RESULT

1. Description of the study area

1.1 Location and boundary

The Land Reform Project Area (LRA) at Chom Thong district, Chiang Mai, was selected for on-farm research. This area is located in the northern part of Chom Thong district in Tambon Yang Kharm and Tambon Doi Lor. It lies between latitudes 18^{O} 31′ N to 18^{O} 34′North and longitudes 98^{O} 47′ E to 98^{O} 50′ East (Figures 2 and 3).

It is about 40 kilometers away from Chiang Mai. There are two available routes going from Chiang Mai to the area. Both routes use the Chiang Mai - Hot highway. The first route can be reached by going through Tambon Ban Kad of San Pa Thong district. The second route is by making a right turn at the 37^{th} kilometer post on the Chiang Mai - Hot Highway, and going on about three kilometers.

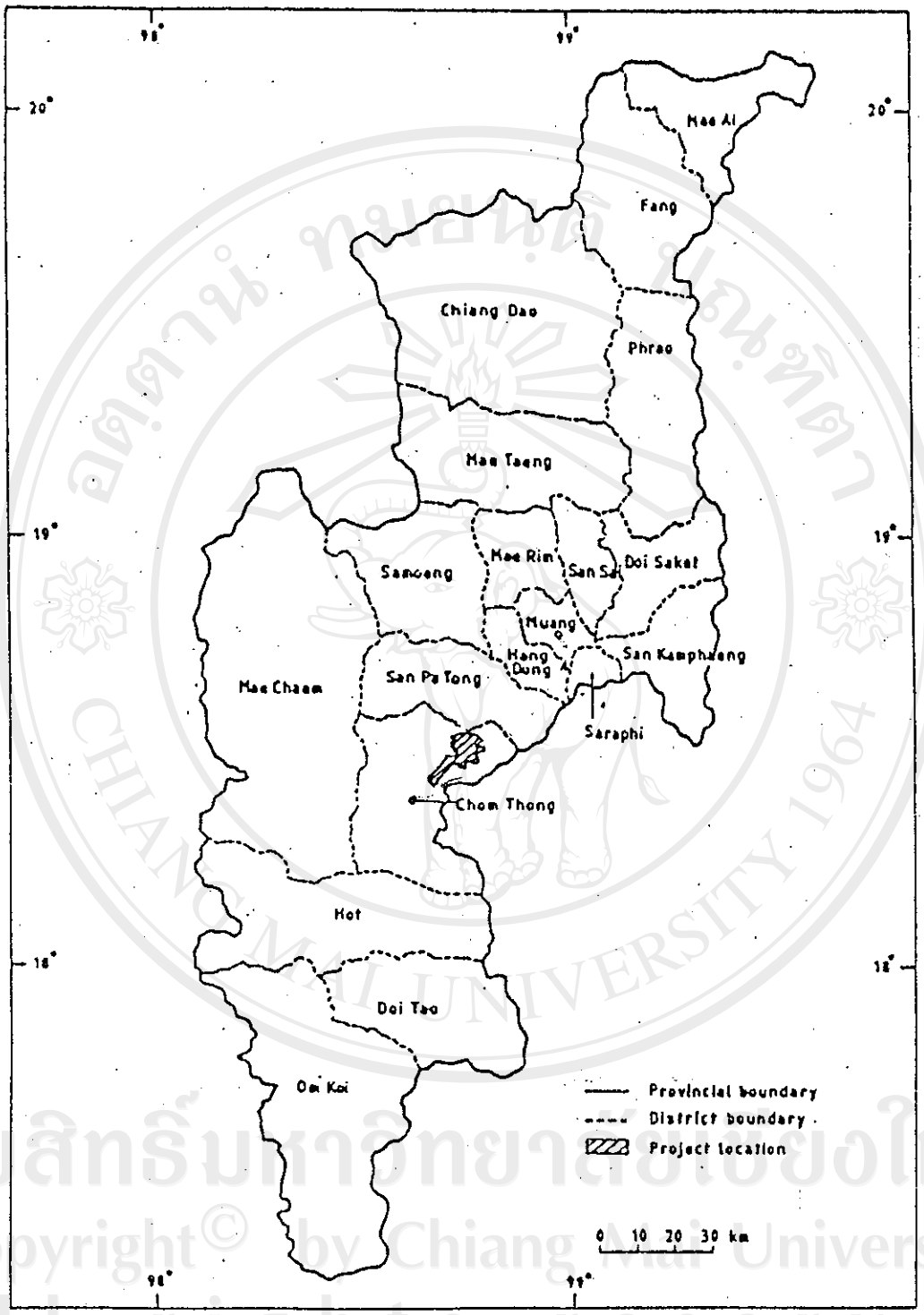

Figure 2. Chiang Mai province and the Chom Thong Land Reform Project Area location

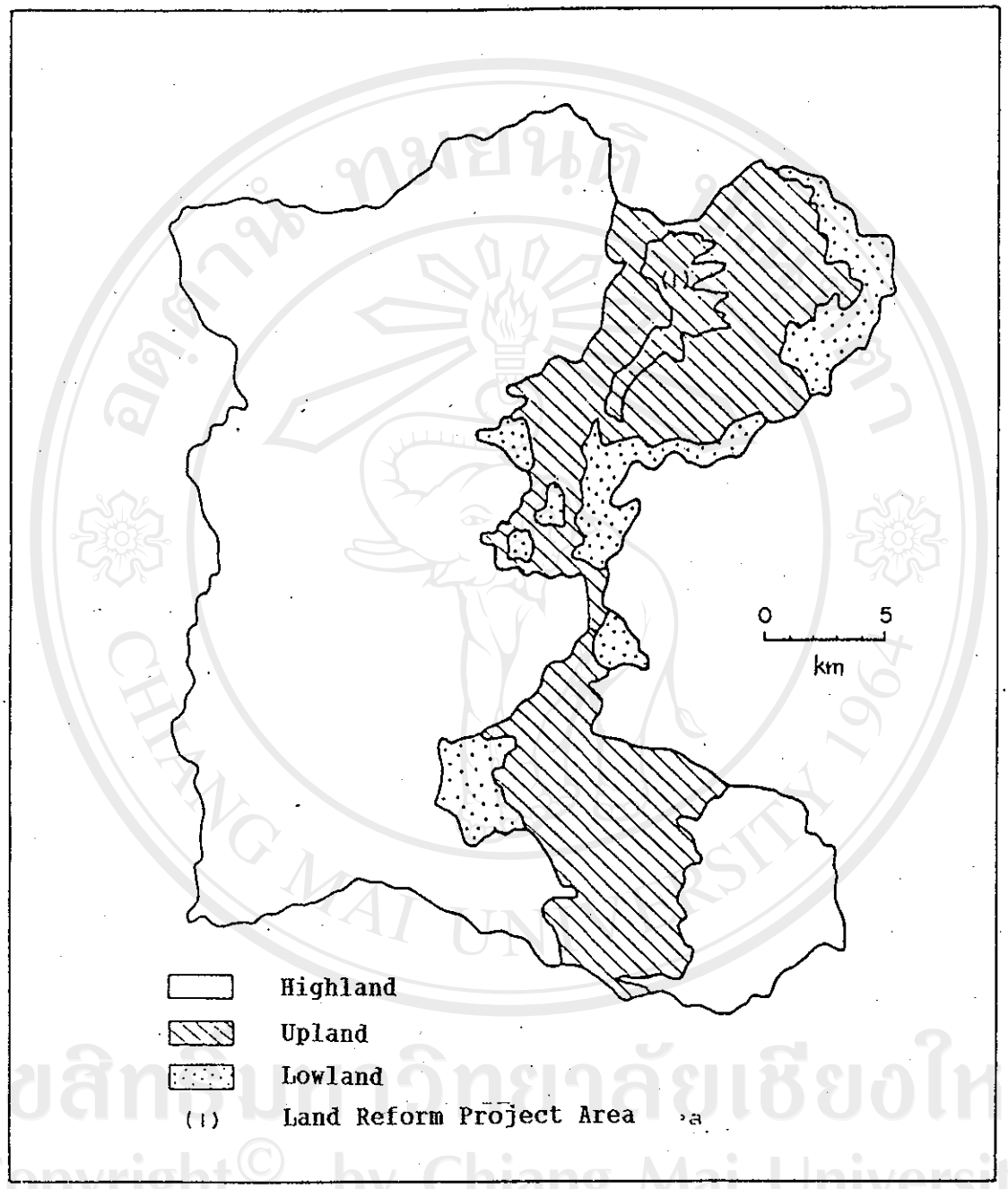

Figure 3. Topography of Chom Thong district, Chiang Mai (Agricultural Economic Office, 1987)

1.2 Physical aspects

Most of the area are undulating and rolling with slope from 3 to 10 percent. Elevation ranges from 300 meter to 360 meter above mean sea level. (Department of Land Development, 1979). Average annual precipitation was about 966 mm., but in 1989, total precipitation was 708.4 mm. (Figure 4, Appendix Table 3). Daily minimum air temperature varies from 8^{o}c to 27^{o}c (Appendix Table 4), meanwhile, daily maximum air temperature varied from 22^{o}c to 40^{o}c. (Appendix Table 5). Monthly mininmum and maximum air temperature were presented in Figure 5.

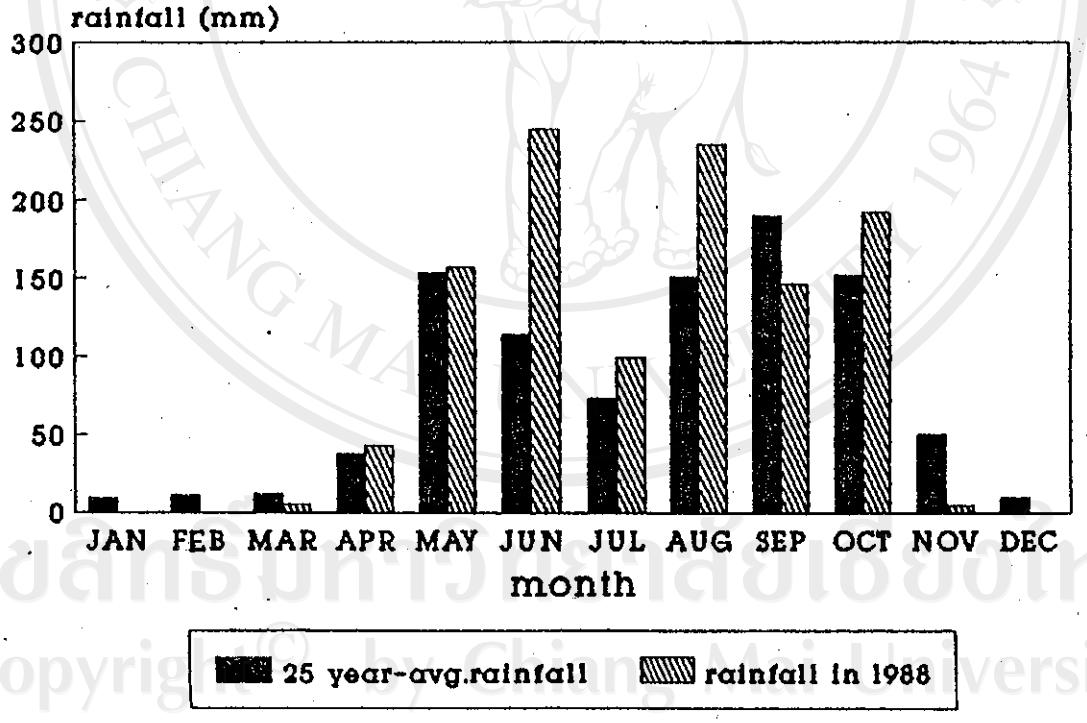

Figure 4. Rainfall data in 1989 of the Chom Thong LRA comparing with 25-year average rainfall (1959-1983) of Chom Thong district, Chiang Mai

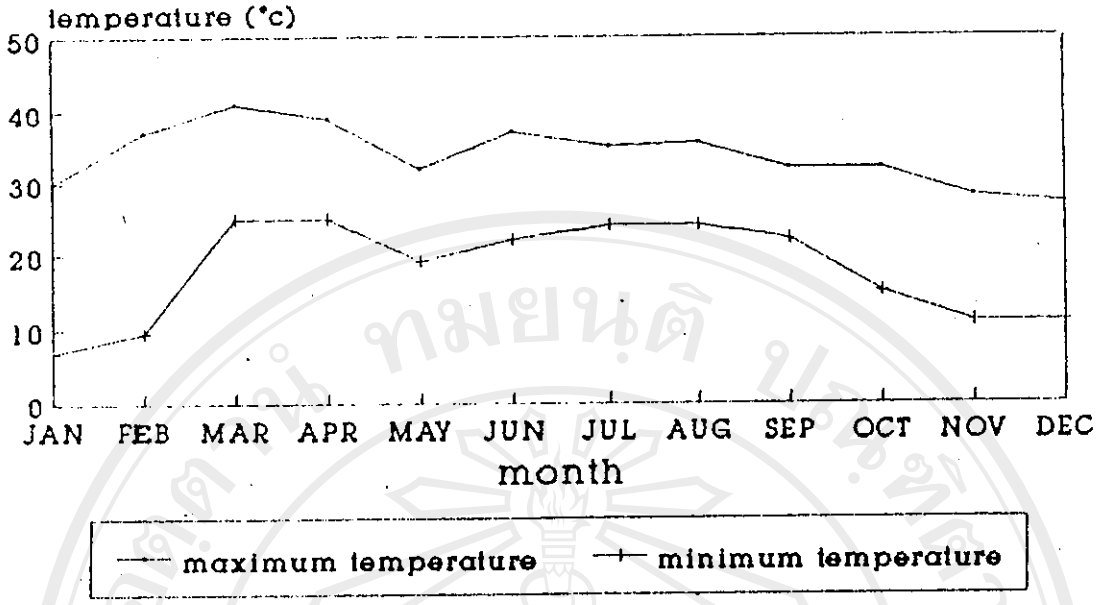

Figure 5. Monthly maximum and minimum air temperature of the Chom Thong LRA, Chom Thong district, Chiang Mai, 1989

The Korat/San Pa Thong association (Kt/Sp) are dominant soil series in this area (Figure 6.). They are deep soils and are characterized by sandy loam texture which is moderately well drained. The analysis of soil samples from the upper and lower terraces (Table 2) revealed similar chemical and physical properties. Soil reaction was acid, with average pH of 5.25. Only two farms had soil reaction strongly acid with pH 4.92 to 4.96. Organic matter was low, averaging 0.64 percent. Available phosphorus appeared to be quite adequate for soybean production, all having the values higher than 10 ppm. Available potassium was also adequate as the values were higher than 50 ppm (Tearanant, 1980).

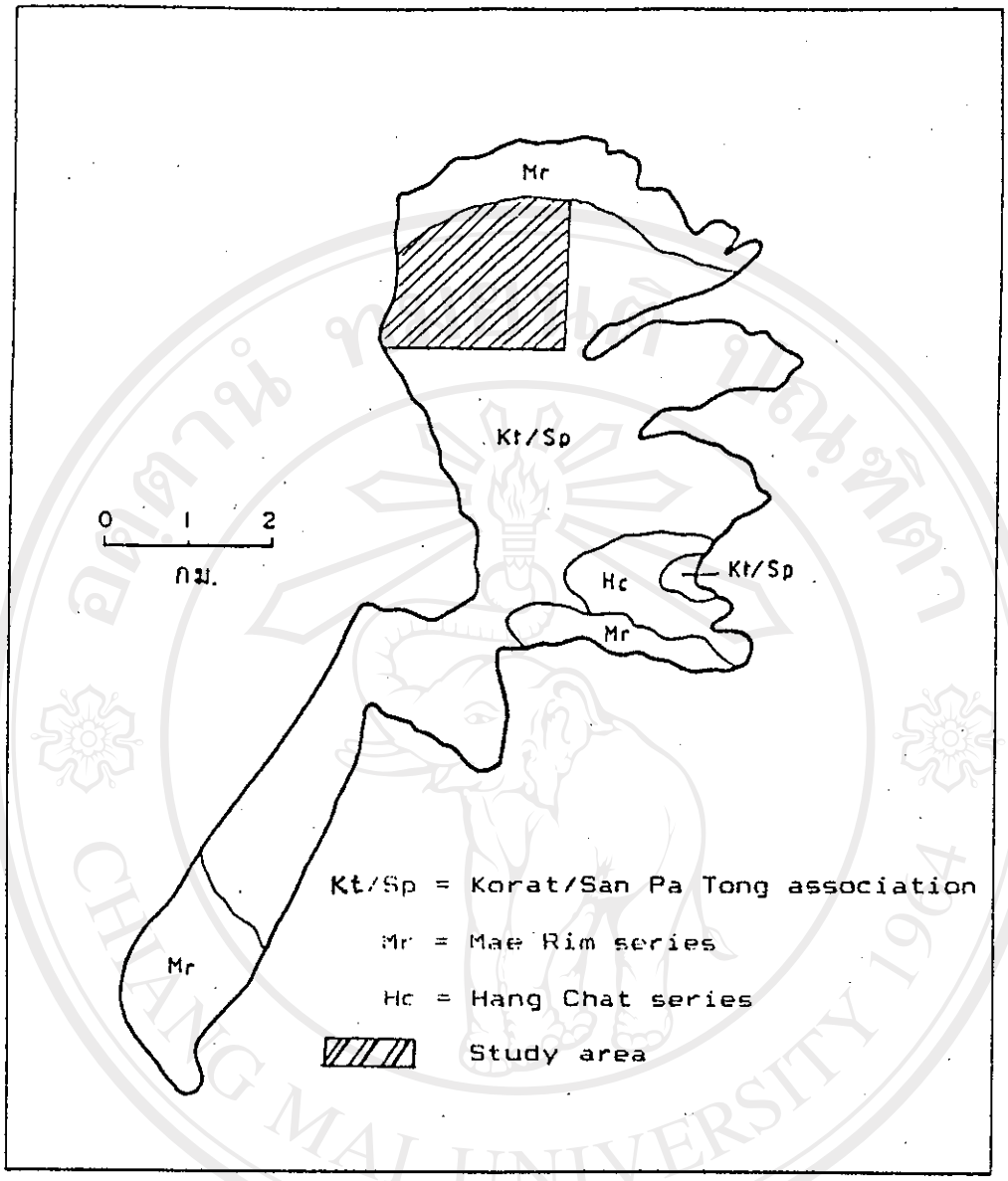

Figure 6. Soil series of the Chom Thong LRA, Chom Thong district, Chiang Mai (Soil Survey Division, 1979)

Soil survey studied by the Department of Land Development indicated that permeability was moderate to rapid whereas surface runoff was moderate. Ground water level remained below one meter throughout the year. The site was orginally a mixed decidious forest, but large areas have been cleared for cultivation of

various upland crops such as groundnut, soybean, upland rice and corn. However, since the establishment of new settlement, soybean is the dominant crop.

1.3 Biological aspects.

Most farmers in the Chom Thong LRA grew a single crop of soybean during the post rainy season. They all used recommended commercial varieites, either SJ 5 or CM 60, and applied about 30 kg/rai of 16-20-0 ($N-P_2O_5-K_2O$) fertilizer. Average farm yield was 140 kg/rai (Table 3). Other field crops grown in this area were tobacco, mungbean, upland rice and peanut which produced average yield of 1925, 90, 240 and 185 kg/rai respectively (Chiang Mai Agricultural Land Reform Office, 1987).

Table 2. Chemical and physical properties of the surface soils on farmers fields, the Chom Thong LRA, Chom Thong district, Chiang Mai, 1989

Farm Number	Soil pH	Organic Matter (%)	Nitro-gen (%)	Phospho-rus (ppm)	Potas-sium (ppm)	Sand (%)	Silt (%)	Clay (%)	Soil texture
Lower terrace									
1	5.31	0.93	0.032	30.84	62.50	74.00	16.00	8.00	Sandy loam
2	5.19	0.52	0.019	30.13	63.75	72.00	17.00	9.00	Sandy loam
3	4.96	0.77	0.027	27.28	90.00	72.00	17.00	9.00	Sandy loam
4	5.23	0.86	0.033	13.68	72.50	64.76	22.24	13.00	Sandy loam
5	5.42	0.63	0.025	10.63	65.00	72.76	17.24	10.00	Sandy loam
6	5.62	0.45	0.027	15.21	98.75	76.76	15.24	8.00	Sandy loam
Upper terrace									
7	5.36	0.58	0.023	13.95	51.25	76.76	15.24	8.00	Sandy loam
8	5.27	0.55	0.022	12.16	66.25	72.76	17.24	10.00	Sandy loam
9	5.20	0.60	0.025	20.56	90.00	72.76	17.24	10.00	Sandy loam
10	4.92	0.55	0.020	35.84	55.00	76.00	14.00	8.00	Sandy loam
11	5.09	0.52	0.019	38.70	62.50	76.00	14.00	8.00	Sandy loam
12	5.40	0.69	0.025	12.92	55.00	70.76	20.24	9.00	Sandy loam
Mean	5.25	0.64	0.025	21.83	69.38	73.11	16.89	9.17	Sandy loam

Table 3. The information on soybean production in the Chom Thong LRA, Chom Thong district, Chiang Mai, 1989

Information	Minimum	Maximum	Mean
soybean planting area (rai)	1.00	22.00	6.24
seed rate (kg/rai)	8.33	24.00	14.55
row spacing (cm)	27.50	60.00	40.27
hill spacing (cm)	17.00	35.00	22.21
grain yield (kg/rai)	72.00	238.89	138.66
family labor cost (baht/rai)	85.71	1350.00	592.74
hired labor cost (baht/rai)	77.00	873.00	469.76
cost of seed (baht/rai)	50.00	240.00	157.63
cost of herbicide (baht/rai)	0.00	175.00	44.60
cost of fertilizer (baht/rai)	63.33	390.00	180.26
cost of pesticide (baht/rai)	6.40	185.00	53.69
grain price (baht/kg)	7.00	13.50	9.77
total income (baht/rai)	671.76	2281.50	1339.78
total cost (baht/rai)	488.60	1365.71	905.95
net income (baht/rai)	-215.11	1255.43	433.83

1.4 Economic and social aspects.

The Chiang Mai Office of Land Reform had allocated plots to 912 households in Tambon Yang Khram and Tambon Doi Lor (Table 4). The average family member was four and three for family labour. The average age of family head was ranging from 21 to 59 years old (Table 5). Most of the household incomes derived from agriculture. In terms of land accessibility, there were two types of farmers. One who held only the land in the Chom Thong LRA and the other who held land both in and outside the Chom Thong LRA. Both groups of farmers had average holding area of 7.54 rai (Table 5). Average on-farm and off-farm income per year was approximately 6,550 and 4,840 baht per household, repectively (The Chiang Mai Office of Land Reform, 1987). Soybean production during post rainy season was the main enterprise generating on-farm income. Apart from cultivating soybean, the farmers who held the land outside the Chom Thong LRA would grow other crop such as lowland rice, tobacco, garlic and peanut but the farmers who held only the land in the Chom Thong LRA would left their farms for off-farm employment such as longan fruit picking, construction and/or agricultural labour. These suggested that earning from their farms in the LRA would not be able to support the family. Therefore, increasing farm income through the use of appropriate technologies to improve agricultural productivity, would be one of the alternative to sustain farmer living, in addition to off-farm opportunity.

Table 4. Total household number, population, number of household in The LRA and number of The LRA utilization household by village in Tambon Yang Khram and Tambon Doi Lor

Tambon	Village number	Name of village	Total HH	Population	Total HH having cultivation right in the area
Yang Khram	2	Ban Nong Hiang	248	964	25
	4	Ban Huay Rark Mai	200	1000	155
	5	Ban Don Chai	116	480	85
	6	Ban Mae Aow Noi	125	437	80
	9	Ban Huay Nam Kao	182	743	110
	10	Ban San Nok Kaew	105	386	20
	11	Ban Nong Hoi	189	750	60
	13	Ban Mai Pattana	161	615	na
	14	Ban Mai Don Chai	116	480	na
Doi Lor	3	Ban Laow Pao	396	1958	100
	4	Ban Pak Tang Charoen	583	2810	225
	5	Ban Huay Jo	324	1440	9
	6	Ban Doi Lor	350	1455	5
	8	Ban Dong Pawai	406	2024	38
Total	14	14	3501	15542	912

HH = Household

Source: Community Development Office of Chom Thong district, Chiang Mai, 1987.

Table 5. Social characters of soybean farmers in the Chom Thong LRA, Chom Thong district, Chiang Mai, 1989

Farm Number	Age (years)	Family Member	Family Labour	Land Holding Area (rai)
1	37	3	3	7.75
2	53	5	3	10.00
3	38	4	2	5.00
4	41	4	1	10.00
5	53	4	4	5.00
6	41	4	3	12.00
7	36	4	3	22.00
8	51	8	5	12.00
9	45	4	4	10.00
10	41	4	2	5.00
11	54	5	5	5.00
12	39	4	2	6.00
13	24	4	2	5.00
14	42	4	2	5.00
15	33	6	2	5.00
16	40	3	3	9.00
17	46	5	3	7.00
18	48	3	3	9.00
19	32	3	2	5.00
20	24	5	3	10.00
21	27	6	4	5.00
22	41	3	3	5.00
23	29	3	2	7.00
24	30	3	2	5.00
25	38	3	2	6.25
26	40	4	2	8.50
27	53	4	4	5.50
28	59	5	5	10.00
29	42	4	3	10.00
30	40	2	2	5.00
31	53	4	3	13.25
32	48	4	2	7.25
33	53	5	4	5.00
34	36	3	2	8.00
35	40	3	2	5.00
36	30	4	2	5.00
37	29	3	2	5.00
38	38	4	2	9.50
39	31	3	2	5.00
40	21	5	4	10.00
41	25	4	2	5.00
42	26	5	3	8.00
Average	39.21	4.05	2.76	7.54

2. Farm resources and soybean production practices

The 42 respondent-farmrs in the Chom Thong LRA were monitored throughout the post rainy season of 1989. Informations such as farm size, family size, family labour, soybean management practices, yield, price and input cost were gathered.

The soybean farmer respondents had a mean family size of 4.05 composing of man 1.6, woman 1.83 and children 0.53 head per family. There was 2.76 labour force per family. The mean age of family head was 39.21 year-old (Table 6).

Table 6. Family structure of the soybean farmers in the Chom Thong LRA, 1989

	Mean	S.D.
Age	39.21	9.58
Family size	4.05	1.07
- man	1.69	0.64
- woman	1.83	0.82
- children	0.53	0.67
Family labour	2.76	0.97

Mean total land holding area was 7.54 rai per household of which 85 percent was devoted to soybean production (Table 7). Upland rice, corn, mungbean, peanut and vegetables were also cultivated.

Table 7. Total land holding area (rai per household) and soybean growing area of the Chom Thong LRA farmers, 1989

	Mean	S.D.
Land holding area	7.54	3.30
Soybean growing area	6.24	3.15
Proportion of soybean growing area to land holding area	0.85	0.23

About 74% of the respondents used SJ 5 soybean variety. CM 60 variety was recently introduced to this area, but only 14% of the farmers grew CM 60 during post rainy season of 1989 because of inadequate information about this variety and the short supply of seed. The others prefered both SJ 5 and CM 60 varieties. Most farmers applied 16-20-0 ($N-P_2O_5-K_2O$) fertilizer (Table 8).

Table 8. Number and percentage of the farmers using soybean varieties and fertilizer in the Chom Thong LRA, 1989

	Number of farmer	percentage (%)
Soybean variety		
SJ 5	31	74
CM 60	6	14
Both SJ 5 and CM 60	5	12
Total	42	100
Fertilizer		
16-20-0	27	64
13-13-21	9	21
12-24-12	4	10
15-15-15	2	5
Total	42	100

Farmers prepared their land by hiring the tractors with rotary disc plough. The land preparation commenced from late July to early August. All farmers used row planting with distance about 40 cm. The distance between hill was about 22 cm. Soybean seeds were sown at average rate of 15 kg/rai (Table 9).

Table 9. Seeding rate and spacing as practised by soybean farmers in the Chom Thong LRA, 1989

	Mean	S.D.
Seeding rate (kg/rai)	14.55	3.80
Row spacing (cm)	40.27	5.24
Hill spacing (cm)	22.21	3.21

Input costs of soybean production in the upland rainfed farms are presented in Table 10. Hired labour cost was about 480 baht/rai. Most labour were hired for sowing, hand weeding, harvesting and threshing. Cost of seed, herbicide, fertilizer and pesticide were about 158, 45, 180 and 55 baht/rai, respectively. The farmers could buy these inputs at the local market near their villages.

Table 10. Variable costs of soybean production (baht/rai) by the farmers in the Chom Thong LRA, 1989

	Mean	S.D.
Hired lobour cost	480.08	252.69
Cost of seed	157.63	43.01
Cost of herbicide	44.60	31.68
Cost of fertilizer	180.26	70.56
Cost of pesticide	55.12	47.13

In 1989, mean soybean yield of the farmer respondents was 139 kg/rai. The estimated gross field benefit of about 1,340 baht/rai. Mean total variable cost was about 918 baht/rai. Hence, the net benefit was 422 baht/rai (Table 11). Since, soybean growing area was only about 6 rai per household (Table 7), the crop could provide net benefit of about 2,532 baht per household per year.

Table 11. On-farm income of soybean production by the Chom Thong LRA farmers, 1989

	Mean	S.D.
Yield (kg/rai)	138.66	34.04
Gross field benefit (baht/rai)	1,339.78	381.57
Total variable cost (baht/rai)	917.69	265.90
Net benefit (baht/rai)	422.09	342.50

3. The 1989 growing environment

In 1989, the total rainfall was 708.4 mm which was 27 percents less than the 25 years average rainfall (Figure 4, Appendix Table 3). However, rainfall distribution was not evenly distributed, with 430 mm occurred in October. It would not be expected to sustain high soybean yield. The growing period of Chom Thong district was 167 days which was started on May 20 at 80% probability (Randhawa, 1988). But in 1989, four dry spells of 10-18 days occured during the growing period. (Appendix Table 3). The four dry spells were between June 6 to June 18, July 3 to July 12, July 25 to August 11 and August 23 to September 2, 1989. Therefore, This climatic constraint was one of the factors that restricted high and stable soybean yield in this upland rainfed area.

Weekly soil moisture content was measured from two representative fields at level 0-20, 20-40, 40-60 and 60-80 soil depth, started from August 13 to November 26, 1989. One representative field was located on the lower terrace while the other was on the upper terrace. The upper limits of soil moisture content

at the upper terrace were lower than the lower terrace at 0-20 and 20-40 cm soil depth, but at the 40-60 and 60-80 cm depth, both fields exhibited similar soil moisture limits (Figure 7 and 8). Apparently, the texture of surface soils at both fields were different. The depletion of soil moisture from mid September to early October occured when the growth of soybean plant was at flowering and seed-filling periods, which was a major factor cansing low seed yield in this season.

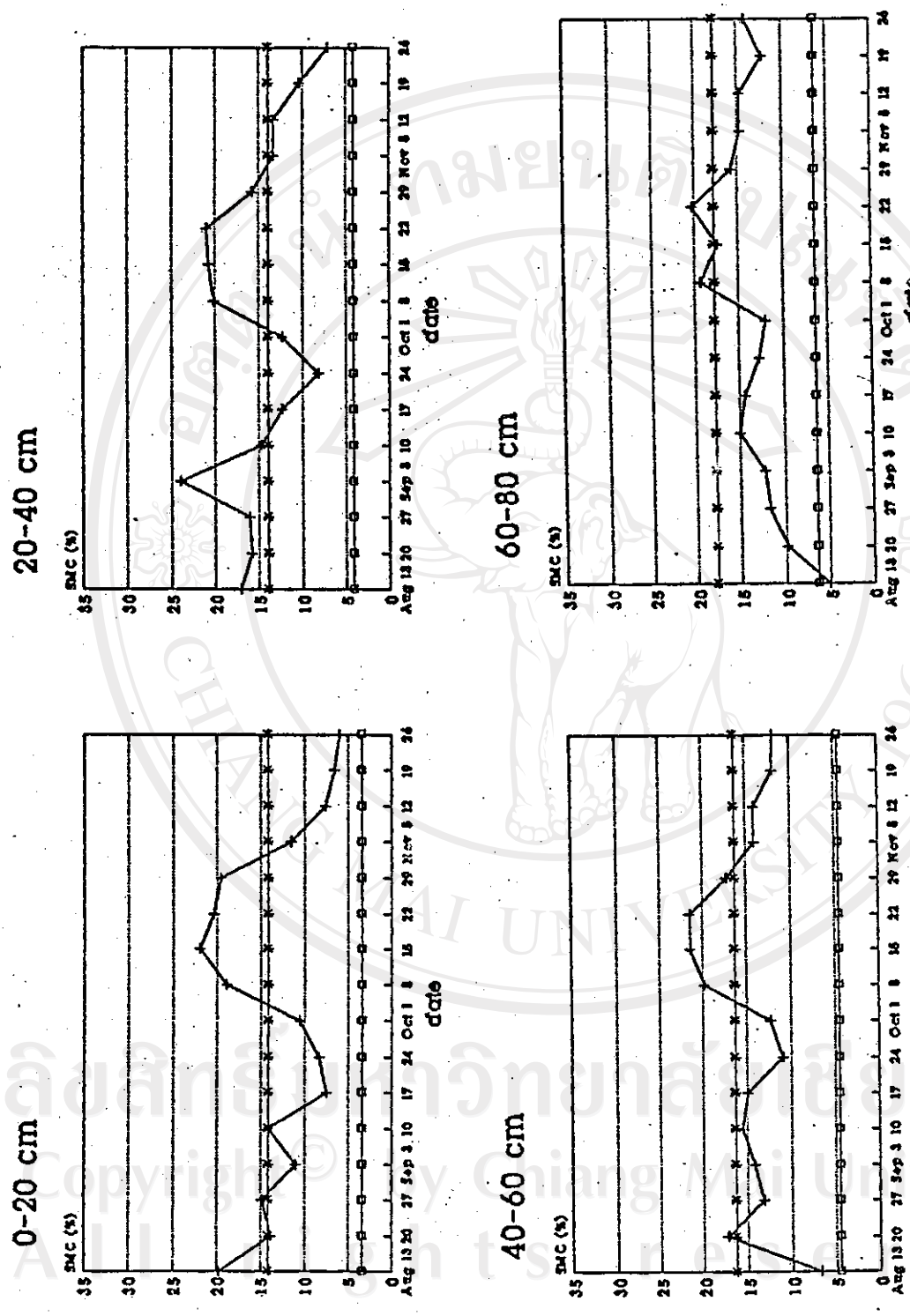

Figure 7. Soil moisture contents (percentage by volume) on different soil depth on lower terrace field. The Chom Thong LRA, Chom Thong district, Chiang Mai, 1989.
(—*—*— field capacity, —□—□— permanent wilting point).

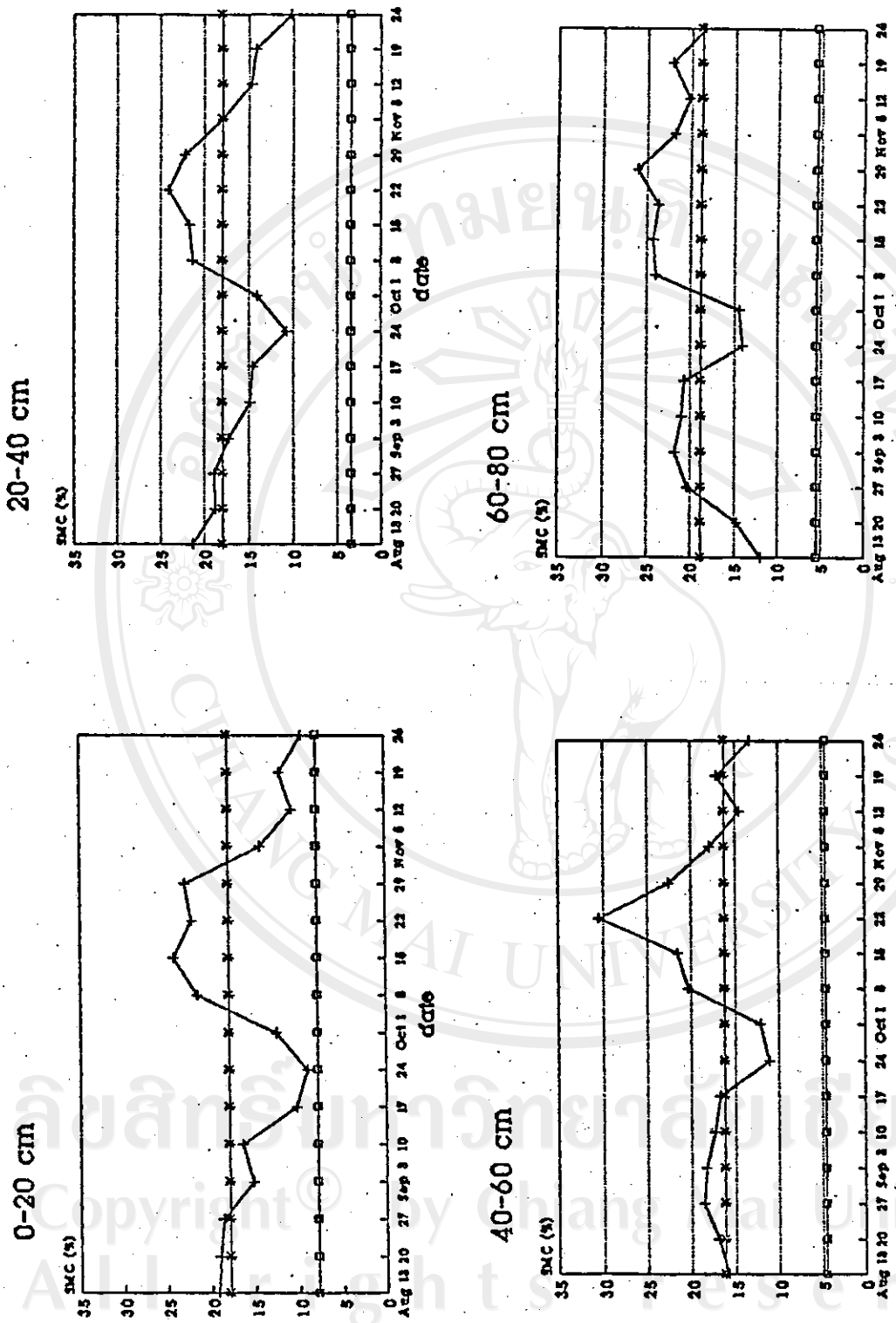

Figure 8. Soil moisture contents (percentage by volume) on different soil depth on upper terrace field. The Chom Thong LRA, Chom Thong district, Chiang Mai, 1989.
(—*—*— field capacity, —□—□— permanent wilting point).

4. Crop Growth

4.1 Seedling Emergence

Soybean seedlings were counted between 4 to 10 days after sowing to determine the speed of emergence (Figure 9). Soybean planted on the lower terrace tended to emerge faster than those on the upper terrace. This was evident that at the 20 cm soil depth the lower terrace fields provided higher and more stable water availability than the upper terrace fields during 10 days after sowing (Figure 7 and 8).

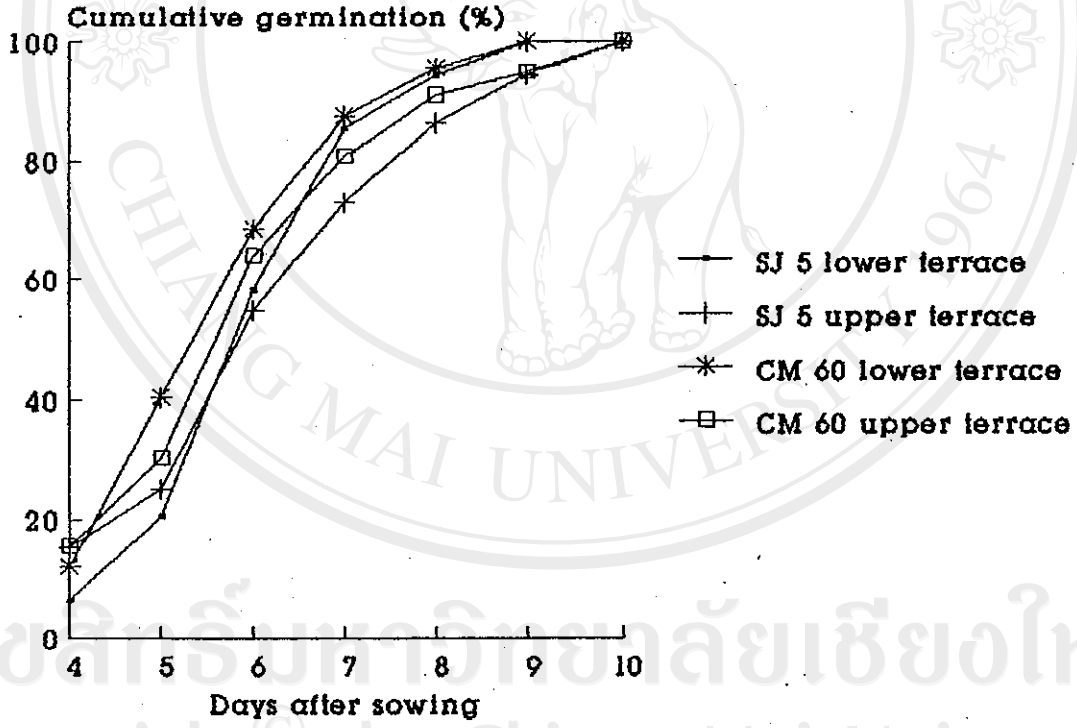

Figure 9. Cumulative germination percentage of SJ 5 and CM 60 grown on lower and upper terrace fields, averaging from six sites

4.2 Crop phenology

The soybean sown on the lower and upper terrace fields showed similar pattern of phenological development for each variety (Table 12 and 13). The variety CM 60 would flower (R1) at 31 days after sowing (DAS) while the SJ 5 flowered at 33-34 DAS. The CM 60 also showed 3-5 days earlier seed development (R5) than the SJ 5 variety, at average 49 and 53 DAS, respectively. However, the CM 60 had longer seed filling period than the SJ 5 variety, averaging 34 and 31 days, respectively. Both varieties matured (R8) at 83-84 DAS.

Table 12. Stage of development for soybean SJ 5 variety sown at lower and upper terrace fields, the Chom Thong LRA, Chom Thong district, Chiang Mai, 1989

Farm Number [a]	Field Number	Stage of development (days after sowing)														
		V1	V2	V3	V4	V5	V6	V7	R1	R2	R3	R4	R5	R6	R7	R8	Harv.
1	1	11	15	18	24	27	30	34	34	39	43	47	54	63	72	80	85
2	11	11	14	17	24	27	28	33	33	36	44	49	54	61	75	84	90
3	90	11	14	17	22	25	31	34	34	39	43	47	53	62	74	87	91
4	91	11	14	17	22	25	30	34	34	40	43	47	53	63	73	84	87
5	94	10	15	18	21	24	29	31	35	40	45	49	55	61	76	83	86
6	232	10	14	18	21	24	27	29	33	37	41	46	56	60	81	86	88
Average		10	14	17	22	25	29	32	33	38	43	47	54	61	75	84	87.8
7	78	11	14	17	22	27	34	34	34	38	41	47	52	65	80	85	86
8	87	11	14	17	21	25	29	32	35	40	43	49	55	65	75	84	86
9	118	10	14	18	20	24	28	30	35	38	42	46	50	56	67	83	88
10	119	9	13	17	22	26	31	35	35	38	42	46	53	57	72	84	86
11	157	10	14	18	21	26	29	33	33	37	40	44	51	61	80	82	85
12	227	10	14	19	22	25	29	30	36	41	46	50	56	62	83	87	91
Average		10	13	17	21	25	30	32	34	38	42	47	52	61	76	84	87
Grand mean		10	14	17	21	25	29	32	34	38	42	47	53	61	75	84	87.4

[a] farm number 1-6 were in lower terrace and farm number 7-12 were in upper terrace.

Table 13. Stage of development for soybean CM 60 variety sown at lower and upper terrace fields, the Chom Thong LRA, Chom Thong district, Chiang Mai, 1989

Farm Number[a]	Field Number	Stage of development (days after sowing)														
		V1	V2	V3	V4	V5	V6	V7	R1	R2	R3	R4	R5	R6	R7	R8	Harv.
1	1	11	15	18	24	27	32	32	32	36	42	47	52	59	70	79	86
2	11	11	14	17	24	27	31	31	31	36	42	49	55	61	73	83	92
3	90	11	14	17	22	25	32	32	32	34	38	41	49	57	71	85	91
4	91	11	14	17	22	25	31	31	31	35	39	42	50	57	69	82	87
5	94	10	15	18	21	24	29	32	32	36	40	45	50	56	72	83	86
6	232	10	14	18	21	24	27	31	31	34	37	45	54	61	79	87	91
Average		10	14	17	22	25	30	31	31	35	39	44	51	58	72	83	88.8
7	78	11	14	17	22	26	32	32	32	33	37	42	46	59	78	82	85
8	87	11	14	17	21	25	30	33	33	35	39	45	51	61	71	82	85
9	118	10	14	18	20	24	28	31	32	35	39	42	46	56	64	83	88
10	119	9	13	17	22	26	30	31	31	34	38	42	47	55	72	82	86
11	157	10	14	18	21	26	29	30	30	34	38	42	47	56	76	82	85
12	227	10	14	19	22	25	29	33	33	37	41	46	50	58	79	87	91
Average		10	13	17	21	25	29	31	31	34	38	43	47	57	73	83	86.6
Grand mean		10	14	17	21	25	30	31	31	34	39	44	49	58	72	83	87.7

[a] farm number 1-6 were in lower terrace and farm number 7-12 were in upper terrace.

It was noted that the phenological development of each soybean variety was uniform and not affected by the fertilizer treatments.

4.3 Dry matter yield

The dry matter yields of soybean varieties were determined at 30, 60 days after emergence (DAE) and at harvest. The soybean varieties did not show significant difference of dry matter yields at 30 and 60 DAE; but the CM 60 provided significantly higher dry matter yield than SJ 5 at harvest, averaging 267 and 237 g/m^2, respectively (Table 14).

The fertilizer treatments showed significantly higher dry matter yields than the non-treated plots at all three stages of growth. Only at harvest when the high dosage (3-9-6 kg/rai) of fertilizer treatment produced significantly higher dry matter yield than the low treatment (1.5-4.5-3.0 kg/rai), averaging 288 and 259 g/m^2, respectively.

4.4 Plant height

Plant height was measured once at the full bloom stage (R2), and was found to vary among farms. The variety SJ 5 showed significantly taller than the CM 60, averaging 45 and 39 cm, respectively. The fertilizer treatments were significantly different at all three levels, averaging 46, 42 and 38 cm for the high, the low and the non-treated, respectively (Tables 15, 16 and 17).

It was also found that there was significant interaction between variety and fertilizer treatments.

Table 14. Weight of above ground dry matter of soybean, measured at three growth stages, with six treatment combinations of two soybean varieties and three levels of fertilizer application, the Chom Thong LRA, Chom Thong district, Chiang Mai, 1989

Treatment (variety+N-P_2O_5-K_2O)	Dry matter weight,[a] g/m^2		
	At 30 DAE	At 60 DAE	At harvest
T1 (SJ 5 + 0-0-0)	66.25	246.2	194.4
T2 (SJ 5 + 1.5-4.5-3)	89.43	420.9	242.3
T3 (SJ 5 + 3-9-6)	89.22	443.6	273.6
T4 (CM 60 + 0-0-0)	73.98	230.8	221.0
T5 (CM 60 + 1.5-4.5-3)	92.35	433.9	276.6
T6 (CM 60 + 3-9-6)	82.81	426.4	303.2
LSD 5%	18.0	87.9	27.4
SE	6.4	31.1	9.7

[a] Average of 24 samples ± standard error of the mean.
Mean seperation in columns by LSD at 5% level.
DAE = days after emergence.

Variety	Dry matter weight,[b] g/m^2		
	At 30 DAE	At 60 DAE	At harvest
SJ 5	81.6	370.2	236.8
CM 60	83.1	363.7	266.9
LSD 5%	NS	NS	15.8
SE	3.7	17.9	5.6

[b] Average of 72 samples ± standard error of the mean.

Rate of fertilizer application (N-P_2O_5-K_2O)	Dry matter weight,[c] g/m^2		
	At 30 DAE	At 60 DAE	At harvest
0-0-0	70.1	238.5	207.7
1.5-4.5-3	90.9	427.4	259.4
3-9-6	86.0	435.0	288.4
LSD 5%	12.7	62.2	19.4
SE	4.5	22.0	6.8

[c] Average of 48 samples ± standard error of the mean.

Table 15. Plant height of soybean at bloom stage in RCB design with six treatment combinations on 12 farms, two replications per farm, the Chom Thong LRA, Chom Thong district, Chiang mai, 1989 (cm)

Treatment[a]	Farm number												Mean
	1	2	3	4	5	6	7	8	9	10	11	12	
T1	37.4	39.1	36.5	50.6	41.1	36.4	36.8	44.2	50.7	46.1	37.0	48.5	42.0
T2	43.5	40.1	45.6	54.2	44.4	37.7	31.7	39.3	53.0	50.2	41.4	46.0	43.9
T3	49.7	45.3	44.5	50.8	46.1	43.6	37.1	52.4	57.9	54.3	49.2	51.9	48.6
T4	30.8	32.7	36.0	43.3	28.8	38.7	30.8	36.8	35.0	31.2	32.7	32.3	34.1
T5	38.7	34.8	44.7	47.5	29.9	55.5	36.9	39.7	39.9	41.5	36.1	39.3	40.4
T6	40.9	42.9	40.7	46.7	34.6	49.3	38.9	54.3	43.1	44.5	37.6	42.0	43.0
Mean	40.2	39.1	41.3	48.9	37.5	43.5	35.4	44.4	46.6	44.6	39.0	43.3	42.0
LSD 5%	8.3	NS	NS	NS	4.3	7.3	NS	11.6	NS	12.3	NS	NS	2.4
CV (%)	8.0	14.2	10.2	9.0	4.5	6.3	10.5	10.2	12.1	10.8	9.7	11.0	10.1

[a] T1 = SJ 5 + 0-0-0 ($N-P_2O_5-K_2O$) fertilizer application.
T2 = SJ 5 + 1.5-4.5-3 ($N-P_2O_5-K_2O$) fertilizer application.
T3 = SJ 5 + 3-9-6 ($N-P_2O_5-K_2O$) fertilizer application.
T4 = CM 60 + 0-0-0 ($N-P_2O_5-K_2O$) fertilizer application.
T5 = CM 60 + 1.5-4.5-3 ($N-P_2O_5-K_2O$) fertilizer application.
T6 = CM 60 + 3-9-6 ($N-P_2O_5-K_2O$) fertilizer application.

Table 16. Plant height comparison among two soybean varieties at bloom stage, by farm (cm)

Variety	Farm number												Mean
	1	2	3	4	5	6	7	8	9	10	11	12	
SJ 5	43.5	41.5	42.2	51.9	43.9	47.8	35.2	45.3	53.9	50.2	42.6	48.8	44.8
CM 60	36.8	36.8	40.5	45.9	31.1	39.2	35.6	43.6	39.4	39.1	35.5	37.9	39.2
Mean	40.2	39.1	41.3	48.9	37.5	43.5	35.4	44.4	46.6	44.6	39.0	43.3	42.0
LSD 5%	4.8	NS	NS	NS	2.3	6.7	NS	NS	6.6	6.0	5.2	6.5	1.4

Table 17. Plant height comparison of soybean among three levels of fertilizer application by farm (cm)

Rate of fertilizer	Farm number												Mean
	1	2	3	4	5	6	7	8	9	10	11	12	
0-0-0	34.1	35.9	36.3	47.0	34.9	37.5	33.9	40.5	42.9	38.7	34.9	40.4	38.1
1.5-4.5-3	41.2	37.4	45.1	50.9	37.1	46.6	34.3	39.5	46.5	45.9	38.8	42.7	42.2
3-9-6	45.3	44.1	42.7	48.8	40.4	46.5	38.0	53.3	50.5	49.4	43.4	47.0	45.8
Mean	40.2	39.1	41.3	48.9	37.5	43.5	35.4	44.4	46.6	44.6	39.0	43.3	42.0
LSD 5%	5.9	NS	NS	NS	2.8	NS	NS	7.8	NS	7.4	6.4	NS	1.7

4.5 Crop yield

As the error variances of 12 farms were tested and shown to be homogeneous, the combined analysis of variance of yield character was conducted (Appendix Table 8).

The combined analysis of variance indicated that there was significant variation among farms (Appendix Table 6). Comparison among average farm yields revealed that significant differences between average farm yields were found within the lower and the upper terrace fields. There was no concrete evidence to show the effect of these two land types on average farm yields of soybean (Table 18).

Table 18. Grain yield (kg/rai) of soybean in RCB design with six treatment combinations on 12 farms, two replication per farm

Treatment[a]	Farm number												Mean
	1	2	3	4	5	6	7	8	9	10	11	12	
T1	128.5	112.6	67.0	171.5	160.6	114.2	107.8	142.3	154.8	158.7	114.2	177.3	134.1
T2	150.2	162.8	135.7	197.2	197.6	128.4	82.1	178.5	176.7	148.0	141.1	186.9	157.1
T3	169.1	175.2	111.7	164.5	198.6	179.5	117.4	144.2	262.1	177.3	186.9	233.7	176.7
T4	141.6	163.4	130.2	218.7	171.6	155.1	119.6	148.7	209.0	124.9	163.3	152.7	158.2
T5	167.9	182.8	172.7	212.4	203.0	274.4	141.2	146.0	235.4	174.0	184.1	206.4	191.7
T6	174.7	179.2	190.1	204.8	207.4	194.3	137.7	193.6	284.6	227.7	151.5	271.1	201.4
Mean	155.3	162.7	134.5	194.9	189.8	174.3	117.6	158.9	220.4	168.4	156.8	204.7	169.9
LSD 5%	61.5	99.2	66.7	79.4	49.7	87.9	41.8	75.4	91.4	62.6	121.5	138.9	19.0
CV (%)	15.4	20.2	19.3	15.9	10.2	19.6	13.8	18.4	16.1	14.5	30.1	26.4	19.3

[a] T1 = SJ 5 + 0-0-0 ($N-P_2O_5-K_2O$) fertilizer application.
T2 = SJ 5 + 1.5-4.5-3 ($N-P_2O_5-K_2O$) fertilizer application.
T3 = SJ 5 + 3-9-6 ($N-P_2O_5-K_2O$) fertilizer application.
T4 = CM 60 + 0-0-0 ($N-P_2O_5-K_2O$) fertilizer application.
T5 = CM 60 + 1.5-4.5-3 ($N-P_2O_5-K_2O$) fertilizer application.
T6 = CM 60 + 3-9-6 ($N-P_2O_5-K_2O$) fertilizer application.

There were significant effects of varieties and fertilizer treatments on soybean grain yields, but there was no indication of variety x fertilizer interaction. (Appendix Table 7). Table 19 showed variety CM 60 out yielded SJ 5 by 18 percent, averaging 184 and 156 kg/rai, respectively.

For CM 60, there was no difference between high and low rates of fertilizer application. The fertilizer treated plot were 24 percent significant higher than the no fertilizer, averaging 197 and 158 kg/rai, respectively.

Table 19. Yield of soybean grown in the upland rainfed area, with two soybean varieties and three levels of fertilizer application

Variety	Yield[a](kg/rai)
SJ 5	156.0 ± 3.9
CM 60	183.8

[a] average of 72 samples ± standard error of the mean, mean seperation by LSD at 5% level (10.95).

Rate of fertilizer application ($N-P_2O_5-K_2O$)	Yield[b](kg/rai)
0-0-0	146.2
1.5-4.5-3	174.4 ± 4.7
3-9-6	189.0

[b] average of 48 samples ± standard error of the mean, mean seperation by LSD at 5% level (13.42).

On the contrary, there were significant difference among the fertilizer treatments for SJ 5 variety. The average yields of high, low and no fertilizer were 177, 157 and 134 kg/rai, respectively (Table 18).

5. Economic analysis

The economic assessment of the treatment effects was conducted by using partial budgeting method. The effect of fertilizer on each variety was evaluated separately.

When the combined fertilizer of ($N-P_2O_5-K_2O$) was used in the SJ 5 variety, the rate 3-9-6 kg/rai produced the highest yield of 177 kg/rai and highest net benefit of 1,409 Baht/rai. However, the half dosage treatment (1.5-4.5-3.0 kg/rai) gave the highest marginal rate of return of 37.44 percent, while the 3-9-6 kg/rai treatment provided only 24.75 percent. Therefore, the low rate of fertilizer used would be more appropriate (Table 20).

Table 20. Partial budgeting analysis of fertilizer treatments for SJ 5

Data	Treatment ($N-P_2O_5-K_2O$) in kg/rai		
	0-0-0	1.5-4.5-3.0	3-9-6
Average yield (kg/rai)	134.10	157.10	176.70
Gross field benefit (baht/rai)	1310.16	1534.87	1726.36
Cost of fertilizer (baht/rai)	0.00	153.50	307.00
Cost of labour (baht/rai)	0.00	10.00	10.00
Total variable cost (baht/rai)	0.00	163.50	317.00
Net benefit (baht/rai)	1310.16	1371.37	1409.36
Marginal rate of return (%)	-	37.44	24.75

With the CM 60 variety, the fertilizer treatments between the high and the low rate did not produce significantly different yields. Evidently the low rate of fertilizer gave the marginal rate of return of over 100 percent and it would be the most economically viable among the treatments (Table 21).

Table 21. Partial budgeting analysis of fertilizer treatments for CM 60

Data	Treatment ($N-P_2O_5-K_2O$) in kg/rai		
	0-0-0	1.5-4.5-3.0	3-9-6
Average yield (kg/rai)	158.20	191.70	201.40
Gross field benefit (baht/rai)	1545.61	1872.91	1967.68
Cost of fertilizer (baht/rai)	0.00	153.50	307.00
Cost of labour (baht/rai)	0.00	10.00	10.00
Total variable cost (baht/rai)	0.00	163.50	317.00
Net benefit (baht/rai)	1545.61	1709.41[a]	1650.68
Marginal rate of return (%)	-	100.18	-

[a] treatment 1.5-4.5-3.0 ($N-P_2O_5-K_2O$) kg/rai was dominated.

6. Determination of recommendation domain

The data for each variety and for each fertilizer application level were fitted to simple linear regression equations. The results are shown in Figures 10, 11 and 12. In each case, the R^2 value indicated an adequate fit and "t" values were highly significant, indicating positive responses to environment for both varieties and all levels of fertilizer application.

A graph distribution of confidence interval ($\bar{X} \pm t_a s_{\bar{x}}$) of the combined result of the 12 farms for each variety and for each fertilizer application level (Figures 13, 14, 15, 16, and 17) showed that the CM 60 variety had a higher mean yield for all fertilizer situations. But it would be less stable at higher fertilizer treatment (wider confidence intervals). Conclusion based on this evidence would indicate that CM 60 was more appropriate soybean variety than SJ 5 for this study area. Since both varieties and all levels of fertilizer application responded over

sites positively, thus, this area would be considered as one recommendation domain.

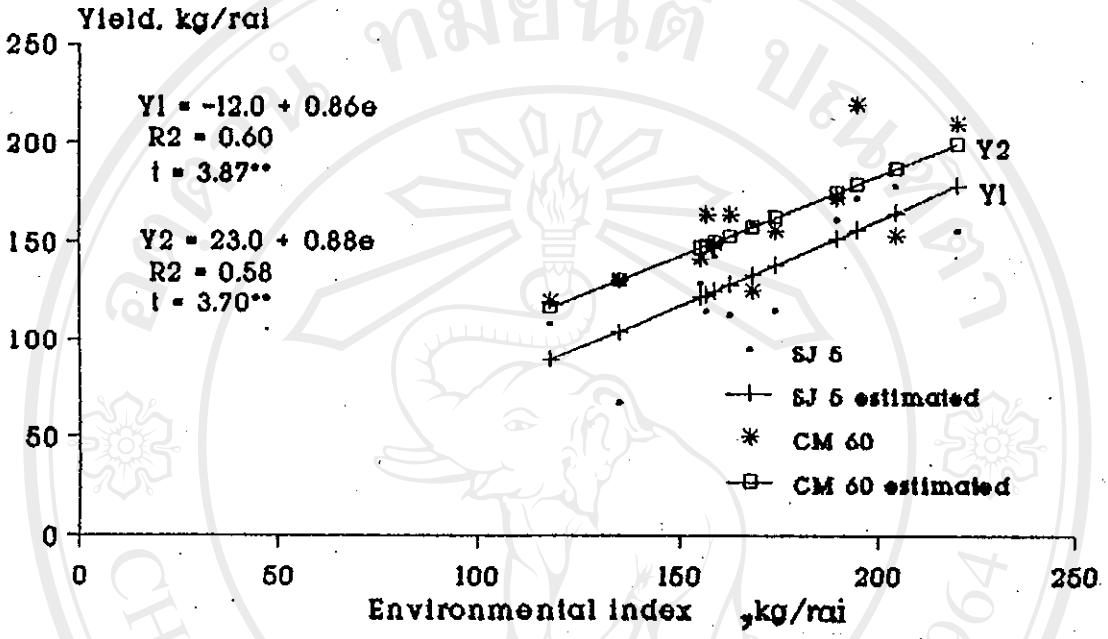

Figure 10. Grain yield response for SJ 5 and CM 60 to environment without fertilizer. The Chom Thong LRA, Chom Thong district, Chiang Mai, 1989

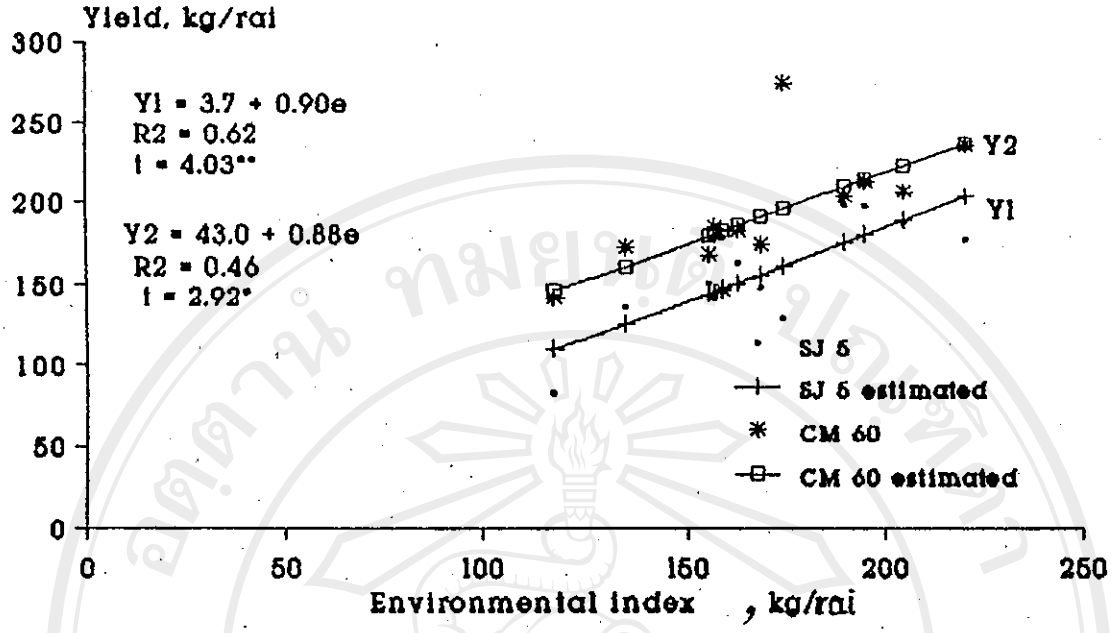

Figure 11. Grain yield response for SJ 5 and CM 60 to environment with 1.5-4.5-3.0 kg/rai ($N-P_2O_5-K_2O$) fertilizer. The Chom Thong LRA, Chom Thong district, Chiang Mai, 1989

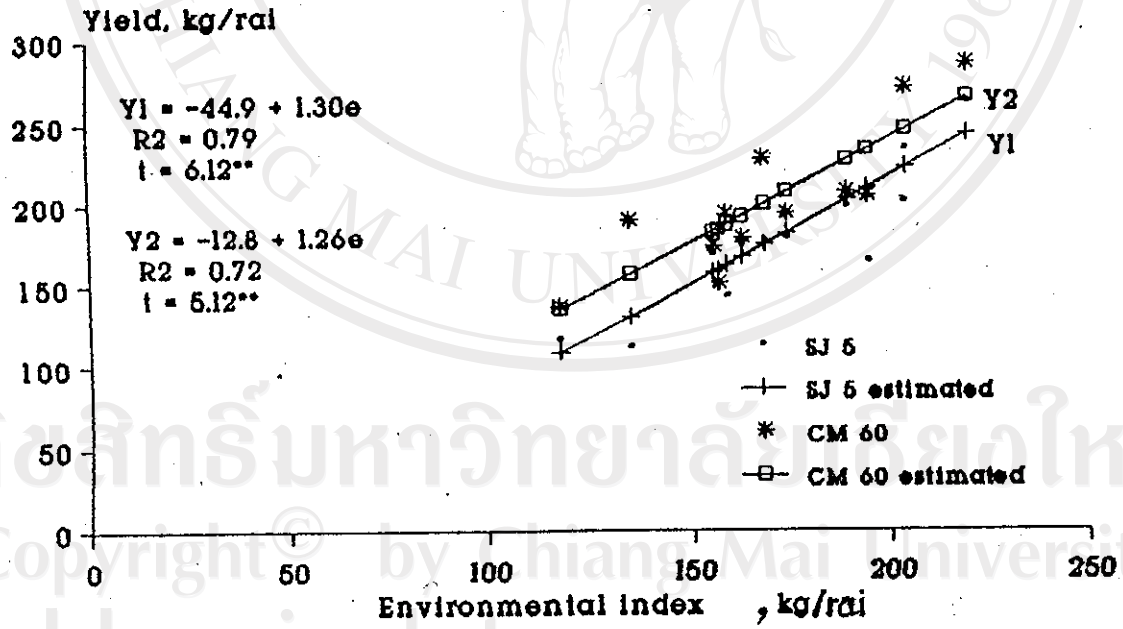

Figure 12. Grain yield response for SJ 5 and CM 60 to environment with 3-9-6 kg/rai ($N-P_2O_5-K_2O$) fertilizer. The Chom Thong LRA, Chom Thong district, Chiang Mai, 1989

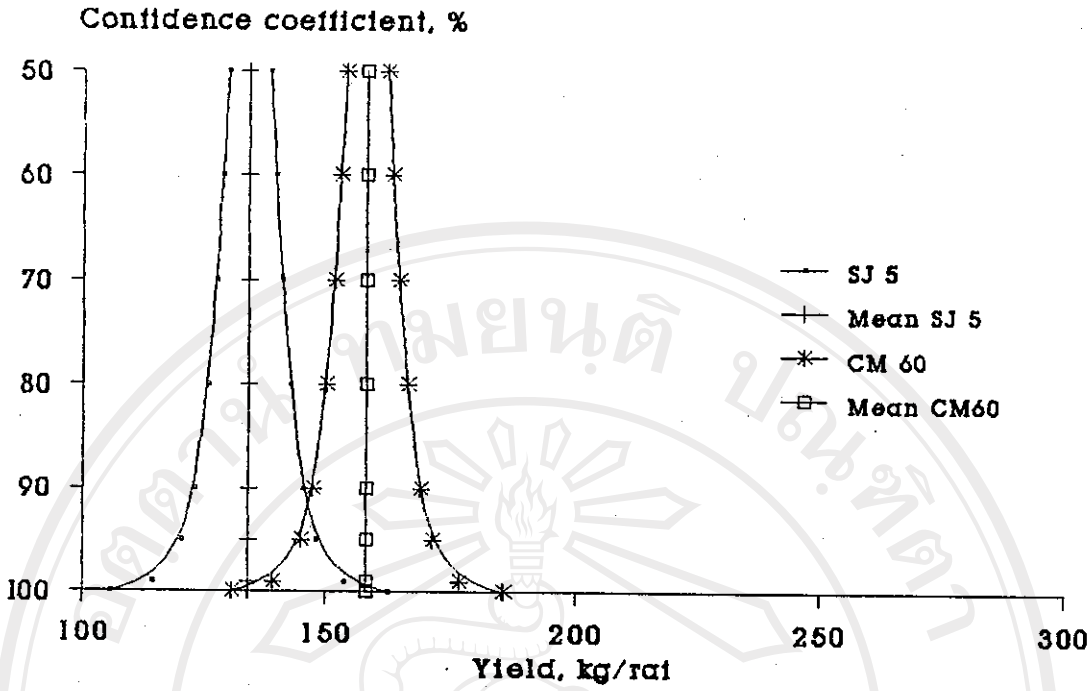

Figure 13. Distribution of confidence intervals for grain yield of soybean without fertilizer.

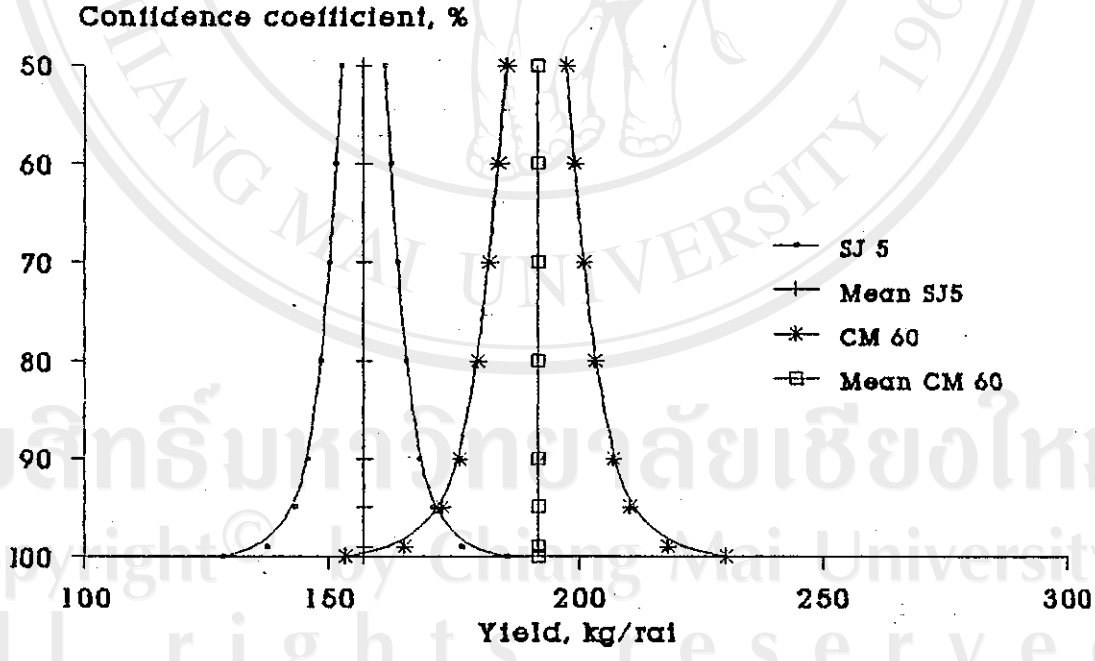

Figure 14. Distribution of confidence intervals for grain yield of SJ 5 and CM 60 with 1.5-4.5-3.0 kg/rai ($N-P_2O_5-K_2O$).

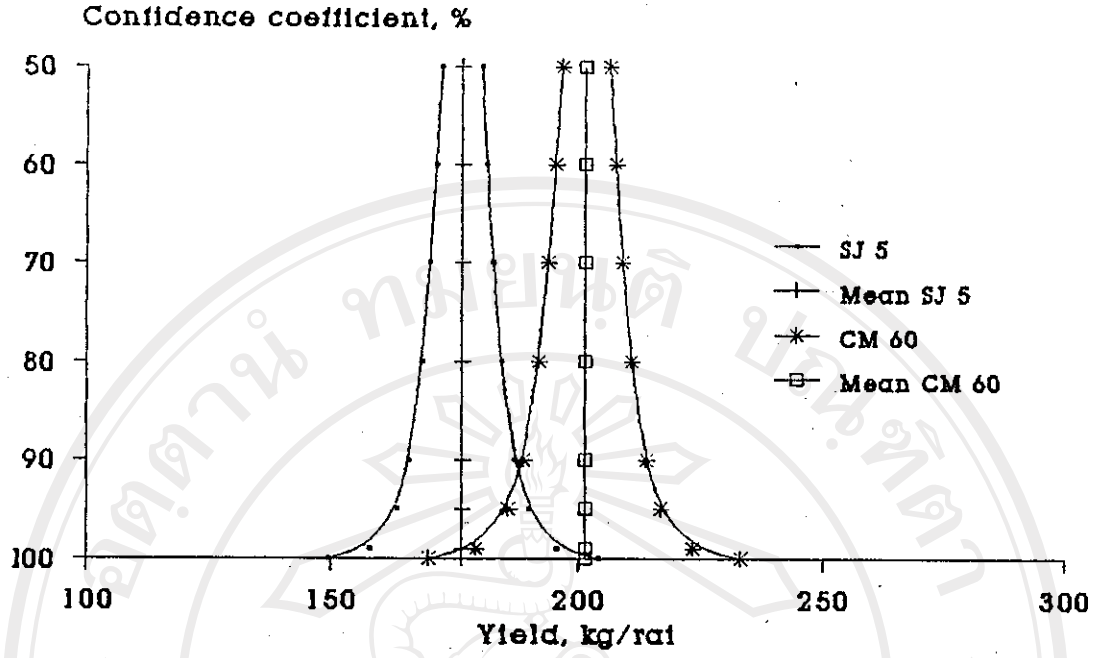

Figure 15. Distribution of confidence intervals for grain yield of SJ 5 and CM 60 with 3-9-6 kg/rai ($N-P_2O_5-K_2O$).

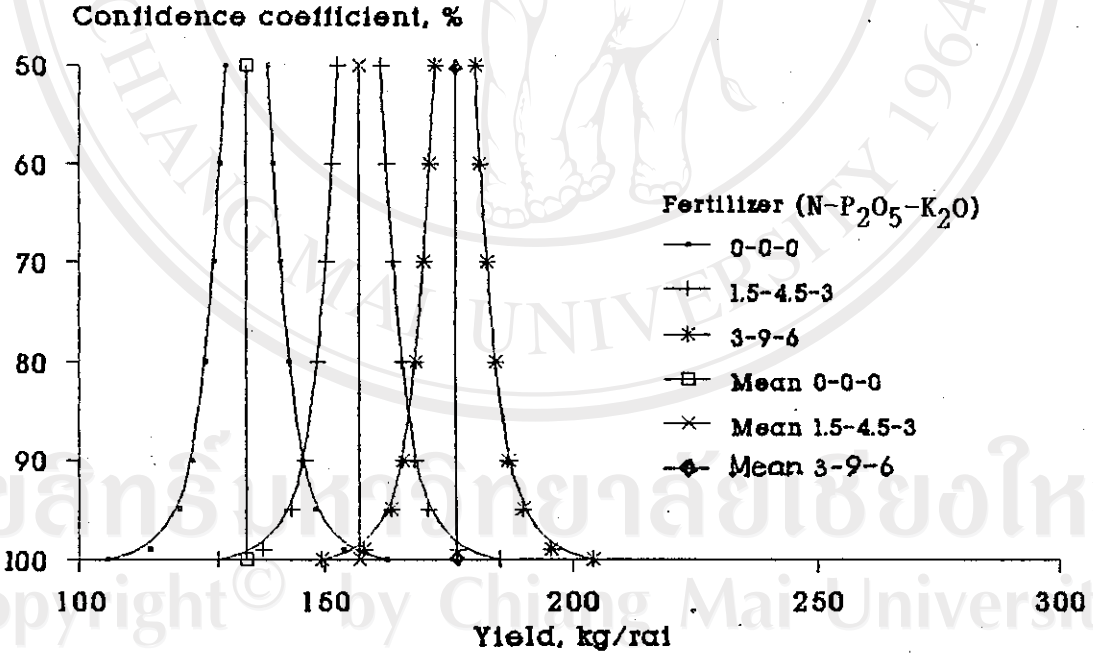

Figure 16. Distribution of confidence intervals for grain yield of SJ 5 at three rates of fertilizer application.

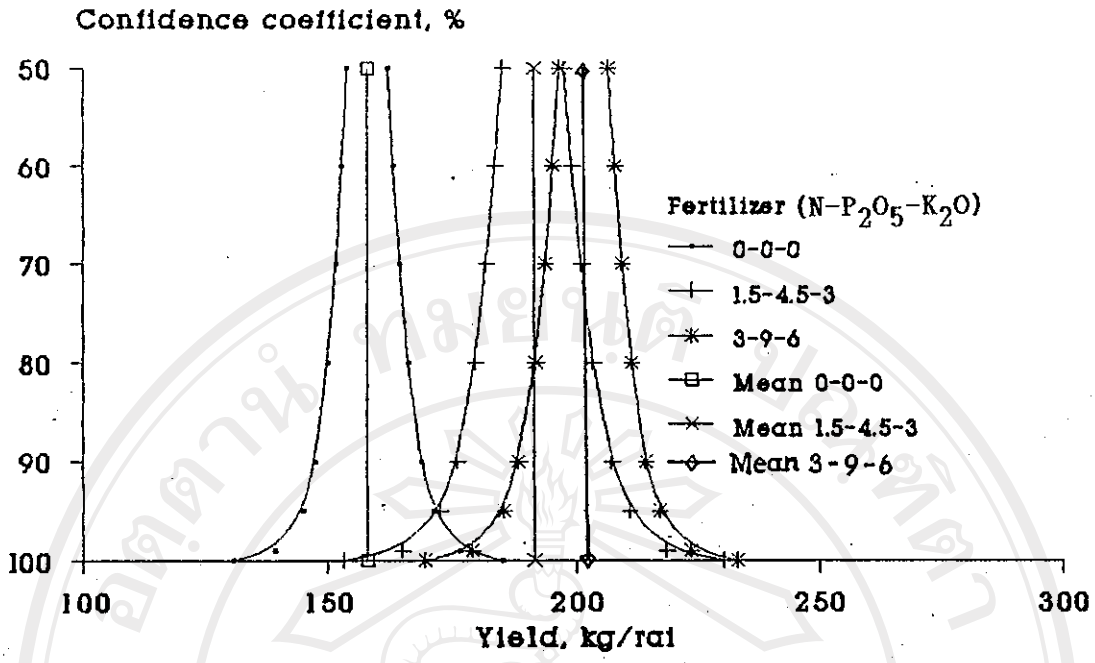

Figure 17. Distribution of confidence intervals for grain yield of CM 60 at three rates of fertilizer application