47
10	38.07	2.12	0.44	0.44	40.32	2.22	0.42	0.42	40.09	2.23	0.46	0.46	39.45	2.19	0.44	0.44
20	42.36	1.55	0.41	0.41	44.39	1.61	0.39	0.39	44.53	1.62	0.43	0.43	43.71	1.59	0.41	0.41
30	46.35	1.25	0.38	0.38	48.19	1.29	0.37	0.37	48.65	1.31	0.40	0.40	47.67	1.28	0.38	0.38
40	50.04	1.07	0.35	0.35	51.73	1.10	0.34	0.34	52.45	1.12	0.36	0.36	51.34	1.09	0.35	0.35
50	53.43	0.94	0.32	0.32	55.02	0.97	0.32	0.32	55.93	0.98	0.33	0.33	54.70	0.96	0.32	0.32
60	56.52	0.85	0.29	0.29	58.04	0.87	0.29	0.29	59.08	0.88	0.30	0.30	57.77	0.86	0.29	0.29
70	59.31	0.77	0.26	0.26	60.81	0.79	0.26	0.26	61.92	0.81	0.27	0.27	60.53	0.79	0.26	0.26
80	61.80	0.71	0.23	0.23	63.31	0.73	0.24	0.24	64.44	0.74	0.24	0.24	62.99	0.72	0.23	0.23
90	63.98	0.66	0.20	0.20	65.55	0.68	0.21	0.21	66.64	0.69	0.20	0.20	65.16	0.67	0.20	0.20
100	65.87	0.61	0.17	0.17	67.54	0.63	0.19	0.19	68.52	0.64	0.17	0.17	67.02	0.62	0.17	0.17
110	67.46	0.57	0.14	0.14	69.26	0.59	0.16	0.16	70.07	0.59	0.14	0.14	68.59	0.58	0.14	0.14
120	68.75	0.54	0.11	0.11	70.73	0.55	0.13	0.13	71.31	0.56	0.11	0.11	69.85	0.54	0.11	0.11
130	69.74	0.50	0.08	0.08	71.93	0.52	0.11	0.11	72.23	0.52	0.08	0.08	70.81	0.51	0.08	0.08
140	70.43	0.47	0.05	0.05	72.87	0.49	0.08	0.08	72.83	0.49	0.04	0.04	71.48	0.48	0.05	0.05
150	70.82	0.44	0.02	0.02	73.56	0.46	0.06	0.06	73.11	0.46	0.01	0.01	71.84	0.45	0.02	0.02
160	70.91	0.42	-0.01	-0.01	73.98	0.44	0.03	0.03	73.06	0.43	-0.02	-0.02	71.91	0.42	-0.01	-0.01
170	70.70	0.39	-0.04	-0.04	74.15	0.41	0.00	0.00	72.70	0.40	-0.05	-0.05	71.67	0.40	-0.04	-0.04
180	70.19	0.37	-0.07	-0.07	74.05	0.39	-0.02	-0.02	72.02	0.37	-0.08	-0.08	71.13	0.37	-0.07	-0.07
190	69.37	0.34	-0.10	-0.10	73.69	0.37	-0.05	-0.05	71.02	0.35	-0.12	-0.12	70.30	0.35	-0.10	-0.10
200	68.26	0.32	-0.13	-0.13	73.08	0.34	-0.07	-0.07	69.70	0.32	-0.15	-0.15	69.16	0.32	-0.13	-0.13
210	66.85	0.30	-0.16	-0.16	72.20	0.32	-0.10	-0.10	68.05	0.30	-0.18	-0.18	67.73	0.30	-0.16	-0.16
220	65.14	0.27	-0.19	-0.19	71.07	0.30	-0.13	-0.13	66.09	0.28	-0.21	-0.21	65.99	0.28	-0.19	-0.19
230	63.13	0.25	-0.22	-0.22	69.67	0.28	-0.15	-0.15	63.81	0.26	-0.24	-0.24	63.95	0.26	-0.22	-0.22
240	60.82	0.23	-0.25	-0.25	68.01	0.26	-0.18	-0.18	61.21	0.23	-0.28	-0.28	61.62	0.24	-0.25	-0.25
250	58.21		-0.28	-0.28	66.10	0.23	-0.20	-0.20	58.29		-0.31	-0.31	58.98		-0.28	-0.28

TABLE 4.12 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF GRAIN SORGHUM,
ASSOCIATED WITH INCREASED NITROGEN LEVELS, ON IRRIGATED LAND OF
WEST-CENTRAL KANSAS, 1966-1970

LBS. OF N PER ACRE	532			536			540			544		
	YIELDS IN CWT/ACRE WITH P, K = 0			YIELDS IN CWT/ACRE WITH P = 40, K = 0			YIELDS IN CWT/ACRE WITH P = 40, K = 40			YIELDS IN CWT/ACRE WITH P AND K VARIABLE		
	TOTAL	AVER- : AGE	MARG- : INAL	TOTAL	AVER- : AGE	MARG- : INAL	TOTAL	AVER- : AGE	MARG- : INAL	TOTAL	AVER- : AGE	MARG- : INAL
0	39.35		0.46	49.76		0.49	40.73		0.53	40.39		0.49
10	43.73	4.37	0.42	54.53	5.45	0.46	45.81	4.58	0.49	45.14	4.51	0.46
20	47.75	2.39	0.38	58.99	2.95	0.43	50.53	2.53	0.45	49.55	2.48	0.42
30	51.40	1.71	0.35	63.12	2.10	0.40	54.89	1.83	0.42	53.61	1.79	0.39
40	54.70	1.37	0.31	66.94	1.67	0.37	58.88	1.47	0.38	57.34	1.43	0.36
50	57.64	1.15	0.28	70.44	1.41	0.33	62.52	1.25	0.35	60.73	1.21	0.32
60	60.21	1.00	0.24	73.61	1.23	0.30	65.80	1.10	0.31	63.78	1.06	0.29
70	62.43	0.89	0.20	76.47	1.09	0.27	68.72	0.98	0.27	66.48	0.95	0.25
80	64.29	0.80	0.17	79.00	0.99	0.24	71.28	0.89	0.24	68.85	0.86	0.22
90	65.78	0.73	0.13	81.22	0.90	0.21	73.48	0.82	0.20	70.88	0.79	0.19
100	66.92	0.67	0.10	83.12	0.83	0.17	75.32	0.75	0.17	72.56	0.73	0.15
110	67.70	0.62	0.06	84.69	0.77	0.14	76.80	0.70	0.13	73.91	0.67	0.12
120	68.12	0.57	0.02	85.95	0.72	0.11	77.92	0.65	0.09	74.92	0.62	0.08
130	68.17	0.52	-0.01	86.88	0.67	0.08	78.68	0.61	0.06	75.58	0.58	0.05
140	67.87	0.48	-0.05	87.50	0.63	0.05	79.07	0.56	0.02	75.91	0.54	0.02
150	67.21	0.45	-0.08	87.80	0.59	0.01	79.11	0.53	-0.01	75.90	0.51	-0.02
160	66.18	0.41	-0.12	87.77	0.55	-0.02	78.79	0.49	-0.05	75.55	0.47	-0.05
170	64.80	0.38	-0.16	87.43	0.51	-0.05	78.11	0.46	-0.09	74.85	0.44	-0.09
180	63.06	0.35	-0.19	86.76	0.48	-0.08	77.07	0.43	-0.12	73.82	0.41	-0.12
190	60.95	0.32	-0.23	85.78	0.45	-0.11	75.67	0.40	-0.16	72.45	0.38	-0.15
200	58.49	0.29	-0.26	84.48	0.42	-0.15	73.91	0.37	-0.19	70.73	0.35	-0.19
210	55.67	0.27	-0.30	82.85	0.39	-0.18	71.79	0.34	-0.23	68.68	0.33	-0.22
220	52.49	0.24	-0.34	80.91	0.37	-0.21	69.31	0.32	-0.27	66.29	0.30	-0.26
230	48.94	0.21	-0.37	78.64	0.34	-0.24	66.47	0.29	-0.30	63.55	0.28	-0.29
240	45.04	0.19	-0.41	76.06	0.32	-0.27	63.26	0.26	-0.34	60.48	0.25	-0.32
250	40.78	0.16	-0.44	73.16	0.29	-0.31	59.70	0.24	-0.37	57.07	0.23	-0.36

TABLE 4.13 ESTIMATED TOTAL, MARGINAL AND AVERAGE PER ACRE YIELDS OF GRAIN SORGHUM, ASSOCIATED WITH INCREASED NITROGEN LEVELS, ON IRRIGATED LAND OF WEST-CENTRAL KANSAS, 1961-1970

LBS. OF N PER ACRE	560				564				568				572			
	YIELDS IN CWT/ACRE WITH P, K = 0				YIELDS IN CWT/ACRE WITH P = 40, K = 0				YIELDS IN CWT/ACRE WITH P = 40, K = 40				YIELDS IN CWT/ACRE WITH P AND K VARIABLE			
	TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-		TOTAL	AVER-	MARG-	
	: AGE	: AGE	: INAL		: AGE	: AGE	: INAL		: AGE	: AGE	: INAL		: AGE	: AGE	: INAL	
0	36.93	4.14	0.46	39.03	4.36	0.47	38.47	0.51	4.34	0.48	38.12	4.28	0.48		0.48	
10	41.42	2.28	0.43	43.61	2.39	0.44	43.42	0.48	2.40	0.44	42.80	2.36	0.45		0.45	
20	45.60	1.65	0.40	47.89	1.73	0.41	48.04	0.44	1.74	0.41	47.15	1.71	0.42		0.42	
30	49.48	1.33	0.37	51.87	1.39	0.38	52.32	0.41	1.41	0.38	51.19	1.37	0.39		0.39	
40	53.06	1.13	0.34	55.56	1.18	0.35	56.25	0.38	1.20	0.34	54.90	1.17	0.36		0.36	
50	56.34	0.99	0.31	58.94	1.03	0.32	59.85	0.34	1.05	0.31	58.29	1.02	0.32		0.32	
60	59.33	0.89	0.28	62.02	0.93	0.29	63.10	0.31	0.94	0.27	61.37	0.92	0.29		0.29	
70	62.01	0.80	0.25	64.80	0.84	0.26	66.02	0.27	0.86	0.24	64.12	0.83	0.26		0.26	
80	64.39	0.74	0.22	67.28	0.77	0.23	68.60	0.24	0.79	0.21	66.56	0.76	0.23		0.23	
90	66.47	0.68	0.19	69.47	0.71	0.20	70.83	0.21	0.73	0.17	68.67	0.70	0.20		0.20	
100	68.25	0.63	0.16	71.35	0.66	0.17	72.73	0.17	0.68	0.14	70.46	0.65	0.16		0.16	
110	69.74	0.59	0.13	72.93	0.62	0.14	74.28	0.14	0.63	0.10	71.94	0.61	0.13		0.13	
120	70.92	0.55	0.10	74.21	0.58	0.11	75.50	0.10	0.59	0.07	73.09	0.57	0.10		0.10	
130	71.80	0.52	0.07	75.19	0.54	0.08	76.38	0.07	0.55	0.04	73.93	0.53	0.07		0.07	
140	72.38	0.48	0.04	75.88	0.51	0.05	76.91	0.04	0.51	0.00	74.44	0.50	0.04		0.04	
150	72.67	0.45	0.01	76.26	0.48	0.02	77.11	0.00	0.48	-0.03	74.63	0.47	0.00		0.00	
160	72.65	0.43	-0.02	76.34	0.45	-0.01	76.96	-0.03	0.45	-0.07	74.51	0.44	-0.03		-0.03	
170	72.33	0.40	-0.05	76.12	0.42	-0.04	76.48	-0.07	0.42	-0.10	74.06	0.41	-0.06		-0.06	
180	71.71	0.37	-0.08	75.60	0.39	-0.07	75.66	-0.10	0.39	-0.13	73.30	0.38	-0.09		-0.09	
190	70.79	0.35	-0.11	74.79	0.37	-0.10	74.49	-0.13	0.36	-0.17	72.21	0.35	-0.12		-0.12	
200	69.57	0.32	-0.14	73.67	0.34	-0.16	71.14	-0.20	0.34	-0.24	70.80	0.33	-0.16		-0.16	
210	68.06	0.30	-0.17	72.25	0.32	-0.19	68.96	-0.24	0.31	-0.27	69.08	0.30	-0.19		-0.19	
220	66.24	0.28	-0.20	70.53	0.30	-0.22	66.44	-0.27	0.29	-0.30	67.03	0.28	-0.22		-0.22	
230	64.12	0.26	-0.23	68.51	0.28	-0.25	63.57	-0.30	0.26	-0.34	64.67	0.26	-0.25		-0.25	
240	61.70	0.24	-0.26	66.20	0.25	-0.28	60.37	-0.34	0.24	-0.34	61.98	0.24	-0.28		-0.28	
250	58.99		-0.29	63.58		-0.28					58.97		-0.28		-0.28	

APPENDIX D

Table 6: Nitrogen/Corn price ratios and Optimum Rates of nitrogen application

Nitrogen/Corn Price Ratios	Optimum Rates of Nitrogen Applications in Pounds/acre	Nitrogen/Corn Price Ratios	Optimum Rates of Nitrogen Applications in Pounds per acre
0.020	174.18	0.29	129.18
0.025	173.35	0.30	127.51
0.030	172.52	0.32	124.18
0.035	171.68	0.34	120.85
0.040	170.85	0.36	117.52
0.045	170.02	0.38	114.18
0.050	169.18	0.40	110.85
0.055	168.35	0.42	107.52
0.060	167.52	0.44	104.18
0.065	166.68	0.46	100.85
0.070	165.85	0.48	97.52
0.075	165.02	0.50	94.18
0.080	164.18	0.52	90.85
0.085	163.35	0.54	87.52
0.090	162.52	0.56	84.18
0.095	161.68	0.58	80.85
0.10	160.85	0.60	77.52
0.11	159.18	0.62	74.18
0.12	157.52	0.64	70.85
0.13	155.85	0.61	67.52
0.14	154.18	0.68	64.18
0.15	152.52	0.70	60.85
0.16	150.85	0.72	57.52
0.17	149.18	0.74	54.18
0.18	147.52	0.76	50.85
0.19	145.85	0.78	47.52
0.20	144.18	0.80	44.18
0.21	142.52	0.82	40.85
0.22	140.85	0.84	37.52
0.23	139.18	0.86	34.18
0.24	137.52	0.88	30.85
0.25	135.85	0.90	27.52
0.26	134.18	0.92	24.18
0.27	132.52	0.94	20.85
0.28	130.85	0.96	17.52
		0.98	14.18
		1.00	10.85

Table 7: Nitrogen/Sorghum price ratios and optimum rates of nitrogen application

Nitrogen/Sorghum Price Ratios	Optimum Rates of Nitrogen Applications in Pounds per acre	Nitrogen/Sorghum Price Ratios	Optimum Rates of Nitrogen Applications in Pounds per acre
0.020	144.81	0.29	60.44
0.025	143.25	0.30	57.31
0.030	141.69	0.31	54.19
0.035	140.13	0.32	51.06
0.040	138.56	0.33	47.94
0.045	137.00	0.34	44.81
0.050	135.44	0.35	41.69
0.055	133.87	0.36	38.56
0.060	132.31	0.37	35.44
0.065	130.75	0.38	32.31
0.070	129.19	0.39	29.19
0.075	129.63	0.40	26.06
0.080	126.06	0.41	22.94
0.085	124.50	0.42	19.81
0.090	122.94	0.43	16.69
0.095	121.38	0.44	13.56
0.10	119.81	0.45	10.44
0.11	116.69	0.46	7.31
0.12	113.56	0.47	4.19
0.13	110.44	0.48	1.06
0.14	107.31		
0.15	104.19		
0.16	101.06		
0.17	97.94		
0.18	94.81		
0.19	91.69		
0.20	88.56		
0.21	85.44		
0.22	82.31		
0.23	79.19		
0.24	76.06		
0.25	72.94		
0.26	69.18		
0.27	66.69		
0.28	63.56		

Table 8: Marginal yields of corn and optimum rates of nitrogen at specified corn and nitrogen prices

Application N of Pounds/acre	Marginal Yields	Value of Marginal Yields When Price of corn is at						
		\$0.80	\$0.90	\$1.00	\$1.10	\$1.20	\$1.30	\$1.40
10	1.01	0.81	0.91	1.01	1.11	1.21	1.31	1.41
20	0.95	0.76	0.86	0.95	1.05	1.14	1.23	1.33
30	0.89	0.71	0.80	0.89	0.89	1.07	1.16	1.24
40	0.83	0.66	0.74	0.83	0.91	1.00	1.08	1.16
50	0.77	0.62	0.69	0.77	0.85	0.93	1.00	1.08
60	0.71	0.57	0.64	0.71	0.78	0.85	0.92	0.99
70	0.65	0.52	0.59	0.65	0.72	0.78	0.85	0.91
80	0.59	0.47	0.53	0.59	0.65	0.71	0.77	0.83
90	0.53	0.42	0.48	0.53	0.58	0.64	0.70	0.74
100	0.47	0.38	0.42	0.47	0.52	0.56	0.61	0.66
110	0.41	0.33	0.37	0.41	0.45	0.49	0.53	0.57
120	0.35	0.28	0.32	0.35	0.39	0.42	0.46	0.49
130	0.29	0.23	0.26	0.29	0.32	0.35	0.38	0.41
140	0.23	0.18	0.21	0.23	0.25	0.28	0.30	0.32
150	0.17	0.14	0.15	0.17	0.19	0.20	0.22	0.23
160	0.11	0.09	0.10	0.11	0.12	0.13	0.14	0.15
170	0.05	0.04	0.05	0.05	0.06	0.06	0.07	0.07
180	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
190	-0.07	-0.06	-0.06	-0.07	-0.08	-0.08	-0.09	-0.10
200	-0.13	-0.10	-0.12	-0.13	-0.14	-0.16	-0.17	-0.18
210	-0.19	-0.15	-0.17	-0.19	-0.21	-0.23	-0.25	-0.27
220	-0.25	-0.20	-0.23	-0.25	-0.28	-0.30	-0.33	-0.35
230	-0.31	-0.25	-0.28	-0.31	-0.34	-0.37	-0.40	-0.43
240	-0.37	-0.30	-0.33	-0.37	-0.41	-0.44	-0.48	-0.52
250	-0.43	-0.34	-0.39	-0.43	-0.47	-0.52	-0.56	-0.60

Table 9: Marginal yields of grain sorghum and optimum rates of nitrogen at specified sorghum and nitrogen prices

Application N of Pounds/acre	Marginal Yields	Value of Marginal Yields when Price of grain sorghum is at						
		\$1.00	\$1.20	\$1.40	\$1.60	\$1.80	\$1.00	\$2.20
10	0.45	0.45	0.45	0.63	0.72	0.81	0.90	
20	0.42	0.42	0.50	0.59	0.67	0.76	0.84	
30	0.39	0.39	0.47	0.55	0.62	0.70	0.78	
40	0.36	0.36	0.43	0.50	0.58	0.65	0.72	
50	0.32	0.32	0.38	0.45	0.51	0.58	0.64	
60	0.29	0.29	0.35	0.41	0.46	0.52	0.58	
70	0.26	0.26	0.31	0.36	0.42	0.47	0.52	
80	0.23	0.23	0.28	0.32	0.37	0.41	0.46	
90	0.20	0.20	0.24	0.28	0.32	0.36	0.40	
100	0.16	0.16	0.19	0.22	0.26	0.29	0.32	
110	0.13	0.13	0.16	0.18	0.21	0.23	0.26	
120	0.10	0.10	0.12	0.14	0.16	0.18	0.20	
130	0.07	0.07	0.08	0.10	0.11	0.13	0.14	
140	0.04	0.04	0.05	0.06	0.06	0.07	0.08	
150	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
160	-0.03	-0.03	-0.00	-0.04	-0.05	-0.05	-0.06	
170	-0.06	-0.06	-0.07	-0.08	-0.10	-0.11	-0.12	
180	-0.09	-0.09	-0.11	-0.13	-0.14	-0.16	-0.18	
190	-0.12	-0.12	-0.14	-0.17	-0.19	-0.22	-0.24	
200	-0.16	-0.16	-0.19	-0.22	-0.26	-0.29	-0.32	
210	-0.19	-0.19	-0.23	-0.27	-0.30	-0.34	-0.38	
220	-0.22	-0.22	-0.26	-0.31	-0.35	-0.40	-0.44	
230	-0.25	-0.25	-0.30	-0.35	-0.40	-0.45	-0.50	
240	-0.28	-0.28	-0.34	-0.39	-0.45	-0.50	-0.56	
250	-0.32	-0.32	-0.38	-0.45	-0.51	-0.58	-0.64	

Table 10: Returns at various rates of nitrogen application to irrigated corn (Price of corn at \$1.13 per bu. and \$0.0865 per lb. for nitrogen)

1	2	3	4	5	6	7
N Application in	Estimated Total Yields	Increase in Yields	Value of Additional Increase in Yield	Cost of Additional Unit of Nitrogen	Returns Above Cost of Additional Unit of Nitrogen	Return per Dollar on the Last Unit of Nitrogen
lbs	(Bu.)	(Bu.)	(\$)	(\$)	(\$)	(\$)
10	75.60	10.06	11.37	0.865	10.50	13.14
20	85.35	9.75	11.02	0.865	10.15	12.74
30	94.50	9.15	10.34	0.865	9.47	11.95
40	103.05	8.55	9.66	0.865	8.79	11.17
50	111.00	7.95	8.98	0.865	8.11	10.28
60	118.36	7.36	8.32	0.865	7.45	9.62
70	125.11	6.75	7.63	0.865	6.76	8.82
80	131.26	6.15	6.94	0.865	6.07	8.02
90	136.81	5.55	6.27	0.865	5.40	7.25
100	141.76	4.95	5.59	0.865	4.72	6.46
110	146.11	4.35	4.92	0.865	4.05	5.69
120	149.86	3.75	4.24	0.865	3.37	4.90
130	153.01	3.15	3.56	0.865	2.69	4.12
140	155.56	2.55	2.88	0.865	2.01	3.33
150	157.51	1.95	2.20	0.865	1.33	2.57
160	158.87	1.36	1.54	0.865	0.67	1.78
170	159.62	0.75	0.85	0.865	-0.01	0.98
180	159.77	0.15	0.17	0.865	-0.60	0.20
190	159.32	-0.45	-0.51	0.865	-1.37	-0.59
200	158.27	-1.05	-1.19	0.865	-2.05	-1.38
210	156.62	-1.65	-1.86	0.865	-2.72	-2.15
220	154.37	-2.25	-2.54	0.865	-3.40	-2.94
230	151.52	-2.85	-3.22	0.865	-4.08	-3.72
240	148.07	-3.45	-3.90	0.865	-4.76	-4.52
250	144.02	-4.05	-4.58	0.865	-5.44	-5.29

Table 11: Returns at various rates of nitrogen application to irrigated sorghum (Price of sorghum at \$1.72 per cwt. and \$0.0865 per lb. for nitrogen)

1	2	3	4	5	6	7
N Application in lbs	Estimated Total Yields (Bu.)	Increase in Yields (Bu.)	Value of Additional Increase in Yield (\$)	Cost of Additional Unit of Nitrogen (\$)	Returns Above Cost of Additional Unit of Nitrogen (\$)	Return per Dollar on the Last Unit of Nitrogen (\$)
10	42.80	4.68	8.05	0.865	7.19	9.31
20	47.15	4.35	7.48	0.865	6.62	8.65
30	51.19	4.04	6.95	0.865	6.08	8.03
40	54.90	2.71	6.38	0.865	5.51	7.37
50	58.29	3.39	5.83	0.865	4.96	6.73
60	61.37	3.08	5.30	0.865	4.43	6.12
70	64.12	2.75	4.73	0.865	3.86	5.46
80	66.56	2.44	4.20	0.865	3.33	4.85
90	68.67	2.11	3.63	0.865	2.76	4.19
100	70.46	1.79	3.08	0.865	2.21	3.56
110	71.94	1.48	2.55	0.865	1.68	2.94
120	73.09	1.15	1.98	0.865	1.11	2.28
130	73.93	0.84	1.44	0.865	0.57	1.66
140	74.44	0.51	0.88	0.865	0.01	1.01
150	74.63	0.19	0.33	0.865	-0.53	0.38
160	74.51	-0.12	-0.21	0.865	-1.07	-0.24
170	74.06	-0.45	-0.77	0.865	-1.63	-0.89
180	73.30	-0.76	-1.31	0.865	-2.17	-1.51
190	72.21	-1.09	-1.87	0.865	-2.73	-2.16
200	70.80	-1.41	-2.43	0.865	-3.29	-2.80
210	69.08	-1.72	-2.96	0.865	-3.82	-3.42
220	67.03	-2.00	-3.44	0.865	-4.30	-3.97
230	64.67	-2.36	-4.06	0.865	-4.92	-4.69
240	61.98	-2.69	-4.63	0.865	-5.49	-5.35
250	58.97	-3.01	-5.18	0.865	-6.04	-5.98

Table 12: Total returns at various nitrogen rates to irrigated corn
(Price of corn at \$1.13 per bu. cost of nitrogen at \$0.0865 per lb.)

1	2	3	4	5	6
Application of N	Cumulative Cost of N	Cumulative Increase in Yield	Value of Cumulative Increase in Yield	Cumulative Total Return to Nitrogen	Average Return per dollar spent on N
lb	\$	bu.	\$	\$	\$
10	0.865	10.06	11.37	10.50	13.14
20	1.730	19.81	22.39	20.66	12.94
30	2.595	28.96	32.34	29.74	12.46
40	3.460	37.51	42.00	38.54	12.14
50	4.325	45.46	50.98	46.65	11.79
60	5.190	52.82	59.30	54.11	11.42
70	6.055	59.57	66.93	60.87	11.05
80	6.920	65.72	73.87	66.95	10.67
90	7.785	71.27	80.14	72.35	10.29
100	8.650	76.22	85.73	77.08	9.91
110	9.515	80.57	90.65	81.13	9.52
120	10.380	84.32	94.89	84.51	9.14
130	11.245	87.47	98.45	87.20	8.75
140	12.110	90.02	101.33	89.22	8.36
160	13.840	93.33	105.07	91.23	7.59
170	14.705	94.08	105.92	91.21	7.20
180	15.570	94.23	106.09	90.52	6.81
190	16.435	93.78	105.58	89.14	6.42
200	17.300	92.73	104.39	87.09	6.03
210	18.165	91.08	102.53	84.36	5.64
220	19.030	88.83	99.99	88.96	5.25
230	19.895	85.98	96.77	76.87	4.86
240	20.760	82.53	92.87	72.11	4.47
250	21.625	78.48	88.29	66.66	4.08

Table 13: Total returns at various nitrogen rates to irrigated sorghum (Price of sorghum at \$1.72 per cwt. and cost of N at \$0.0865 per lb)

1	2	3	4	5	6
Application of N	Cumulative Cost of N	Cumulative Increase in Yield	Value of Cumulative Increase in Yield	Cumulative Total Return to Nitrogen	Average Return per dollar spent on N
lb	\$	bu.	\$	\$	\$
10	0.865	4.68	8.05	7.19	9.31
20	1.720	9.03	15.53	13.80	8.98
30	2.595	13.07	22.48	19.88	8.66
40	3.460	16.78	28.86	25.40	8.34
50	4.325	20.17	34.69	30.36	8.02
60	5.190	23.25	39.99	34.80	7.70
70	6.055	26.00	44.72	38.66	7.38
80	6.920	28.44	48.92	42.00	7.06
90	7.785	30.55	52.55	44.76	6.75
100	8.650	32.44	55.63	46.98	6.43
110	9.515	33.82	58.18	48.66	6.11
120	10.380	34.97	60.16	49.78	5.79
130	11.245	35.81	61.60	50.35	5.47
140	12.110	36.32	62.48	50.37	5.15
150	12.975	36.51	62.81	49.83	4.84
160	13.840	36.39	62.60	48.76	4.52
170	14.705	35.94	61.83	47.12	4.20
180	15.570	35.18	60.52	44.95	3.88
190	16.435	34.09	58.65	42.21	3.56
200	17.300	32.68	56.22	38.92	3.24
210	18.165	30.96	53.26	35.09	2.93
220	19.030	28.96	49.82	30.79	2.61
230	19.895	26.60	45.76	25.86	2.30
240	20.760	23.91	41.13	20.37	1.98
250	21.625	17.89	35.95	14.32	1.66

Table 14: Effect of price of nitrogen/lb on the most profitable rate of nitrogen application/acre and on return to nitrogen above its cost for corn

1	2	3	4	5
Price of Nitrogen per acre	Most Profitable Rate of Nitrogen lb/acre	Estimated Yield Under Most Profitable Rate Bu./acre	Increased Yield for Application of Nitrogen* Bu./acre	Returns to Nitrogen Above Its cost** \$
\$				
0.01	176.05	159.78	94.53	105.06
0.02	174.57	159.76	94.51	103.30
0.03	173.10	159.71	94.46	101.55
0.04	171.62	159.68	94.43	99.84
0.05	170.15	159.62	94.37	98.13
0.06	168.67	159.55	94.30	96.44
0.07	167.20	159.47	94.22	94.76
0.08	165.72	159.37	94.12	93.10
0.09	164.25	159.26	94.01	91.45
0.10	162.77	159.13	93.88	89.81
0.11	161.30	159.00	93.75	88.19
0.12	159.82	158.85	93.60	86.59
0.13	158.35	158.68	93.43	84.99
0.14	156.87	158.51	93.26	83.42
0.15	155.40	158.32	93.07	81.86
0.16	153.20	158.01	92.76	80.31
0.17	152.45	157.90	92.65	78.78
0.18	150.97	157.67	92.42	77.26
0.19	149.50	157.43	92.18	75.76
0.20	148.02	157.18	91.93	74.27

**With price of corn at \$1.13 per bu. and nitrogen at the prices shown in column 1.

*Obtained by subtracting 65.25 from the estimated yield.

This assumes that the price of corn remains unchanged.

Table 15: Effect of price of nitrogen/lb on the most profitable rate of nitrogen application/acre and on return to nitrogen above its cost for sorghum

1	2	3	4	5
Price of Nitrogen per acre	Most Profitable Rate of Nitrogen	Estimated Yield Under Most Profitable Rate	Increased Yield for Application of Nitrogen*	Returns to Nitrogen Above Its cost**
\$	lb/acre	Bu./acre	Bu./acre	\$
0.01	149.25	74.63	36.51	61.30
0.02	147.44	74.61	36.49	59.81
0.03	145.63	74.58	36.46	58.34
0.04	143.78	74.55	36.43	56.91
0.05	141.97	74.50	36.38	55.48
0.06	140.16	74.44	36.32	54.06
0.07	138.34	74.37	36.25	52.67
0.08	136.53	74.29	36.17	51.29
0.09	134.72	74.20	36.08	49.93
0.10	132.91	74.10	35.98	48.59
0.11	131.06	73.99	35.87	47.28
0.12	129.25	73.87	35.75	45.98
0.13	127.44	73.74	35.62	44.70
0.14	125.63	73.60	35.48	43.44
0.15	123.81	73.44	35.32	42.18
0.16	122.00	73.28	35.16	40.96
0.17	120.19	73.11	34.99	39.75
0.18	118.34	72.92	34.80	38.55
0.19	116.53	72.72	34.60	37.37
0.20	114.72	72.52	34.40	36.22

*Obtained by subtracting 38.1239 from the estimated yield.

**With price of sorghum at \$1.72 per cwt. and nitrogen at the prices shown in column 1.

This assumes that the price of sorghum is constant.

Table 16: Decrease in most profitable N application and returns above cost for every 1 cent increase in price of nitrogen for corn

Change in Cost of Nitrogen	Decrease in most profitable N applica- tion Rate	Decrease in predicted Yield of corn under most profitable N application	Decrease in Return to N Above its cost
1	1.48	0.02	1.76
1	1.47	0.05	1.75
1	1.48	0.03	1.71
1	1.47	0.05	1.71
1	1.48	0.07	1.69
1	1.47	0.08	1.68
1	1.48	0.10	1.66
1	1.47	0.11	1.65
1	1.48	0.13	1.64
1	1.47	0.13	1.62
1	1.48	0.15	1.60
1	1.47	0.17	1.60
1	1.48	0.17	1.57
1	1.47	0.19	1.56
1	2.20	0.31	1.55
1	0.75	0.11	1.53
1	1.48	0.23	1.52
1	1.47	0.24	1.50
1	1.48	0.25	1.49

Table 17: Decrease in most profitable N application and returns above cost for every 1 cent increase in price of nitrogen for sorghum

Change in Cost of Nitrogen	Decrease in most profitable N application Rate	Decrease in predicted Yield of corn under most profitable N application	Decrease in Return to N Above its cost
	lbs/acre	Bu./acre	\$
1	1.81	0.02	1.49
1	1.81	0.03	1.47
1	1.85	0.03	1.43
1	1.81	0.05	1.43
1	1.81	0.06	1.42
1	1.82	0.07	1.39
1	1.81	0.08	1.38
1	1.81	0.09	1.36
1	1.81	0.10	1.34
1	1.85	0.11	1.31
1	1.81	0.12	1.30
1	1.81	0.13	1.28
1	1.81	0.14	1.26
1	1.82	0.16	1.26
1	1.81	0.16	1.23
1	1.81	0.17	1.20
1	1.85	0.19	1.20
1	1.81	0.20	1.18
1	1.81	0.20	1.15

Table 18: Effects of price of corn on most profitable N application and returns above cost (Price of N taken at \$0.0865)

Price of Corn	Most Profitable Rate of N	Cost of Nitrogen	Yield at Most Profitable Rate of N	Yield Increase	Value of Yield Increase	Return to N Above its Cost
\$/bu.	lbs/acre	\$	bu./acre	bu.	\$	\$
0.10	33.35	2.88	97.52	32.27	3.23	0.35
0.15	81.42	7.04	132.08	66.83	10.02	2.98
0.20	105.43	9.12	144.19	78.94	15.79	6.67
0.25	119.85	10.37	149.81	84.56	21.14	10.77
0.30	129.47	11.20	152.86	87.61	26.28	15.08
0.35	136.33	11.79	154.70	89.45	31.31	19.52
0.40	141.48	12.24	155.89	90.64	36.26	24.02
0.45	145.48	12.58	156.71	91.46	41.16	28.58
0.50	148.68	12.86	157.29	92.04	46.02	33.16
0.55	151.32	13.09	157.73	92.48	50.86	37.77
0.60	153.50	13.28	158.05	92.80	55.68	42.40
0.65	155.35	13.44	158.31	93.06	60.49	47.05
0.70	156.93	13.57	158.51	93.26	65.28	51.71
0.75	158.30	13.69	158.68	93.43	70.07	56.38
0.80	159.50	13.80	158.81	93.56	74.85	61.05
0.85	160.57	13.89	158.92	93.67	79.62	65.73
0.90	161.50	13.97	159.01	93.76	84.38	70.41
0.95	162.35	14.04	159.09	93.84	89.15	75.11
1.00	163.10	14.11	159.16	93.94	93.94	79.83
1.05	163.80	14.17	159.22	93.97	98.67	84.50
1.10	164.42	14.22	159.27	94.02	103.42	89.20
1.15	164.98	14.27	159.31	94.06	108.17	93.90
1.20	165.52	14.32	159.35	94.10	112.92	98.60
1.25	165.98	14.36	159.38	94.13	117.66	103.30
1.30	166.43	14.40	159.42	94.17	122.42	108.02
1.35	166.85	14.43	159.44	94.19	127.16	112.73
1.40	167.23	14.47	159.47	94.22	131.91	117.44
1.45	167.58	14.49	159.49	94.24	136.65	122.16
1.50	167.92	14.52	159.51	94.26	141.39	126.87
1.55	168.22	14.55	159.53	94.28	146.13	131.58
1.60	168.52	14.58	159.54	94.29	150.86	136.28
1.65	168.78	14.60	159.55	94.30	155.60	141.00

Table 19: Effects of price of sorghum on most profitable N application and returns above cost (Price of N taken as \$0.0865)

Price of Corn	Most Profitable Rate of N	Cost of Nitrogen	Yield at Most Profitable Rate of N	Yield Increase	Value of Yield Increase	Return to N Above its Cost
\$ per cwt	lbs/acre	\$	cwt/acre	cwt.	\$	\$
0.50	97.00	8.39	70.04	31.92	15.96	7.57
0.55	101.94	8.82	70.77	32.65	17.96	9.14
0.60	106.03	9.17	71.39	33.27	19.96	10.79
0.65	109.50	9.47	71.87	33.75	21.94	12.47
0.70	112.47	9.73	72.25	34.13	23.89	14.16
0.75	115.03	9.95	72.56	34.44	25.83	15.88
0.80	117.28	10.14	72.81	34.06	27.25	17.11
0.85	119.28	10.32	73.02	34.90	29.66	19.34
0.90	121.03	10.47	73.19	35.07	31.56	21.09
0.95	122.62	10.61	73.34	35.22	33.46	22.85
1.00	124.03	10.73	73.46	35.34	35.34	24.61
1.05	125.34	10.84	73.58	35.46	37.23	26.39
1.10	126.50	10.94	73.67	35.55	39.10	28.16
1.15	127.56	11.03	73.75	35.63	40.97	29.94
1.20	128.56	11.12	73.82	35.70	42.84	31.72
1.25	129.44	11.20	73.89	35.77	44.71	33.51
1.30	130.28	11.27	73.94	35.82	46.56	35.29
1.35	131.06	11.34	73.99	35.87	48.42	37.08
1.40	131.78	11.40	74.04	35.92	50.29	38.89
1.45	132.44	11.45	74.08	35.96	52.14	40.69
1.50	133.06	11.51	74.12	36.00	54.00	42.49
1.55	133.62	11.56	74.15	36.03	55.84	44.28
1.60	134.19	11.61	74.17	36.05	57.68	46.08
1.65	134.69	11.65	74.20	36.08	59.53	47.88
1.70	135.19	11.69	74.23	36.11	61.39	49.70
1.75	135.62	11.73	74.73	36.13	63.23	51.50
1.80	136.06	11.77	74.27	36.15	65.07	53.30
1.85	136.47	11.80	74.29	36.17	66.91	55.11
1.90	136.84	11.83	74.31	36.19	68.76	56.93
1.95	137.22	11.87	74.32	36.20	70.59	58.72
2.00	137.56	11.90	74.34	36.22	72.44	60.54

Table 20: Increase in most profitable N application and return above cost for each 5 cent increase in corn price

Increase in Price of Corn in cents	Increase in Most Profitable N Application	Increase in Predicted Yield Under Most Profitable N Application	Increase in Return to Nitrogen Above its Cost
5	48.07	34.56	2.63
5	24.01	12.11	3.69
5	14.42	5.62	4.10
5	9.62	3.05	4.31
5	6.86	1.84	4.44
5	5.15	1.19	4.50
5	4.00	0.82	4.56
5	3.20	0.58	4.58
5	2.64	0.44	4.61
5	2.18	0.32	4.63
5	1.85	0.26	4.65
5	1.58	0.20	4.66
5	1.37	0.17	4.67
5	1.20	0.13	4.67
5	1.07	0.11	4.68
5	0.93	0.09	4.68
5	0.85	0.08	4.70
5	0.75	0.07	4.72
5	0.70	0.06	4.67
5	0.62	0.05	4.70
5	0.56	0.04	4.70
5	0.54	0.04	4.70
5	0.46	0.03	4.70
5	0.46	0.04	4.72
5	0.42	0.02	4.71
5	0.38	0.03	4.71
5	0.35	0.02	4.72
5	0.34	0.02	4.71
5	0.30	0.02	4.71
5	0.30	0.01	4.70
5	0.26	0.01	4.72

Table 21: Increase in most profitable N application and return above cost for each 5 cent increase in sorghum price

Increase in Price of Sorghum	Increase in Most Profitable N Application	Increase in Predicted Yield Under Most Profitable N Application	Increase in Return to Nitrogen Above its Cost
5	4.94	0.73	1.57
5	4.09	0.62	1.65
5	4.70	0.48	1.68
5	2.97	0.38	1.69
5	2.56	0.31	1.72
5	2.25	0.25	1.23
5	2.00	0.21	2.23
5	1.75	0.17	1.75
5	1.59	0.15	1.76
5	1.41	0.12	1.76
5	1.31	0.12	1.78
5	1.16	0.09	1.77
5	1.06	0.08	1.78
5	1.00	0.07	1.78
5	0.88	0.07	1.79
5	0.84	0.05	1.78
5	0.78	0.05	1.79
5	0.72	0.05	1.81
5	0.66	0.04	1.80
5	0.62	0.04	1.80
5	0.56	0.03	1.79
5	0.57	0.02	1.80
5	0.50	0.03	1.80
5	0.50	0.03	1.82
5	0.43	0.02	1.80
5	0.44	0.02	1.80
5	0.41	0.02	1.81
5	0.37	0.02	1.82
5	0.38	0.01	1.79
5	0.34	0.02	1.82

Table 22: Most profitable rate of nitrogen by year compared with extension service recommendations

CORN

1	2	3	4	5	6
Year	Equation No	Price \$/Bu.	Nitrogen Price \$	Most Profitable Rate of Nitrogen lbs/acre	Recommendation for Western Kansas lbs/acre N
1961	9	1.00	0.0969	147.78	160-240
1962	21	1.03	0.0963	151.59	160-240
1963	31	1.12	0.0956	186.73	160-240
1964	46	1.16	0.0944	161.81	160-240
1965	61	1.21	0.0925	170.37	160-240
1966	79	1.26	0.0894	150.21	160-240
1967	100	1.19	0.0863	160.70	160-240
1968	118	1.08	0.0775	220.18	160-240
1969	138	1.12	0.0706	143.75	160-240
1970	158	1.20	0.0688	162.24	160-240
1961-1965	224	1.10	0.0951	160.87	160-240
1966-1970	243	1.17	0.0785	164.25	160-240
1961-1970	265	1.13	0.0868	164.71	160-240
SORGHUM					
1961	287	1.53	0.0969	135.06	120-180
1962	300	1.61	0.0963	123.25	120-180
1963	316	1.67	0.0956	132.16	120-180
1964	326	1.74	0.0944	151.62	120-180
1965	339	1.86	0.0925	153.83	120-180
1966	358	1.80	0.0894	126.94	120-180
1967	378	1.84	0.0863	132.08	120-180
1968	397	1.69	0.0775	143.52	120-180
1969	418	1.68	0.0706	123.30	120-180
1970	442	1.82	0.0688	138.53	120-180
1961-65	522	1.68	0.0951	138.26	120-180
1966-70	544	1.76	0.0785	131.50	120-180
1961-70	572	1.72	0.0868	135.29	120-180

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PRODUCTION FUNCTIONS AND ECONOMIC OPTIMA
FOR CORN AND GRAIN SORGHUM UNDER FERTILIZATION
ON IRRIGATED EXPERIMENTAL PLOTS IN WEST-CENTRAL KANSAS

by

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B.Sc., Ahmadu Bello University, 1968

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

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KANSAS STATE UNIVERSITY
Manhattan, Kansas

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This study is an economic analysis of experimental data for irrigated corn and grain sorghum conducted between 1961 and 1970 at Tribune Branch Experiment Station. The yield response to different rates and combinations of fertilizers nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) is the main consideration in this study. Since production functions have been fitted to the data 1961-1965 for corn and 1959-1965 for grain sorghum by Yung Liu, the aim of the present analysis is to update the results to 1970 for both crops. According to Yung Liu's study, yield responses to phosphorus and potassium were negligible. An attempt has been made in this study to find the year when the yield responses to phosphorus and potassium become statistically significant.

The analysis of variance results show that for both crops, yield response to phosphorus becomes and was significant in 1966 through 1970. This implies, that farmers need not apply phosphorus to corn until the sixth year and the eighth year for sorghum (since sorghum experiment started in 1959) after the start of irrigation. The interpretation of these results should be applied only to conditions prevailing during the experiment because of these reasons:

(a) The response of corn and grain sorghum to nitrogen and phosphorus varies with soil, climate and other environmental conditions.

(b) It is easier to control small experimental plots than large acreages cultivated by farmers.

(c) The terms 'average year', 'average price', 'average yield' used are only a matter of convenience because it is rare to find a particular farmer's condition meeting all of these categories.

(d) Sufficient irrigation water was applied at preplant stages and during the growing seasons therefore these results will not apply to

conditions where soil moisture is a limiting factor.

(e) It has been assumed that maximization of returns from an acre of corn or grain sorghum is the objective of the farmer whereas it may be maximization of income from all the enterprises in his farming business.

In spite of the above limitations, the results can be useful to (1) extension workers in making generalized recommendations; (2) all people dealing with fertilizers; (3) future research workers; and (4) the numerous derived production functions can be used for teaching purposes. The most profitable rates of nitrogen applications obtained, using each year's yield data and prices of nitrogen, corn and grain sorghum agree with the recommendations followed by the Kansas Extension Service.

Among the different types of functions used, the quadratic form gave consistently, statistically significant variables at 0.05 probability level for each treatment in each year's data. The algebraic forms $Y = 65.2495 + 1.0651B - 0.0030N^2$ for corn and $Y = 38.1239 + 0.4834N - 0.0016N^2$ for grain sorghum were chosen to illustrate the economic applications. The algebraic forms $Y = 59.8987 + 1.0651N - 0.0030N^2 + 0.2007P$ for corn and $Y = 35.4679 + 0.4834N - 0.0016N^2 + 0.0996P$ for grain sorghum incorporate yield response to phosphorus which is fixed at 40 pounds per acre.

Using 1960-1971 average prices for nitrogen as \$0.0865 per pound, corn as \$1.13 per bushel and grain sorghum as \$1.72 per cwt., the most profitable pounds per acre of nitrogen are 164.77 and 135.38 while the returns to nitrogen above cost are \$92.06 and \$50.40 per acre respectively. Returns to nitrogen above its cost change by \$2.63 to \$4.73 and \$1.57 to \$1.83 per acre with successive 5 cents changes in corn price per bushel

and sorghum price per cwt. respectively. Thus adjusting nitrogen dosage to the most profitable rate of application for a five-cent change in the price of corn and sorghum will give higher returns.