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PROGRESS REPORT NO. 6

SOIL SALINITY CONTROL FOR THE

GROWTH OF PLANTS WHICH

CAN SERVE AS

ENERGY SOURCE

A RESEARCH PROJECT

USAID/PSTC PROGRAM

GRANT NO. 936-5542-G-SS-3036-00

SUBMUTTED BY

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## Project Profile

Country : Thailand

Grant No. : 936-5542-G-SS-3036-00

Program : Program on Science and Technology Cooperation

Project Title : Soil Salinity Control For The Growth Of Plants Which Can Serve As Energy Source

Project Leader : Benjamas Chattong M.S (Soils)

Organization : King Mongkut's Institute Of Technology North Bangkok

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Project Consultants : -

Authorized Officer : Rector Of King Mongkut's Institute Of Technology North Bangkok

Total Project Budget : US$ 150,000

Project Duration : $3\frac{1}{2}$ years

Reporting Period : January 1, 1986 - June 30, 1986

Budget Allocation for This Period : US$ 8,500

1. Background/Introductions

Salinization of marine soil in humid region especially Smutsongkram province has become serious problems to orchardmen for many years. The intrusion of sea water and lacking the rain during hot season make the soil be more and more saline. Besides the clay structure also causes poor drainage. Because of these results, the water - table has been rising and often endanger plants for two reasons : first the root zone become saturated leading to rotting of trees : second the water itself contains high salt content, so that even short term water - logging can cause substantial tree wilting and dieing ultimately. The purpose of this research is to develop a proper method to control soil salinity for growing physic - nut trees and prohibiting the expansion of salinization to the neighbourhood.

2. Objective : to compare the efficiency of soil salinity control methods by leaching and leaching with the addition of 3% rice husk + 6% gypsum correlating to plant response.

3. Materials and Methods

Irrigation

A field experiment was conducted continuing from the last period ending December 31, 1985. Plants in all plots were watered by diesel pumpage alternating with wind pump from aquifer once a day. The depth of irrigated

water was estimated from mean temperature in the previous year using Blaney - Cliddle method (table 1). On - site wind data was statistically analysed in order to adjust wind pump proper to water utilization for irrigating plants in the experimental field.

Comparing the efficiency of the two soil salinity control methods

Soil moisture characteristic curve was done by installing twelve tensiomenters in the field plots at the depth of 30cm and 60cm. Soil samples were taken around porous cup of individual instrument after moisture tension was read. Soil moisture content was determined from the collected samples by oven dry method at 105 °c for 24 hours. Soil moisture characteristic curve was plotted between soil moisture content by volume and moisture tension (Figure 1). Sixteen iron cylinders of 33cm diameter and 40.5cm high for each were pressed into the plot soil at the depth of 30.5cm (Figure 2,3,4,5,6,7,8 and 9). Tensiometers were installed at the distance of 15cm from cylinders at the same depth. Water was filled into each cylinder. Heads of water were measured at initial time and after six hours later. At the meantime moisture tensions were recorded from tensiometers and soil samples were taken after tensiometers were put up in order to determine E.C. values. All measurements were done every month. Depth of rainfall and evaporation were recorded from pan and pan evaporator. Difference of infiltration among the two treatments were tested using F statistics.

A study of plant response

After physic - nut trees have been grown in the field plots for six months, stem mean height of each plant row was observed and recorded (Figure 10, 11,12,13,14,15,16 and 17). Data obtained from the observation were tested for significant difference using similar statistics as mentioned above.

4. Results/Discussion/Tables :

The results of this study are presented in four parts. In the first part, infiltrations of water in plot soil treated by leaching, and leaching with the addition of 3% rice husk plus 6% gypsum were comparatively studied; the second part studied input - output variables in those two control methods; the third part was concerned with plant response to the two treatment soils; and the fourth dealt with statistical analysis of on - site wind data.

Difference between infiltration soil treated with leaching and leaching +3% rice husk + 6% gypsum.

The addition of rice husk and gypsum slightly affected to infiltration (Table 2). Soils treated with leaching had infiltration 15% less than that when treated with leaching plus 3% rice husk and 6% gypsum. However the F statistical test indicated no significant difference between the effects of these treatments on infiltration.

Input - output variables in soil salinity control systems

Addition of rice husk and gypsum did not only improve infiltration but also decreased soil salinity (Table 3). Soil treated with leaching plus 3% rice husk and 6% gypsum had E.C. value 20.5% less than that of the soil treated with leaching solely.

Plant response to two control methods

Although F statistical test indicated no significant difference between the effects of these treatments on plant growth (Table 4). Nevertheless plants grown in soil treated with leaching only had better growth than those grown in another treatment. This phenomena implied that either rice husk or gypsum might retard plant growth.

Table 1 Calculation Of Water Input To Physic - nut Field In Six Months Followed Blaney - Criddle Method

| Month | Mean temperature °C | Mean temperature °F | P % | $\frac{t.P}{100}$ |
|---|---|---|---|---|
| January | 25.6 | 78.1 | 8.02 | 6.26 |
| February | 22.5 | 72.5 | 7.41 | 5.37 |
| March | 29.6 | 85.3 | 8.43 | 7.17 |
| April | 30.6 | 87.1 | 8.42 | 7.32 |
| May | 29.5 | 84.2 | 8.91 | 7.50 |
| June | 27.8 | 82.0 | 8.73 | 7.16 |
| | | | $\varepsilon \frac{t.P}{100}$ | 40.78 |

t = monthly mean temperature in °F

P = daylength for each month at 13.5° N

u = Water required in six - month

K = Crop coefficient

= 0.75

$$u = K \, \varepsilon \frac{t.P}{100}$$

$$= 0.75 \times 40.78 \times 25 = 765 \text{ mm}$$

Table 2 Difference Between Infiltration In Soil Treated With Leaching And Leaching + 3% Rice Husk + 6% Gypsum

| day | Infiltration (mm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Leaching | | | | Leaching + 3% Rice Husk + 6% Gypsum | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | 5.0 | 6.5 | 6.0 | 11.1 | 10.5 | 4.9 | 5.0 | 11.5 |
| 2 | 6.0 | 7.3 | 4.9 | 8.6 | 8.9 | 6.2 | 4.8 | 9.8 |
| 3 | 4.8 | 7.0 | 7.1 | 9.5 | 9.0 | 5.0 | 5.4 | 10.3 |
| 4 | 5.3 | 6.0 | 5.8 | 7.6 | 8.6 | 5.5 | 4.6 | 11.0 |
| 5 | 6.8 | 5.8 | 5.5 | 9.1 | 9.4 | 4.1 | 6.5 | 12.5 |
| 6 | 5.2 | 6.3 | 6.5 | 8.4 | 10.6 | 5.6 | 5.5 | 10.9 |
| Total Values | 33.1 | 38.9 | 35.8 | 54.3 | 57.0 | 31.3 | 31.8 | 66.0 |
| Trt total $x_i$ | 162.1 | | | | 186.1 | | | |
| Trt mean $\bar{x}_i$ | 6.75 | | | | 7.75 | | | |

$\bar{x}$ = 7.25, s = 5.79, $s_{\bar{x}}$ = 2.36, $s_{\bar{d}}$ = 3.34, $F_t$ < 1 with 7 and 1 df

Table 3 Input - Output Variables In Soil Salinity Control Systems

| Treatments | Replication | Irrigation $\bar{W}$ mm/d | Rainfall $\bar{P}$ mm/d | Soil moisture $\bar{\theta}_v$ % | Infiltration at 30.5cm $\bar{I}$ mm/d | Evaporation $\overline{ET}$ mm/d | $E.C_f$(1:5) mmhos/cm |
|---|---|---|---|---|---|---|---|
| Leaching | 1 | 4.25 | 16.2 | 28.0 | 5.5 | 7.1 | 9.43 |
| | 2 | 4.25 | 16.2 | 30.3 | 6.5 | 7.1 | 7.54 |
| | 3 | 4.25 | 16.2 | 26.5 | 6.0 | 7.1 | 6.60 |
| | 4 | 4.25 | 16.2 | 35.0 | 9.0 | 7.1 | 5.56 |
| Leaching + 3% Rice Husk + 6% Gypsum | 1 | 4.25 | 16.2 | 32.5 | 9.5 | 7.1 | 4.72 |
| | 2 | 4.25 | 16.2 | 25.8 | 5.2 | 7.1 | 5.66 |
| | 3 | 4.25 | 16.2 | 28.5 | 5.3 | 7.1 | 9.25 |
| | 4 | 4.25 | 16.2 | 45.0 | 11.0 | 7.1 | 3.78 |

Table 4 Stem Mean Height Of Physic - nut Trees Grown In Two Treatment Soils

| Tree rows | Stem mean height cm | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Leaching | | | | Leaching + 3% rice husk + 6% gyps. | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | 22.50 | 20.0 | 47.5 | 21.5 | 7.5 | 60.0 | 12.5 | 12.5 |
| 2 | 50.0 | 17.5 | 51.25 | 42.5 | 5.0 | 67.5 | 18.5 | 35.0 |
| 3 | 75.0 | 12.5 | 65.0 | 37.5 | 7.5 | 60.0 | 25.0 | 10.0 |
| 4 | 75.0 | 12.5 | 32.5 | 20.0 | 15.0 | 20.0 | 15.0 | 8.5 |
| 5 | 35.0 | 10.0 | 62.5 | 27.5 | 25.0 | 20.0 | 20.0 | 17.5 |
| 6 | 55.0 | 25.0 | 35.0 | 50.0 | 22.5 | 50.0 | 27.5 | 12.5 |
| 7 | 65.0 | 12.5 | 80.0 | 50.0 | 22.5 | 55.0 | 80.0 | 12.5 |
| 8 | 125.0 | 22.5 | 87.5 | 10.0 | 17.5 | 70.0 | 30.0 | 10.0 |
| 9 | 120.0 | 17.5 | 27.5 | 20.0 | 17.5 | 32.5 | 10.0 | 32.5 |
| 10 | 15.0 | 15.0 | 80.0 | 10.0 | 22.5 | 45.0 | 2.5 | 55.0 |
| 11 | 65.0 | 25.0 | 52.5 | 15.0 | 17.5 | 37.5 | 22.5 | 82.0 |
| 12 | 57.5 | 27.5 | 7.5 | 25.0 | 15.0 | 47.5 | 7.5 | 85.0 |
| 13 | 17.5 | 75.0 | 72.5 | 7.5 | 85.0 | 12.5 | 22.5 | 90.0 |
| 14 | 37.5 | 32.5 | 10.0 | 27.5 | 30.0 | 10.0 | 42.5 | 32.5 |
| 15 | 27.5 | 17.5 | 12.5 | 10.0 | 17.5 | 17.5 | 32.5 | 57.5 |
| 16 | 27.5 | 12.5 | 25.0 | 10.5 | 11.0 | 10.0 | 10.0 | 80.0 |
| 17 | 22.5 | 7.5 | 5.0 | 47.5 | 11.0 | 10.0 | 10.0 | 37.5 |
| 18 | 32.5 | 27.5 | 12.5 | 30.0 | 5.0 | 12.5 | 55.0 | 20.0 |
| 19 | 15.0 | 17.5 | 7.5 | 22.5 | 17.5 | 10.0 | 52.5 | 47.5 |
| 20 | 17.5 | 77.5 | 10.0 | 25.0 | 10.0 | 30.0 | 15.0 | 42.5 |
| 21 | 2.5 | 65.0 | 7.5 | 5.0 | 4.0 | 7.5 | 22.5 | 22.5 |
| 22 | 3.0 | 10.0 | 30.0 | 2.5 | 7.0 | 32.5 | 22.5 | 40.0 |
| 23 | 4.0 | 10.0 | 30.0 | 7.5 | 7.5 | 7.5 | 10.0 | 15.0 |
| 24 | 2.5 | 10.0 | 47.5 | 10.0 | 4.0 | 12.5 | 15.0 | 4.0 |
| 25 | 10.0 | 10.0 | 57.5 | 10.0 | 40.0 | 5.0 | 25.0 | 17.5 |
| Plant total | 979.5 | 590.0 | 956.25 | 544.5 | 444.5 | 742.5 | 606.0 | 879.5 |
| Treatment total | 3,070.25 | | | | 2,672.5 | | | |
| Treatment means | 122.81 | | | | 106.9 | | | |
| | $\bar{x}$ = 114.86, s = 42.10, $s_{\bar{x}}$ = 17.19, $s_{\bar{d}}$ = 24.31, CV = 36.6% | | | | | | | |
| | $F_t$ < 1 with 7 and 1 df, $f_\varepsilon$ = 3.40 with 6 and 192 df | | | | | | | |

## Statistical Analysis of On-site Wind Data

Bundit Fungtammasan

This part of the report describes the results of applying statistical analysis to the wind data recorded at the experimental site. The analyses yielded such basic statistical results as seasonal mean wind speeds, standard deviations as well as the statistical distribution of the wind speeds.

The wind speed data used for the analyses were hourly-averaged wind speeds obtained at the site using the M800 Weather Measure microprocessor controlled data logger (Progress Report No.3). Field recording of the wind data actually commenced in November, 1984. However, the recording was interrupted during May-July 1985, due to the multifunctioning of an electronic component (the outputing RAM) of the data logger. Consequently, a new one-year cycle data recording had to be reinitiated, beginning August 1985 to July, 1986. Therefore, the results contained in this report are for the period August 1985 - April 1986 only. The results for the one remaining season (May-July 1986) and the overall assessment of the results will be presented in the final report.

### The Weibull Distribution

It is well known that the wind speed fluctuations at a given site can be satisfactorily represented by a statistical model called "Weibull distribution", expressed as

$$F(V) = 1 - \exp\left(-(V/c)^k\right), \qquad (1)$$

where $F(V)$ is the cumulative distribution function of the wind speed $V$ ; $c$ and $k$ are parameters determined to best fit the given data set. The frequency distribution function corresponding to the above is given by

$$f(V) = (k/c)\ (V/c)^{k-1} \exp(-(V/c)^{k}). \qquad (2)$$

The shape of this distribution is determined primarily by the dimensionless factor k, while the scale factor c which has the dimensions of velocity, indicates approximately the magnitude of the mean value of the data set.

It can be shown that the parameter c is related to the mean wind speed as follows,

$$\bar{V} = c\,\Gamma\ (1 + 1/k) \qquad (\ )$$

where $\Gamma$ is the gamma function.

For a given wind data set, -say the hourly wind speed record of a given season, a method exists for testing whether the data could "reasonably" be represented by a Weibull model. The testing involves the use of a probability graph paper with a suitably distorted vertical scale, so that the measured cumulative distribution curve can be made to plot as a straight line if the data are sufficiently close to allow the use of the Weibull model. However, when the data set is large, the manual sorting and plotting of data becomes a tedious task. On the other hand, the testing can be hardled by a computer with ease. In this case, equation (1) is rearranged to give

$$\log_{10} \left[-\ln\ (1-F(V))\right] = k \log_{10} V - k \log_{10} C\ . \qquad (4)$$

By plotting values of $\log_{10} \left[-\ln\ (1-F(V))\right]$ on the vertical axis against values of $\log_{10} V$ on the horizontal axis from a sorted data set, a straight line would be obtained if the data set did conform to the Weibull model. Hence the value of parameter k can be obtained as the slope of the straight-line, and that of parameter c obtained as the intercept on the vertical axis.

Wind Speed Distribution at the Site

The wind data obtained are divided into four three-month seasons, namely August-October, November-January, February-April and May-July. A histogram plot of the velocity frequency distributions revealed that the number of occurences of calm periods is high for all the three seasons observed. Since this phenomena does not fit the Weibull function, the cumulative frequency distribution F(V) were evaluated with the occurrences of calm ($V < 0.25$ m/sec) omitted. Figures 1 to 3 show the plot of values of $\log_{10}\left[-\ln\,(1-F(V))\right]$ against $\log_{10} V$ for each of the three observed seasons. It can be seen that straight lines fit reasonably well with the observed data points. The parameters k and c were then determined by the method described in the previous section, and the results are listed in table 1. The k values lie between 1.81 - 2.17 which indicate that the distributions are relatively steady. The c values range from 3.44 to 3.68 m/sec.

Using equation (3), the mean wind speed $\bar{V}$ (excluding the calm periods) can be calculated. The c values are seen to be greater than the estimated mean by approximately 13%

When the calm periods are taken into account, the calculated mean wind speeds have to be adjusted accordingly (table 2). They are seen to differ from the measured mean speed by no more than 4.3%.

Figures 4-6 show the Weibull distribution curves obtained from equation (2) using the k and c values determined above. They are seen plotted over their respective histograms of the seasonal wind data set.

TABLE 1

Weibull Distribution Parameters

| SEASON | k | c (m/s) | $\bar{V}$ (m/s) | Δ% |
|---|---|---|---|---|
| AUG - OCT | 2.01 | 3.44 | 3.05 | 12.8 |
| NOV - JAN | 1.81 | 3.68 | 3.27 | 12.5 |
| FEB - APR | 2.17 | 3.47 | 3.07 | 13.0 |

TABLE 2

Comparison of estimated and measured mean wind speeds

| Season | Frequency of calm $f_c$ (%) | Estimated speed, $\bar{V}_e$ (m/s) | Measured speed, $\bar{V}_m$ Zm/s) | Error (%) |
|---|---|---|---|---|
| AUG - OCT | 32.7 | 2.05 | 2.01 | +0.2 |
| NOV - JAN | 30.7 | 2.27 | 2.23 | +1.6 |
| FEB - APR | 26.7 | 2.25 | 2.35 | -4.3 |

Note : $\bar{V}_e = (1 - f_c)\,\bar{V}$

where $\bar{V}$ = estimated mean wind speeds with calm period excluded.

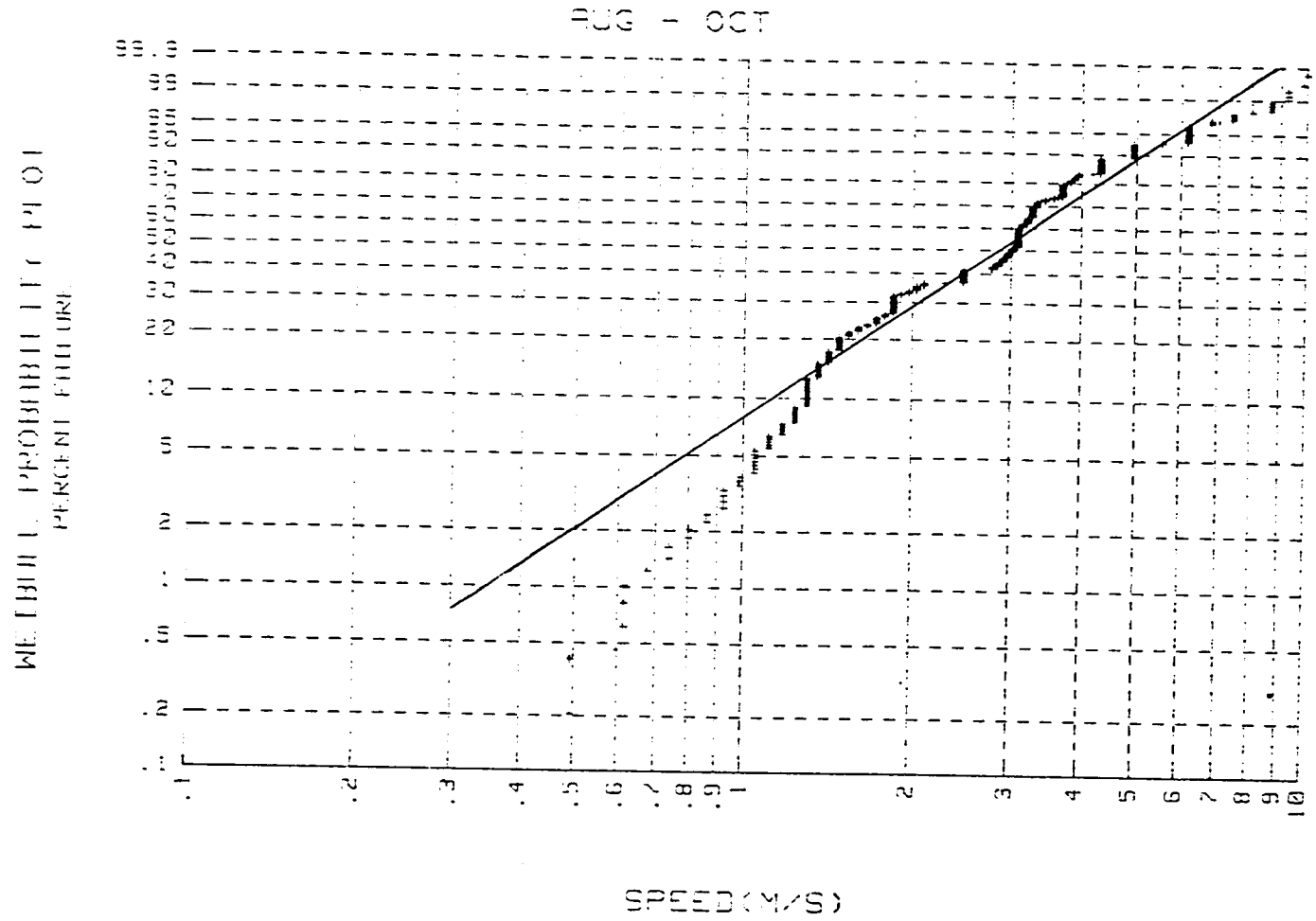


Figure 1. Weibull probability plot of wind data for August-October

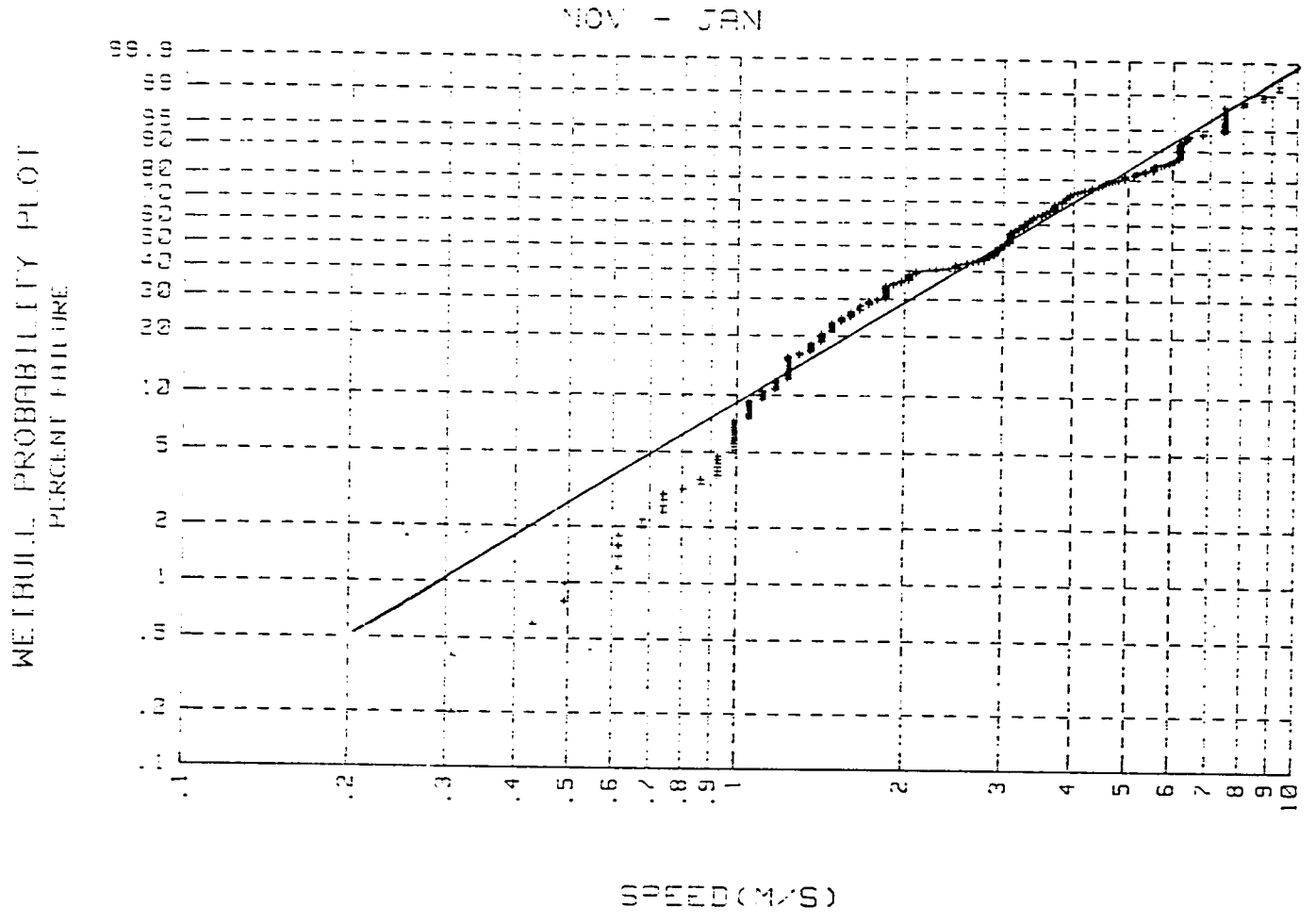


Figure 2. Weibull probability plot of wind data for November-January

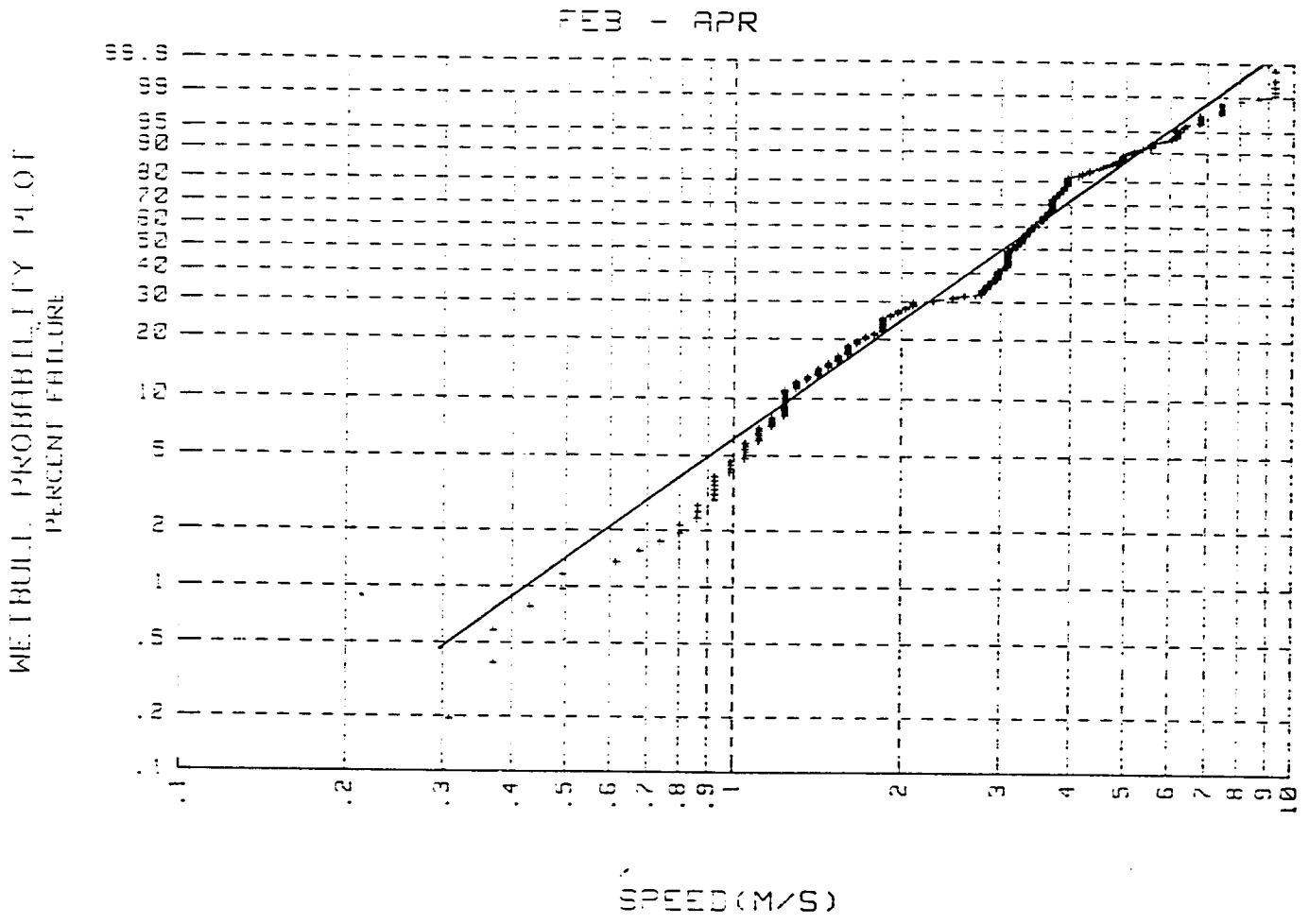


Figure 3. Weibull probability plot of wind data for February-April

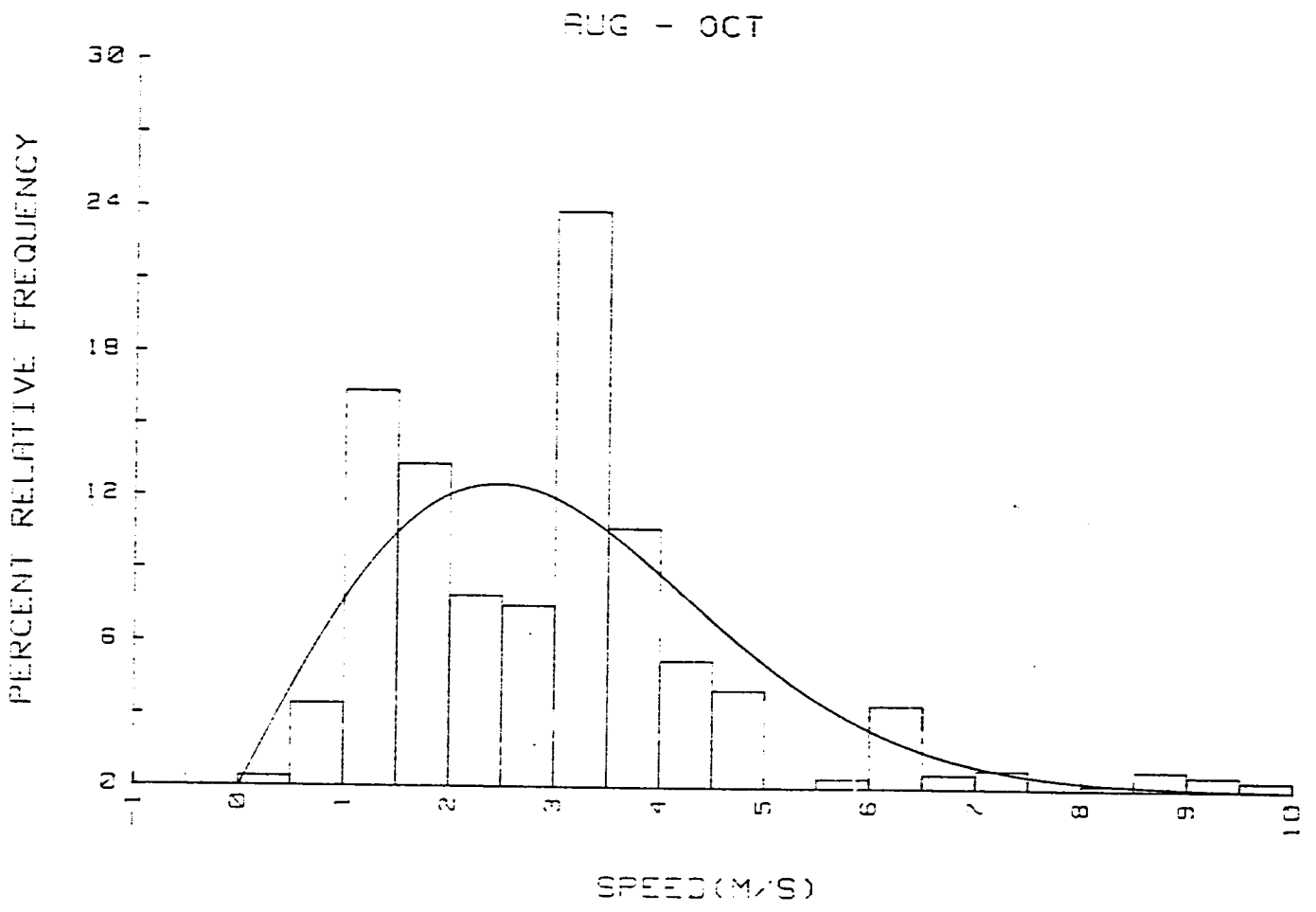


Figure 4. Histogram of wind data and the corresponding Weibull distribution function for August-October

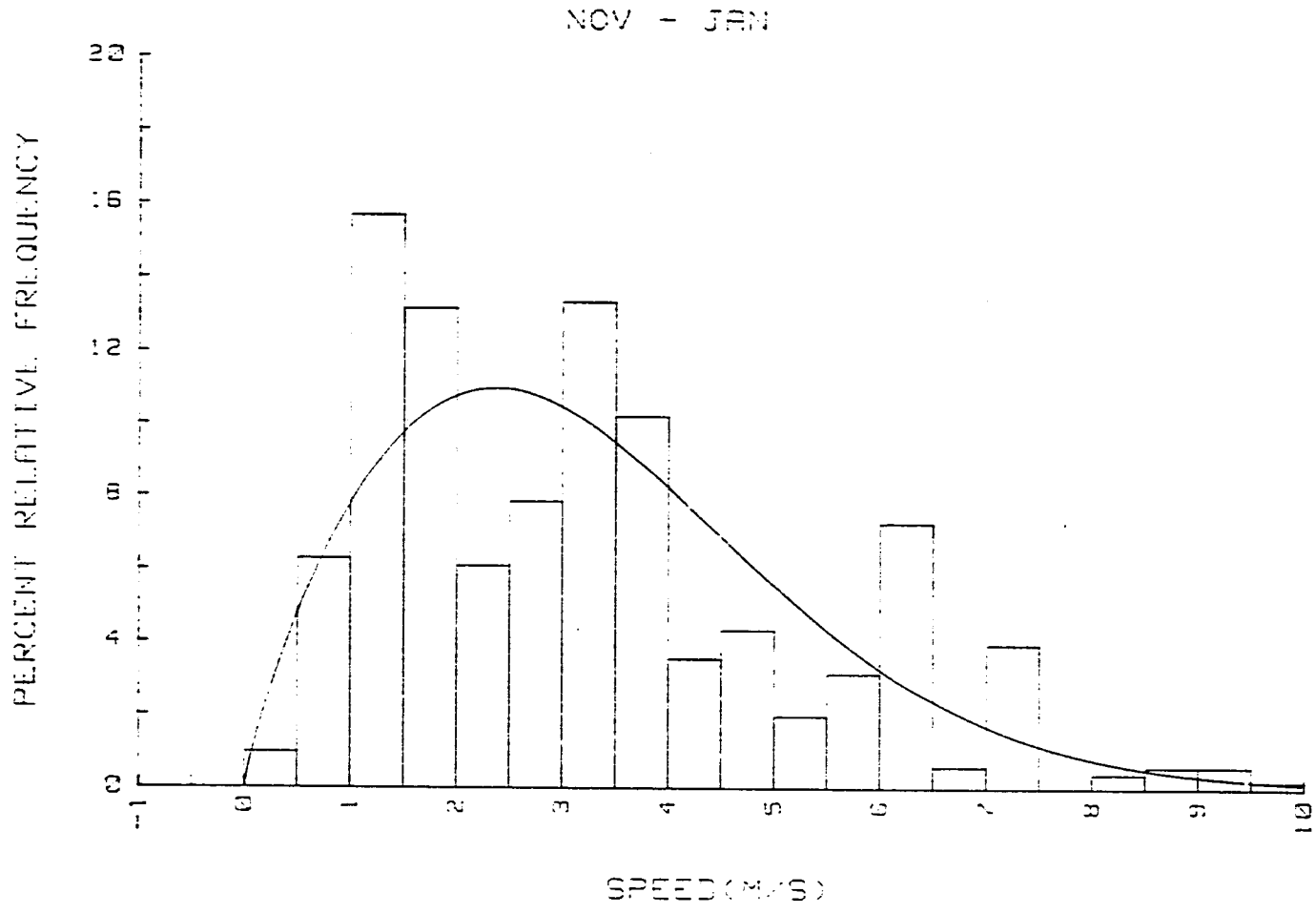


Figure 5. Histogram of wind data and the corresponding Weibull distribution function for November-January

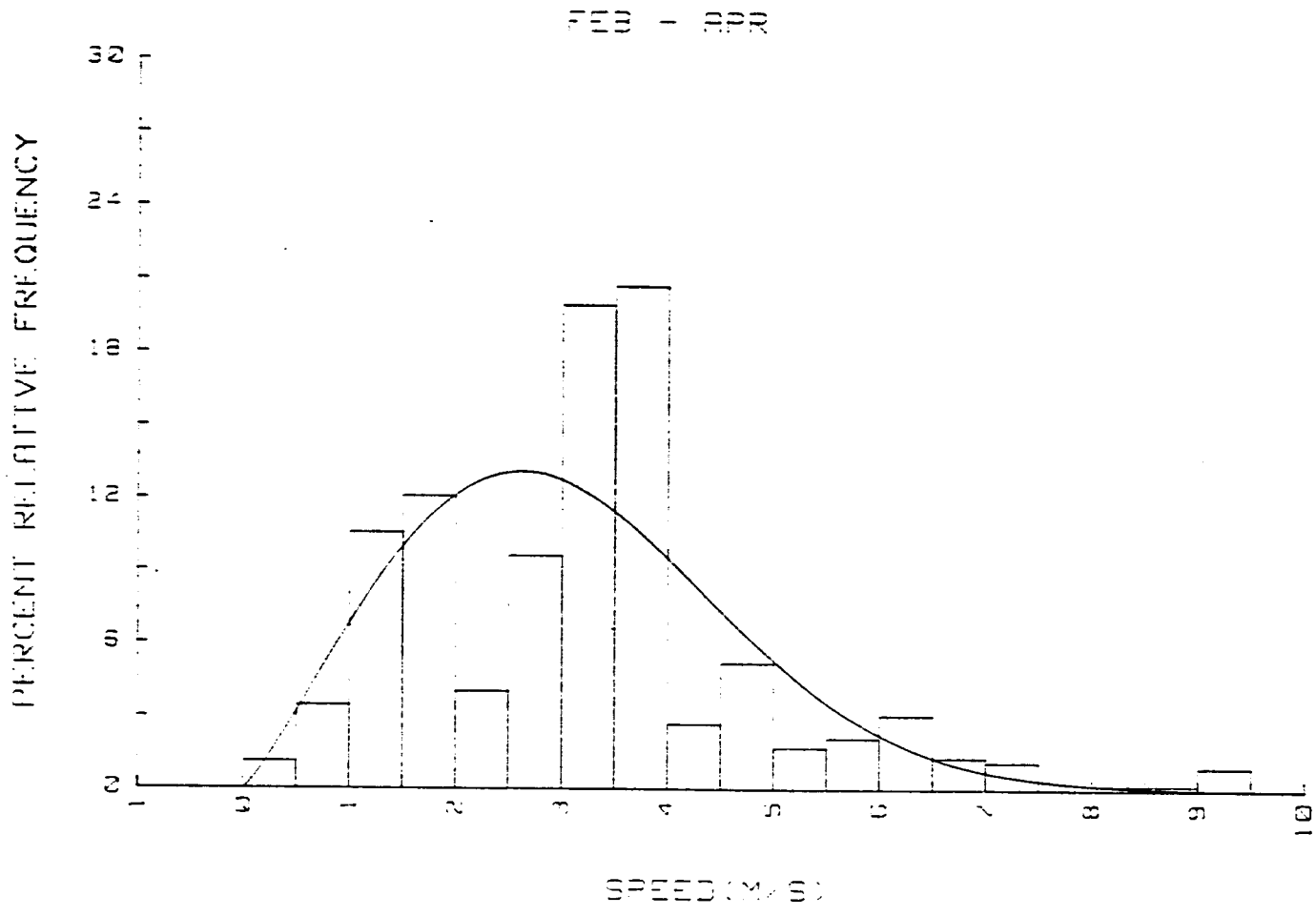


Figure 6. Histogram of wind data and the corresponding Weibull distribution function for February-April

5. Conclusion/Remarks :

Field experiment was conducted in order to study the efficiency of soil salinity control methods by leaching and leaching with the addition of 3% rice husk + 6% gypsum correlating to plant growth with the following results :

1. Adding rice husk and gypsum in the soil increased infiltration but decreased EC value.

2. Rice husk and gypsum might retard plant growth.

6. Workplan for the Next Period

1. Some biological factors which may damage plants will be studied relating to plant yield.

2. Full report will be written.

7. References :

1. Duckstein,L., and W.T.G. Brien, 1978. Joint Control of Salinity and Water - logging - An Australian Case Study. Proceedings of the Autumn Course in Applied Systems Aualysis, International Centre For Theoretical Physics, Trieste, Italy.

2. Steel, R.G.D., and J.H. Torrie 1960. Principles and Procedures of Statistics. Pp. 119 - 123 in Analysis of Variance I : The One - way Classification. McGraw - Hill Book Company, Inc. New York.

3. Tingsapat,S., and K. Takeda 1977 Manual For Hydrology And Irrigation. Pp 54-58 in Evapotranspiration. Society Of International Extension For Technical Knowledge. (Published in Thai Language.)

8. Annex/Picture :

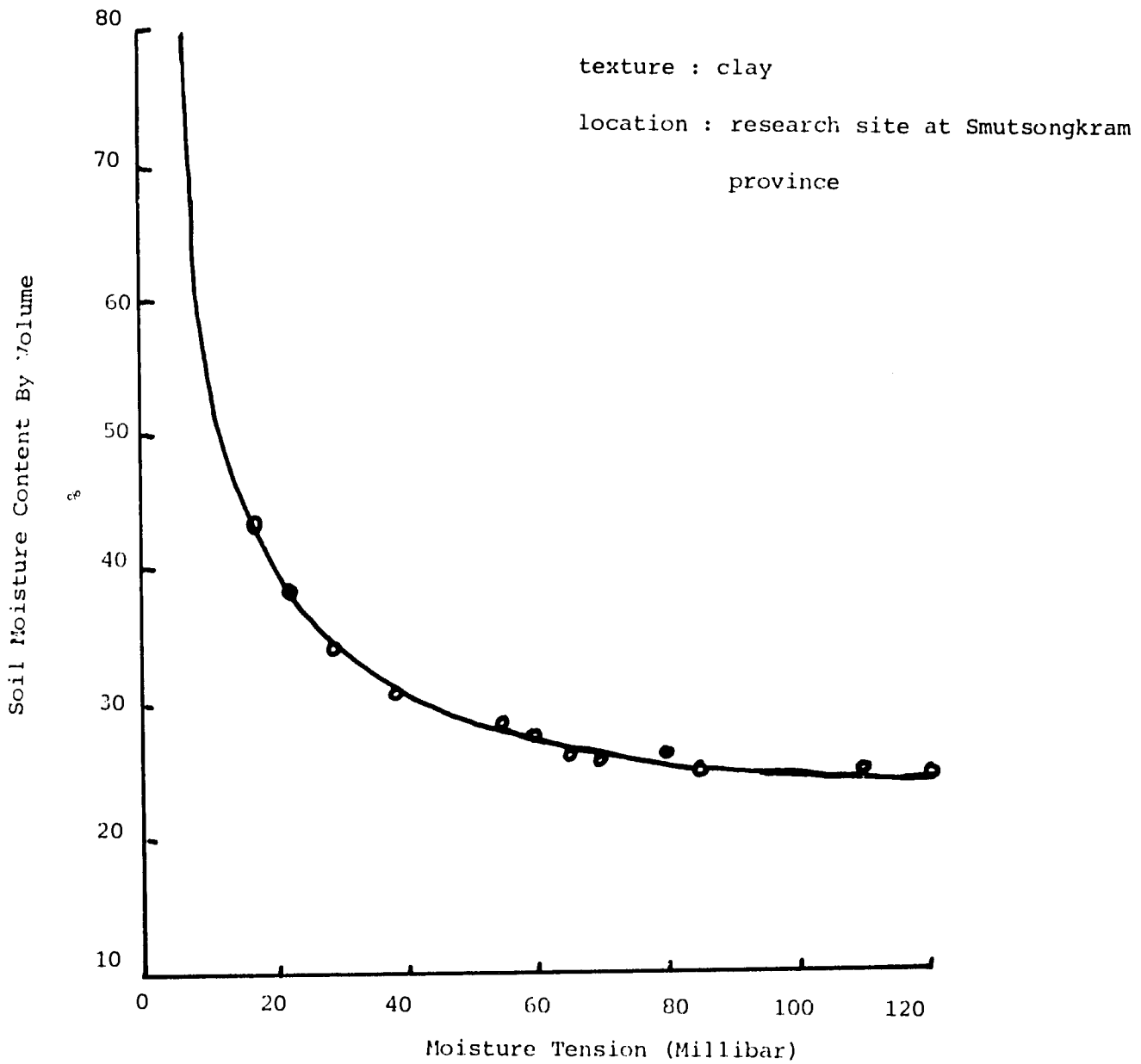


Figure 1 Soil moisture characteristic curve

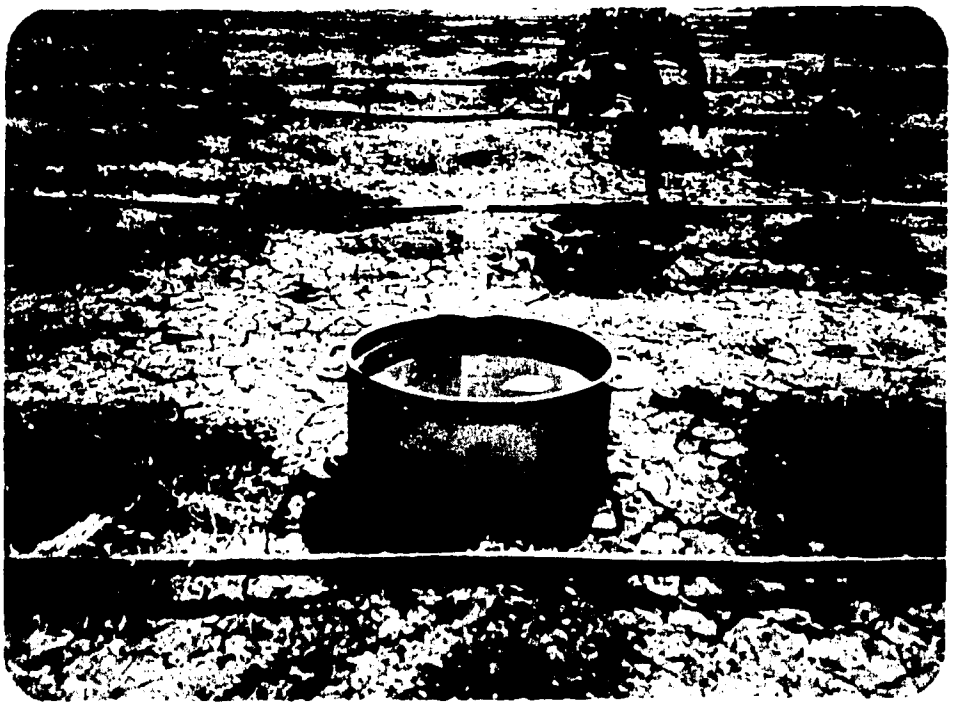

Figure 2 Infiltration monitoring for $T_1R_1$

Figure 3 Infiltration monitoring for $T_1R_2$

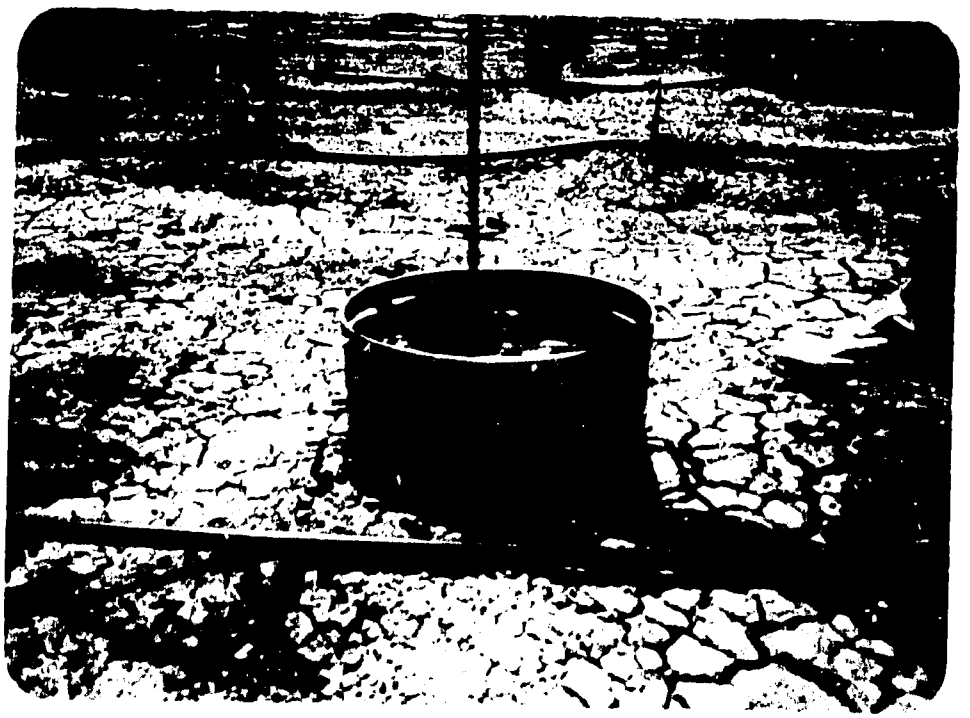

Figure 4 Infiltration monitoring for $T_1R_3$

Figure 5 Infiltration monitoring for $T_1R_4$

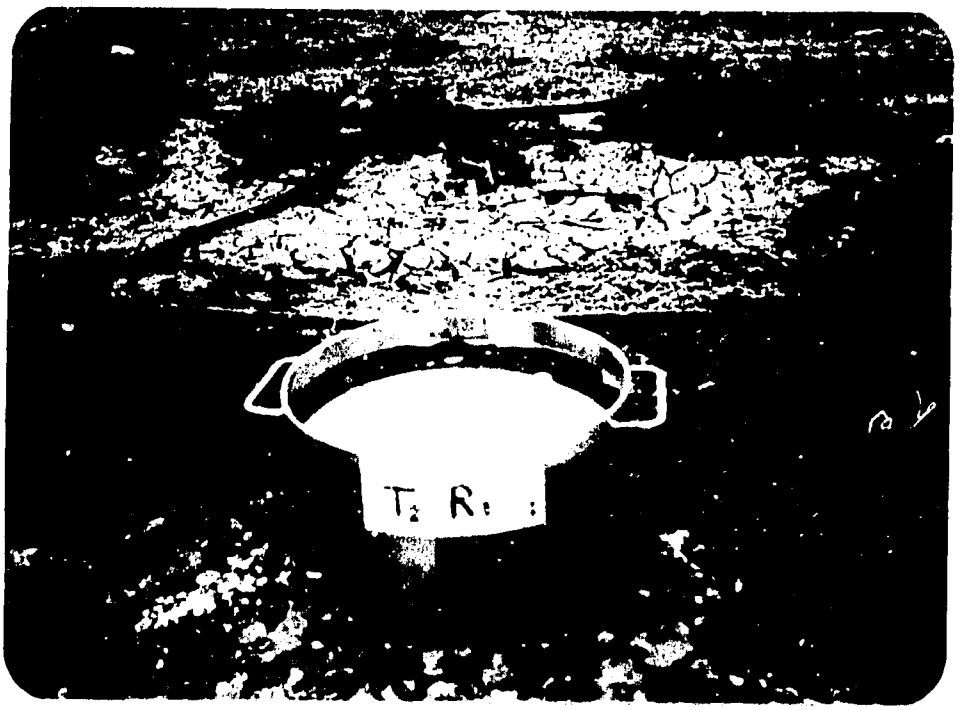


Figure 6 Infiltration Monitoring for $T_2R_1$

Figure 7 Infiltration monitoring for $T_2R_2$

Figure 8 Infiltration monitoring for $T_2R_3$

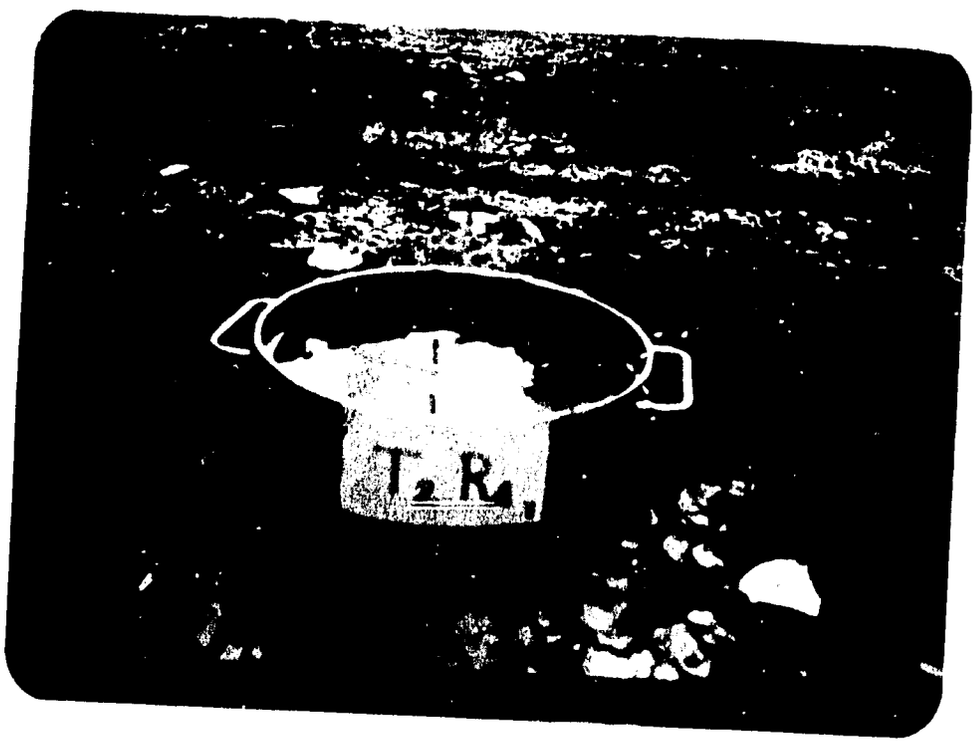

Figure 9 Infiltration monitoring for $T_2R_4$

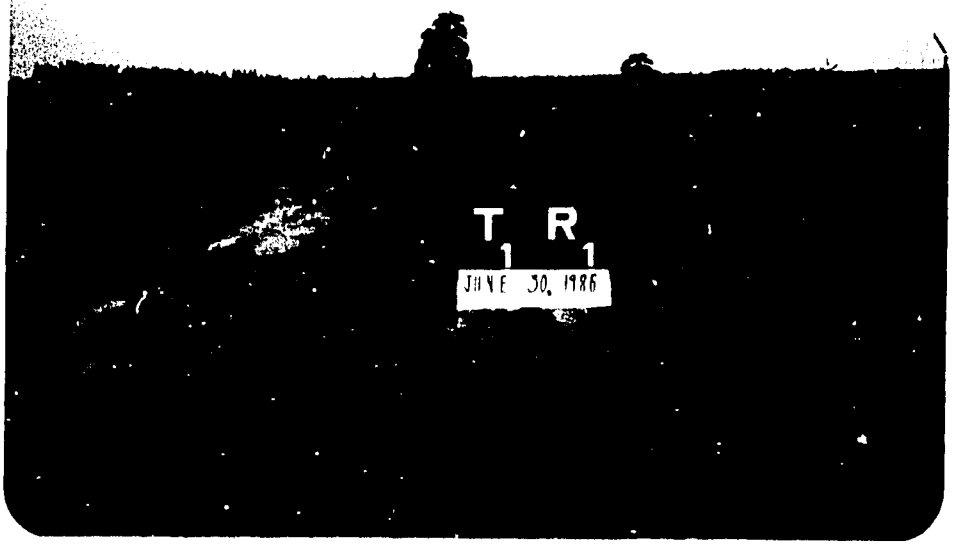


Figure 10 Growth of physic - nut trees in $T_1R_1$

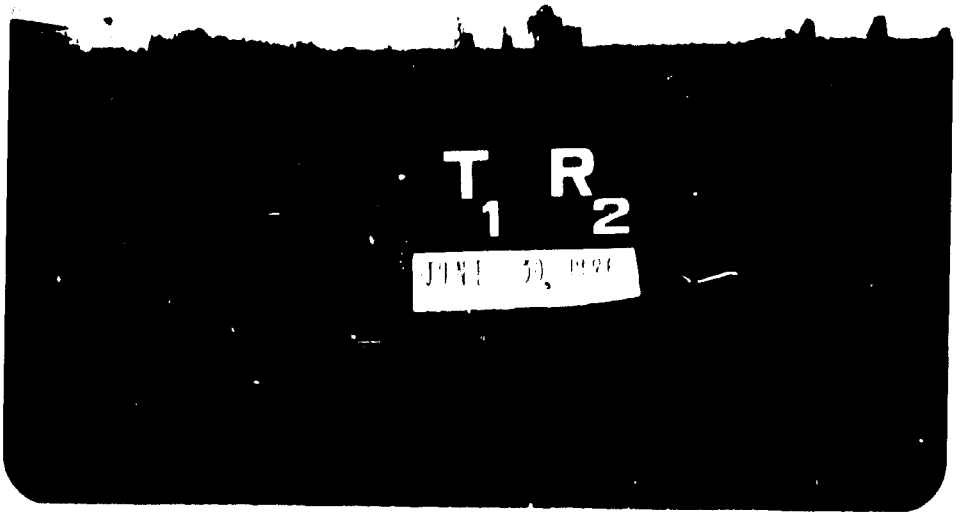


Figure 11 Growth of physic - nut trees in $T_1R_2$

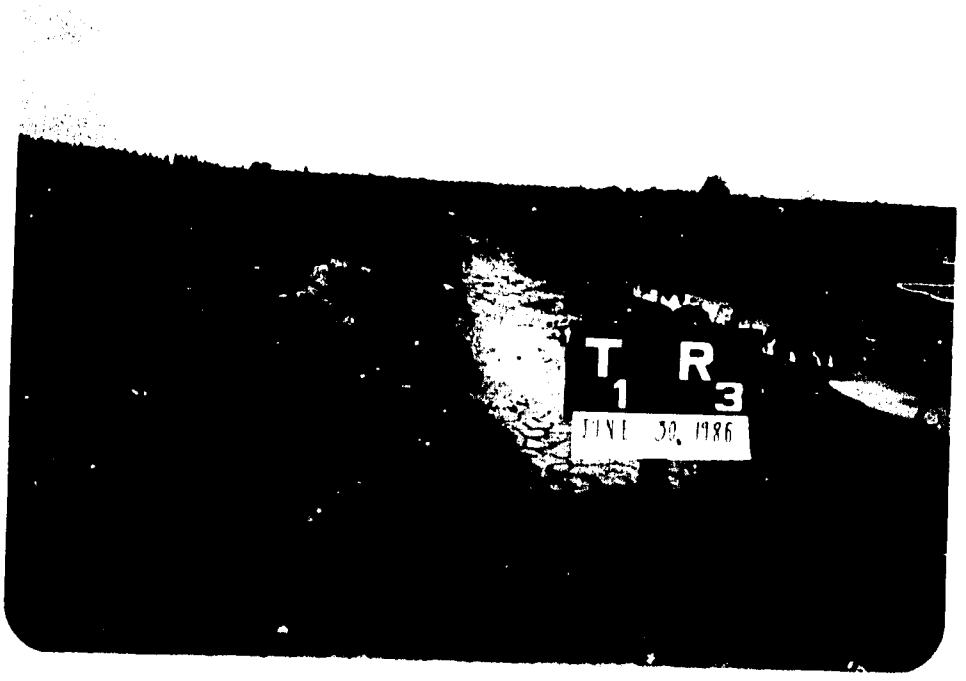


Figure 12 Growth of physic - nut trees in $T_1R_3$

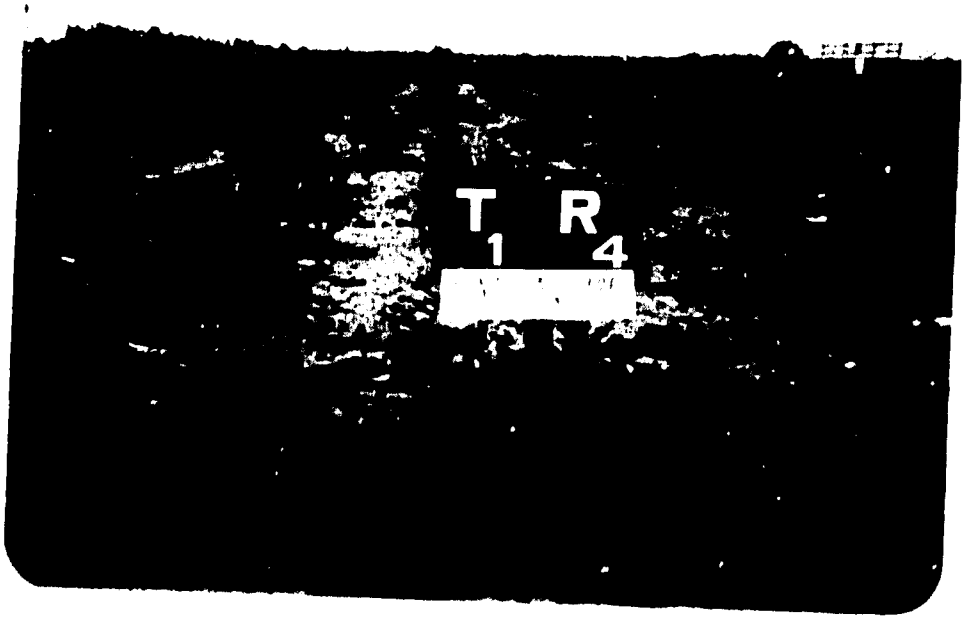


Figure 13 Growth of physic - nut trees in $T_1R_4$

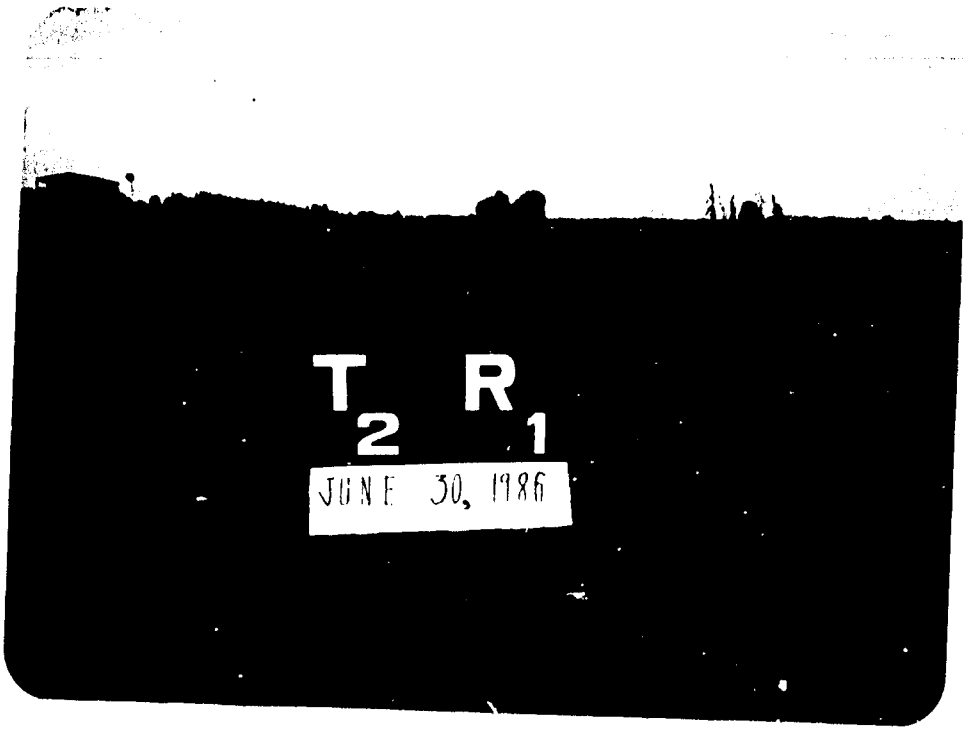


Figure 14 Growth of physic - nut trees in $T_2R_1$

Figure 15 Growth of physic - nut trees in $T_2R_2$

Figure 16 Growth of physic - nut trees in $T_2R_3$

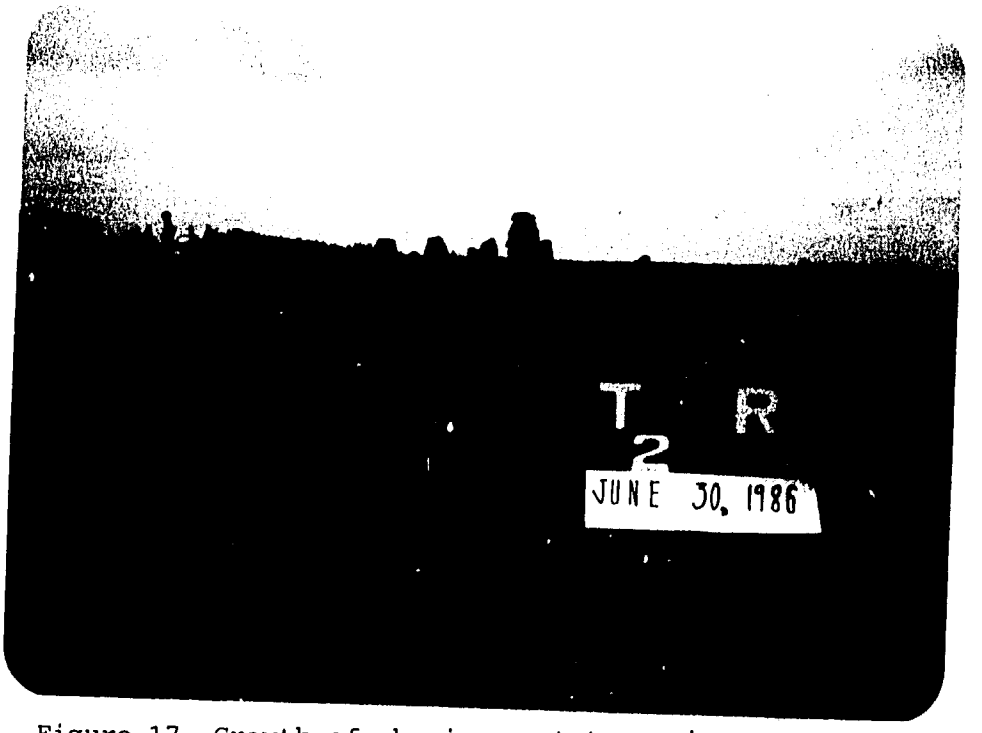


Figure 17 Growth of physic - nut trees in $T_2R_4$