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PROGRESS REPORT № 2

FIBER FARMING THROUGH WEED UTILIZATION

A RESEARCH PROJECT

USAID/PSTC PROGRAM

GRANT NO. 936-5542-G-00-5058-00

SUBMITTED BY

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PROJECT PROFILE

Country	:	Thailand
Grant No.	:	936-5542-G-00-5058-00
Program	:	Program on Science and Technology Cooperation
Project Title	:	Fiber Farming Through Weed Utilization
Project Leader	:	Dr. Thanakorn Uan-On
Organization	:	Faculty of Environment and Resource Studies, Mahidol University
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Project Consultants	:	Mr. Manu Srikhajon Mr. Lek Monchareon Mrs. Sriprapan Foungkiat
Authorized Officer	:	Dr. Thanakorn Uan-On Dean, Faculty of Environment and Resource Studies
Total Project Budget	:	131,500 $
Project Duration	:	3 Years
Reporting Period	:	6 Months
Budget Allocation for this period	:	489,026.00 B.

SECOND INTERIM PROGRESS REPORT

January-June 1986

TITLE : FIBER FARMING THROUGH WEED UTILIZATION

AGENCY : FACULTY OF ENVIRONMENT AND RESOURCE STUDIES, MAHIDOL UNIVERSITY.

I. INTRODUCTION

This report will cover the work which have been carried out during the period January-June 1986. The purposes of the study and the scope of work will follow and serve project's objectives in order to evaluate germplasm in agronomy, assess the variation and select superior varieties for further study, and evaluate physio-chemical properties of Rux fiber. The emphasis will be on the detailed studies of floral biology, fiber production, insects, and fiber properties. It also demonstrates the progress of plant growth in various experimental stations.

The major tasks carried on since the beginning of the project are the study of plant growths and their yields which involve highly burden of data collection and data processing. Plant taxonomy, especially, floral biology in which data collection and identification are time consuming study, and their contributions will extend to the variety selection

study. Therefore, this study if completed will be one of the detailed investigation on *Calotropis gigantea* R.Br. in Thailand.

Besides monitoring all experimental stations at various locations in the country, field observation in neighborhood country has been arranged in May 1986. The route plan for observation is extended from the south of Thailand at Sa Doa district, Songkhla province running down to Alor Star, Ipoh, Kuala Lumpur and Jahor Bahru, Malaysia.

Furthermore, Rux physio-chemical properties determination are planned, and the experiment are conducted at the the Faculty's laboratory and at the Textile Industrial Division, Department of Industrial Promotion, Ministry of Industry. There are 120 samples from the experimental stations used in the determination of such properties. They represent the collections of 60 clones of Rux from 5 regions. Primary data of Rux physical and chemical properties are reported in Section 2.3.

II. WORK TO BE REPORTED

2.1 Floral Biology

This study follows the plant taxonomy investigation which will be the important basic data for variety selection and its future improvement.

2.1.1 Scope of work

The followings are the concerned subjects in floral biology study.

(1) Type and morphology of flower

(2) Floral structure

(3) Type and morphology of pollen

(4) Pollen viability

(5) Growth development of flower

(6) Blooming day of flower

(7) Pollen shed and stigma receptive

2.1.1 Methodology

(1) White and purple flowers will be selected from the variety collection plot using random sampling method.

(2) Study on type and morphology of flower using flora and manual of plant taxonomy, taxonomist and speciment in herbarium.

(3) Study on floral structure using plant taxonomy index, floral diagram and floral formula.

(4) Study on the type and morphology of pollen by light microscope and pollen samples will be prepared by standard acetolysis method (Erdtman, 1952).

(5) Study on pollen viability using germination test suggested by Brewbaker and Knack (1960) with 5, 10, 15 and 20 % sucrose solution.

(6) Study on growth development of flower by measuring width and length of flower at diferrent period of age, and computing mean values.

(7) Study on flowering period by recording number of days since the first flowering day to the last flowering day for one inflorescence.

(8) Study on anthesis day to finding suitable period for fertilization by hand pollination, 10 flowers per treatment.

2.1.3 Results

The studied results of Rux flower development, structure, and its components can be summarized as follows:

Rux flower is classified as umbelliform inflorescence, racemose blooming type. Flower in the inflorescence is a perfect flower. There are 40.4 - 41 flowers per inflorescence. Flower development period from the beginning

until flowering is 18-22 days. The average width and length of white and purple flower are 17.85, 14.73, and 19.68, 17.37 mm. respectively. Flower will fall down in 5 - 7 days after flowering if it is not pollinated by insect. The suitable period for fertilizing is at the flowering day and last for 2 days.

Figure 1 (a)-(d) demonstrate type and morphology of flower structure,floral and type and morphology of pollen. Growth development of both Rux flowers (white and purple) are shown in Figure 2-7 and Table 1. Table 2-4 show the number of flower in the inflorescene, flower period, and the number of pollinted flowers from hand pollination experiment respectively.

The study on pollen viability is used germination test suggested by Brewbaker and Knack (1960) with 5, 10, 15 and 20 % sucrose solutions. It found that the pollen can be well germinated at the food formula of 15 % and 20 % sucrose.

Pollinator species found in the experimental plot are Xylocopa aestunus(L.), Xylocopa nasalis West W. and Xylocopa tenuiscapa West W. All are in Anthophoridae family and in order Hymenoptera, "Malang phoo" is the local name.

TYPE AND MORPHOLOGY OF FLOWER

Family : Asclepiadaceae

Scientific name : Calotropis gigantea R.Br.

Inflorescence , Actinomorphic.

Hermaprodite flower.

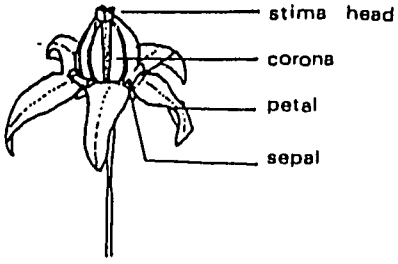
Racemose (Umbelliform)

Entomophilous .

FIGURE 1(a) Rux flower morphology

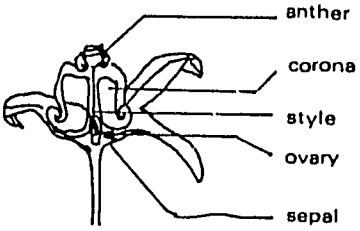
Structure of Flowers

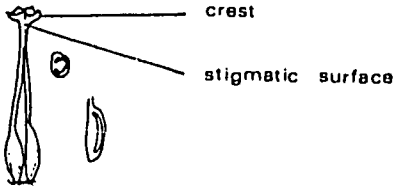
Calotropis gigantea R. Br.



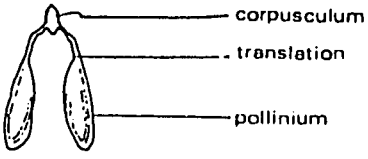
FLOWERS

HALF – FLOWER





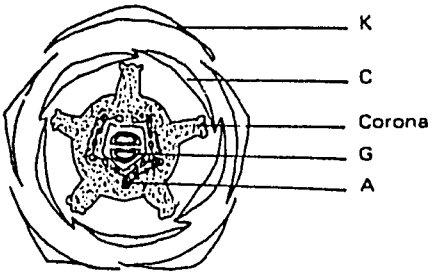
GYNOECIUM AND OVARY SECTIONS



PAIR OF POLLINATION

FIGURE 1(b) Rux flower structure

FLORAL DIAGRAM



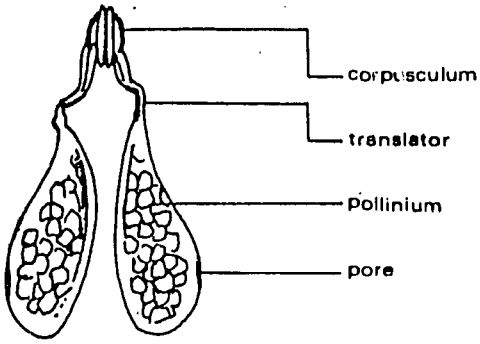
FLORAL FORMULA

*, K(5), C(5), A(5), P(1), G̲, G(2), O(∞), Corona(5)

*	radial symmetry
K	sepal
C	petal
A	stamen
P	pistil
G̲	superior ovary, superior gynoecium
G	carpel
O	ovule

FIGURE 1(c) Rux floral diagram

TYPE AND MORPHOLOGY OF POLLEN



Type of pollen

- pollinia

  pollinia solitary in each cell.

  pendulous.

Pollination

- entomophilous.
- pollen masses are attached to clip which grasp the proboscis or legs of an insect.

FIGURE 1(d) Rux pollen type and morphology

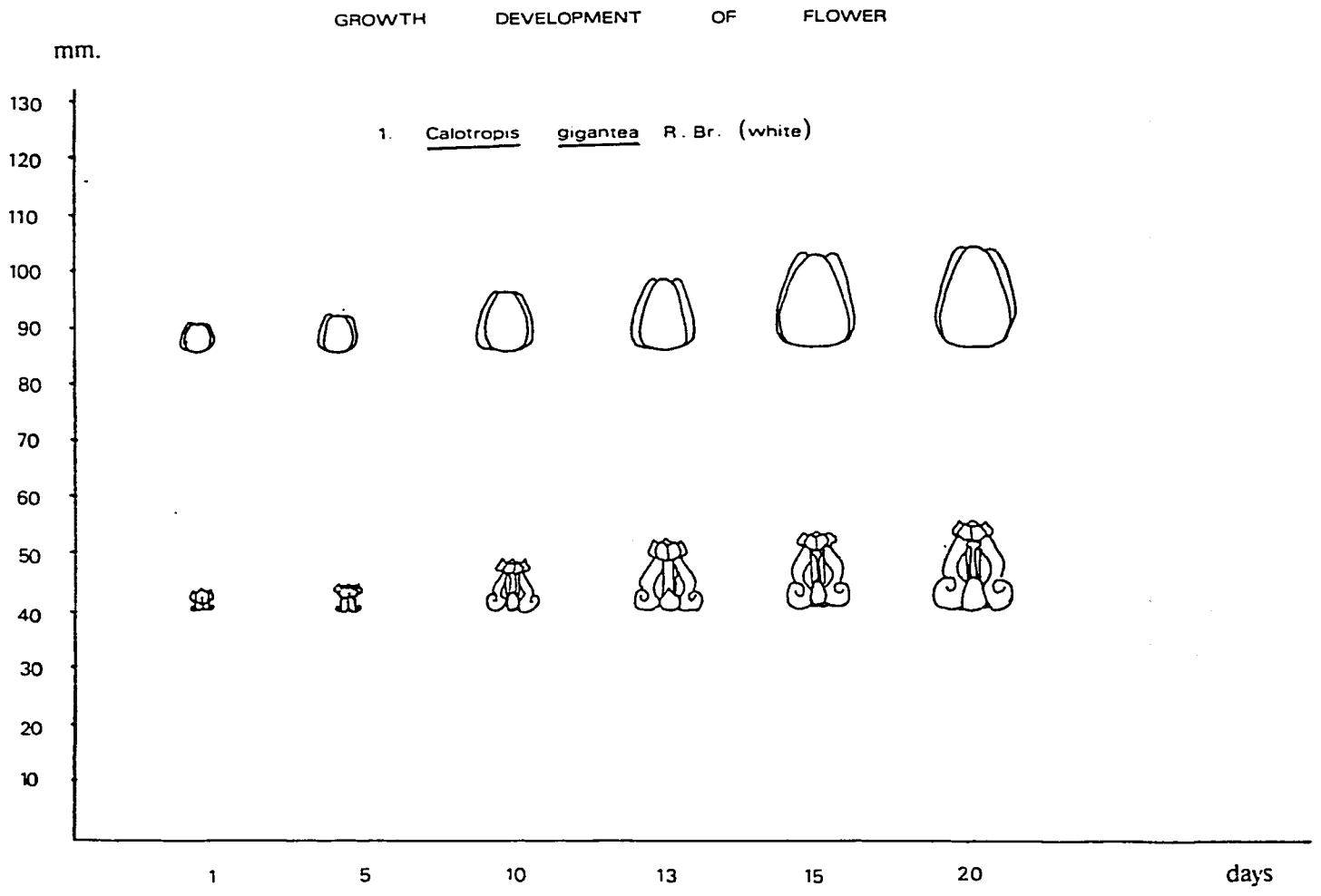


FIGURE 2 Growth development of Rux flower (white)

FIGURE 3 WIDTH OF FLOWER (WHITE)

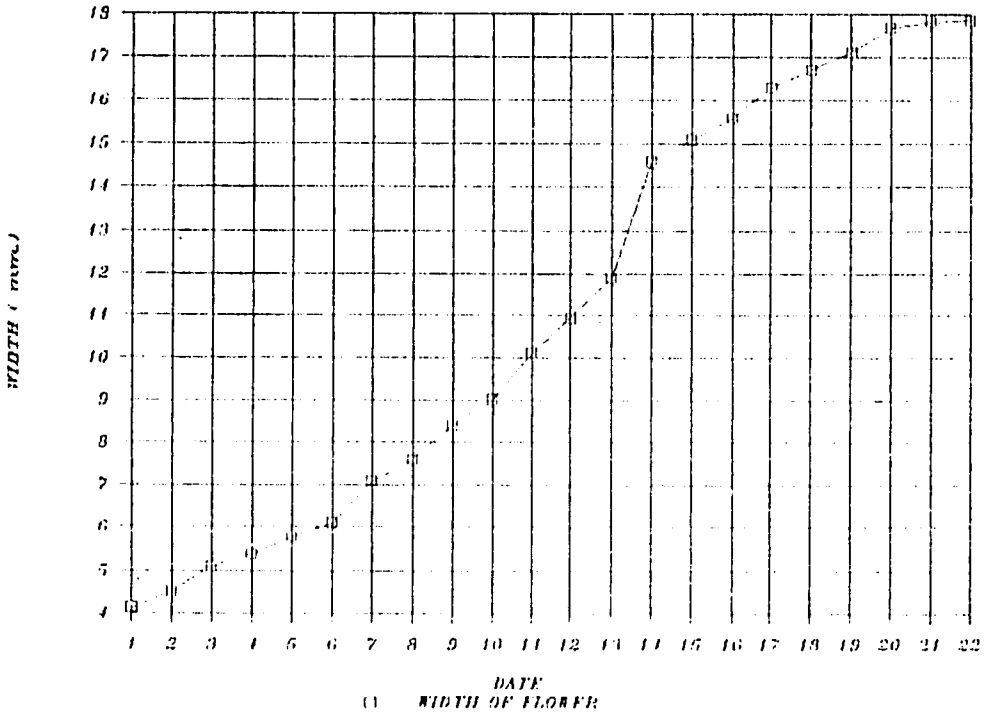
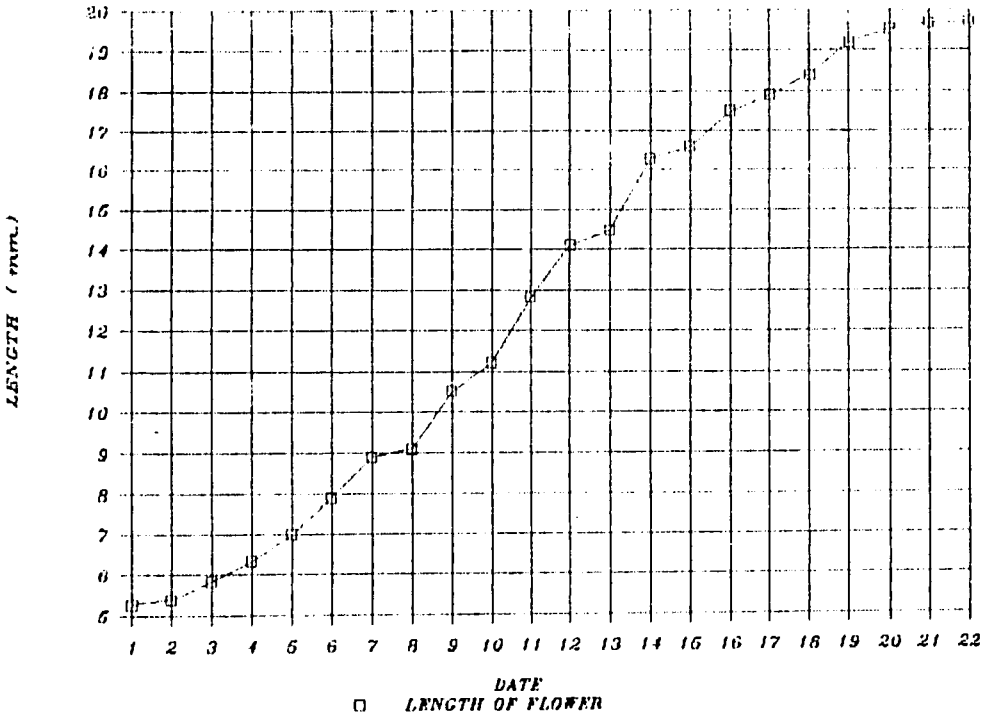


FIGURE 4 LENGTH OF FLOWER (WHITE)



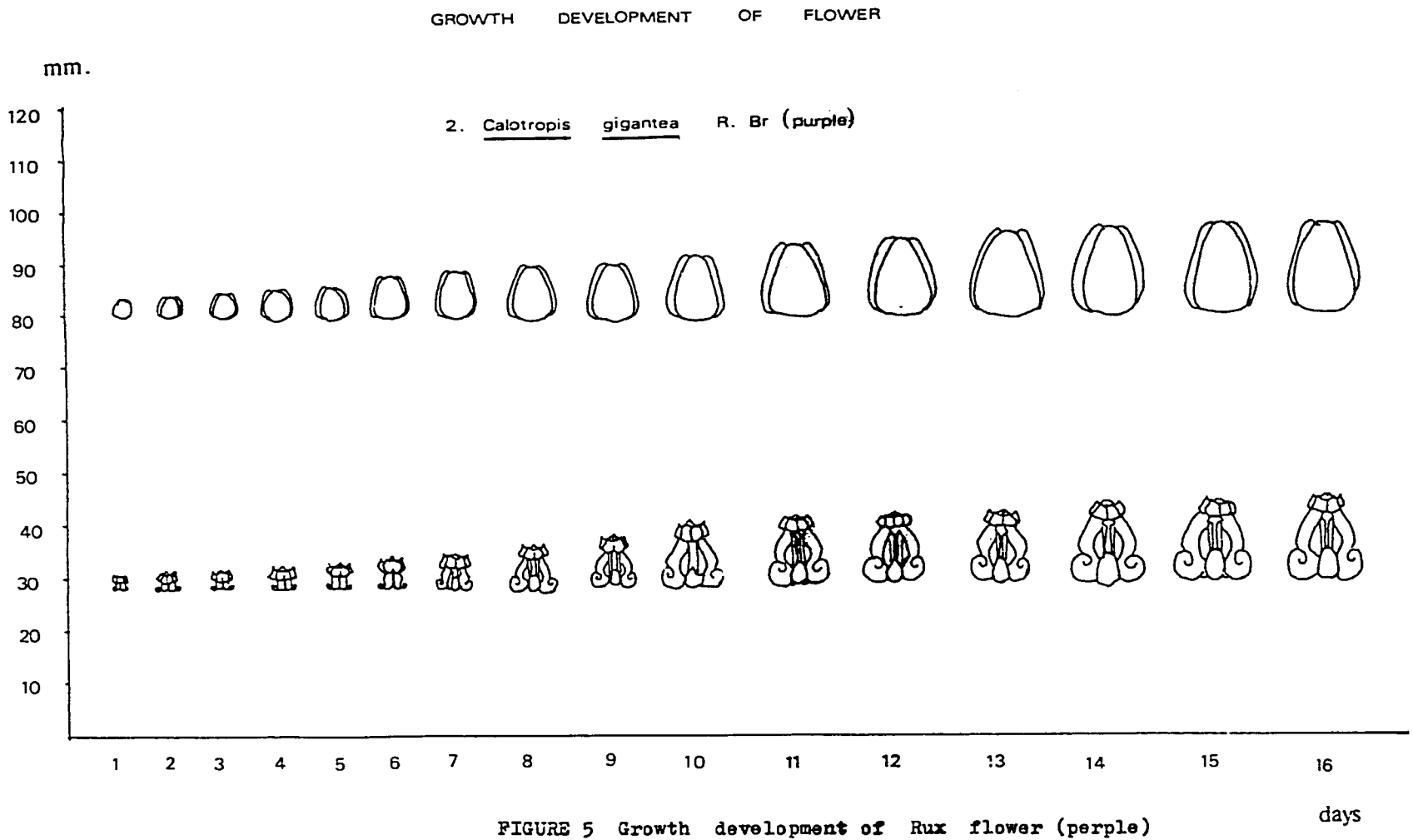


FIGURE 5 Growth development of Rux flower (perple)

FIGURE 6 WIDTH OF FLOWER (PURPLE)

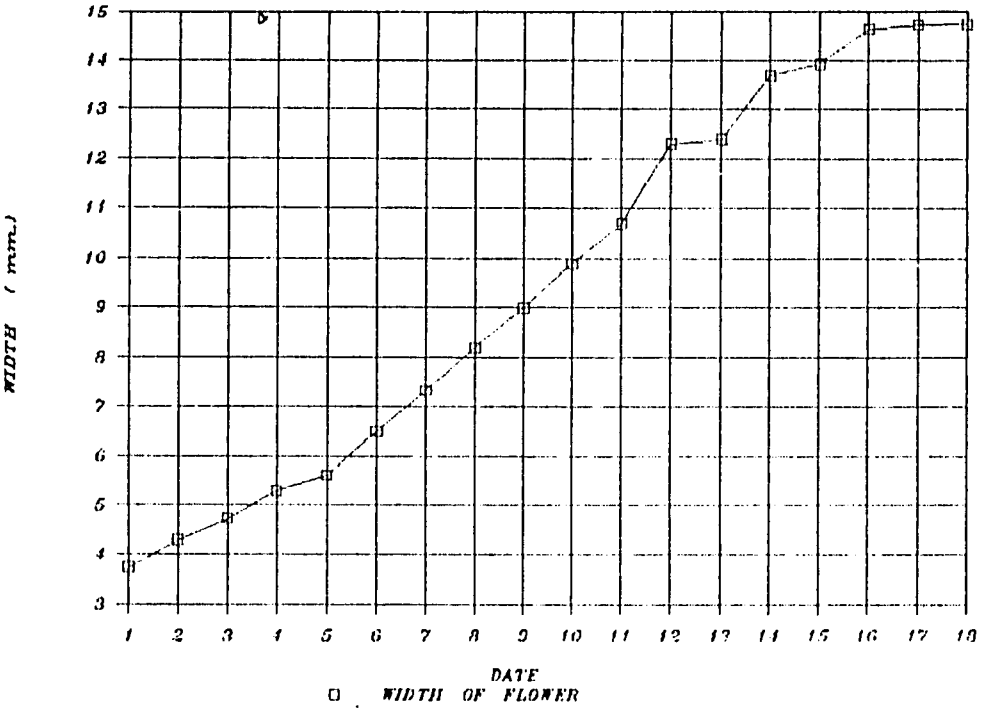


FIGURE 7 LENGTH OF FLOWER (PURPLE)

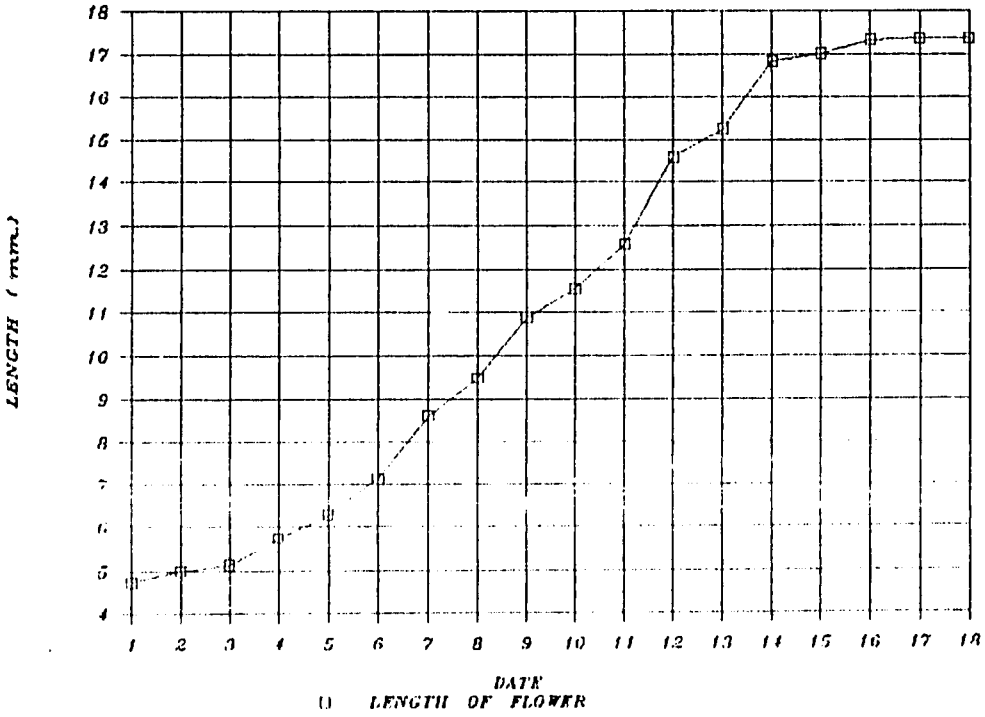


Table 1. Growth Development of Flower

Day	White		Purple	
	Width (mm)	Length (mm)	Width (mm)	Length(mm)
1	4.15	5.29	3.75	4.75
2	4.50	5.40	4.30	5.00
3	5.10	5.82	4.73	5.14
4	5.40	6.33	5.30	5.75
5	5.80	7.00	5.60	6.29
6	6.10	7.90	6.50	7.14
7	7.10	8.90	7.33	8.60
8	7.60	9.10	8.20	9.49
9	8.40	10.50	9.00	10.88
10	9.00	11.20	9.90	11.57
11	10.10	12.80	10.70	12.58
12	10.95	14.10	12.30	14.61
13	11.90	14.50	12.40	15.26
14	14.60	16.30	13.70	16.83
15	15.10	16.60	14.42	17.01
16	15.60	17.50	14.63	17.33
17	16.30	17.90	14.72	17.36
18	16.70	18.40	14.73	17.37
19	17.10	19.20	-	-
20	17.67	19.53	-	-
21	17.81	19.67	-	-
22	17.85	19.68	-	-

Table 2 Number of Flowers in the inflorescence

Type of flower	inflorescence #										
	1	2	3	4	5	6	7	8	9	10	Average
White	31	40	26	49	52	45	55	41	25	40	40.4
Purple	49	46	41	34	33	41	52	42	37	35	41.0

Table 3 Number of flowering Days of Flowers in inflorescence (Days)

Type of flower	inflorescence #										
	1	2	3	4	5	6	7	8	9	10	Average
White	24	28	31	32	35	21	34	25	19	26	27.5
Purple	27	24	28	20	19	24	30	25	23	21	24.1

Table 4 Pollinated Flowers during flowering period

Observed Time	Blooming day		1 day after		2 day after		3 day after	
	W	P	W	P	W	P	W	P
am.	9	10	9	9	8	9	5	5
pm.	10	10	9	9	9	9	3	4

2.2 Production

Experimental stations are located at Lampang, Khonkaen, Cha Choang Sao, Chumporn, Burirum, and Nakornpathom provinces. Their locations are shown in Figure A.1 and the progress in plant growth at each station are deplicted in Figure A.2-A.7 in Annex A.

2.2.1 Methodology

The area of 1,500 - 2,000 square metres are designed for each plot size. Rux are planted using Split-plot Design plan. An experimental plot consists of two treatments --- low and high inputs with 3 replications each. This is called the Main or Whole plot. Within the main plot, there are sub- plots which Rux seedlings were planted randomly.

Yield and growth factors of each variety are the studied variables. The Duncan's New Multiple Range Test was applied to testing the diferrence of yield among treatments in main plot and varieties in subplot.

2.2.2 Results

Rux seedling were planted at various experimental plots in November 1985. Growth period until giving yields is about 2 months. Data were systematically recorded and processed by hand and computer. Examples of the plant output in terms of yield by weight of fiber are in Table B.1-B.6,

Annex B. The tables show the recorded from February to June,1986 at various experimental locations. Data codings are now on processing in which the expected time for the completion of this section is on December, 1986 or at the beginning of 1987. There are two major variables in the process---yields and growth rate. Detailed analysis results and conclusion for varieties selection based on such variables will, further, be reported.

Data from 4-months records were used for the analysis of variance pretest and Duncan' New Multiple Range Test. Results are summarized in Table 5, five varieties were selected, at this stage, to represent the high yield varieties.

The test were run for each experimental station and the overall results can be concluded that using the analysis of variance, number of pods/tree between "high" and "low" input plots at various locations are significantly and not significantly diferrent. But the number of pods/tree among varieties are significantly diferent.

Duncan's New Multiple Range Test is applied to compare the average yield of each variety. It is found that the maximum-yield variety gives at least 12.979 pods/tree/ 6 months in Salaya Station (Nakornpathom). This group or the max-range varieties at each locations are depicted by the asterisk(*) sign in Table BB.1-BB.6, Annex B.

TABLE 5 The Analysis of Production Compared by DMRT from each experimental plots

	Varieties					
	Nakorn Pathom	Lampamg	Khon Khaen	Cha Choang Sao	Chum Porn	Burirum
1	C10(a)	N3 (a)	NE13(a)	E1 (a)	S7 (a)	A NE45(a)
2	C4 (b)	N16(a)	NE52(ab)	E2 (ab)	S9 (ab)	E NE4 (ab)
3	C3 (b)	N7 (ab)	NE10(ab)	E6 (ab)	S17(ab)	H NE24(ab)
4	C12(bc)	N2 (bc)	NE37(ab)	E11(b)	S13(b)	G NE9 (ab)
5	C7(bcd)	N8 (bc)	NE38(b)	E7 (b)	S12(b)	C NE23(b)
6	C11(cde)	N6 (bc)	NE29(b)	E9 (b)	S3 (b)	D NE27(b)
7	C9 (de)	N9 (bc)	NE26(b)	E5 (b)	S2 (b)	F NE14(b)
8	C14(e)	N1 (c)	NE25(b)	E8 (b)	S5 (b)	B NE43(b)
9		N11(c)	NE16(b)			
10		N12(c)	NE21(b)			
11		N14(c)	NE17(b)			
12		N13(c)	NE47(b)			
13		N17(c)	NE20(b)			
14		N15(c)				
15		N18(c)				

Attribute	Yield/tree (from DMRT)					
Subplot(b)	Nakorn Pathom	Lampamg	Khon Khaen	Cha Choang Sao	Chum Porn	Burirum
B1	12.979 (a)	9.972 (a)	1.194 (a)	5.917 (a)	3.111 (a)	6.944 (a)
B2	6.313 (b)	9.611 (a)	0.639 (ab)	3.583 (ab)	1.806 (ab)	5.556 (ab)
B3	6.042 (b)	7.306 (ab)	0.556 (ab)	3.083 (ab)	1.194 (ab)	5.417 (ab)
B4	5.188 (bc)	4.861 (bc)	0.500 (ab)	1.611 (b)	0.806 (b)	4.306 (ab)
B5	4.271 (bcd)	4.000 (bc)	0.444 (ab)	1.278 (b)	0.278 (b)	3.750 (b)
B6	2.396 (cde)	2.917 (bc)	0.417 (b)	0.861 (b)	0.167 (b)	3.556 (b)
B7	1.604 (de)	2.667 (bc)	0.333 (b)	0.750 (b)	0.083 (b)	2.972 (b)
B8	0.750 (e)	2.000 (c)	0.278 (b)	0.639 (b)	0.000 (b)	2.444 (b)
B9		1.972 (c)	0.250 (b)			
B10		1.750 (c)	0.083 (b)			
B11		1.444 (c)	0.028 (b)			
B12		1.333 (c)	0.028 (b)			
B13		1.306 (c)	0.028 (b)			
B14		1.278 (c)				
B15		0.444 (c)				

2.3 Fiber Properties

The physical and chemical properties are preliminary determined at the Faculty's and Textile Industrial Division laboratories. The methodologies and primary results can be summarized as follows:

2.3.1 Physical properties

The physical properties of Thai Rux fiber are rarely found in the literature. This study will originately develop the properties which will be useful for future investigation. The methodologies will follow "Cotton's properties testing" (Lord, 1961) for the fiber length, fineness, bundle strength, and fiber maturity.

2.3.1.1 Methodology

(1) Fiber length

- Effective length measurement using Comb Sorter Diagram and finding its mean value.
- Span length measurement using Fibrograph measured at 2.5% and 50% (Hanby, D.S, 1965)

2.5% Span length Std.

less than 25 mm.	Short
25-28 mm.	Medium
29-32 mm.	Long
more than 32 mm.	Extra long

The uniformity ratio can be determined from,

$$U.R. = \frac{50\ \%\ \text{Span length}}{2.5\ \%\ \text{Span length}} \times 100$$

and the ratio may be devided and be represented as,

50%/2.5% Uniformity ratio

less than 41	very low
41-43	low
44-46	medium
42-48	high
more 49	very high

(2) Fiber fineness

- Using WIRA Cotton fineness meter measures the fineness is micronaire unit inwhich;

less than 3.0	very fine
3.0-3.9	fine
4.0-4.9	medium
5.0-5.9	coarse
6.0 or more	very coarse

(3) Fiber bundle Strength

Fiber bundle Strength will be determined using Stelometer, measuring in g/tex unit (Burley et.al.,1955).

g/tex	
19-21	low
22-24	medium
25-27	high

(4) **Maturity**

This measurement considers the thickness of fiber secondary wall. The maturity ratio demonstrates the percentage of secondary to the thin wall (dead fiber) as follows:

more than 0.80	good
0.76-0.80	medium
0.70-0.75	low
less than 0.69	unmature

2.3.1.2 Results

The preliminary results of the physical properties show below are their mean values from 10 selected samples.

(1) Fiber length		
- Effective length	31.0	mm.
- Span length; 2.5%	33.0	mm.
50%	17.0	mm.
- Unformity ratio	>50	%
(2) Fiber fineness; micronaire	<2.0	
(3) Fiber bundle strength	32.5	g/tex
(4) Maturity; ratio	0.85	

2.3.2 Chemical properties

This study, at present, involves only the chemical color absorbing aspect. The experiment is carried out using chemical color absorbing test for;

a) Only Rux fiber

b) Rux fiber mixed with cotton

c) Rux fiber mixed with synthetic fiber

The experimental results revealed that;

a) The fiber has a good characteristics for color absorbtion like cotton, its color can last long if passing through coloring process.

b) Rux fiber mixed with cotton also have good quality for permanent color absorbtion.

c) Color processing has to be repeated twice for Rux fiber mixed with synthetic fiber.

2.4 Insect

Generally, Rux has highly resistance to pests and diseases. By observing low-input and high-input treatment plots, it can be reported that plants are slightly disturbed by pest. There are 4 species of Rux's pests which are found in experimental plots. Some common species are:

2.4.1 Chinch bug: Blissus leucopterus(Say)

Chinch bug or "Muan Dok Rux" is a common and probably the most injurious bug in Lygaeidae family. It is about 3.5 mm. in length. Each front wing has a black spot near the middle of the coastal margin. Both long-winged and short-winged forms occur in this species. The eggs are laid during April or May either in the ground or grass stems near the ground and hatch about a week or ten days later. Each female of Chinch bug may lay several hundred eggs.

The nymphs feed themselves on the juices from seed and stem of Rux. The maturity stage will be reached within 4-6 weeks. When these nymphs become adult they will seek out for places of hibernation.

2.4.2 Red bug: Stainers: Dysdercus spp.

Red bug and Stainers or "Muan Daeng" are in Pyrrhocoridae family. The members or species of this group are medium size to large, elongate-oval bugs that are usually brightly marked with red and black spot. There are many branched veins and cells in the membrane of the hemelytra.

In Thailand, an important pest species in this family is the cotton stainers (Dysdercus spp.), which is a serious pest of cotton; it stains the cotton fibers by its feeding, then the fiber value is greatly reduced.

Female of Dysdercus spp. lay eggs on the ground surface or grass, and hatch within 5-7 days later. After passing 4 or 5 molting stages, adults will start feeding on juice from Rux's pods, and the fiber and seed will then be destroyed.

2.4.3 Milkweed butterflies: Monarch butterfly: Danaus plexippus

Danaus plexippus is the most common in Danaidae family. The monarch is a reddish-brown butterfly with the black-bordered wings. There are two of rows of small white spots within the black marginal band.

The caterpillar is yellowish green, banded with black and has two threadlike appendages at the body end.

Monarch's larvas feed on leaves, bark and Rux flowers. Both catterpillar and adult are protected by distaseful fluid body which obtained from Rux.

2.4.4 Green weevil: Hypomeces squamosus Fabr.

Green weevil or "Com Thong" is a plant feeder, injuriously pest of Rux. Almost every part of Rux may be attacked, especially, fiber pods. The larvas usually feed inside the tissues and the adults drill holes in pods or other parts.

III. WORK PLAN FOR THE NEX PERIOD

The technical work plan for the next period will follow the activities plan and timeframe. Activities can be listed as follows:

	Expected Result
1. Biological and Agronomical Studies	
1.1 Data collection and analysis	1/1
1.2 Selection of varieties	1/1
1.3 Management trials	1/3
2. Engineering, Physio-chemical studies	
2.1 Separation of Rux fiber from seeds	1/1
2.2 Blending Rux fiber with cotton	1/1
2.3 Yarn properties evaluation	1/2
3. Economic studies	
3.1 Estimating fiber cost	1/2

It is expected that the biological and agronomical studies of Rux in terms of varieties selection will be completed for the first phase. Management trial will run through the 3rd year as well as the engineering and economic studies.

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ANNEX A

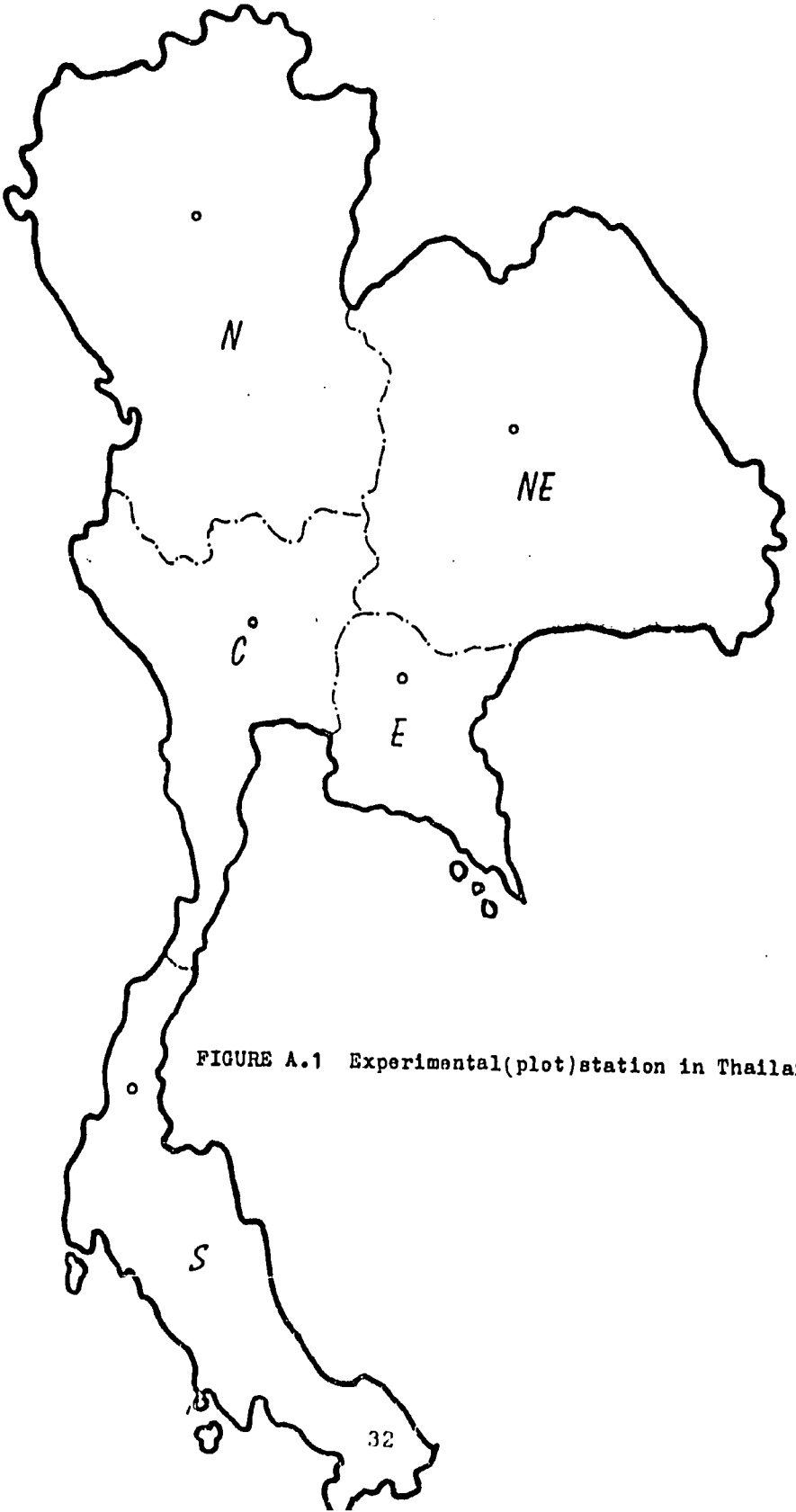


FIGURE A.1 Experimental(plot)station in Thailand

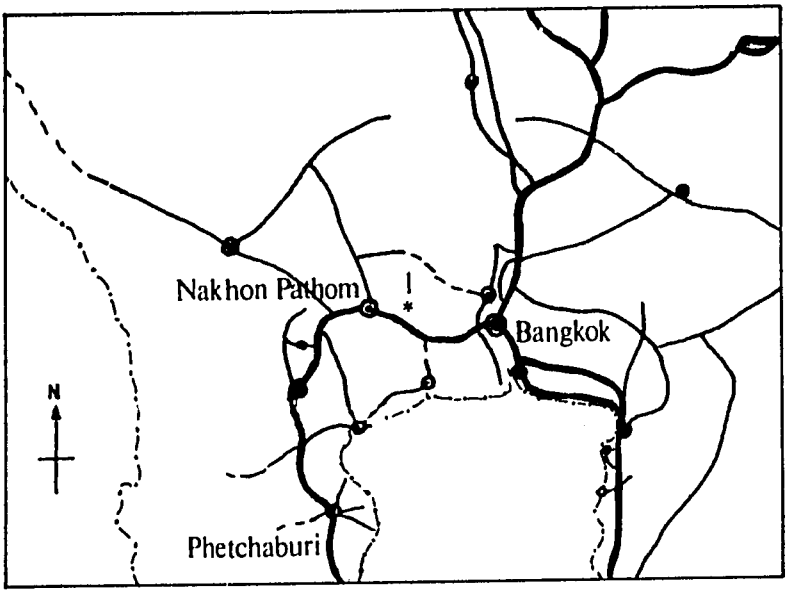


FIGURE A.2 Nakhon Pathom (Salaya) station

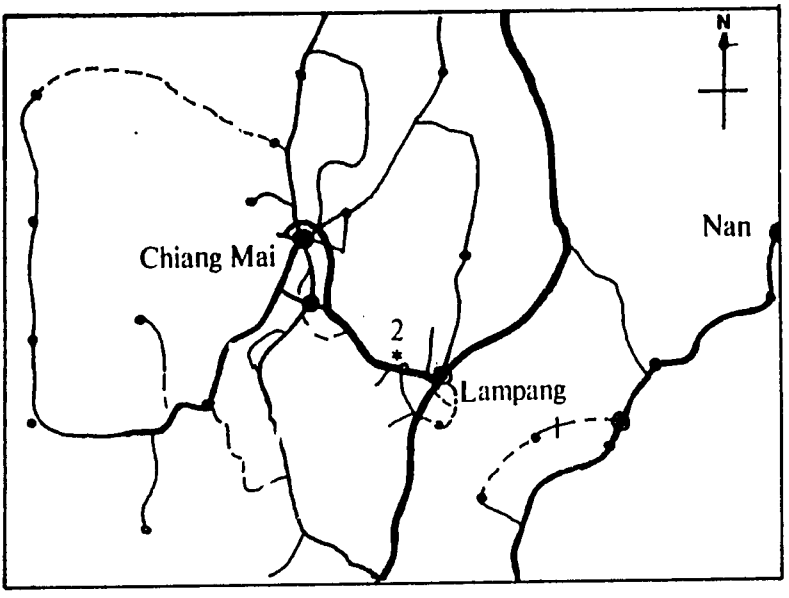
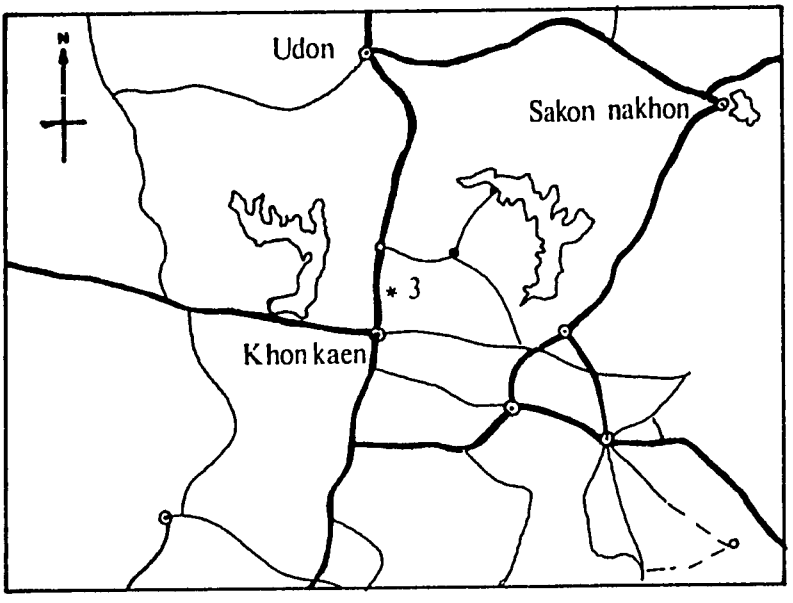


FIGURE A.3 Lampang station



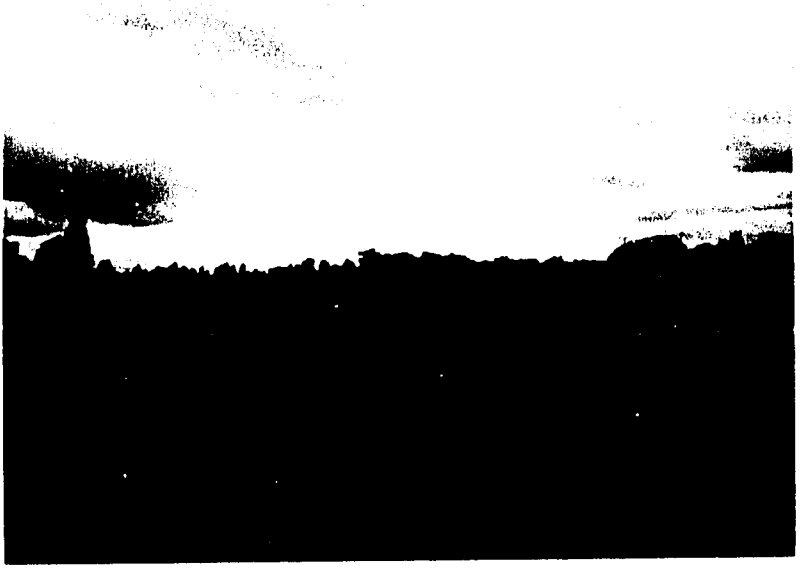
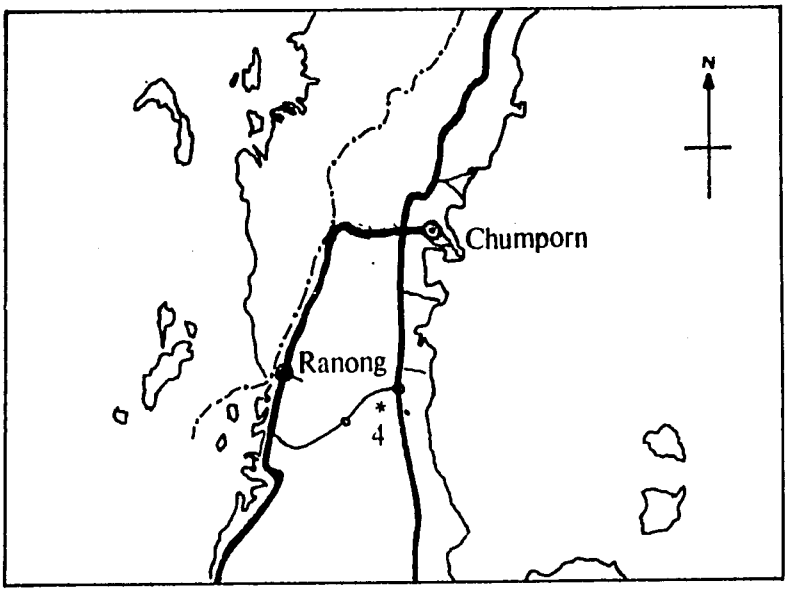


FIGURE A.4 Khon Kaen station



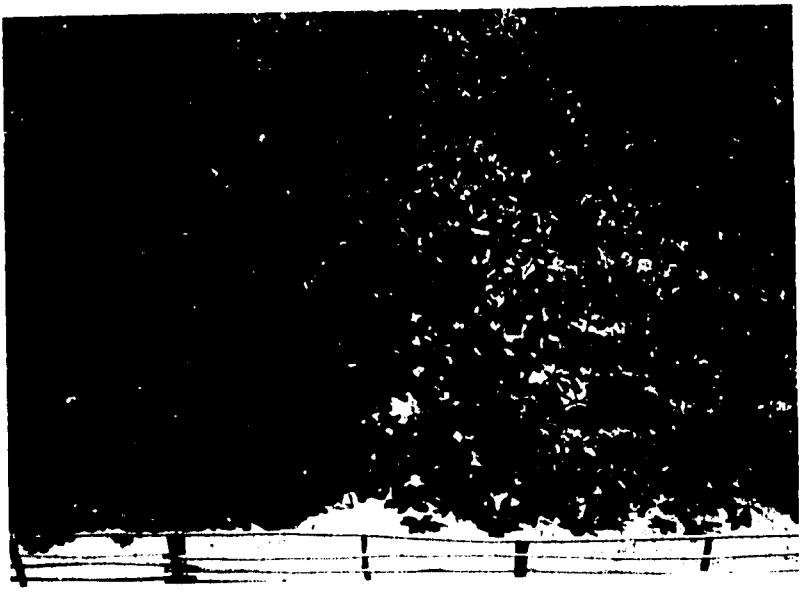


FIGURE A.5 Chumporn station

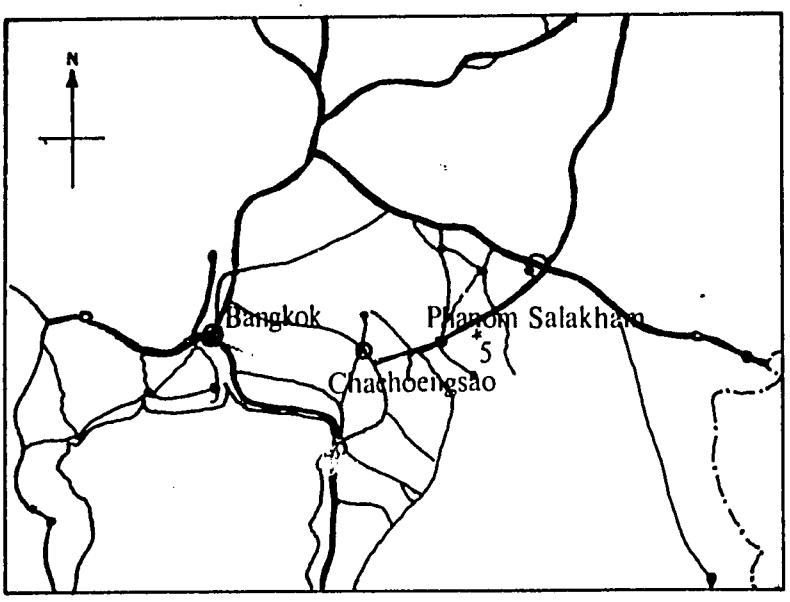


FIGURE A.6 Cha Choeng Sao station

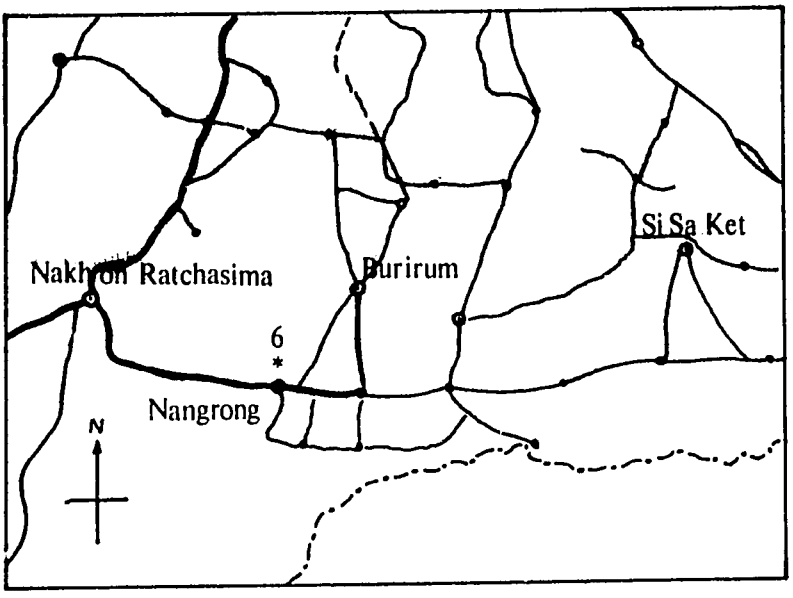


FIGURE A.7 Burirum station

ANNEX B

TABLE B.1 Yield of Ramie fiber (Nakornpathom)

CODE	YIELD (g/rai)[1] HIGH INPUT	YIELD (g/rai)[1] LOW INPUT	REMARKS
C 3	4,430	1,330	
C 4	4,830	1,130	
C 7	3,000	1,980	
C 9	1,080	460	
C 10	9,380	3,050	
C 11	1,400	900	
C 13	4,160	830	
C 14	460	260	

[1] Fiber in dry weight from Feb 18,1986 to Jun 16, 1986 (5 Months)

TABLE B.2 Yield of Rux fiber (Lampang)

CODE	YIELD (g/rai)* HIGH INPUT	YIELD (g/rai)* LOW INPUT	REMARKS
N 1	1,306	613	
N 2	3,466	1,200	
N 3	7,173	2,400	
N 6	1,360	1,440	
N 7	5,013	2,000	
N 8	2,240	1,600	
N 9	1,546	1,013	
N 11	826	1,066	
N 12	640	1,040	
N 13	346	933	
N 14	933	453	
N 15	800	426	
N 16	7,786	1,440	
N 17	853	400	
N 18	186	240	

* Fiber in dry-weight from Feb 21, 1986 to April 11, 1986 (2 Months)

TABLE B.3 Yield of Rux fiber (Khon Khaen)

CODE	YIELD (g/rai)* HIGH INPUT	YIELD (g/rai)* LOW INPUT	REMARKS
NE 10	80	533	
NE 13	26	373	
NE 16	53	186	
NE 17	-	26	
NE 20	-	26	
NE 21	-	80	
NE 25	26	240	
NE 26	26	293	
NE 29	133	293	
NE 37	53	480	
NE 38	-	480	
NE 47	-	26	
NE 52	80	1,066	

* Fiber in dry weight from Feb, 1986 to April 11, 1986 (2 Months)

TABLE B.4 Yield of Rux fiber (Cha Choang Sao)

CODE	YIELD (g/rai)* HIGH INPUT	YIELD (g/rai)* LOW INPUT	REMARKS
E 1	3,013	2,666	
E 2	1,440	2,000	
E 5	180	533	
E 6	2,160	800	
E 7	720	506	
E 8	106	506	
E 9	346	480	
E 11	586	960	

* Fiber in dry-weight from April, 1986 to May 30, 1986 (2 Months)

TABLE B.5 Yield of Rux fiber (Chum Porn)

CODE	YIELD (g/rai)* HIGH INPUT	YIELD (g/rai)* LOW INPUT	REMARKS
S 17	1,680	-	
S 9	1,626	106	
S 7	2,986	-	
S 2	80	-	
S 5	-	-	
S 12	266	-	
S 3	160	-	
S 13	746	26	

* Fiber in dry-weight from April 7, 1986 to Jul 14, 1986 (3 Months)

TABLE B.6 Yield of Rux fiber (Burirum)

CODE	YIELD (g/rai)* HIGH INPUT	YIELD (g/rai)* LOW INPUT	REMARKS
NE 45 (A)	4,853	1,813	
NE 43 (B)	1,946	400	
NE 23 (C)	2,986	613	
NE 27 (D)	2,266	1,146	
NE 4 (E)	3,493	1,840	
NE 14 (F)	2,613	240	
NE 9 (G)	3,440	693	
NE 24 (H)	4,346	1,040	

* Fiber in dry-weight from Feb, 1986 to May 23, 1986 (2 Months)

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ANNEX BB

44a

TABLE BB.1 TOTAL YIELD OF SALAYA STATION (Count at 16 Jun 86)

NO.	HIGH R1	HIGH R2	HIGH R3	HIGH TOTAL	LOW R1	LOW R2	LOW R3	LOW TOTAL
C3	109	41	74	224	18	35	13	66
C4	107	47	90	244	14	14	31	59
C7	35	54	62	151	16	28	10	54
C9	13	16	25	54	5	15	3	23
C10	155	143	171	469	44	42	68	154
C11	17	15	38	70	16	12	17	45
C12	66	87	55	208	15	9	17	41
C14	8	9	6	23	5	3	5	13

TABLE BB.2 TOTAL YIELD OF LAMPANG STATION (Count at 24 Apr 86)

NO.	HIGH R1	HIGH R2	HIGH R3	HIGH TOTAL	LOW R1	LOW R2	LOW R3	LOW TOTAL
N1	21	8	20	49	1	9	13	23
N2	54	36	40	130	13	24	8	45
N3	107	118	44	269	21	29	40	90
N6	3	1	47	51	8	31	15	54
N7	98	49	41	188	20	15	40	75
N8	5	77	2	84	4	20	36	60
N9	33	12	13	58	14	19	5	38
N11	13	15	3	31	6	8	26	40
N12	14	8	2	24	6	22	11	39
N13	0	3	10	13	2	12	21	35
N14	26	9	0	35	3	8	6	17
N15	11	6	13	30	2	6	8	16
N16	64	148	80	292	7	18	29	54
N17	5	19	8	32	2	4	9	15
N18	0	5	2	7	0	4	5	9

TABLE BB.3 TOTAL YIELD OF KHONKAEN STATION (Count at 11 apr 86)

NO.	HIGH R1	HIGH R2	HIGH R3	HIGH TOTAL	LOW R1	LOW R2	LOW R3	LOW TOTAL
NE10	3	0	0	3	9	9	2	20
NE13	0	1	0	1	8	5	1	14
NE16	2	0	0	2	4	3	0	7
NE17	0	0	0	0	1	0	0	1
NE20	0	0	0	0	1	0	0	1
NE21	0	0	0	0	1	1	1	3
NE25	0	0	1	1	6	0	3	9
NE26	1	0	0	1	5	3	3	11
NE29	2	2	1	5	4	2	5	11
NE37	0	0	2	2	10	5	3	18
NE38	0	0	0	0	9	5	4	18
NE47	0	0	0	0	0	0	1	1
NE52	2	1	0	3	28	9	3	40

TABLE BB.4 TOTAL YIELD IN CHA CHOANG SAO STATION(Count at 30 May 86)

NO.	HIGH R1	HIGH R2	HIGH R3	HIGH TOTAL	LOW R1	LOW R2	LOW R3	LOW TOTAL
E1	23	67	23	113	36	37	27	100
E2	15	32	7	54	31	19	25	75
E5	3	0	4	7	10	1	9	20
E6	6	74	1	81	12	16	2	30
E7	8	15	4	27	8	11	0	19
E8	2	2	0	4	13	2	4	19
E9	4	9	0	13	0	15	3	18
E11	9	9	4	22	27	1	8	36

TABLE BB.5 TOTAL YIELD IN CHUM PORN STATION (Count at 14 Jul 86)

NO.	HIGH R1	HIGH R2	HIGH R3	HIGH TOTAL	LOW R1	LOW R2	LOW R3	LOW TOTAL
S17	31	10	2	43	0	0	0	0
S9	39	14	8	61	3	0	1	4
S7	27	24	61	112	0	0	0	0
S2	1	0	2	3	0	0	0	0
S5	0	0	0	0	0	0	0	0
S12	2	7	1	10	0	0	0	0
S3	1	1	4	6	0	0	0	0
S13	8	10	10	28	0	0	1	1

TABLE BB.6 TOTAL YIELD IN BURIRUM STATION (Count at 30 May 86)

NO.	HIGH R1	HIGH R2	HIGH R3	HIGH TOTAL	LOW R1	LOW R2	LOW R3	LOW TOTAL
NE45(A)	5	116	61	182	3	23	42	68
NE43(B)	4	31	38	73	0	9	6	15
NE23(C)	11	44	57	112	1	5	17	23
NE27(D)	4	48	33	85	6	15	22	43
NE 4(E)	38	31	62	131	6	24	39	69
NE14(F)	5	31	62	98	5	1	3	9
NE 9(G)	7	64	58	129	2	7	17	26
NE24(H)	18	67	78	163	5	18	9	32

TABLE OF YIELD IN SALAYA STATION

TREATMENT	REP 1	REP 2	REP 3	SUM AB(1)	(SUM B)	(AVR B)
C3	13.625	5.125	9.25	28	36.25	6.042
C4	13.375	5.875	11.25	30.5	37.875	6.313
C7	4.375	6.75	7.75	18.875	25.625	4.271
C9	1.625	2	3.125	6.75	9.625	1.604
C10	19.375	17.875	21.375	58.625	77.875	12.979
C11	2.125	1.875	4.75	8.75	14.375	2.396
C12	8.25	10.875	6.875	26	31.125	5.188
C14	1	1.125	0.75	2.875	4.5	0.750
SUM A1R	63.75	51.5	65.125	180.375	237.25	4.943
C3	2.25	4.375	1.625	8.25		
C4	1.75	1.75	3.875	7.375		
C7	2	3.5	1.25	6.75		
C9	0.625	1.875	0.375	2.875		
C10	5.5	5.25	8.5	19.25		
C11	2	1.5	2.125	5.625		
C12	1.875	1.125	2.125	5.125		
C14	0.625	0.375	0.625	1.625		
SUM A2R	16.625	19.75	20.5	56.875		
SUM R	80.375	71.25	85.625	237.25		

C.F.= 1172.657
TOTAL SS=835.2812 552.9062 309.2343 50.67187 69.1875 101.0312 1172.657 1245.654
REP SS= 6.613932
A SS= 317.7552
ERROR(a)SS= 8.508463
B SS= 620.3476
[AXB]SS= 196.3020
ERROR(b)SS= 96.12760
C.V.(A)= 41.72973 %
C.V.(B)= 37.48694 %
*********OUT PUT*********

TABLE ANOVA OF YIELD OF SALAYA STATION

SOURCE OF VAR.	df	SS	MS	F TEST	F- TABLE 95%	F- TABLE 99%
REP	2	6.613932	3.306966	0.777335 ns	19	99
A	1	317.7552	317.7552	74.69156 *	18.51	98.49
ERROR(A)	2	8.508463	4.254231			
B	7	620.3476	88.62109	25.81350 **	2.36	3.36
A*B	7	196.3020	28.04315	8.168395 **	2.36	3.36
ERROR(B)	28	96.12760	3.433128			
TOTAL	47					

P	P	W	P	W	P	W	W
C10	C4	C3	C12	C7	C11	C9	C14
623	303	290	249	205	115	77	36
12.979	6.3125	6.042	5.188	4.2708	2.396	1.604	0.75

TABLE OF YIELD IN LAMPANG

TREATMENT	REP 1	REP 2	REP 3	SUM AB(1)	[SUM B]	[AVR B]
A1B1	3.500	1.333	3.333	8.167	12.000	2.000
A1B2	9.000	6.000	6.667	21.667	29.167	4.861
A1B3	17.833	19.667	7.333	44.833	59.833	9.972
A1B4	0.500	0.167	7.833	8.500	17.500	2.917
A1B5	16.333	8.167	6.833	31.333	43.833	7.306
A1B6	0.833	12.833	0.333	14.000	24.000	4.000
A1B7	5.500	2.000	2.167	9.667	16.000	2.667
A1B8	2.167	2.500	0.500	5.167	11.833	1.972
A1B9	2.333	1.333	0.333	4.000	10.500	1.750
A1B10	0.000	0.500	1.667	2.167	8.000	1.333
A1B11	4.333	1.500	0.000	5.833	8.667	1.444
A1B12	1.833	1.000	2.167	5.000	7.667	1.278
A1B13	10.667	24.667	13.333	48.667	57.667	9.611
A1B14	0.833	3.167	1.333	5.333	7.833	1.306
A1B15	0.000	0.833	0.333	1.167	2.667	0.444
SUM A1R	75.667	85.667	54.167	215.500	317.167	3.524
A2B1	0.167	1.500	2.167	3.833		
A2B2	2.167	4.000	1.333	7.500		
A2B3	3.500	4.833	6.667	15.000		
A2B4	1.333	5.167	2.500	9.000		
A2B5	3.333	2.500	6.667	12.500		
A2B6	0.667	3.333	6.000	10.000		
A2B7	2.333	3.167	0.833	6.333		
A2B8	1.000	1.333	4.333	6.667		
A2B9	1.000	3.667	1.833	6.500		
A2B10	0.333	2.000	3.500	5.833		
A2B11	0.500	1.333	1.000	2.833		
A2B12	0.333	1.000	1.333	2.667		
A2B13	1.167	3.000	4.833	9.000		
A2B14	0.333	0.667	1.500	2.500		
A2B15	0.000	0.667	0.833	1.500		
SUM A2R	18.167	38.167	45.333	101.667		
SUM R	93.833	123.833	99.500	317.167		

C.F.= 1117.718
TOTAL SS= 856 1290.666 409.6944 39.69444 127.5833 201.7777 1117.718 1807.697
REP SS= 16.93580
A SS= 143.9780
ERROR(a)SS= 44.03950
B SS= 795.0172
[AXB]SS= 374.2765
ERROR(b)SS= 433.4506
C.V.(A)= 133.1561 %
C.V.(B)= 78.94611 %

TABLE ANOVA OF YIELD IN LAMPANG

SOURCE OF VAR.	df	SS	MS	F-TEST	F- TABLE 95%	F- TABLE 99%
REP	2	16.93580	8.467901	0.384559 ns	19	99
A	1	143.9780	143.9780	6.538587 ns	18.51	98.49
ERROR(A)	2	44.03950	22.01975			
B	14	795.0172	56.78694	7.336635 **	1.876	2.424
A*B	14	374.2765	26.73403	3.453925 **	1.876	2.424
ERROR(B)	56	433.4506	7.740189			
TOTAL	89					

W	P	W	P	P	P	W	P	P
N3	N16	N7	N2	N8	N6	N9	N1	N11
359.000	346.000	263.000	175.000	144.000	105.000	96.000	72.000	71.000
9.972	9.611	7.306	4.861	4.000	2.917	2.667	2.000	1.972

W	W	P	W	P	P
N12	N14	N13	N17	N15	N18
63.000	52.000	48.000	47.000	46.000	16.000
1.750	1.444	1.333	1.306	1.278	0.444

TABLE OF YIELD OF KHON KAEN STATION

TREATMENT	REP 1	REP 2	REP 3	SUM AB(1)	[SUM B]	[AVR B]
A1B1	0.500	0.000	0.000	0.500	3.833	0.639
A1B2	0.000	0.167	0.000	0.167	2.500	0.417
A1B3	0.333	0.000	0.000	0.333	1.500	0.250
A1B4	0.000	0.000	0.000	0.000	0.167	0.028
A1B5	0.000	0.000	0.000	0.000	0.167	0.028
A1B6	0.000	0.000	0.000	0.000	0.500	0.083
A1B7	0.000	0.000	0.167	0.167	1.667	0.278
A1B8	0.167	0.000	0.000	0.167	2.000	0.333
A1B9	0.333	0.333	0.167	0.833	2.667	0.444
A1B10	0.000	0.000	0.333	0.333	3.333	0.556
A1B11	0.000	0.000	0.000	0.000	3.000	0.500
A1B12	0.000	0.000	0.000	0.000	0.167	0.028
A1B13	0.333	0.167	0.000	0.500	7.167	1.194
SUM A1R	1.667	0.667	0.667	3.000	28.667	0.368
A2B1	1.500	1.500	0.333	3.333		
A2B2	1.333	0.833	0.167	2.333		
A2B3	0.667	0.500	0.000	1.167		
A2B4	0.167	0.000	0.000	0.167		
A2B5	0.167	0.000	0.000	0.167		
A2B6	0.167	0.167	0.167	0.500		
A2B7	1.000	0.[illegible]	0.500	1.500		
[illegible]	0.833	0.500	0.500	1.833		
A2B9	0.667	0.333	0.833	1.833		
A2B10	1.667	0.833	0.500	3.000		
A2B11	1.500	0.833	0.667	3.000		
A2B12	0.000	0.000	0.167	0.167		
A2B13	4.667	1.500	0.500	6.667		
SUM A2R	14.333	7.000	4.333	25.667		
SUM R	16.000	7.667	5.000	28.667		

C.F.= 10.53561
TOTAL SS 0.611111 0.166666 0.166666 33.5 7.222222 2.33333 10.53561 33.46438
REP SS= 2.532763
A SS= 6.586894
ERROR(a)SS= 1.643874
B SS= 7.612535
[AXB]SS= 5.653846
ERROR(b)SS= 9.434472
C.V.(A)= 246.6816 %
C.V.(B)= 120.6300 %

TABLE ANOVA OF YIELD OF KHONKAEN STATION

SOURCE OF VAR.	df	SS	MS	F-TEST	F- TABLE 95%	F- TABLE 99%
REP	2	2.532763	1.266381	1.540727 ns	19	99
A	1	6.586894	6.586894	8.013864 ns	18.51	98.49
ERROR(A)	2	1.643874	0.821937			
B	12	7.612535	0.634377	3.227540 **	1.96	2.58
A*B	12	5.653846	0.471153	2.397101 *	1.96	2.58
ERROR(B)	48	9.434472	0.196551			
TOTAL	77					

P	P	W	W	W	W	P
NE13	NE52	NE10	NE37	NE38	NE29	NE26
95.000	43.000	23.000	20.000	18.000	16.000	12.000
1.194	0.639	0.556	0.500	0.444	0.417	0.333

W	P	P	W	W	W
NE25	NE16	NE21	NE17	NE47	NE20
10.000	9.000	3.000	1.000	1.000	1.000
0.278	0.250	0.083	0.028	0.028	0.028

TABLE OF YIELD IN CHA CHOANG SAO STATION

TREATMENT	REP 1	REP 2	REP 3	SUM AB(I)	(SUM B)	(AVR B)
A1B1	3.833	11.167	3.833	18.833	35.500	5.917
A1B2	2.500	5.333	1.167	9.000	21.500	3.583
A1B3	0.500	0.000	0.667	1.167	4.500	0.750
A1B4	1.000	12.333	0.167	13.500	18.500	3.083
A1B5	1.333	2.500	0.667	4.500	7.667	1.278
A1B6	0.333	0.333	0.000	0.667	3.833	0.639
A1B7	0.667	1.500	0.000	2.167	5.167	0.861
A1B8	1.500	1.500	0.667	3.667	9.667	1.611
SUM A1R	11.667	34.667	7.167	53.500	106.333	2.215
A2B1	6.000	6.167	4.500	16.667		
A2B2	5.167	3.167	4.167	12.500		
A2B3	1.667	0.167	1.500	3.333		
A2B4	2.000	2.667	0.333	5.000		
A2B5	1.333	1.833	0.000	3.167		
A2B6	2.167	0.333	0.667	3.167		
A2B7	0.000	2.500	0.500	3.000		
A2B8	4.500	0.167	1.333	6.000		
SUM A2R	22.833	17.000	13.000	52.833		
SUM R	34.500	51.667	20.167	106.333		

```
C.F.=     235.5578
TOTAL SS=26.77777 316.1111 17.41666 96.19444 64.94444 42.44444 235.5578 328.3310
REP SS=   31.09143
A SS=     0.009259
ERROR(a)SS=        29.41782
B SS=     144.2106
[AXB]SS=        18
ERROR(b)SS=        105.6018
C.V.(A)= 173.1259 %
C.V.(B)= 87.66546 %
          *********OUT PUT**********
```

TABLE ANOVA OF YIELD IN CHA CHOANG SAO STATION

SOURCE OF VAR.	df	SS	MS	F TEST	F- TABLE 95%	F- TABLE 99%
REP	2	31.09143	15.54571	1.056891 ns	19	99
A	1	0.009259	0.009259	0.000629 ns	18.51	98.49
ERROR(A)	2	29.41782	14.70891			
B	7	144.2106	20.60152	5.462428 **	2.36	3.36
A*B	7	18	2.571428	0.681806 ns	2.36	3.36
ERROR(B)	28	105.6018	3.771494			
TOTAL	47					

W	P	P	P	W	P	W	W
E1	E2	E6	E11	E7	E9	E5	E8
213.000	129.000	111.000	58.000	46.000	31.000	27.000	23.000
5.917	3.583	3.083.	1.611	1.278	0.861	0.750	0.639

TABLE OF YIELD IN CHUMPORN STATION

TREATMENT	REP 1	REP 2	REP 3	SUM AB(1)	[SUM B]	[AVR B]
S17	5.167	1.667	0.333	7.167	7.167	1.194
S9	6.500	2.333	1.333	10.167	10.833	1.806
S7	4.500	4.000	10.167	18.667	18.667	3.111
S2	0.167	0.000	0.333	0.500	0.500	0.083
S5	0.000	0.000	0.000	0.000	0.000	0.000
S12	0.333	1.167	0.167	1.667	1.667	0.278
S3	0.167	0.167	0.667	1.000	1.000	0.167
S13	1.333	1.667	1.667	4.667	4.833	0.806
SUM A1R	18.167	11.000	14.667	43.833	44.667	0.931
S17	0.000	0.000	0.000	0.000		
S9	0.500	0.000	0.167	0.667		
S7	0.000	0.000	0.000	0.000		
S2	0.000	0.000	0.000	0.000		
S5	0.000	0.000	0.000	0.000		
S12	0.000	0.000	0.000	0.000		
S3	0.000	0.000	0.000	0.000		
S13	0.000	0.000	0.167	0.167		
SUM A2R	0.500	0.000	0.333	0.833		
SUM R	18.667	11.000	15.000	44.667		

C.F.= 41.56481
TOTAL SS=91.13888 28.38388 108.6111 0.25 0 0.055555 41.56481 186.8796
REP SS= 1.837962
A SS= 38.52083
ERROR(a)SS= 1.388888
B SS= 49.19444
[AXB]SS= 47.20138
ERROR(b)SS= 48.73611
C.V.(A)= 89.55223 %
C.V.(B)= 141.7764 %
**********OUT PUT**********

TABLE ANOVA OF YIELD IN CHUMPORN STATION

SOURCE OF VAR.	df	SS	MS	F TEST		F- TABLE 95%	99%
REP	2	1.837962	0.918981	1.3233333	ns	19	99
A	1	38.52083	38.52083	55.47	*	18.51	98.49
ERROR(A)	2	1.388888	0.694444				
B	7	49.19444	7.027777	4.0376175	**	2.36	3.36
A*B	7	47.20138	6.743055	3.8740381	**	2.36	3.3
ERROR(B)	28	48.73611	1.740575				
TOTAL	47						

W	F	P	P	W	W	F	W
S7	S9	S17	S13	S12	S3	S2	S5
112	65	43	29	10	6	3	0
18.667	10.833	7.167	4.833	1.667	1.000	0.500	0.000
3.111	1.806	1.194	0.806	0.278	0.167	0.083	0.000

TABLE OF YIELD IN BURIRUM STATION

TREATMENT	REP 1	REP 2	REP 3	SUM AB(I)	(SUM B)	(AVR B)
A1B1	0.833	19.333	10.167	30.333	41.667	6.944444
A1B2	0.667	5.167	6.333	12.167	14.667	2.444444
A1B3	1.833	7.333	9.500	18.667	22.500	3.75
A1B4	0.667	8.000	5.500	14.167	21.333	3.555555
A1B5	6.333	5.167	10.333	21.833	33.333	5.555555
A1B6	0.833	5.167	10.333	16.333	17.833	2.972222
A1B7	1.167	10.667	9.667	21.500	25.833	4.305555
A1B8	3.000	11.167	13.000	27.167	32.500	5.416666
SUM A1B	15.333	72.000	74.833	162.167	209.667	34.94444
A2B1	0.500	3.833	7.000	11.333		
A2B2	0.000	1.500	1.000	2.500		
A2B3	0.167	0.833	2.833	3.833		
A2B4	1.000	2.500	3.667	7.167		
A2B5	1.000	4.000	6.500	11.500		
A2B6	0.833	0.167	0.500	1.500		
A2B7	0.333	1.167	2.833	4.333		
A2B8	0.833	3.000	1.500	5.333		
SUM A2B	4.667	17.000	25.833	47.500		
SUM B	20.000	89.000	100.667	209.667		

C.F.= 915.8356
TOTAL SS=56.11111 810.1111 739.9722 3.777777 50.27777 124.25 915.8356 868.664
REP SS= 237.5879
A SS= 273.9259
ERROR(a)SS= 72.31018
B SS= 95.05324
[AXB]SS= 29.68518
ERROR(b)SS= 160.1018
C.V.(A)= 17.20765 %
C.V.(B)= 6.842913 %
*********OUT PUT**********

TABLE ANOVA OF YIELD IN BURIRUM

SOURCE OF VAR.	df	SS	MS	F-TEST	F- TABLE 95%	F- TABLE 99%
REP	2	237.5879	118.7939	3.285677 ns	19	99
A	1	273.9259	273.9259	7.576413 ns	18.51	98.49
ERROR(A)	2	72.31018	36.15509			
B	7	95.05324	13.57903	2.374819 *	2.36	3.36
A*B	7	29.68518	4.240740	0.741657 ns	2.36	3.36
ERROR(B)	28	160.1018	5.717923			
TOTAL	47					

P	W	W	W	W	W	P	W
A	E	H	G	C	D	F	B
250.000	200.000	195.000	155.000	135.000	128.000	107.000	88.000
6.944	5.556	5.417	4.306	3.750	3.556	2.972	2.444