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STATISTICAL ANALYSIS OF NITROGENOUS (N) FERTILIZERS DEMAND IN N-WEST PAKISTAN
STATISTIČKA ANALIZA POTREBA ZA KORIŠĆENJEM AZOTNIH ĐUBRIVA U SJEVEROZAPADNOM PAKISTANU

Abstract

Fertilizer is a kingpin in enhancing crop production and a key to securing the food need of a country. No country has been able to increase agricultural productivity without expanding the use of chemical industry. In this paper an effort has been made to identify the factors affecting the demand of N-fertilizers in N-W Pakistan and to select an optimum subset regression model. The most important factors found were the annual credit, weighted average price of N-fertilizers, weighted average price of P-fertilizers and the annual on farm income. The effect of weighted average price of K-fertilizers, the farm area and the farmer's age was found non-significant ($p > 0.05$) for the demand of N-fertilizers at both 1% and 5% levels of significance and were not included in the selected optimum subset regression model.

Key words: N - fertilizer, regresive model, price, credit, yield.

INTRODUCTION

Pakistan is an agricultural country and its increased production depends on the use of chemical fertilizers. The rate of fertilizer application in Pakistan, in spite of the fact that marvelous growth of fertilizer consumption during 60's, remained below the optimum rate and like wise far below than the rates in advanced countries (USDA, 1973). Chemical fertilizer holds strategic place amongst the improved farm inputs responsible for increased agricultural production. The use of fertilizers has gained momentum in the past and further potential of its use is being exploited in Pakistan (Mustafa, 1977). The rise in farm income and overtime awareness of farmers about fertilizer's usefulness

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significantly determined the increased use of fertilizers in Pakistan and price of fertilizers least affected its demand (Leonard, 1969). The real price of fertilizers, agricultural income index and the acreage under crop significantly affect the demand of N-fertilizer (Mustafa, 1977). Ayub (1975) concluded that demand for fertilizers in West Pakistan over the years 1958-65 was not determined by its 'real' price whereas it ('real' price') was significant determinant of the demand for fertilizers over the years 1966-73. On the basis of his findings he suggested the Government not to withdraw subsidy on the sale of fertilizers. Raju (1989) determined that the net income significantly effect while fertilizer prices relative to output prices appeared not to have a strong influence on fertilizer use. Iqbal (1979) concluded that farmer's age" and farmer's tenurial status don't effect the consumptions of N-fertilizers in Pakistan.

Many attempts have been made to quantify the contribution of fertilizers to agriculture production. Estimates of the contribution ranges from 50-75% or more in some developing countries. Studies indicated that fertilizers, though not only the factor, but also, regarded as the leading contributor to agricultural production (FAO, 1981).

The main objective of the given study was to find out the optimum subset model for the demand of N-fertilizers as a function of various factors affecting its use and the extent of current fertilizers use per crop in N-W Pakistan.

MATERIALS AND METHODS

To carry out the research study, a sample of 300 farmers was interviewed from six randomly selected locations by selecting 50 farmers from each location during the year 2002-2003 in N-W Pakistan, using the technique of multi-stage sampling (Cochran, 1977). The major cause variables in the study were;

X_{1N} = the weighted average price of N-fertilizers;

X_{2P} = the weighted average price of phosphatic (P) fertilizers;

X_{3K} = the weighted average price of potashic (K) fertilizers;

X_{4I} = the annual on farm income (X_{4I});

X_{5A} = the farm area in acre (X_{5A});

X_{6C} = the annual credit in rupees and

X_{7Ag} = the farmer's age in years (X_{7Ag}).

For the given study, the model for demand of N-fertilizers was specified as follow:

$$Y_N = \beta_0 + \beta_1 X_{1N} + \beta_2 X_{2P} + \beta_3 X_{3K} + \beta_4 X_{4I} + \beta_5 X_{5A} + \beta_6 X_{6C} + \beta_7 X_{7Ag} + \varepsilon$$

Where, Y_N = aggregate quantity of N-fertilizers in nutrient kilograms and "ε" is the random error component follow a normal distribution with zero mean and constant variance σ^2 i.e. $\varepsilon \sim N(0, \sigma^2)$.

To find the optimum subset model, a technique of "all possible regressions" was applied and the best subset models having one, two, three, four, five and six predictor variable(s) were selected.

ALL POSSIBLE REGRESSIONS

All possible regressions technique requires that the investigator fit all the regression models involving one predictor variable, two predictor variables and so on. Several computing algorithms have been written to perform the necessary calculations efficiently. These algorithms are based on 2^P subsets in such a way that consecutive subsets differ by only one variable. Each regression model is evaluated according to some suitable criterion like R^2, R^2-adjusted, residual mean square (s^2) and Mallow's C_P statistic and the best regression model is selected (Draper, 1998).

In the present study there were $2^7 = 128$ subset regression models including the model having only the intercept term and the full model. All possible subset regression models were divided into 8 sets of models as given below:

Set A: $Y = \beta_0 + \varepsilon \Rightarrow$ (7 combination 0) = 1 possible model.

Set B: $Y = \beta_0 + \beta_i X_i + \varepsilon$, $i = 1, 2, \ldots, 7 \Rightarrow$ (7 combination 1) = 7 possible models.

Set C: $Y = \beta_0 + \beta_i X_i + \beta_j X_j + \varepsilon$, $i \neq j$
$i, j = 1, 2, \ldots, 7 \Rightarrow$ (7 combination 2) = 21 possible models.

Set D: $Y = \beta_0 + \beta_i X_i + \beta_j X_j + \beta_k X_k + \varepsilon$, $i \neq j \neq k$
$i, j, k = 1, 2, \ldots, 7 \Rightarrow$ (7 combination 3) = 35 possible models.

Set E: $Y = \beta_0 + \beta_i X_i + \beta_j X_j + \beta_k X_k + \beta_l X_l + \varepsilon$, $i \neq j \neq k \neq l$
$i, j, k, l = 1, 2, \ldots, 7 \Rightarrow$ (7 combination 4) = 35 possible models.

Set F: $Y = \beta_0 + \beta_i X_i + \beta_j X_j + \beta_k X_k + \beta_l X_l + \beta_m X_m + \varepsilon$, $i \neq j \neq k \neq l \neq m$
$i, j, k, l, m = 1, 2, \ldots, 7 \Rightarrow$ (7 combination 5) = 21 possible models.

Set G: $Y = \beta_0 + \beta_i X_i + \beta_j X_j + \beta_k X_k + \beta_l X_l + \beta_m X_m + \beta_n X_n + \varepsilon$, $i \neq j \neq k \neq l \neq m \neq n$
$i, j, k, l, m, n = 1, 2, \ldots, 7 \Rightarrow$ (7 combination 6) = 7 possible models.

Set H: $Y = \beta_0 + \beta_i X_i + \beta_j X_j + \beta_k X_k + \beta_l X_l + \beta_m X_m + \beta_n X_n + \beta_r X_r + \varepsilon$, $i \neq j \neq k \neq l \neq m \neq n \neq r$
$i, j, k, l, m, n = 1, 2, \ldots, 7 \Rightarrow$ (7 combination 7) = 1 possible models.

Each subset model was evaluated through different statistical criteria like model R^2, R^2-adjusted, C_p-statistic and the residual mean squares (s^2) and the optimum subset model for the demand of N-fertilizers was selected.

RESULTS AND DISCUSSION

The estimated multiple regression model containing all the predictor variables obtained is:

$Y_N = 635.496 - 1.916\ X_{1N} + 0.371\ X_{2P} + 0.0098\ X_{3K} + 0.0007\ X_{4I} - 1.555\ X_{5A} + 0.0153\ X_{6C} - 1.223\ X7_{Ag}$ ---(1)

t-ratios: (5.394) (-7.456) (5.766) (0.166) (5.736) (-0.225) (7.935) (-1.146)
Standard errors: (117.82) (0.2570) (0.064) (0.059) (0.00012) (6.911) (0.0019) (1.067)

The above model explained 80% variation in response variable (Y_N) with a significant F-ratio of 171.825. On individual basis the effect of X_{3K}, X_{5A} and X_{7Ag} was found non-significant at 5% and 1% levels of significance. While highly significant effect of other variables i.e. X_{1N}, X_{2P}, X_{4I} and X_{6C} was found at both 5% and 1% levels of significance.

To find out the optimum subset model, a technique of all possible regressions was applied and the following best models in one predictor variable, two, three, four, five and six predictor variables with their respective R^2, R^2_{adj}, C_P-statistic and residual mean squares, F-ratio and p-values were obtained.

Table 1. Best models for N-fertilizers with one, two, three, four, five and six Predictors, all possible regression output.

Regressors in subset model	R^2	R^2_{adj}	C_P-value	s^2	F-ratio	p-value
(X_{6C})	0.704	0.703	146.316	26586.429	709.068	0.000
(X_{4I}, X_{6C})	0.752	0.750	74.867	22366.849	450.027	0.000
(X_{1N}, X_{4I}, X_{6C})	0.781	0.779	35.643	19826.821	351.470	0.000
(X_{1N}, X_{2P}, X_{4I}, X_{6C})	0.804	0.801	3.450	17817.884	301.917	0.000
(X_{1N}, X_{2P}, X_{4I}, X_{6C}, X_{7Ag})	0.805	0.801	4.075	17794.694	242.125	0.000
(X_{1N},X_{2P}, X_{4I}, X_{5A}, X_{6C}, X_{7Ag})	0.805	0.801	6.028	17852.527	201.125	0.000

Table-1 shows that best selected model with one predictor for the demand of N-fertilizers by using all possible regression technique was the model having annual credit as independent variable and is specified as:

$Y_N = -40.830 + 0.0284\ X_{6C}$ --- (2)

t-ratios: (-2.056) (26.628)
Standard errors: (19.859) (0.0011)

The best subset selected model explained 70.3% variation in the consumption of N-fertilizers with minimum Cp statistic and residual mean squares as 146.316 and 26586.429 respectively. The annual credit has a significant effect ($p < 0.05$) for the demand of N-fertilizers. The second variable following the annual credit was the on farm income (X_4) with R^2 adjusted, C_P statistic and residual mean squares 0.696, 157.287 and 27245.840, respectively. Leonard (1969), Mustafa (1977) and Raju (1989) reported that farm income significantly effect the consumptions of fertilizers.

In two variables, the best subset regression model selected, having the annual on farm income and the annual credit as independent variables, which explained 75% variation in response (Y_N) with smallest C_p statistic (74.867) and the residual mean squares (22366.849) respectively. The best subset model selected is:

$Y_N = 6.702 + 0.0006745\ X_{4I} + 0.01555\ X_{6C}$ ---(3)

t-ratios: (0.348) (7.564) (8.124)

Standard errors: (19.259) (0.000009) (0.00191)

The model shows that the annual on farm income and the annual credit exert significant effect ($p < 0.05$) on the demand for N-fertilizers.

Results pertaining to best selected subset regression having three predictor variables for the demand of N- fertilizers are shown in Table-1. The value of R^2-adjusted for weighted average price of N-fertilizer (X_{1N}), the annual on farm income (X_{4I}) and the annual credit (X_{6C}) was the highest of 0.684 with a minimum Cp statistic and residual mean squares as 106.172 and 3165.869, respectively. The best selected subset regression model amongst all the fitted models was the model having X_{1N}, X_{4I} and X_{6C} as predictor variables, having the highest value of R^2-adjusted and, the lowest C_P statistic and residual mean squares. The model had a significant effect ($p < 0.05$) on demand for N-fertilizers, while the effect of weighted average price of P-fertilizer (X_{2P}), the weighted average price of K-fertilizer (X_{3K}) and the farmer's age (X_7) was found non significant ($p = 0.096$) at both 1% and 5% levels of significance. Hence, the best-selected subset regression model having three predictors is:

$Y_N = 676.602 - 1.575\ X_{1N} + 0.0006115\ X_{4I} + 0.01623\ X_{6C}$ ------------------------------ (4)

t-rtios: (6.223) (-6.249) (7.233) (8.992)

Standard errors: {108.726} {0.252} {0.00008} {0.0018}

The lowest value of R^2-adjusted and highest value of C_P statistic was observed for the model having X_{1N}, X_{2P}, X_{3K} and X_{7Ag} as predictor variables as 0.081 and 1065.912 respectively. Amongst all the fitted models the best selected model was the model having X_{1N}, X_{2P}, X_{4I} and X_{6C} as predictor variables which explained 80.1% variation in the consumption of N-fertilizers with a minimum

C_P statistic of 3.450. The selected model had a significant effect ($p < 0.05$) on demand for nitrogenous fertilizers. The best selected model is:

$$Y_N = 584.753 - 1.921\,X_{1N} + 0.374\,X_{2P} + 0.000687\,X_{4I} + 0.01483\,X_{6C} \text{ ------------------ } (5)$$

t-ratios: (5.609) (-7.806) (5.863) (8.458) (8.581)

Standard errors: {104.425} {0.2461} {0.0638} {0.00008} {0.0017}

In similar way, the best selected models having five and six predictor variables are model (6) and (7) respectively.

$$Y_N = 642.001 - 1.917\,X_{1N} + 0.371\,X_{2P} + 0.00068\,X_{4I} + 0.0151\,X_{6C} - 1.247\,X_{7Ag} \text{ ----- } (6)$$

t-ratios; (5.583) (-7.792) (5.819) (8.332) (8.667) (-1.177)

S.errors: {114.992} {0.246} {0.064} {0.00008} {0.0017} {1.0595}

$$Y_N = 638.16 - 1.91\,X_{1N} + 0.372\,X_{2P} + 0.0007\,X_{4I} - 1.51\,X_{5A} + 0.015\,X_{6C} - 1.227\,X_{7Ag} \text{ ------ } (7)$$

t-ratios: (5.477) (-7.613) (5.812) (5.757) (-0.218) (7.952) (-1.152)

S.errors: {116.516} {0.251} {0.064} {0.00012} {6.926} {0.0019} {1.065}

In model (6) the effect of farmer's age (X_{7Ag}) was found non-significant, while model (7) shows that the effect of farm area (X_{5A}) and that of farmer's age (X_{7Ag}) was non-significant ($p > 0.05$) at both 1% and 5% levels of significance.

The relationship between demand of N-fertilizer and the factors affecting its use are graphically presented in Fig-2 to Fig-8 in appendix. Figure-2 depicts the negative and significant correlation coefficient of N-fertilizer demand and its own weighted average price. Figure-3, 4 and 8 present the non significant correlation between demand of N-fertilizers and the weighted average price of P-fertilizers, the weighted average price of K-fertilizers and the farmer's age, respectively. While, the correlation of the annual on farm income, the farm area, and the annual credit with N-fertilizers demand was significant (Figure-4, 5 and 6), respectively.

Selection of Optimum Subset Regression Model

From model (1) it is clear that X_{3K}, X_{5A} and X_{7Ag} exert non-significant effect ($p > 0.05$) on the demand for N-fertilizers, while the effect of X_{1N}, X_{2P}, X_{4I} and X_{6C} was found significant at both 5% and 1% levels of significance. Similar results are also obtained from model (6) and (7). Further Table-1 shows that up to four regressors model, the value of R^2 adjusted becomes stabilized. Hence the optimum subset model for the demand of N-fertilizers selected is model (5) i.e. the model having X_{1N}, X_{2P}, X_{4I} and X_{6C} as predictor variables.

The coefficients of X_{2P}, X_{4I} and X_{6C} of the selected model (5) are positive which indicate that the increased weighted average price of P-fertilizers, increased annual on farm income of the farmers and increased annual credit exert positive influence on the demand for N-fertilizers. While the negative coefficient of X_{1N} shows the negative relationship between the demand of N-fertilizers and its own weighted average price ($r = -0.265$ with $p < 0.05$). It means that the decreased price of N-fertilizers can boost its demand and vice versa. It was also found in the study that the farmer's age don't effect the demand of fertilizers. Similar result was reported by Iqbal (1979).

Average Consumptions of N-fertilizers Crop wise

Table 2 and figure-1 depict results pertaining to the average consumption of N-fertilizers in kilograms, crop wise by each farmer. On the average, a farmer used 424.82 kg of N-fertilizers.

Table 2. Average Consumption of N-fertilizers (Kgs) Crop Wise

Crops	Wheat	Barley	Maize	Vegetables (Rabi)
Consumptions of N-fertilizers	163.37	4.36	96.98	12.44
Crops	Sugar beet	Shaftal	Sugar Cane	Vegetables (Kharif)
Consumptions of N-fertilizers	10.42	38.86	83.15	15.24

Of 424.82, major quantity was used for wheat (163.94 kg), followed by maize (96.98 kg), sugar cane (83.15 kg) and Shaftal (38.86 kg) along with some other quantities of vegetables (Kharif and Rabi), and sugar beet and very less amount of N-fertilizers was used for barley.

As far as the consumption of N-fertilizers ha^{-1} is concerned, 87.39 kg, 110.61 kg, 74.79 kg, 95.28 kg, 125.41 and 174.79 kg ha^{-1} were used for wheat, sugarcane, maize, sugar beet, Shaftal and barley, respectively. It further investigates, that less amount of N-fertilizers were used for wheat, sugar cane, maize and sugar beet than that of recommended level. Where as, N-fertilizers were used above the recommended levels for Shaftal and barley. Since Shaftal and barley are perennial crops, therefore repeated applications of fertilizers are used to stimulate their growth.

CONCLUSIONS AND RECOMMENDATIONS

The present study showed that the prices of fertilizers, annual on farm income and the annual credit were the most important factors, where as, age was not found to be an important factor affecting the demand of N-fertilizers.

The government should bring down the prices of various fertilizers and stream line the credit facilities to the farmers so that optimum yield can be realized.

REFERENCES

Ayub, M. A. (1975): An Econometric study of the Demand for Fertilizer in Pakistan. Pakistan Development Review, Vol. 14, pp. 135-141.

Draper, N. and Smith, H. (1998): Applied Regression Analysis. John Wiley & Sons New York.

Food and Agriculture Organization (FAO). (1981). Annual Fertilizer Review.

Iqbal, M. (1979): The Study of Fertilizer Use in Pakistan. The Journal of Development Studies, Vol. II. 1979.

Leonard, P. (1969): The Demand for Fertilizers in Pakistan. Pakistan Development Review. Vol. IX, No. 4. Winter 1969.

Mustafa, K. and Saeed, A. (1977). Demand Function for Nitrogenous Fertilizers in the Punjab, 1966-1974. Pakistan Journal of Agricultural Sciences XIV (1), pp. 47.

Raju, S. (1989): "Fertilizer Use in Andhra Pradesh: an Analysis of Factors Affecting Consumption". Artha Vijnana. 31 (4): 313-332.

U.S. Department of Agriculture (1973): Economic Research Service. Pakistan's Agriculture Development and Trade. Washington. D.C. pp. 24.

STATISTIČKA ANALIZA POTREBA ZA KORIŠĆENJEM AZOTNIH ĐUBRIVA U SJEVEROZAPADNOM PAKISTANU

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Sažetak

Polazeći od opšteprihvaćenog saznanja da je đubrenje najglavnija agrotehnička mjera u poboljšanju proizvodnje raznih vrsta usjeva i ključ ka sigurnom obezbjeđenju neophodne hrane za Sjeverozapadni Pakistan, ovaj se rad bavi identifikacijom faktora od kojih zavisi upotreba azotnih đubriva. Pri tome je pokušano da se izaberu optimalni podskupni regresivni modeli za procjenu važnosti i značajnosti utvrđenih faktora.

Efekat srednje tržišne cijene azotnih đubriva, površina i starost farmerskog posjeda izdvojen je kao neznačajna ($P>0,05$) s aspekta potrebe za azotnim đubrivima za oba nivoa signifikantnosti (1 i 5%) i nije uključen u selektivirani optimum podskupova regresivnog modela.

Prikazani rezultati su pokazali da su cijene đubriva, na godišnjem nivou prihoda i krediti bili najznačajniji faktori u pogledu upotrebe azotnih đubriva, dok faktor starosti u ovom trenutku nije značajan.

Na osnovu dobijenih rezultata preporučuje se Vladi Pakistana da smanji cijenu đubriva i otvori linije kreditnih olakšica za farmere da bi oni mogli ostvariti optimalni prinos.

APPENDICES

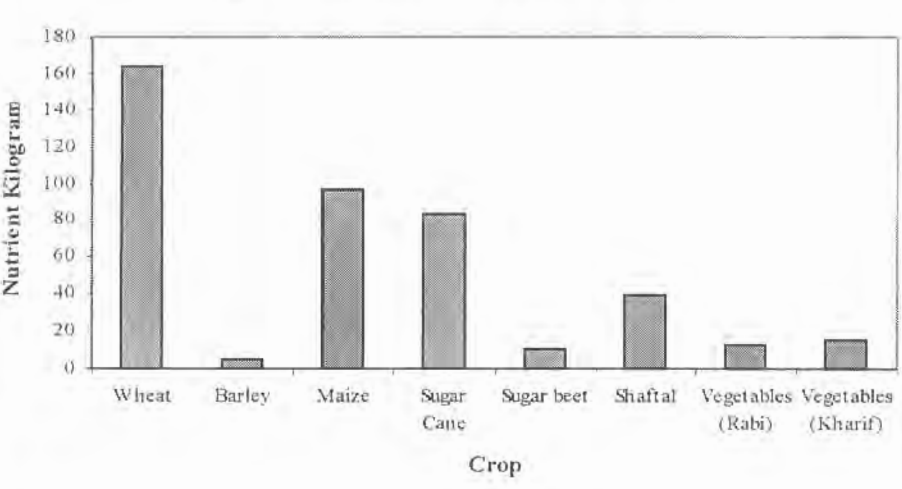

Fig-1 Consumption of N-fertilizer Crop wise

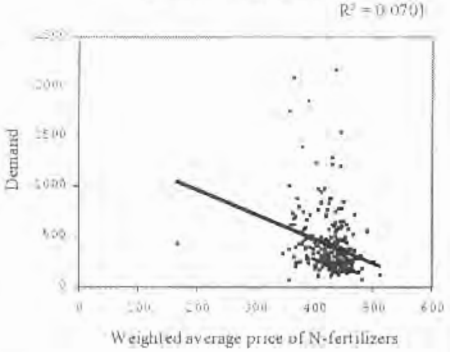

Fig-2 Demand of N-fertilizers and its weighted average price

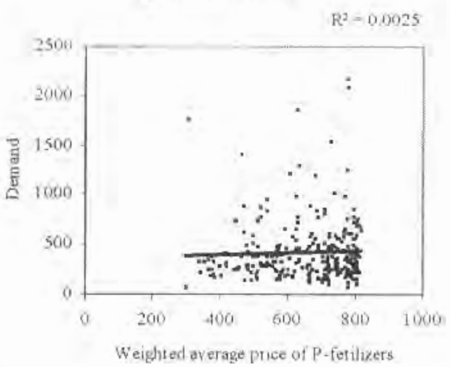

Fig-3 Demand of N-fertilizers and weighted average price of P-fertilizers

Fig-4 Demand of N-fertilizers and the weighted average price of K-fertilizers

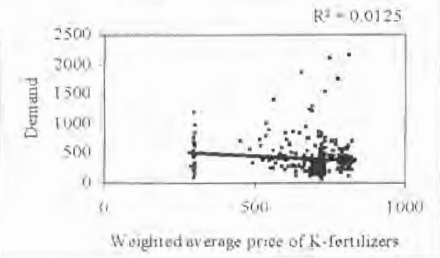

Fig-5 Demand of N-fertilizers and the annual farm income

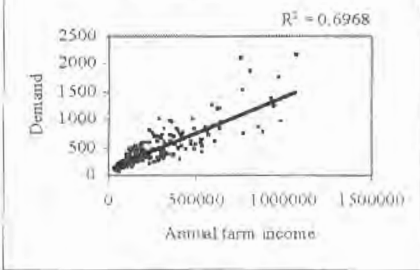

Fig-6 Demand of N-fertilizers and the farm area

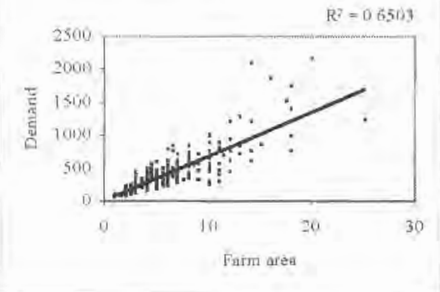

Fig-7 Demand of N-fertilizers and the annual credit

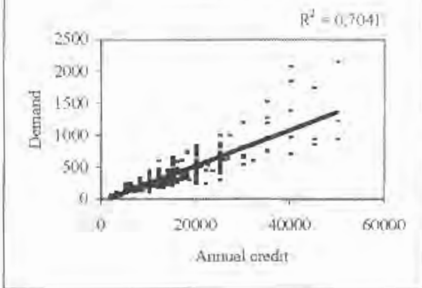

Fig-8 Demand of N-fertilizers and the farmer's age