THE REPORT FOR
THE TECHNICAL CO-OPERATION PROJECT
ON MAIZE DEVELOPMENT IN THAILAND
1977-1984

JAPAN INTERNATIONAL CO-OPERATION AGENCY

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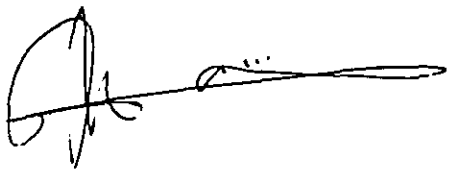
Foreword

This Project started in September, 1976 is going to terminate in September, 1984.

During the period, many activities have been done under close cooperation between Thai officials concerned and Japanese experts at the Project Center as well as in the Project areas covering six provinces.

This report was made by Japanese Experts at the final stage of the Project with the cooperation of Thai counterpart officials, thus comes the gathering of the results of those activities during the Project period.

I am very pleased if this report will be made use of for further development of this Project in the future.



Akira KASAI
Director, Resident-Representative Bangkok Office
Japan International Cooperation Agency, Bangkok

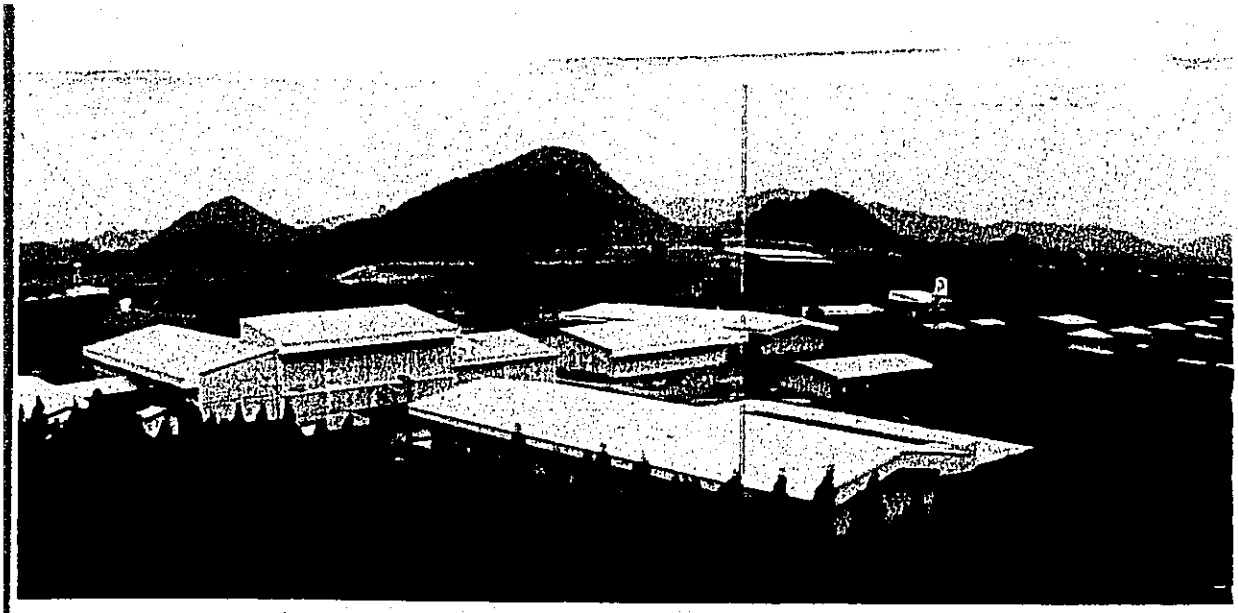
Preface

The Maize Development Project in Thailand is the technical cooperation between the Government of Japan and the Government of Thailand. The Project was initiated in order to develop and produce quality seeds of maize which will be distributed to the farmers through farmers' cooperative societies. In addition, there are various activities which are aiming at increasing members' income together with the strengthening of business operations of farmers' cooperatives in the Project areas.

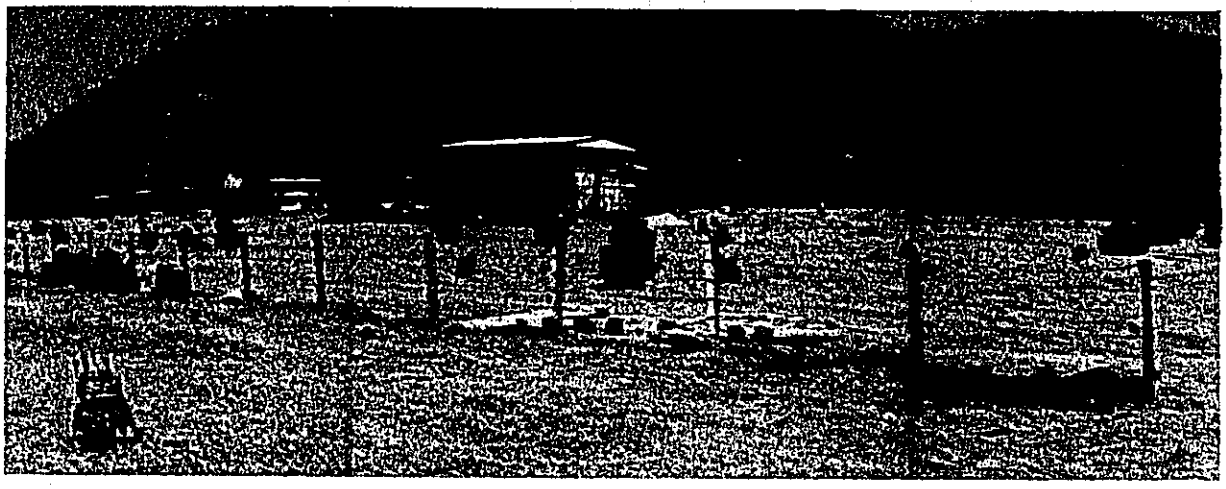
The outcome of the Project as written in this report shows that many activities have been achieved more than the set targets and some can be used as models for other projects in other areas.

The Maize Development Project has been operated for eight years. This long period of the Project has proved the most crucial factor for success in "Cooperation" among the agencies concerned, both the Japanese and Thai sides. Though, other factors such as modern technology and facilities utilized in the Project are also important but without the good cooperation of all people who earnestly work together, the target would be too far to reach. All of them, therefore, deserve much appreciation and thankfulness for the success of this Project.

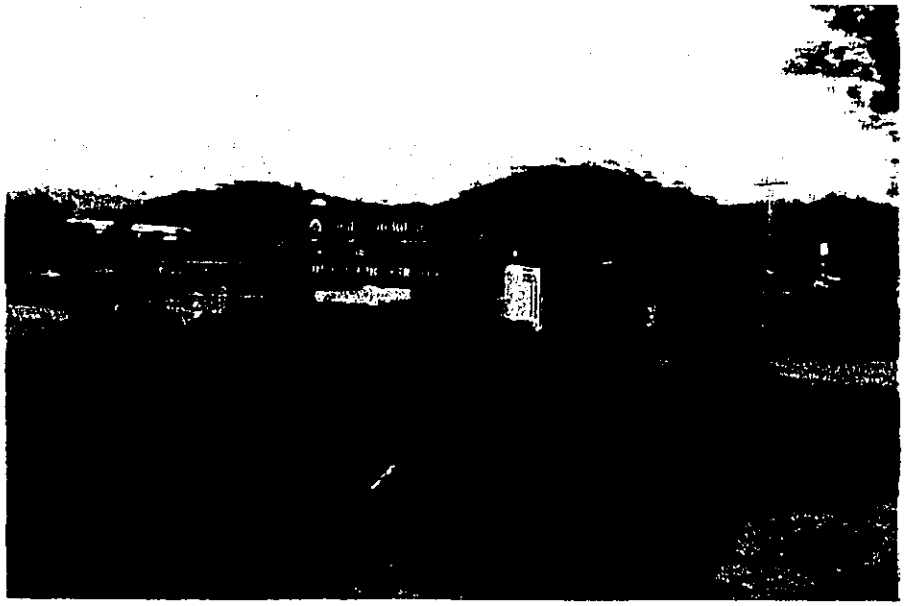
Chern Bamrungwong
Director-General
Cooperatives Promotion Department



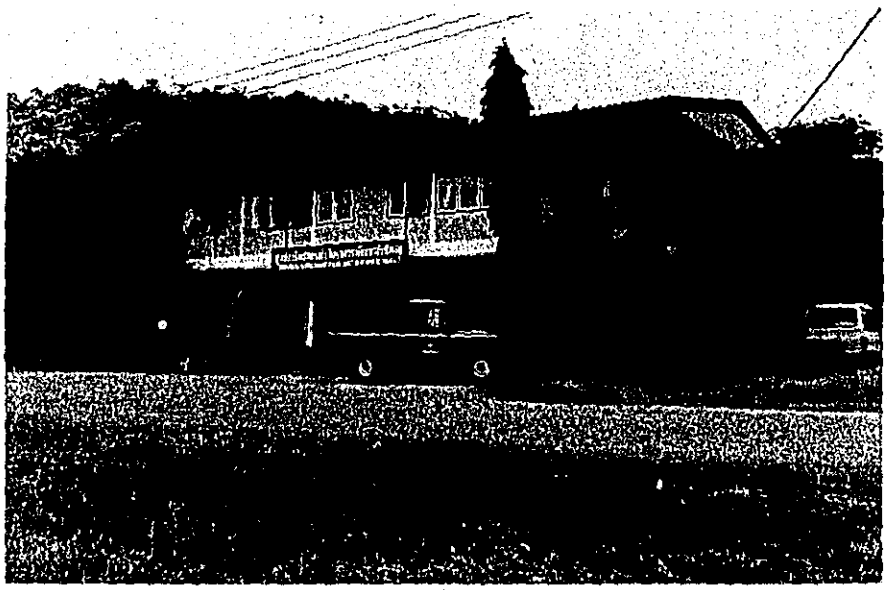
1. Project Center (Cooperatives Demonstration Center)



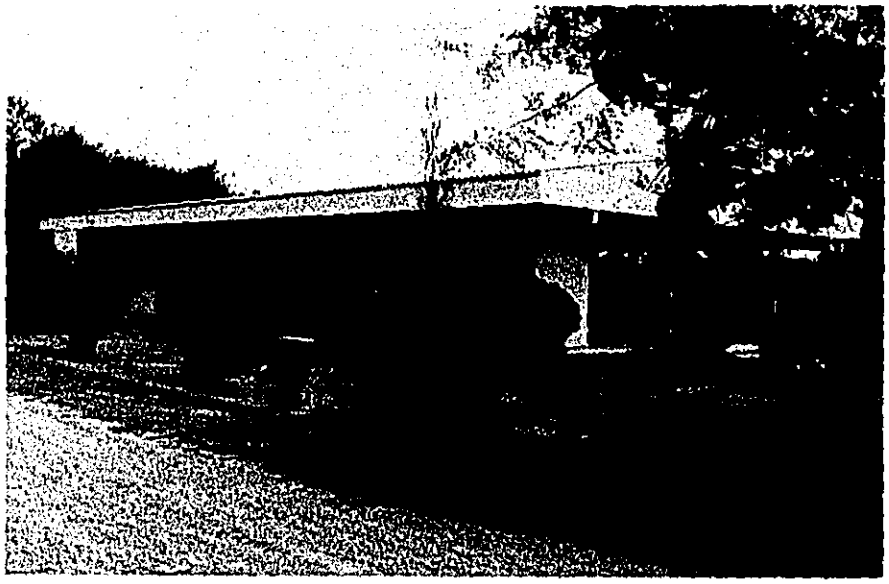
2. The Center under construction in December 1979



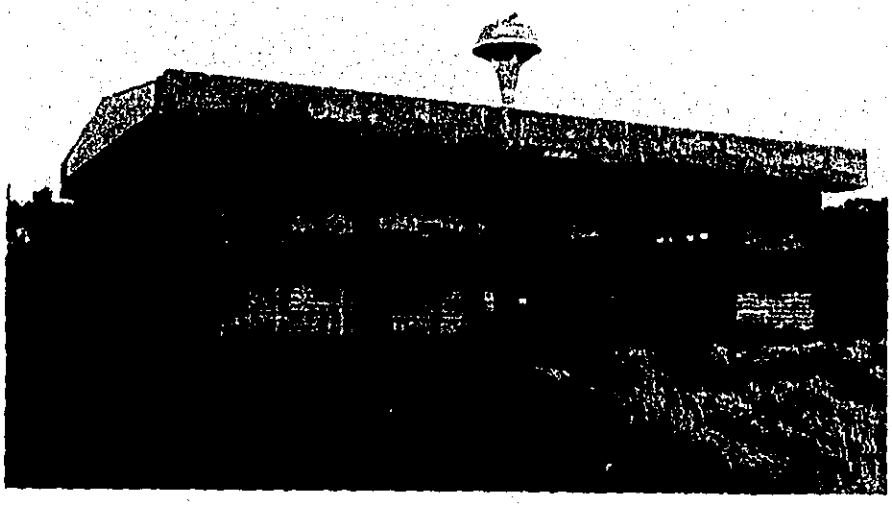
3. Entrance to the Center



4. Main office

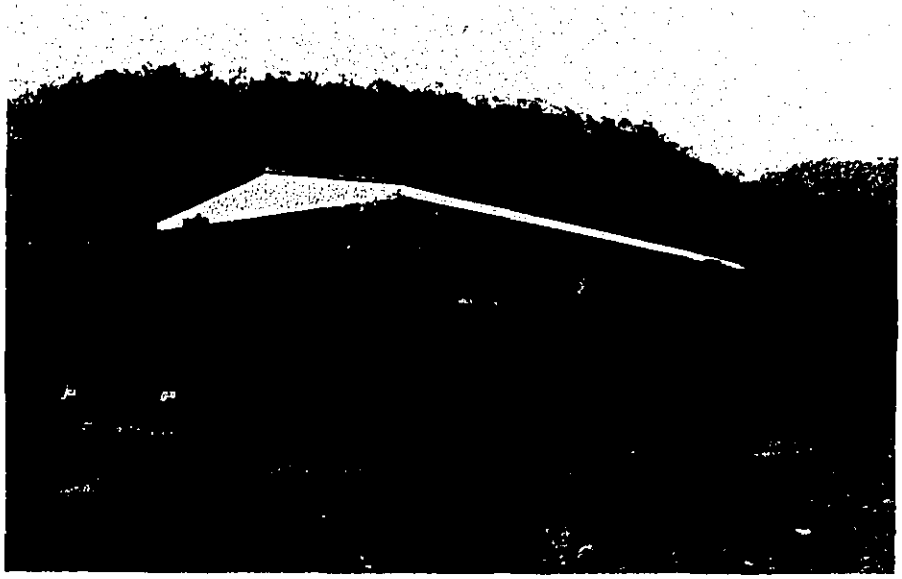


5. Auditorium

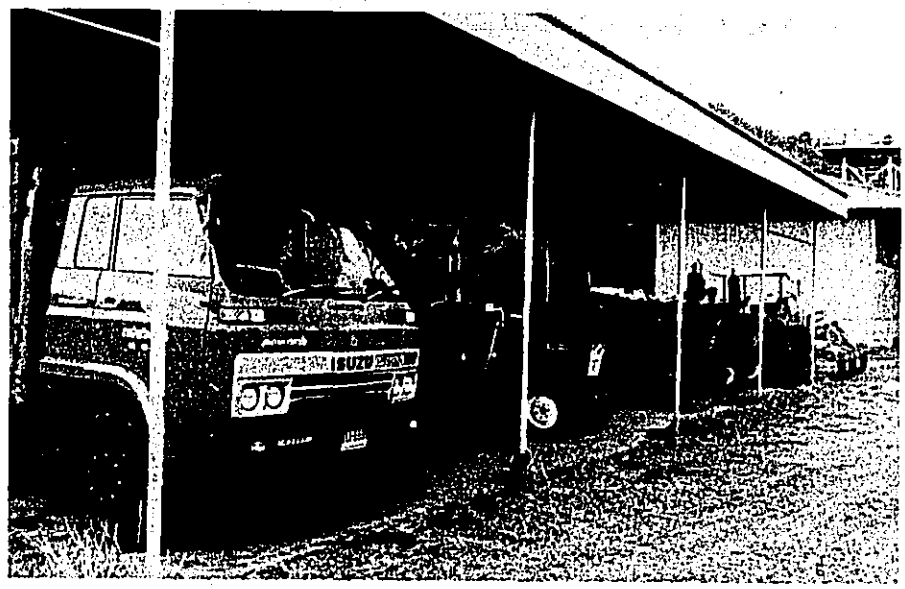


6. Work-shop

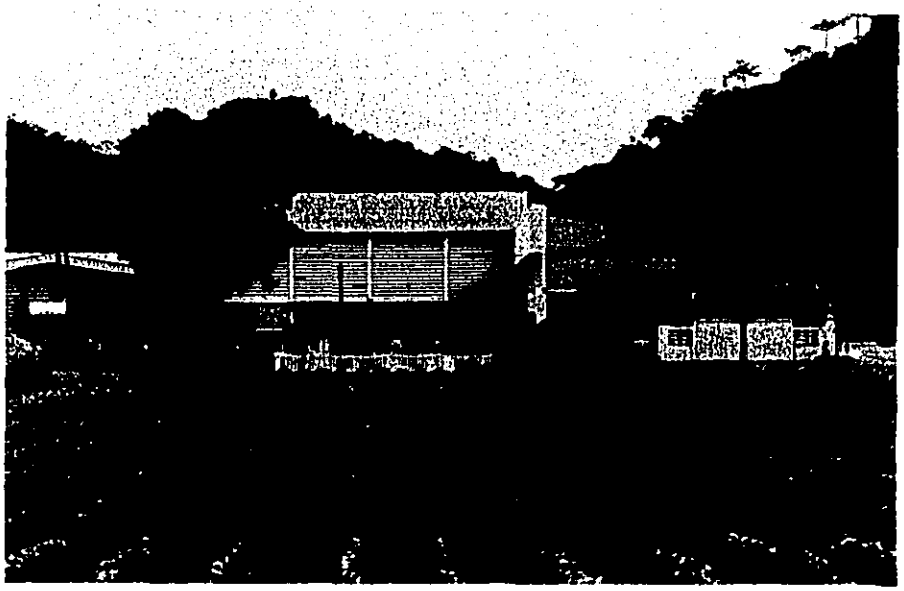
7. Dormitory

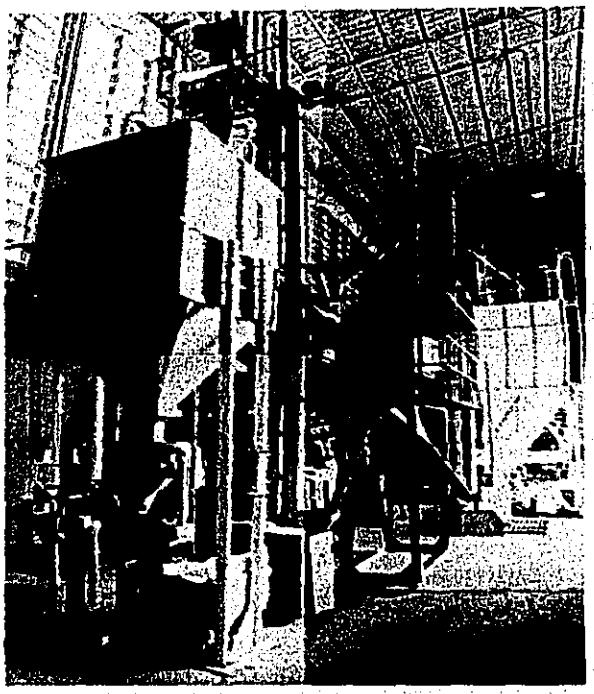


8. Agricultural machines and vehicles

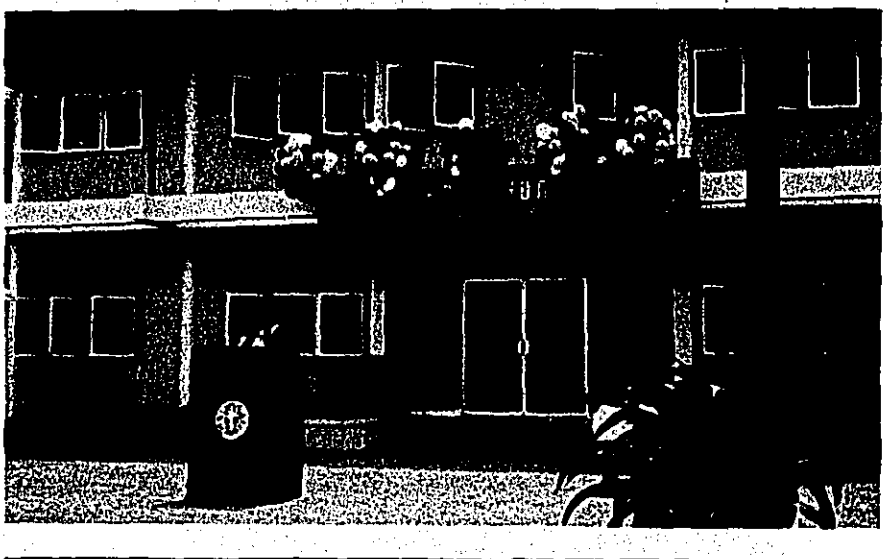


9. Seed processing plant

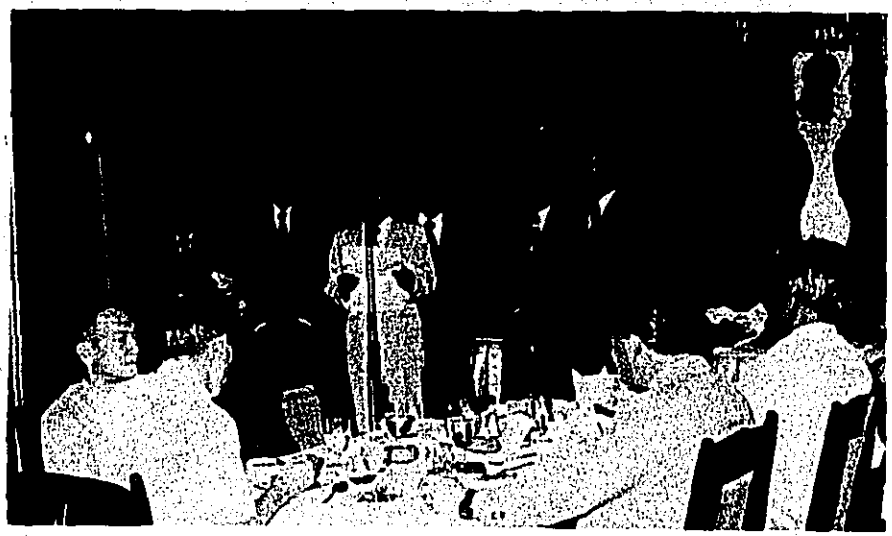




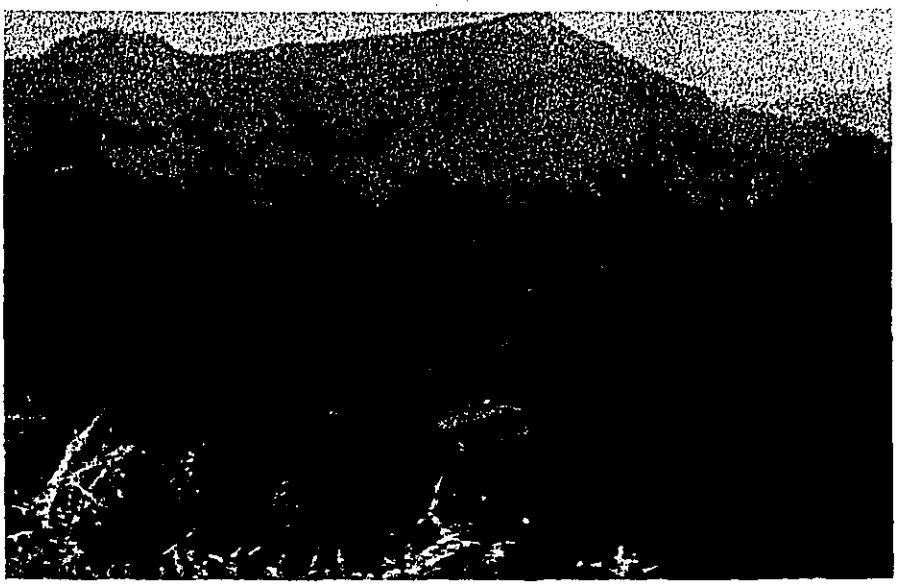
10. Seed processing plant



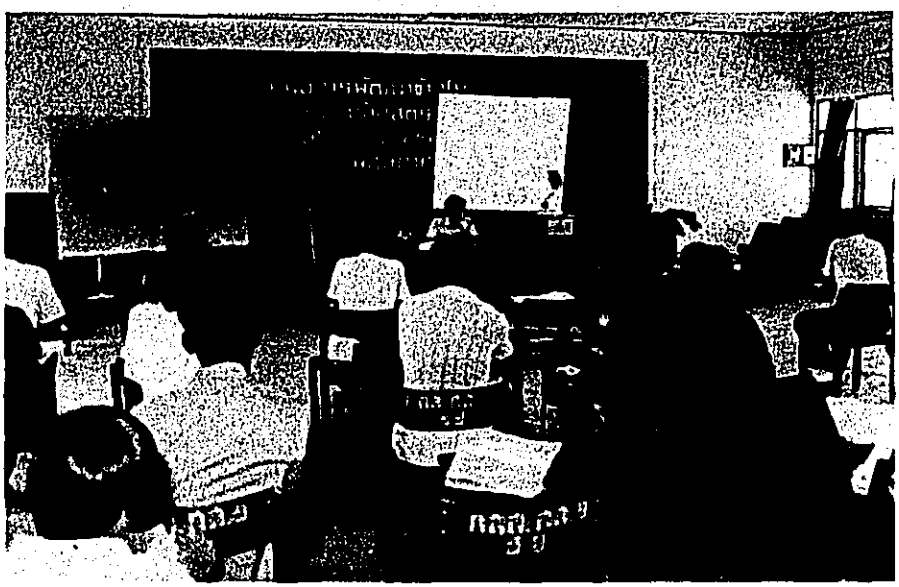
11. Thai vice minister of the Agriculture and Cooperatives on the occasion of the opening ceremony (August 17, 1979)



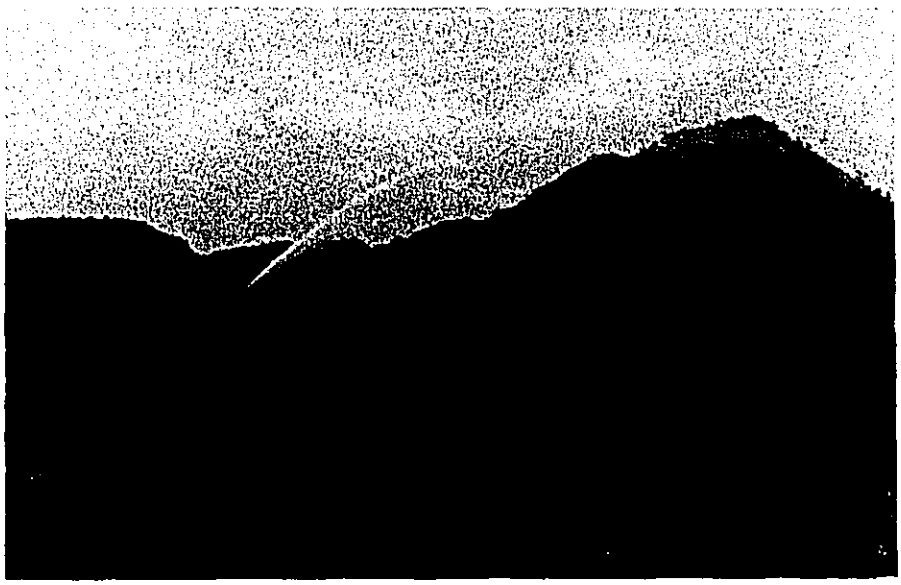
12. Japanese Experts at a ceremony on completion of the second phase of the Project (September 10, 1983)



13. Maize area in the mountains



14. Training course in session



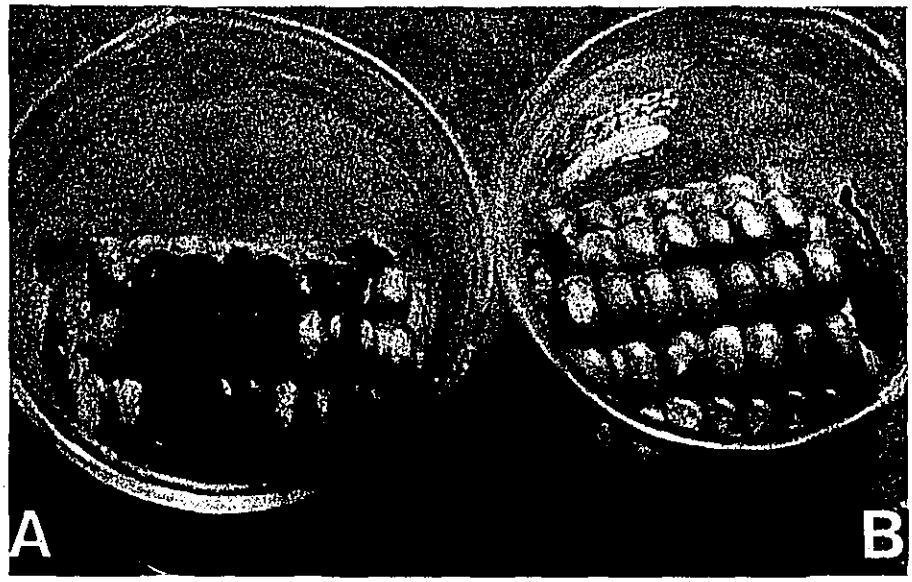
15. Experimental fields

16. Technical guidance to the farmers in the demonstration fields

17. Recommended variety of maize Suwan 1

18. The scene of competition field

19. Thai vice minister of Agriculture and Cooperatives on inspection of the Project



20. Results of inoculation experiments with *Aspergillus Flavus* on grains
A : infected (injured),
B : not infected

21. Spore production of *Aspergillus flavus* on a seed

CONTENTS

I. General Remarks

Introduction :

Yearly production of maize in Thailand which is three million tons nowadays has been achieved during the past twenty years since beginning of the 1950s from fifty thousand tons production.

This rapid expansion of maize production could be set as an example of very dramatical development of new crop productions in the world. (Figure 1.)

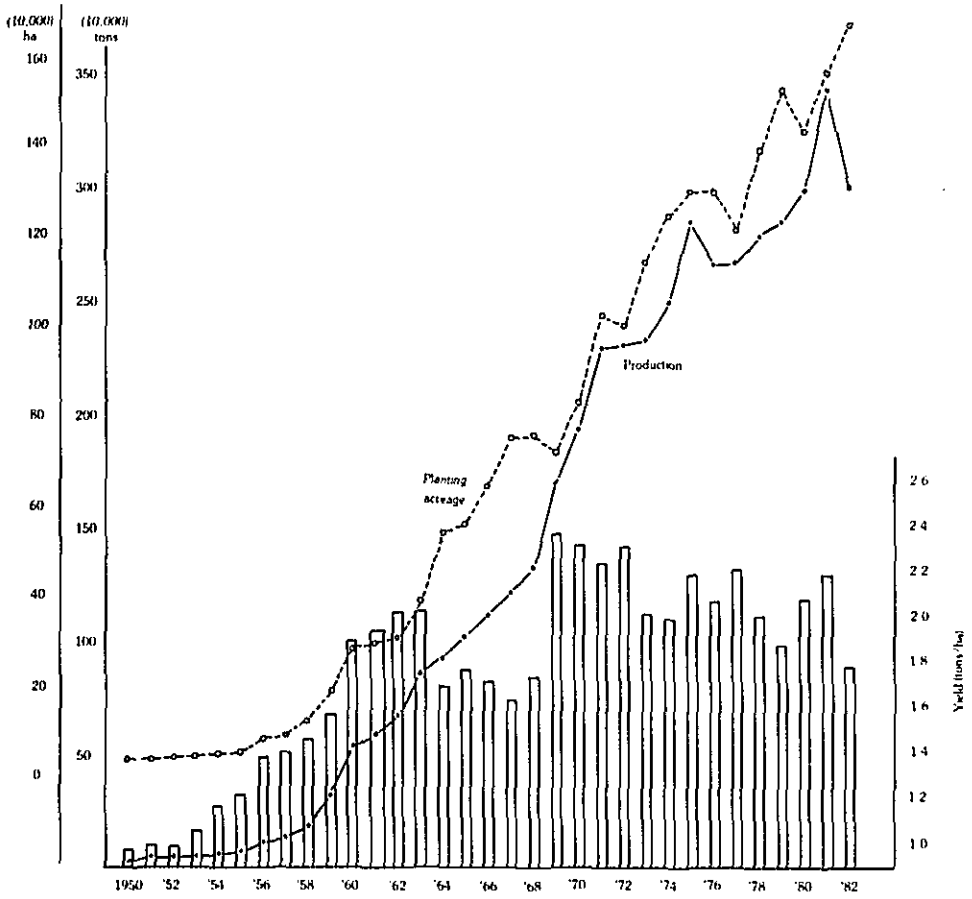


Fig. 1 The Change of Maize Production in Thailand

This production increase was caused by enlargement of planting areas as the result of new reclamation of wide arable lands in connection with the new construction of roads in forest areas.

Upon reaching the 1970s, however, accompanying with this yearly filtration of maize fields into virgin areas, newly reclaimed acreage has come to a stallmate, as well as realization of reduction of forest areas to less than 40% of whole acreage of this country.

In addition, the outbreak of diseases and insects became as a bottleneck. In full realization of this grave situation the Government of Thailand requested the Government of Japan for her cooperation to the effort of Thailand to increase maize production based on yield per unit acreage.

This Project has seen the light of day under the signing of the Record of Discussion between the Thai and Japanese Authorities on September 17, 1976. Thereby, it has been inaugurated from that very day.

Constitution of the Project:

The Project is designed to promote the productivity of maize, and contribute to the development of agricultural cooperatives and modernization of agriculture through the quality improvement of maize and its production technology.

Master Plan for the Project are as follows:

Master Plan for the Project

A. Composition of the Project:

1. The Co-operative Demonstration Center (hereinafter referred to as the "Center"), which will include fields for trials, training, seed production and demonstration, will be established in Chaibadan, Lopburi Province.

Trials, training and extension services, demonstration and other related activities in respect of technology for the improvement of maize production will be conducted at the Center.

2. For the purpose of effective extension of technical cooperation to the following five provinces, key extension bases will be established within these provinces.

Lopburi Province
Saraburi Province
Phetchabun Province
Phitsanulok Province
Sukhothai Province

(1) The following six agricultural cooperatives and five farmer's groups to be designated from each of the provinces mentioned in A2 above by the Joint Committee will be the key extension bases.

Chaibadan Agr. Coop.
Phraphutthabat Reclamation Agr. Coop.
Phetchabun Agr. Coop.
Prompiram Agr. Coop.
Nongtom Agr. Coop.
Sawankaloke Land Settlement Coop.

(2) Demonstration fields of about 13ha will be set up at each of the eight key extension bases,

excluding the Phetchabun Agricultural Cooperative, Nongtom Agricultural Cooperative and Sawankaloke Land Settlement Cooperative.

3. To ensure the smooth supply of extension seeds, seed production fields will be set up within the Center and at appropriate places in its vicinity.

The area required for the seed production fields will be approximately 100ha in the first year, 140ha in the second year and 160 ha in the third year of the Project.

B. Activities under the Project

1. Applied Experiments for Production Techniques

The following experiments will be conducted at the Center for the purpose of identification, utilization, confirmation of local adaptability and other items of specific techniques developed by agricultural experiment and research institutions.

Applied experiments for production techniques
Varieties adaptability tests
Fertilizer tests
Water management tests
Disease and insect control experiments
Cropping system experiments

2. Seed Multiplication

In collaboration with the Department of Agricultural Extension, the foundation seeds which are to be supplied by the Department of Agriculture will be multiplied to produce extension seeds at the seed production fields.

The extension seeds thus produced will be distributed to maize producing farmers in the five provinces mentioned in A2, through agricultural cooperatives and farmer's groups.

3. Disease and Insect Control

Cooperation activities of the Center will be extended to the Projects on the control of maize disease and insect which will be carried out by the Department of Agricultural Extension in the provinces mentioned in A2.

4. Extension and Demonstration

Improved cultivation techniques developed by the Center will be demonstrated at the demonstration fields mentioned in A2, and experts will conduct round trip guidance activities to promote their effective extension bases.

5. Technical Training in Seed Production and Improved Cultivation Techniques

Technical training in seed production and improved cultivation techniques will be provided at the Center for the farmers associated with the seed production fields mentioned in A3 and also for the maize producing farmers.

6. Agricultural Mechanization System

To establish a system for the mechanization of maize cultivation and to promote its extension, applied experiments for the systematization of agricultural mechanization as well as training activities for agricultural machinery operation and repair will be conducted at the Center. At the same time, the agricultural mechanization system will be demonstrated at the Center and at the demonstration fields.

7. Guidance on the Management of Agricultural Cooperatives

To develop and strengthen agricultural cooperatives and farmer's groups, staff officials of agricultural cooperatives and other personnel will be trained and educated at the Center, and experts will conduct round trip guidance activities to the key extension bases.

The project areas cover five major maize producing provinces. Nearly 50% of the total production of maize in the country has been produced in the Project area (Table 1)

Table 1 Planted area, Production and Average yield of maize in the Project area. (1979/1980)

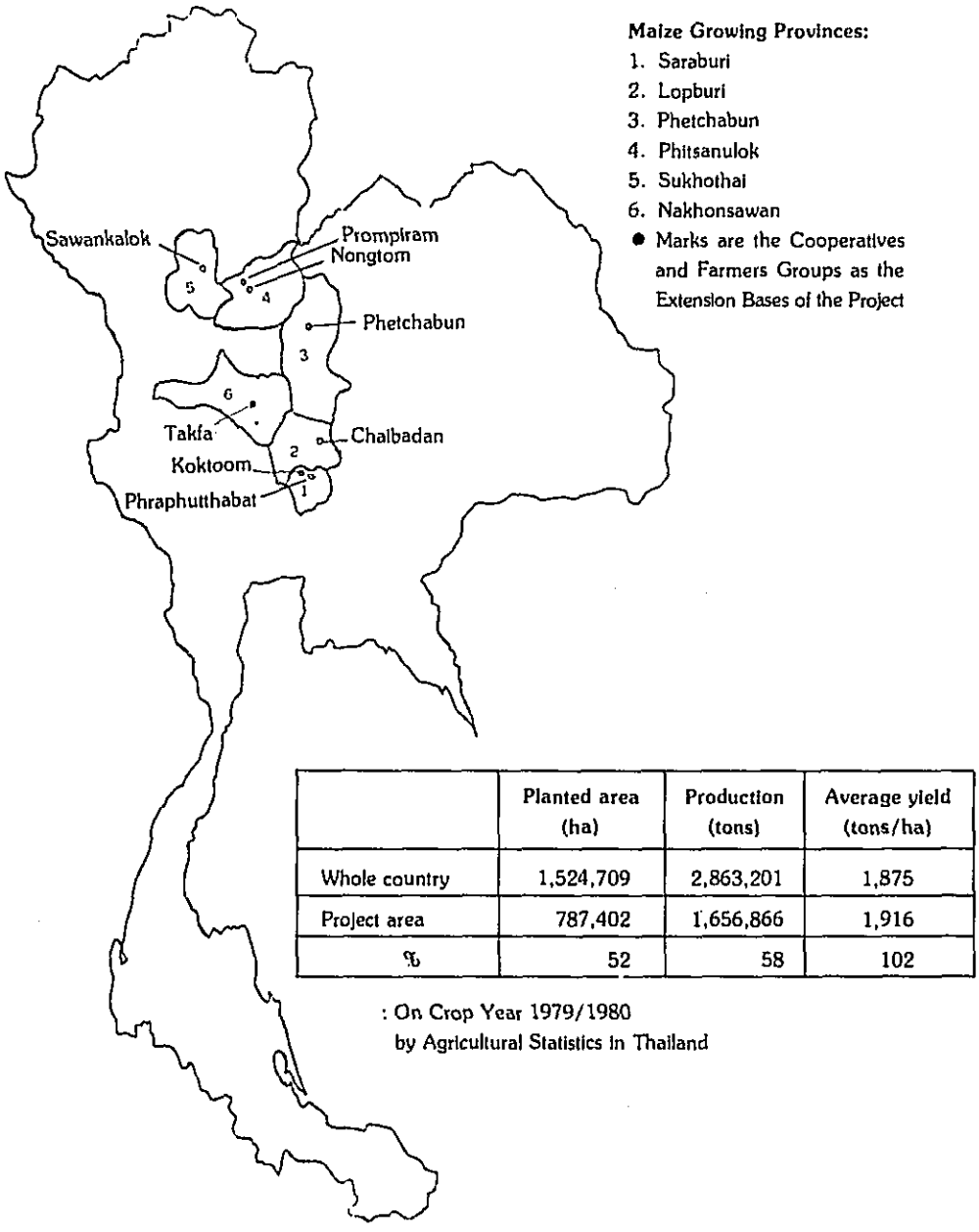
	Planted area (ha)	Production (tons)	Average Yield (kgs/ha)
Saraburi Province	106,567	205,142	1,925
Lopburi Province	155,916	333,267	2,138
Phetchabun Province	265,308	628,448	2,356
Phitsanulok Province	58,239	105,198	1,806
Sukhothai Province	17,489	22,845	1,306
Nakhonsawan Province	183,883	361,966	1,969

Following the decrease of maize area in the northern extension bases, three Cooperatives and five Farmers Groups were enrolled into the Project area as the new extension bases from 1982. They are as follows:

Lopburi Province	Koksamrong Agricultural Cooperative
	Koktoom Agricultural Cooperative
	Yongtone Farmers Groups
Nakhonsawan Province	Takfa Agricultural Cooperative
Saraburi Province	Hinsond Farmers Group

Phetchabun Province	Submaidang Farmers Group
Phitsanulok Province	Ta-Ngam Farmers Group
Sukhothai Province	Ta-Chai Farmers Group

There are shown as in Figure 2:



	Planted area (ha)	Production (tons)	Average yield (tons/ha)
Whole country	1,524,709	2,863,201	1,875
Project area	787,402	1,656,866	1,916
%	52	58	102

: On Crop Year 1979/1980
by Agricultural Statistics in Thailand

Fig. 2 Location of each Extension Base

Progress of the Project:

The first budget on the Project was approved for the fiscal year in 1978 (from September 1977 to October 1978), based on ordinal procedure of budget allocation in Thailand. This budget was limited to only construction expenses of the Center.

After many negotiations, the Project site for the Cooperatives Demonstration Center was decided at Ban Koktoom in Muang District of Lopburi Province in May, 1978 in stead of Chaibadan District stipulated by the R/D in 1976.

The construction of the Center started in April 1978, and it was almost completed in August 1979 with the completion of main buildings and installation of equipment and materials for the implementation of the Project.

The Opening Ceremony of the Center was held in the presence of the respresentatives of both Governments and a large number of farmers in the vicinity of the Center on 17th August 1979.

After the Opening Ceremony, period of the Project was extended to 3 years in accordance with the agreement of Extension Note signed between two countries on 16th August, 1979.

During the next three years extension, implementation of the Project was extended into full operations in every field and achieved targets in many fields set up in the R/D in 1976.

Before the termination of the Project period after three years, evaluation of the Project was carried out by the Evaluation Mission from Japan in July 1982.

The team concluded the results of evaluation on the Project after its observations on each activity and made a recommendation to both Governments as follows:

The Project as a whole made good progress as planned in the original Master Plan. Moreover, some activities which were not envisaged in the original Master Plan were carried out with success. The team considered that the Project should be continued basically on the same organization. On that assumption, the team recommends that the following activities should be continued as priority activities for Japanese Cooperation.

1. The applied experiments which are not completed and some experiments started recently due to the new needs, such as post-harvest quality control.

2. Technology transfer on operation, maintenance and repair of seed processing plant in the Center.

3. Yield Competition.

4. Mobile unit training on mechanisation and the technology transfer in operation of workshop in the Center.

Following the recommendation, the Project was extended another two years follow-up type cooperation.

During this cooperation period, Project activities have been carried out on every field same as before with the close cooperation between Japanese Experts and Thai counterpart officials.

The Cooperatives Demonstration Center was located in Phraphutthabat Land Settlement area at Tombon Koktoom, Muang District, Lopburi Province and next to the Phraphutthabat Field Crop Experiment Station approximate 150 km from Bangkok, It is shown in Fig. 3 and 4.

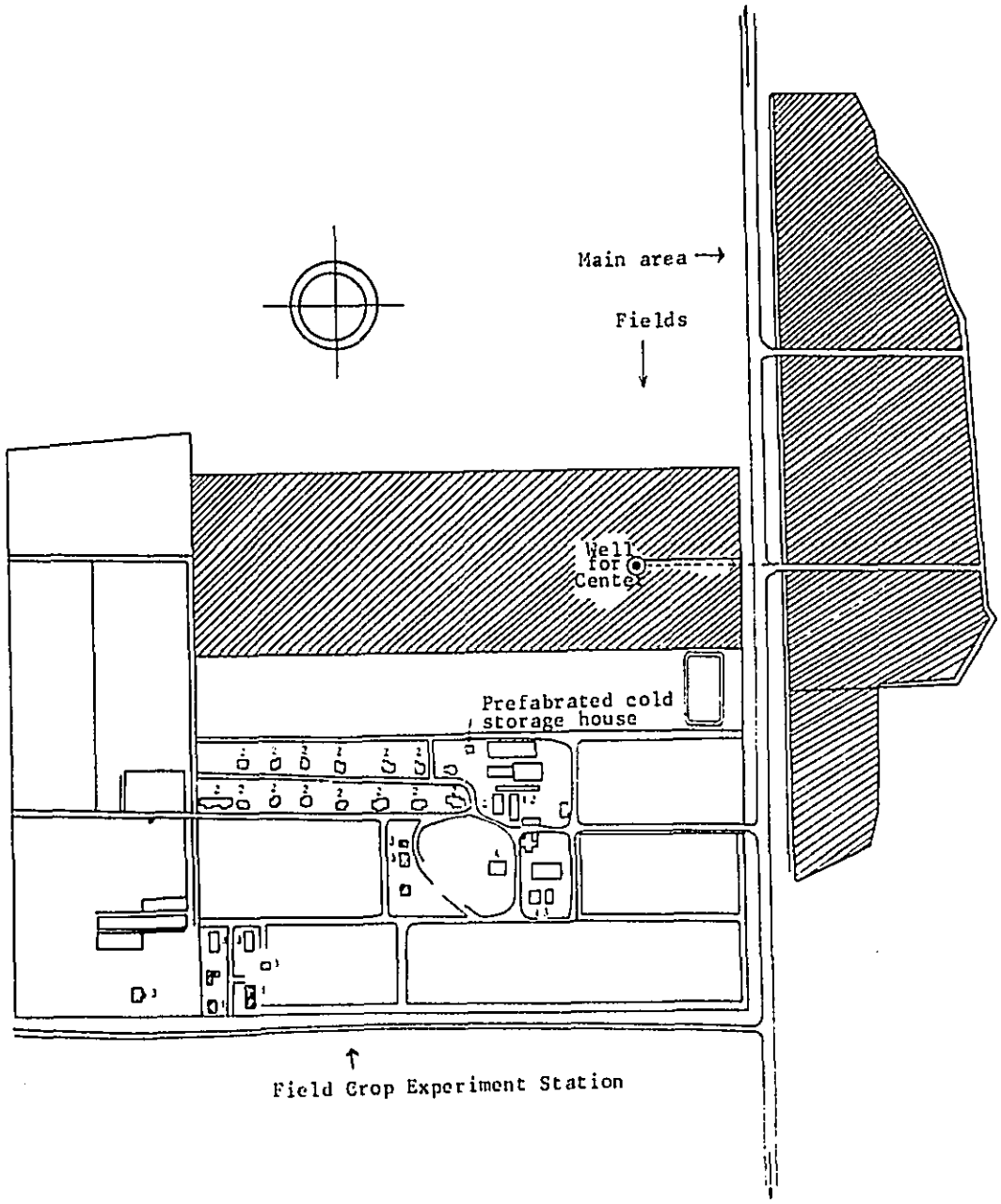


Fig. 3 Location of the Center (Portions oblique line), a scale of 1 to 2000

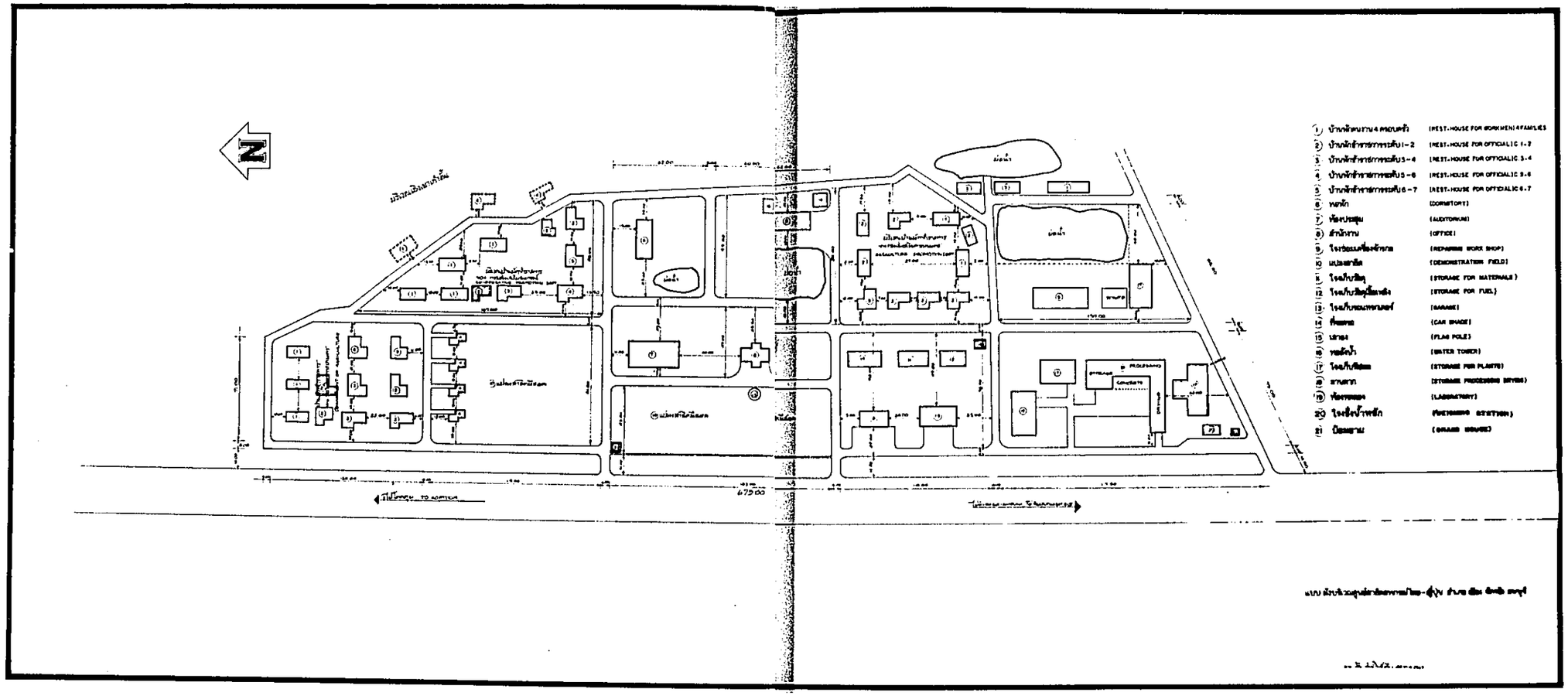


Fig. 4 Placement of buildings at the Center

It was situated 100° 50' of the east longtitude, 14° 47' of the north latitude, and about 16 hectares of flat land included 6 hectares of field. Soil of fields was clay loam and belong to Reddish Brown Lateritic type of Pakchong series. According to data of the Phraphutthabat Experiment Station in 1979, soil texture comprised from 18.2% of clay, 30.4% of silt, 35.6% of coarse sand and 15.9% of fine sand. The component of nutrient in soil was 6.7 of PH, 0.72% of organic matter 0.077% of phosphoric acid and 0.063% of Potassium.

Administration System:

This Project is an attempt to integrated activities of agricultural and cooperative development. There are three Departments under the Ministry of Agriculture and Cooperatives in charge of implementing this Project as follows:

The Cooperatives Promotion Department is responsible for the administration and management of this Project in close cooperation and collaboration with the Departments concerned as well as to take responsibility directly to conduct the activities in extension and demonstration, training, agricultural mechanization system, guidance on the management of agricultural cooperatives, maintenance and repairing of agricultural machinery and equipment.

The Department of Agriculture is responsible for conducting the activities in applied experiments for production techniques and quality control as well as to produce foundation seed of good varieties to apply to the Department of Agricultural Extension for seed multiplication activity. This Department also provides technical assistance in extension and demonstration, and training activities.

The Department of Agricultural Extension has the responsibilities for seed multiplication and insect and disease control, cooperation and collaboration with this Department in extension, demonstration and training activities are also created.

The administration chart is shown in Fig. 5.

Plan of Operation:

The Project has been implemented in accordance with the annual operational work plan to be formulated annually by the Joint Committee which is comprised of representatives from both countries.

The Steering Committee which was comprised of almost the same members of the Joint Committee on Thai side and Japanese Experts has been held every three months for checking and steering the Project activities from more practical viewpoint.

Furthermore, the Sub-Committee meeting has also been held once a month for handling Project from the practical viewpoint. It was also named as Working Groups Committee, and it was comprised of Japanese Experts and Thai counterpart officers.

The Plan of operation from 1978 to 1984 of the Project is shown as Fig. 6.

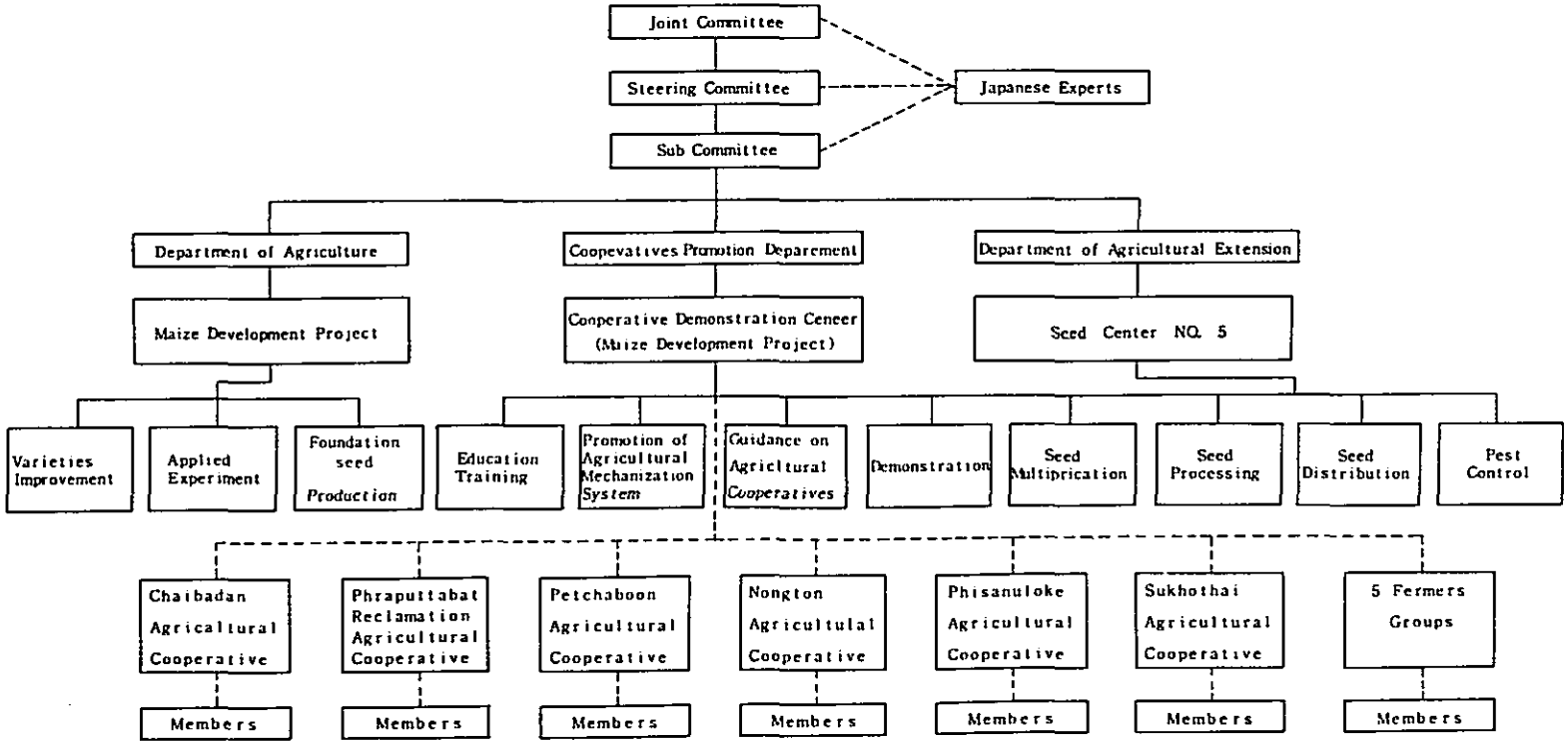
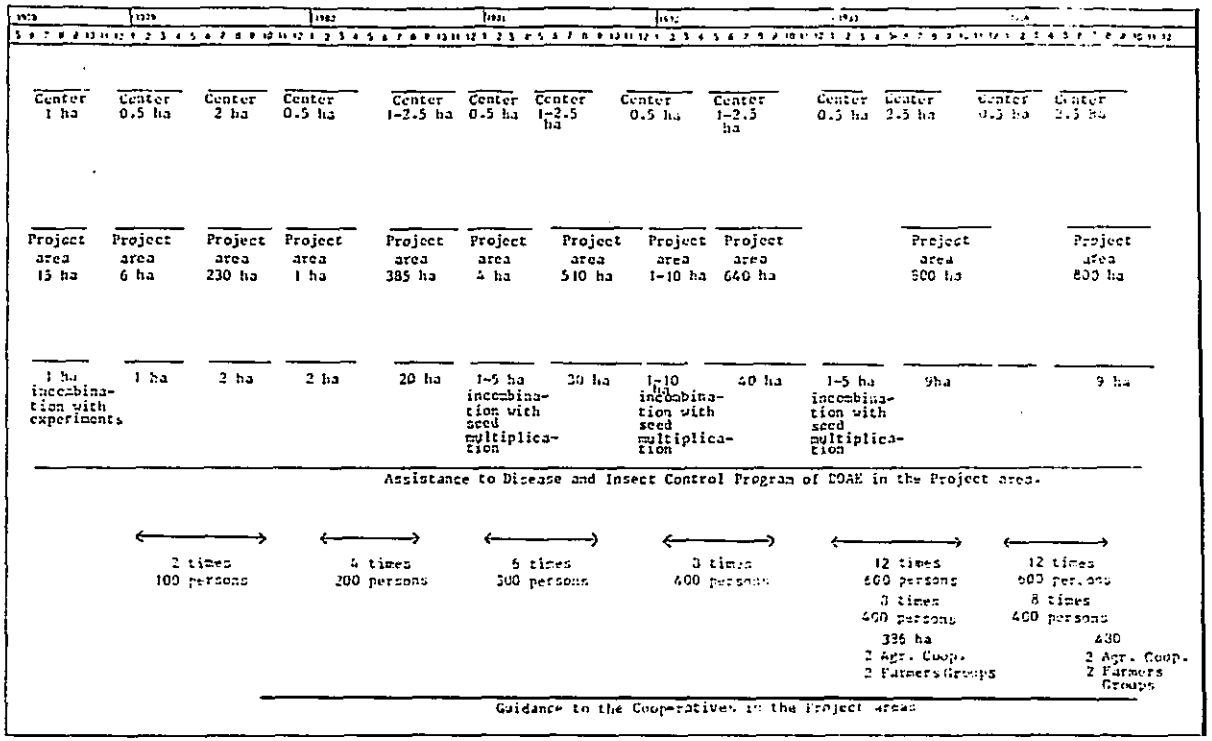


Fig. 5 Administration Chart of the Maize Development Project in THAILAND

1. Applied Experiment
   - 1.1 Varietal Test
   - 1.2 Cropping Pattern
   - 1.3 Planting Time
   - 1.4 Fertilizer Test
   - 1.5 Weed Control
   - 1.6 Mechanized Cultivation
   - 1.7 Irrigation Method
2. Seed Multiplication
   - 2.1 Foundation Seed Production
   - 2.2 Selection of Contract Farmer Project area
   - 2.3 Technical Advice to the Farmer
   - 2.4 Seed Processing
   - 2.5 Seed Distribution
3. Extension and Demonstration
   - 3.1 Demonstration on Maize Cultivation
   - 3.2 Yield Competition
4. Disease and Insect Control
5. Training
   - 5.1 At the Center
   - 5.2 In the Project area by Mobile unit
6. Farm Machinery Services
   - 6.1 Planning and Shelling
   - 6.2 Guidance for Machinery
7. Guidance on Cooperative Activities



Foundation seed shall be provided by DA. 1979 year 10 tons, 1980 year 13 tons, 1981 year 16 tons, 1982 year 20 tons and 1983 year 20 tons.

Fig. 6 Plan of operation (1978 – 1984)

II. Results of the Project Activities

1. Applied Experiment

The experiment has been in effect at the Center and farmer's fields for the purpose of identification, utilization, confirmation of local adaptability and items of specific techniques developed by agricultural experiment and research institutes. The titles of these experiments and integrated conclusion are as follows:

Expt. no.	Title
A – 1	Maize varietal test for the rainy season.
A – 2	Maize varietal test for the dry season.
A – 3	Maize varietal test for the dry season.
B – 1	Time of planting on maize.
B – 2	Time of planting on maize.
C – 1	Plant population trial.
C – 2	Plant population trial on the different maize varieties.
D – 1	Fertilizer test, nitrogen and phosphate fertilizer on yield of maize.
D – 2	Fertilizer test, time of application of compound fertilizer on maize yield.
D – 3	Fertilizer test, study on yields of maize and succeeding crops with manure and chemical fertilizer.
D – 4	Fertilizer test, effect of the different quantity of fertilizer on the grain yield of maize under the present cost of maize and fertilizer.
E – 1	Cropping system, comparison of different planting patterns for maize – mung bean intercropping.
E – 2	Cropping system, a study on the effect of crop rotation on yield of maize, on Reddish Brown Lateritic Soil.
F – 1	Water management test, irrigation in ralation to higher yield of maize.
F – 2	Water management test, comparison of different frequencies of irrigation and use of paddy-straw mulch on maize yield.
F – 3	Water management test, effect of water conservation on maize grain yield during the rainy season.
F – 4	Water management test, a study on the effects of intensive irrigation on the tasseling and pollination period of maize.

G – 1 Seed germination test, a primary study of influence of different ways and means of storing maize seed on its germination.

H – 1 Subsoiling test, a study on the effects of subsoiling treatment on yield of maize.

Integrated conclusion

Problems and some aspect of improved techniques on maize cultivation in Thailand.

A – 1 Maize varietal test for the rainy season

To determine a suitable variety of maize for this area.

Materials and Methods

1. **Time of planting** : The planting date was May 15, 1978.
2. **Varieties** : Four varieties which consisted of Composite Suwan # 1, Thai DMR # 6 and Pakchong # 1602 and Local variety Gatemala were tested.
3. **Design** : Split plot in randomized complete block design, with three replications was used.
4. **Plot size** : Plots were 10 m in length with 5 rows. The spacing was 80 × 25 cm with 1 plant per hill, or at a rate of 50,000 plants per ha.
5. **Treatment:**

Main-plot (Fertilizer)	F 1	Fertilizer 125:125:0 (N:P:K) kg/ha
	F 0	Non fertilizer
Sub-plot (Variety)	V 1	Suwan # 1
	V 2	Thai DMR # 6
	V 3	Pakchong # 1602
	V 4	Gatemala

6. **Fertilizer application:** A fertilizer grade of 20:20:0 (N:P:K) at the rate of 312.4 kg/ha was applied in rows at two weeks after planting. An additional application of 312.4 kg/ha was side dressed when the plants were at the knee-high stage.
7. **Soil** : Soil classification is red-brown earth. Parent material is residuum from limestone. Profile description is as follows: 0 – 20 cm, reddish-brown light clay.

Results and Discussion

Due to a delay in planting, the experiment suffered from a shortage of rainfall in June (the critical growing stage of this maize)

Moreover, the soil in the plots was inadequate for normal maize growing, owing to the new arable land which was reclaimed just before planting. It seems that these yield-limiting factors did not have a good effect on the grain yield.

Grain yield (kg/ha) at 15% moisture content and some agronomic characteristics for the four maize varieties are presented in Tables 2 and 3.

A highly significant difference in the mean grain yield was found between non-fertilized and fertilized plants. The mean yield for the fertilized plants was 2,422 kg/ha while that of the non-fertilized plants was only 1,329 kg/ha.

Suwan # 1 gave the highest mean yield (2,008 kg/ha), but its yield was not significantly higher than the other composite varieties such as DMR # 6 and Pakchong # 1602. The local variety (Gatemala) gave the lowest mean yield (1,710 kg/ha) which was lower than the three composite varieties mentioned, but its yield was not significantly lower than the composite Pakchong # 1602.

Table 2 Grain yield at 15% moisture, kg/ha

Fertilizer	Varieties				Mean
	V1	V2	V3	V4	
F 0	1326	1401	1303	1287	1329.3
F 1	2654	2512	2389	2133	2422.0
Mean	2008.0	1956.5	1846.0	1710.0	

	L.S.D. .05	L.S.D. .01	C.V. %
Main-plot	284.8	657.2	13.6
Sub-plot	173.8	244.3	12.3

Table 3.

Table 3 Grain yield and other agronomic characteristics on different maize varieties, 1978 rainy season.

Fertilizer	Variety	Grain yield in 15% moist (kg/ha)	Relative to check %	Days to 50% silking	"Maturity" in days	Height(cm)		Lodging		Length(cm)		Ear diameter (cm)	No.of kernels		1000 kernel weight (g)
						Plant	Ear	Stalk (%)	Root (%)	Cob	Ear		Row	in Row	
	Suwan # 1	2654	124.4	55	116	188.1	102.3	5.7	23.3	17.5	15.5	4.3	31	13	323.4
125:125:0	Thai DMR # 6	2512	117.7	58	116	232.5	127.5	4.8	24.2	19.3	17.3	4.3	34	13	365.1
(N:P:K) kg/ha	Pakchong # 1602	2389	112.0	59	116	250.1	147.3	7.8	23.3	17.9	15.5	4.1	31	13	326.9
	Gtatemala	2133	100	.60	116	233.8	128.8	8.0	24.9	16.9	14.7	4.0	29	13	319.2
	Suwan # 1	1326	103.0	56	116	171.1	87.8	8.0	26.7	13.6	10.9	3.8	22	13	257.6
Non	Thai DMR # 6	1401	108.8	60	116	187.0	101.5	4.8	30.5	15.7	13.3	3.7	26	12	294.3
	Pakchong # 1602	1303	101.2	60	116	210.8	118.1	4.4	23.2	14.9	12.3	3.6	24	12	259.8
	Guatemala	1287	100	62	116	213.5	121.1	2.2	30.6	15.6	12.1	3.7	22	12	276.7

A – 2 Maize varietal test for the dry season

To determine a suitable variety of maize for the dry season.

Materials and Methods

1. **Time of planting:** November 16, 1978.
2. **Varieties:** Four varieties consisting of composite Suwan # 1, Thai DMR # 6, Pakchong # 1602 and the local Guatemala variety.
3. **Design:** Split plot in randomized complete block design, with three replications.
4. **Plot size:** Plots were 10m in length with 5 rows. The spacing was 80 × 25 cm with 1 plant/hill (a rate of 50,000 plants/ha)
5. **Treatment:**

Main-plot (Fertilizer)	F 1	Fertilizer 125:125:0 (N:P:K) kg/ha
	F 0	Non fertilizer
Sub-plot (Variety)	V 1	Suwan # 1
	V 2	Thai DMR # 6
	V 3	Pakchong # 1602
	V 2	Guatemala

6. **Fertilizer Application:** A fertilizer grade of 20:20:0 (N:P:K) at the rate of 312.4 kg/ha was applied in rows two weeks after planting. An additional application of 312.4 kg/ha was side dressed when the plants were at the knee-high stage.
7. **Irrigation:** Approximately 70 mm of irrigation water was applied at each application at about 10-day intervals during growing stage.

Results and Discussion

Grain yield (kg/ha) at 15% moisture content and some agronomic characteristics for the four maize varieties and presented in Tables 4 and 5.

A highly significant difference in the mean grain yield was found between non-fertilized and fertilized plants. The mean yield for the fertilized plants was 4,776 kg/ha while that of the non-fertilized plants was only 2,170 kg/ha.

Pakchong # 1602 gave the highest mean yield (4,006 kg/ha), but its yield was not significantly higher than the other composite variety Suwan # 1. The local variety (Guatemala) gave the lowest mean yield (2,948 kg/ha) which was lower than the three composite varieties mentioned above, but its yield was not significantly lower than the composite Thai DMR # 6. Interactions among fertilizer levels and varieties was non-significant.

Table 4 Grain yield at 15% moisture, kg/ha

Fertilizer	Varieties				Mean
	V1	V2	V3	V4	
F 0	2258	1942	2663	1820	2170.7
F 1	5257	4424	5349	4077	4776.7
Mean	3757.5	3183.0	4006.0	2948.5	

	L.S.D. .05	C.V. %
Main-plot	1553	25.4
Sub-plot	497	11.3

F 1 = Non-fertilizer
F 1 = 125:125:0 (N.P.K.)kg/ha

V 1 = Suwan# 1 V 3 = Pakchong # 1602

V 2 = Thai DMR # 6 V 4 = Guatemala

Table 5 Grain yield and other agronomic characteristics with regards to different fertilizer applications and maize varieties, 1978/1979 dry season.

Fertilizer	Variety	Grain Yield in 15% moisture (kg/ha)	Relative to check %	Day to 50% Silking	Height(cm)		Lodging		Length(cm)		Ear diameter (cm)	No.of kernels		1000 kernel weight (g)
					Plant	Ear	Stalk	Root	Cob	Ear		Row	in Row	
125:125:0	Suwan# 1	5257	129	60	173	86	4.7	3.1	17.1	14.5	4.6	14	28	288
(N:P:K:) kg/ha	Thai DMR # 6	4424	109	64	179	91	9.5	6.1	16.9	15.0	4.2	13	32	246
	Pakchong # 1602	5349	131	63	189	95	4.0	8.3	16.9	15.4	4.6	13	30	294
	Guatemala	4077	100	66	210	118	3.7	5.9	16.4	14.3	4.3	14	28	239
Non	Suwan # 1	2258	124	66	138	63	0.6	2.4	13.0	10.9	3.7	12	19	235
	Thai DMR # 6	1942	107	70	140	66	2.5	3.3	13.3	11.3	3.5	12	19	196
	Pakchong # 1602	2263	146	67	147	69	2.5	2.6	13.6	11.6	3.8	12	20	273
	Guatemala	1820	100	73	152	73	1.7	3.6	13.1	10.9	3.7	12	20	202

* No Downy Mildew infection was found in all plots.

A – 3 Maize varietal test for the dry season

The experiment was conducted to know the adaptability, yielding ability and agronomic characteristics of the four varieties of maize (composite Suwan # 1, # 2, hybrid Pioneer XI93 and Hycorn 9) which were tested. Split plot in randomized complete block design was statistically employed in the two fertilizer treatments (0:0:0 and 60:60:0 kg/ha of N:P:K) and replicated four times. Plots were 10 m in length with 5 rows. The spacing was 80 x 25 cm with 1 plant per hill, or at a rate of 50,000 plants per ha. Approx. 450 mm of overhead irrigation water was applied through the growing period of maize. The planting date was December 29, 1980.

Grain yield (kg/ha) at 15% moisture content and some agronomic characteristics for the four maize varieties under the two fertilizer treatments are presented in Table 6. Analysis of variance indicated no significant differences among the mean yield of different varieties and different fertilizer treatments.

Table 6 Mean grain yield and several agronomic characteristics of Thai maize varieties at Maize Development Project Center for the 1980/1981 dry season.

Variety & Fertilizer	Grain yield in 15% moist. (kg/ha)	Relative to check (%)	Days to 75% Tass.	Days to 75% Silk	Maturity	Height Plant (cm)	Height Ear (cm)	Lodging Root (%)	Lodging Stalk (%)	Ear Length (cm)	Ear Diameter (cm)	No. of kernals per ear	1000 kernels weight(g)
Composite:													
Suwan 1													
Non-Fert.	2191	100	60	66	108	183	90	3.2	4.6	12.4	4.0	373	254
Fertilizer	3030	138	58	64	106	188	97	3.8	11.9	14.0	4.3	456	235
Composite:													
Suwan 2													
Non-Fert.	1976	90	54	57	97	159	64	2.8	7.5	12.4	4.0	372	246
Fertilizer	2600	118	53	56	96	161	72	2.6	5.2	12.2	4.2	382	254
Hybrid:													
Pioneer X193													
Non-Fert.	2907	132	60	64	106	160	87	1.7	4.0	12.1	4.3	361	268
Fertilizer	3452	157	58	62	104	166	93	0.9	4.5	13.0	4.4	428	268
Hybrid:													
Hycorn 9													
Non-Fert.	2745	125	58	63	105	172	82	2.2	5.4	14.9	4.0	400	286
Fertilizer	3143	143	56	61	103	173	81	2.7	2.2	15.8	4.2	457	288

	Fertilizer (F)	Variety (V)	V x T
C.V. (%)	34.0	24.1	24.1
L.S.D. .05	NS	NS	NS

B – 1 Time of planting on maize

Three maize varieties (Suwan 1, Thai DMR 6, and Guatemala) were tested at five planting dates, at 15-day intervals, to determine the influence of Downy mildew on maize and the maize yield.

A split plot in randomized complete block design with four replications was used. Plot size was 4 × 10 m, and plant spacing was 80 cm between rows and 25 cm between hills of one plant. A fertilizer grade of 20:20:0 at the rate of 312.5 kg/ha was broadcast and mixed with the soil before planting.

The condition and fertility of the soil in some of the plots was inadequate for normal maize growing owing to its being new arable land reclaimed just one year ago. Moreover, some plants were brought down by strong winds. It seems that these yield-limiting factors did not have a good effect on the experimental results.

Grain yield (kg/ha) at 15% moisture content for the two maize varieties are prosented in Table 7. No significant results in grain yield were obtained from this test nor was there any Downy mildew infection

Table 7 Grain yield (kg/ha) at 15% moisture, and Downy mildew infection on maize planted at different times, 1979.

Variety / Date of planting (1979)	Suwan 1		Thai DMR 6		Guatemala		Average	
	Yield	DM%	Yield	DM%	Yield	DM%	Yield	DM%
1. May 4	3216	0	4008	0	4023	0	3749	0
2. May 19	4025	0	3601	0	4330	0	3985	0
3. June 3	3193	0	3519	0	3890	0	3558	0
4. June 18	3106	0	3792	0	4216	0	3704	0
5. July 3	3430	0	2930	0	3776	0	3378	0
Average	3394	0	3584	0	4047	0		

	Variety	Date of planting
C.V. (%)		25.5
L.S.D. (.05)	NS	NS

B – 2 Time of planting on maize

Three maize varieties (Suwan 1, Thai DMR 6, and Guatemala) were tested at six planting dates, at two week intervals, to determine the influence of Downy mildew on maize and the maize yield.

A split plot randomized complete block design with four replications was used. Plot size was 4 × 10 m, and plant spacing was 80 cm between rows and 25 cm between hills of one plant. A fertilizer grade of 20:20:0 at the rate of 312.5 kg/ha was broadcast and mixed with the soil before planting.

Grain yield (kg/ha) at 15% moisture, and Downy mildew infection on the three maize varieties are presented in Table 8. Analysis of variance indicated no significant differences among the mean grain yield of different varieties, but there was a statistical difference among the mean planting time. The plot of the June 4 planting gave the highest yield, but it was not statistically higher than the other two plots planted on May 21 and June 18. It seems that an appropriate seasonal rainfall, especially from June to September, had a good effect on the above crops. It was noted that the plants were not infected by Downy mildew regardless of the varieties of maize used and the times planted.

Table 8 Grain yield (kg/ha) at 15% moisture, and Downy mildew infection on maize planted at different times, 1980.

Time of planting	Variety						Average	
	Suwan 1		Thai DMR 6		Guatemala			
	Yield	DM%	Yield	DM%	Yield	DM%	Yield	DM%
May 7	3767	0	4097	0	3146	0	3670	0
May 21	4706	0	4517	0	4369	0	4530	0
June 4	4961	0	5294	0	5087	0	5114	0
June 18	5239	0	5422	0	3968	0	4876	0
July 2	5092	0	3603	0	4035	0	4243	0
July 16	4372	0	3855	0	4029	0	4085	0
Average	4689	0	4464	0	4105	0		

	Variety (V)	Time of planting (T)	V x T
C.V. (%)	17.7	60.8	60.8
L.S.D. .05	NS	793	NS

C – 1 Plant population trial

To determine further the relationship between plant population and the number of plants per hill on grain yield, and some agronomic characteristics of maize.

Materials and Methods

1. **Time of planting:** The planting date was May 17, 1978.
2. **Variety:** Suwan # 1 was tested.
3. **Treatment:**

Main-plot	S 1	1
(No. of plants/hill)	S 2	2
	S 3	3
Sub-plot	P 1	25,000
(Plant population/ha)	P 2	50,000
	P 3	75,000
	P 4	100,000

4. **Design:** Split plot in randomized complete block design, with four replications was used.
5. **Plot size:** The size of each plot was 5 rows, 10 m in length with 80 cm between rows.
6. **Fertilizer application:** A fertilizer grade of 20:20:0 (N:P:K) at the rate of 156.2 kg/ha was applied in rows at two weeks after planting. An additional application of 156.2 kg/ha was side dressed when the plants were at the knee-high stage.
7. **Soil:** Parent material is residuum from limestone. Profile description is as follows: reddish-brown light clay (0 – 20 cm).

Results and Discussion

Due to a delay in planting, the experiment suffered from a shortage of rainfall in June (the critical growing stage of this maize).

Moreover, the soil in the plots was inadequate for normal maize growing, owing to the new arable land which was reclaimed just before planting. It seems that these yield-limiting factors did not have a good effect on the grain yield.

The analysis of variance for yield showed that there were no significant differences among the number of plants per hill, while a highly significant difference in the mean grain yield was found among the plant population per ha. The highest mean yield (1,974 kg/ha) was obtained from 75,000 plants/ha, followed by 1,898 kg/ha, 1,788 kg/ha and 1,126 kg/ha which were obtained from 100,000, 50,000 and 25,000 plants/ha, respectively. The data are shown in Table 9 and 10, and graphically in Fig. 7.

However, the highest mean yield (1,974 kg/ha, 75,000 plants/ha) was not significantly higher than that of 10,000 and 50,000 plants/ha. Therefore, we are not able to determine from

this test the optimum combination of plant population and the number of plants per hill for maximum yield. It is necessary to carry out more experiments under a varied range of plant populations and other factors, such as climatic, fertilizer and soil conditions, etc.

Table 9 Grain yield at 15% moisture, kg/ha.

No. of plants/hill	Populations/ha				Mean
	P 1	P 2	P 3	P 4	
S 1	1181	1441	1893	1799	1578.5
S 2	1049	2140	2046	1890	1781.2
S 3	1149	1784	1983	2005	1730.2
Mean	1126.3	1788.3	1974.0	1898.0	
			L.S.D. .05	L.S.D. .01	C.V. %
		Main-plot	----	----	----
		Sub-plot	232.5	314.3	16.1

Table 10 Grain yield and other agronomic characterictics at different plant populations, 1978 rainy season.

Plant Population (plants/ha)	No.of Plants/ hill	Grain yield in 15% moist. (kg/ha)	Days to 50% silking	Maturity in days	Height (cm)		Lodging		Length (cm)		Ear diamt. (cm)	No.of kernels		Weight of 1000 kern.(g)
					plant	Ear	Stalk (%)	Root (%)	Cob	Ear		Row	in Row	
25,000	1	1181	57	118	178.8	91.3	1.3	8.7	18.4	16.0	4.8	31	14	318.1
	2	1049	58	118	173.5	78.1	0.6	8.2	17.9	15.0	4.4	27	13	298.2
	3	1149	58	118	178.4	94.5	1.8	4.0	17.6	15.6	4.4	31	13	305.7
50,000	1	1441	59	118	177.5	90.2	1.4	11.7	17.4	15.3	4.4	30	13	283.8
	2	2140	57	118	183.3	91.8	1.5	13.9	17.5	15.2	4.5	28	14	291.1
	3	1784	58	118	204.5	112.5	1.4	8.5	17.7	14.5	4.5	29	13	302.4
75,000	1	1893	60	118	185.0	93.5	2.1	12.1	15.3	12.8	4.1	22	13	241.3
	2	2046	59	118	184.1	94.3	2.8	9.0	15.7	13.8	4.4	25	13	287.2
	3	1983	58	118	177.4	90	2.2	15.1	15.3	12.7	4.2	22	13	273.1
100,000	1	1799	61	118	189.3	95.8	2.6	15.2	14.3	11.9	3.9	25	13	250.5
	2	1890	60	118	190.6	98.3	2.8	14.8	13.8	11.5	3.9	21	13	238.1
	3	2005	60	118	182.0	97.5	2.9	12.0	14.6	12.4	4.1	22	13	253.9

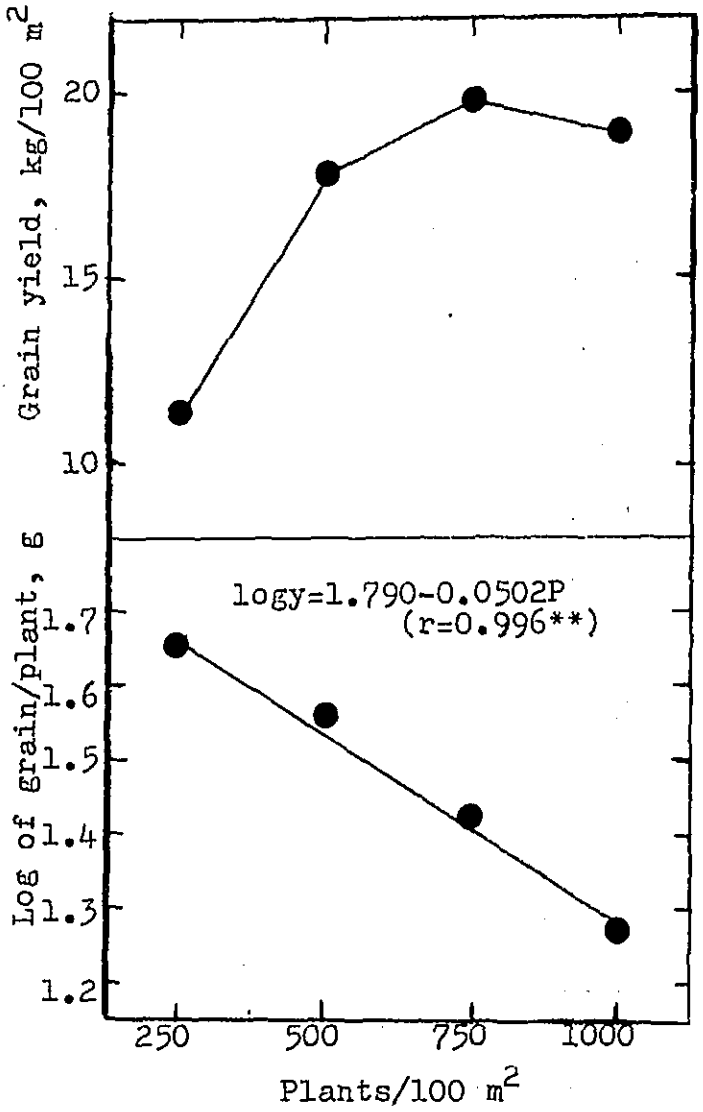


Fig. 7 Relationships between the logarithms of the yield per plant and population, and the corresponding yields per 100 m^2 and population.

C – 2 Plant population trial on the different maize varieties

To further determine the relationships between plant population and the grain yields on the different varieties of maize.

Materials and Methods:

The maize variety used was Suwan # 1 and Suwan # 2. Planting was done on May 28, 1981. Plant spacing was as follows:

(1)	80	×	75 cm	with	2	plants/hill for	33,250 plants/ha
(2)		,,			3	,,	49,875 ,,
(3)		,,			4	,,	66,500 ,,
(4)		,,			5	,,	83,125 ,,
(5)		,,			6	,,	99,750 ,,

Split plot in randomized complete block design, with four replications was used. Plot size was five rows, 10 m long, and 80 cm spacing between rows.

A fertilizer grade of 20:20:0 (N:P:K) at the rate of 312.5 kg/ha (50 kg/rai) was applied. Half the amount of fertilizer was applied to the rows at two weeks after planting, and the remaining half was applied when the plants were at the knee-high stage.

Results and Discussion:–

The analysis of variance for the total yield showed that there were highly significant differences among treatments. The highest mean yield (3501 kgs/ha) was obtained from 66,500 plants/ha of Suwan # 1, whereas the highest mean yield of Suwan # 2 (3487 kgs/ha) was obtained from 83,125 plants/ha. The data is shown in Table 11, 12, 13 and 14, and graphically in Fig. 8.

In order to determine the maximum-yield population, Duncan (1958) has provided a useful mathematical expression. He reported that as maize is planted at increasing populations the yield of the individual plant decreases and that there is a linear relationship between the logarithm of the average plant yield and the population. The formula for the relationship is expressed by an equation (A) as follows:

A) $\log Y = \log k + bp$ or $y = k^{\circ}\ 10^{bp}$

Where y is the yield per plant
k is a constant
b is the slope of the regression in plant per acreage
p is the population of plants per acreage
Y is the yield per acreage

The yield per acreage is the product of the average yield per plant and the number of plants per ha, with symbols as follows:

B) $Y = yp$

Substituting the vale of y from equation (A) gives:

C) $Y = P^{a}K^{a}10^{bp}$

The equation gives the yield per acreage in terms of the population. If this equation is differentiated with respect to P and the result equated to zero and solved for P, the result is:

D) $Pmax = \frac{-1}{2.303b}$

Where Pmax is the population that will give the maximum yield per ha.

We have attempted to apply Duncan's equations to our plant population test on the two varieties of maize mentioned previously. The results are shown in Table 13 and in Fig. 8.

The estimated maximum-yield populations were 73,367 plants per ha for Composite Suwan # 1 and 101,104 plants per ha for Suwan # 2. These estimated values indicate that the early maturing variety (Suwan # 2) requires higher plant populations than the late maturing variety (Suwan # 1) to obtain the maximum grain yield. However, we are not able to determine the optimum combination of plant population and varieties for maximum yield from this test. It is necessary to carry out more experiments under a varied range of plant populations and other factors, such as climatic, fertilizer and soil conditions.

Reference

Duncan, W.G., The Relationship Between Corn Population and Yield, Agron. J. 50:82–84. 1958.

Table 11 Analysis of variance of maize yield experiment, split plot in randomized complete block design.

Source of Variation	Degrees of freedom	Sum of squares	Mean square
Replications	3	3898686.90	1299562.30
Variety, V	1	4579.60	4579.60
Error (a)	3	1451253.80	483751.26
Main-plot	7		
Population, P	4	7031735.75	1757933.93**
V x P	4	767735.15	191933.78*
Error (b)	24	1228866.30	51202.76
Sub-plot	32		
Total	39		

Table 12 Yield of maize grain (15% moisture) as influenced by population and variety.

Plants/ha	Varieties	Suwan # 1	Suwan # 2
33,250		2376	2181
49,875		3168	2902
66,500		3501	3397
83,125		3293	3487
99,750		2904	3382
C.V.	(%)	13.1	11.5
L.S.D.	(.05)	382	311

Table 13 Estimated maximum yields and maximum-yield population calculated by the equation $Y = PK^{\circ} 10^{bp}$

Variety	Suwan # 1	Suwan # 2
Plants per ha	73,367	101,104
Yield per ha	3,253 kgs	3,500 kgs

Note: Y is grain Yield/ha

P is number of plants/ha

K is constant

b is regression co-efficient.

Table 14 Grain yield and other agronomic characteristics of different plant populations, rainy season 1981.

Variety & Plant Population (Plants/ha)	Days to 75% silking	Maturity in days	Height Plant (cm)	Height Ear (cm)	Lodging Root (%)	Lodging Stalk (%)	Length Cob (cm)	Ear (cm)	Ear diam. (cm)	Weight of 1000 kern.(g)	Grain yield (15% moist) (kg/ha)
Suwan # 1											
33,250	64	106	183	103	1.6	6.4	16.6	14.1	4.1	279	2376
49,875	65	106	186	102	1.0	4.9	14.6	11.8	4.1	227	3168
66,500	66	108	195	108	1.8	2.4	13.9	10.7	4.1	225	3501
83,125	67	108	196	110	1.5	3.2	13.9	10.6	4.0	225	3293
99,750	66	108	196	106	0.6	2.6	12.7	10.2	3.9	228	2904
Suwan #2											
33,250	56	95	183	89	0	2.3	14.5	12.5	4.0	234	2181
49,875	56	96	180	89	1.0	5.1	14.0	12.2	3.9	245	2902
66,500	55	97	183	85	0.7	3.2	13.6	11.1	3.8	216	3397
83,125	57	97	174	82	3.7	3.9	13.1	10.6	3.9	219	3487
99,750	58	97	191	98	0.7	5.3	12.4	10.2	3.8	210	3382

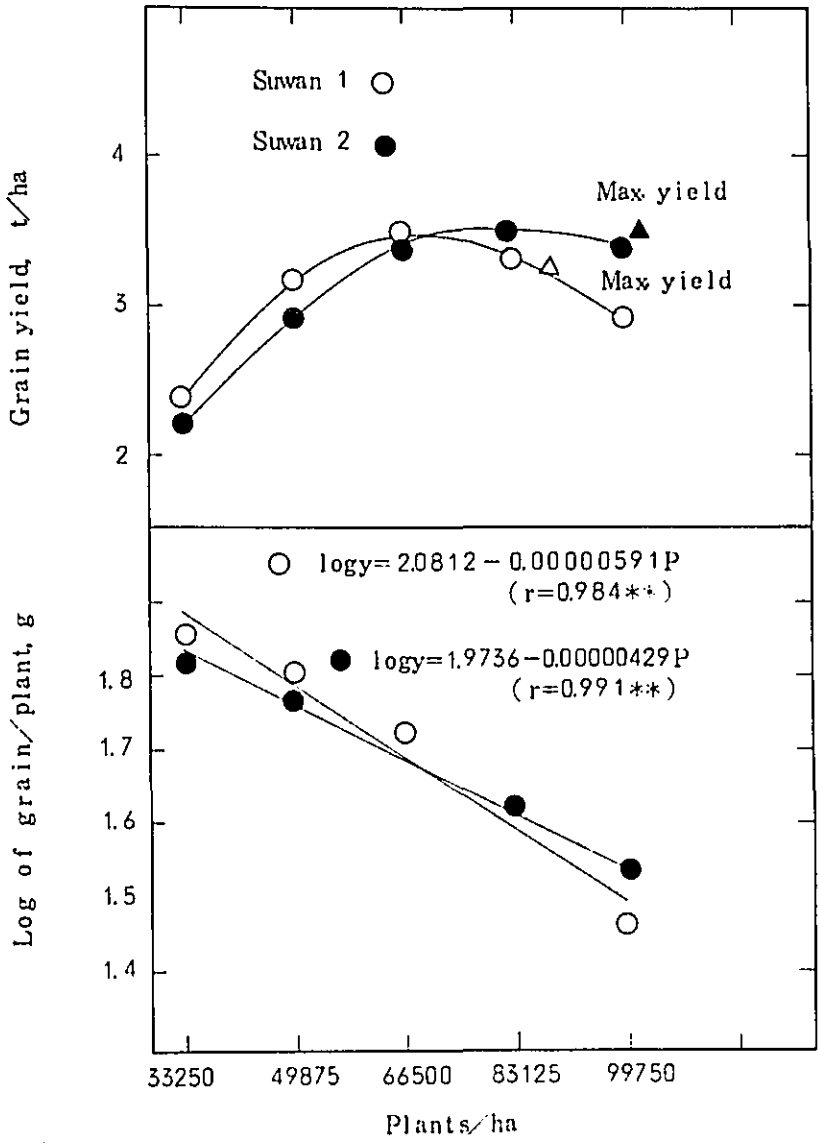


Fig. 8 Relationships between the logarithms of the yield per plant and population, and the corresponding yields per ha and population.

D – 1 Fertilizer test, nitrogen and phosphate fertilizer on yield of maize

This test was conducted to determine the optimum rate or N – P fertilizer on the grain yield of maize.

A randomized complete block design with four replications was used. The treatments were check, and five different mixtures of nitrogen and phosphate from a 20:20:0 compound fertilizer. The entire amount of fertilizer was banded and mixed with the soil before planting. The plot size was 4 × 10 m, and plant spacing was 80 cm between rows and 25 cm between hills of one plant. The maize variety was Suwan 1.

Grain yields are shown in Table 15. No significant results in grain yield were obtained from this test. It was found that some plots were inadequate for normal maize growing owing to soil condition and to the strong winds which brought down the maize plants.

Table 15 Grain yields (kg/ha) at 15% moisture at different rates of N – P fertilizer, 1979.

Fertilizer rate (kg N-P/ha)	Grain yield (kg/ha)
1. 0 - 0	2248
2. 30 - 30	3645
3. 60 - 60	3822
4. 90 - 90	2811
5. 120 - 120	3289
6. 150 - 150	3165
C.V. (%)	34.8
L.S.D. (.05)	NS

Date planted: May 9, 1979.

D – 2 Fertilizer test, time of application of compound fertilizer on maize yield

This trial was conducted to determine the suitable time of compound fertilizer application on the grain yield of maize.

A split plot in randomized complete block design with four replications was used. The treatments were combinations of two levels of N P fertilizer, and four application timings. The plot size was 4 × 10 m, and plant spacing was 80 cm between rows and 25 cm between hills of one plant. The fertilizer was a granulated compound fertilizer of 20:20:0 grade. The method of band application and side-dress at the time of planting and after planting, were adopted. The maize variety was Suwan 1.

Results are summerized in Table 16. No significant difference in grain yield was obtained from this test for the same reasons as Experiments B and C.

Table 16 Grain yields (kg/ha) at 15% moisture of maize as affected by rate of application, time of application of compound fertilizer, 1979.

Time of application	Fertilizer rate(kg N-P/ha) 62.5-62.5	93.75-93.75	Average
1. The entire amount at planting	5113	4199	4656
2. The entire amount at 2 weeks after planting	5204	4291	4747
3. 1/2 the entire amount at planting and 1/2 at 4 weeks after planting	5003	4844	4926
4. 1/2 the entire amount at 2 weeks and 1/2 at 6 weeks after planting	4560	3834	4197
Average	4971	4292	

	Fertilizer ratio	Time of application
C.V. (%)	38.2	17.9
L.S.D. (.05)	NS	NS

Date planted: June 15, 1979.

D – 3 Fertilizer test, a study on yields of maize and succeeding crops with manure and chemical fertilizer

It is known that successive cultivations of rain-fed crops such as maize and its succeeding crops (mung bean, sorghum, etc.) without fertilizer application causes a reduction of soil fertility and a decrease in crop yields, especially an crop cultivated on the Reddish Brown Lateritic soil (very common soil type found in the Saraburi and Lopburi areas). The application of a chemical fertilizer and applied organic matter is needed.

The application of chicken manure, which can be easily obtained in the local area and which is quite reasonably priced, will increase soil fertility and the yield of crops.

A long-term 5 year fertilizer experiment was initiated during the 1980 rainy season to study the long term effects of the application of manure and chemical fertilizers, together with soil fertility, on yields of maize and its succeeding crops.

Materials and Methods

There were four treatments in this experiments, and their descriptions for maize are given in Table 17. A split plot in randomized complete block design with four replications was used. The plot size was 4 × 10 m, and plant spacing was 80 cm between rows and 25 cm between hills of one plant for maize. The spacings of succeeding crops to be carried out from 1980/81 dry season are: Sorghum-80 cm between rows, 10 cm between plants; Mung bean-50 cm between rows, 10 cm between plants. The three fertilizer treatments were applied to the rows at planting time (Mung bean and Sorghum will not receive any fertilizer applications). The maize variety used was Suwan 1. All measurements were made on the three central rows of each plot. Soil samples also were taken before planting and after harvesting, and were analyzed for their chemical and physical properties.

Results and Discussion

The results are presented in Table 17.

Highly significant differences in grain yields were obtained from different fertilizer treatment. Mean grain yields were in order of Chicken manure (12.5 t/ha), Chicken manure (5 t/ha) + Chemical fertilizer, Chemical fertilizer, Check.

The results of soil fertility will be reported at a later date.

Table 17 Treatment descriptions and mean grain yield of maize for the individual treatments, 1980 rainy season.

	Crop	Treatment descriptions				
		Check	Chicken manure 12.5 t/ha	Chicken manure 5 t/ha + Compound fertilizer (N:P:K) 32.25:31.25:0kg/ha	Compound fertilizer (N:P:K:) 62.5:62.5:0 kg/ha	Mean
1.	Maize (Sorghum/1980/81)	1051	3593	3206	2428	2569
2.	Maize (Mung bean/1980/81)	1189	3690	2746	2674	2574
	Mean	1120	3641	2976	2551	
	(Relative to check)	(100%)	(325%)	(265%)	(227%)	
			Crop (c)	Fertilizer (T)	C x T	
		C.V. (%)	13.5	12.7	12.7	
		L.S.D. .05	NS	343	NS	
		.01	NS	470	NS	
		Date planted	July 1, 1980			

D – 4 Fertilizer test, effect of the different quantity of fertilizer on the grain yield of maize under the present cost of maize and fertilizer

To determine the optimum quantity of fertilizer on the grain yield of maize under the relationships between cost of maize and fertilizer.

Materials and Methods

The trial was conducted at the Maize Project Center. Soil classification was Reddish Brown Lateritic soils. A randomized complete block design with 4 replications and 6 different fertilizer quantity, namely, 0 – 0, 30 – 30, 60 – 60, 90 – 90, 120 – 120 and 150 – 150 kg N – P_2O_5/ha (Compound 20 – 20 – 0) was employed. The size of each plot was 5 rows, 10 m in length. The spacing was 80 cm × 25 cm with 1 plant/hill. Maize variety Suwan 1 was sown on May 18, 1982. The entire amount of fertilizer was broadcast and plowed down prior to planting.

Results and Discussion

Rainfall during the growing period was quite favourable. It seems that a good effect on the grain yield was obtained.

The result of the analysis of variances is that the effect of the quantity of fertilizer application on the grain yield of maize is highly significant. The data are shown in Table 18 and graphically in Fig. 9. One fact is discernible at a glance. Increasing the fertilizer application increases the grain yield. The highest mean yield of the Suwan 1 was obtained at 4994 kg/ha at the 120 – 120 kg/ha of N and P_2O_5 application. Other mean yields of Suwan 1 were 2174, 3460, 3784, 4459 and 4750 kg/ha for 0 – 0 (Control plot), 30 – 30, 60 – 60, 90 – 90 and 150 – 150 kg/ha of N and P_2O_5 application.

If we express the results of grain yield of Suwan 1 by an empirical equation, the increased-yield curve can be obtained as follows: $Y = -0.135X^2 + 37.543X = 2234$ where Y is the value of the increase in the yield and X is the cost of the fertilizer.

The value of the increase in yield falls off with the diminishing returns curve. The ฿ 1500 application brought in ฿ 4417.50 return, while the ฿ 2250 application brought in ฿ 5715 return. The profit is more for the higher rate, but the return is 294% for the smaller rate and 254% for the higher rate of fertilizer application on Suwan 1. The highest return per baht invested may not give the greatest profit per hectare, as indicated by Fig. 10 and Table 18. A schematic diagram showing the relation of fertilizer costs to the value of the increased yields resulting from fertilizer applications. The widest point between the cost line and increased-yield curve indicates the point of greatest profit. As a result of the yield differences shown at various fertilizer levels, we can conclude that under the limits of these tests, the highest grain yield can be realized when the 150 – 150 kg/ha of N and P_2O_5 application, while the quantity between 60 – 60 and 90 – 90 kg of N and P_2O_5 (the optimum range) gave the greatest profit when the maize was valued at ฿ 2.5/kg and the compound fertilizer (20 – 20 – 0) was valued at ฿ 5.0/kg.

Here we only introduce an example for maize variety Suwan 1 as a primary study. More detailed experimental research for other prominent varieties of maize under various climatic and soil conditions is required.

Table 18 Effect of quantity of N and P_2O_5 fertilizer on yield of maize, Suwan 1, 1982 rainy season.

Quantity N-P-K kg/ha	Compound fertilizer (20-20-0) kg/ha	Cost of fertilizer ฿ (1)	Yield kg/ha	Yield kg/ha by empirical equation	Yield increase kg/ha	Value of yield increase ฿ (2)	Return per ฿ (2)÷(1)	Profit per ha (2)-(1)
0-0-0	----	----	2174	2234	----	----	----	----
30-30-0	150	750	3460	3238	1004	2510.00	3.34	1760.00
60-60-0	300	1500	3784	4001	1767	4417.50	2.94	2917.50
90-90-0	450	2250	4459	4520	2286	5715.00	2.54	3465.00
120-120-0	600	3000	4994	4795	2561	6402.50	2.13	3402.50
150-150-0	750	3750	4750	4828	2594	6485.00	1.72	2735.00

C.V. (%) 16.6

L.S.D.(.05) 395

(.01) 545

* Fertilizer (20-20-0) valued at ฿ 5.0/kg

** Yield kg/ha is calculated by an empirical equation as:

$$Y = -0.135x^2 + 37.543x + 2234$$

*** Maize valued at ฿ 2.5/kg.

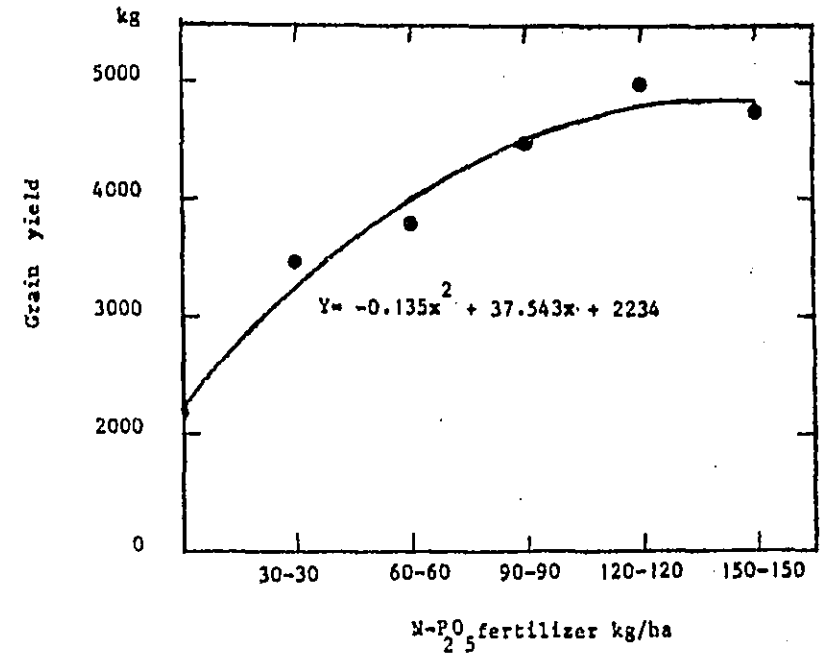


Fig. 9 Relationships between grain yields of maize and quantity of $N-P_2O_5$ fertilizer applications, 1982 rainy season.

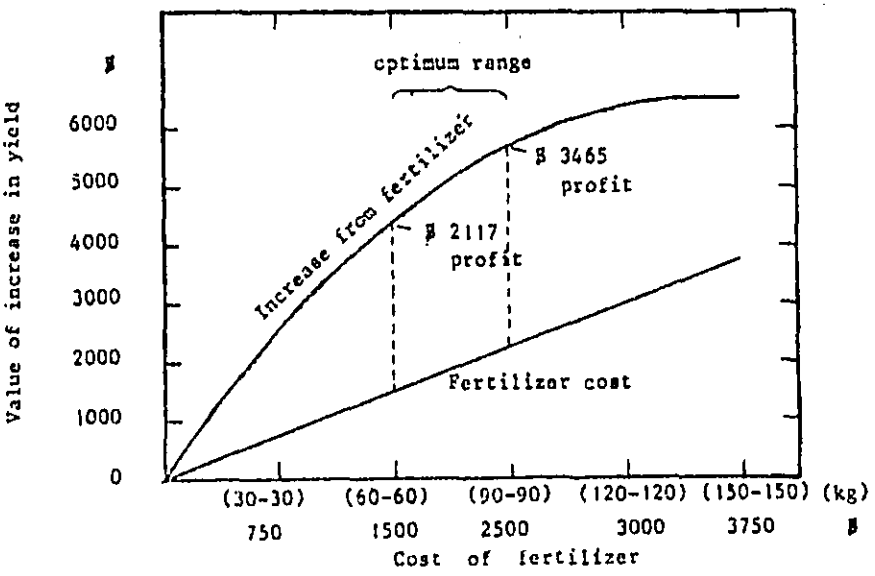


Fig. 10 Effect of quantity of $N-P_2O_5$ fertilizer on yield of maize, Suwan 1.

E – 1 Cropping system, comparison of different planting patterns for maize-mung bean intercropping

Two planting patterns of maize-mung bean intercropping were compared with solid planting of the two crops in order to determine the effect of the intercropping system, together with utilization of land and stability of production. The intercropping patterns alternated one row of maize and two rows of mung bean, and alternated two rows of maize and four rows of mung bean. A randomized complete block design with three replications was used. Row length was 10 m. The spacing between rows were 80 cm for maize, and 40 cm for mung bean. Plant spacing was 25 cm for maize, and 10 cm for mung bean. Fertilizer was applied prior to planting at a rate of 62.6:62.5:0 kg/ha of N:P:K to maize plots. Mung bean did not receive any fertilizer application. The maize variety used was Suwan 1, and mung bean variety was M 7A.

The results are presented in Table 19. The yields of maize and mung bean in the different planting patterns were in the same rank order as the plant populations of the respective crops. However, when compared to the solid plantings, reductions in the yield of maize and mung bean in the intercropping patterns were not in the same proportion as the decreases in plant population. When yields of both maize and mung bean were considered collectively, the alternating one row of maize and two rows of mung bean intercropping pattern seedmed to show a slight advantage as indicated by a slightly superior land equivalent ratio. In terms of total income, however, the above intercropping pattern showed the same value as the solid planting of maize.

References

1. Sanchez, 1976. Properties and management of soils in the tropics, soil management in the multiple cropping system, John Wiley and Sons.
2. Vorasoot, et al. 1976. Crop production and cropping systems, Semiarid crops project, 1976 Annual Report, Faculty of Agriculture, Khon Kaen University.

Table 19 Yields and gross income for maize and mung bean in different planting patterns, 1980 rainy season.

Planting pattern	Maize		Mung bean		Land Equivalent Ratio (LER)	Total income (baht)	Income Equ:V. Ratio (IER)
	Yield (kg/ha)	Net Income[1] (baht)	Yield (kg/ha)	Income (baht)			
Solid Maize	5,040	13,464[2]	-	-	1.00	13,464	1.0
Solid Mung bean	-	-	440	4,400[3]	1.00	4,400	1.0
Alternate one maize two mung bean	3,877	10,803	118	1,180	1.03	11,983	1.07
Alternate two maize four mung bean	3,593	9,951	124	1,240	0.99	11,191	1.02
C.V (%)	14.1		48.5				
L.S.D. .05	1,019		191				
Date planted	June 26, 1980						

1/ Gross maize income minus the cost of fertilizer ฿ 1,656/ha.

2/ Calculated from ฿3.0/kg.

3/ Calculated from ฿10.0/kg.

E – 2 Cropping system, a study on the effect of crop rotation on yield of maize, on Reddish Brown Lateritic Soil

A long-term cropping pattern experiment was initiated during the 1978 rainy season to study the long-term effects of crop rotation. Sorghum, Mung bean, Maize and Fallow were introduced every dry season as rotation crops for maize in the rainy season.

Materials and Methods:

There were seven treatments in this experiment, and their descriptions are given in Table 20. The varieties of maize, soybean, mung bean and sorghum used were Suwan 1, SJ 4, M 7A, and Early Hegari.

A randomized complete block design with three replications was used. The plot size was 4 × 10 m. The spacings were : Maize-80 cm between rows, 25 cm between plants; Sorghum-80 cm between rows, 10 cm between plants; and legumes-50 cm between rows, 10 cm between plants. Mung bean was sown broadcast.

A fertilizer grade of 20:20:0 (N:P:K) at the rate of 156.2 kgs/ha (25 kgs/rai) was applied to the rows at three weeks after planting, and for the maize application plots an additional application of 156.2 kgs/ha was side-dressed when the maize plants were at the knee high stage.

Results and Discussion:

One fact is discernible at a glance in Table 20: a long-term cropping pattern under these treatments, even the common conventional cropping pattern for maize in Thailand such as maize-fallow without fertilizer application, does not decrease the grain yield.

The effect of rotation by leguminous crops on yield increase of maize with fertilizer was observed clearly in every rainy season (Table 20). The yield of maize in 1983 after five years rotation by Mung bean and Soybean was 4.6 and 4.8 tons/ha respectively, as compared with 3.6 and 3.9 tons/ha by the rotation of Sorghum and Maize. The difference of yield between above two groups was about 25%, and lying fallow effects on maize yield were almost the same as those of leguminous crops rotation.

The yield results mainly depended upon the characteristics of each crop that absorbs nutrients out of soil. It would be suggested that the amount of growth of leguminous crops was much less than that of cereal crops in every dry season, and lying fallow during the dry season contributed to getting a higher yield of maize in the rainy seasons as well. We also cannot ignore the fact that leguminous crops improve soil fertility in general.

Supplement experiments were carried out to check the different effects on yield increase of maize under "without fertilizer" application in the rainy season between mung bean and lying fallow in the dry seasons. The effects of mung bean were much higher than those of lying fallow. The results showed that the rotation effects of leguminous crops for maize yield were magnified under "without fertilizer" applications.

The results of soil fertility are shown in Table 21. The percent of organic carbon and the content of inorganic nitrogen (ppm) on the plots with fertilizer application on maize, maize-fallow and maize-mung bean, were given as slightly higher than the other plots, but a satisfactory explanation about the relationship between soil fertility and grain yield of maize was not obtained from the data. It is considered that the reason why the maize yield of plots "with fertilizer" application on maize increased over the plots "without fertilizer" application, is due to the field soil condition characteristic of Reddish Brown Lateritic Soil, which generally has a significantly higher response to fertilizer application.

Furthermore, it is noted that a large amount of weed growing in the lying fallow period and after harvest of maize in rainy season can be observed. It is considered that the maize plants will have some positive effect on the fertility of the soil, such as better conservation and supplying organic matter, as can be seen from the above mentioned weed growth. Therefore, a study on the effect of weed growing in the dry season on the yield of maize is required.

Table 20 First to sixth year results of long term cropping experiments.

Treatment No.	Cropping Pattern	Grain yield (kg/ha) 1978 rainy Maize	1978/79 dry	1979 rainy Maize	1979/80 dry	1980 rainy Maize	1980/81 dry	1981 rainy Maize	1981/82 dry	1982 rainy Maize	1982/83 dry	1983 rainy Maize	Average rainy Maize	Relative in check (%)
1.	Maize-(Sorghum)	1949	Sorghum/1629	2453	Sorghum/619	5402	-	3608	Sorghum/608	3060	Sorghum/688	3582	3621 (1979-83)	100
2.	" -(Mung bean)	1993	Mung bean/222	3636	Mung bean/842	6780	-	4056	Mung bean/1072	4203	Mung bean/356	4497	4634 (")	127
3.	" -(Soybean)	2299	Soybean/62	3900	Soybean/335	6823	-	4153	Soybean/168	4176	Soybean/240	4887	4787 (")	132
4.	" -(Fallow)	2258	-	2930	-	6634	-	5091	-	4408	-	4802	4773 (")	131
5.	" -Maize	2183	Maize/3575	2384	Maize/950	6628	-	2930	Maize/822	4089	Maize/1108	3487	3803 (")	107
								1505	-	1342	-	2092	1646 (1981-83)	100
6.	(Maize)-(Fallow)	1165	-	1773	-	1454	-	1804	Mung bean/1185	2373	Mung bean/411	3192	2656 (")	161
7.	(Maize)-(Mungbean)	-	-	-	-	5156	-							
			Irrigation		Irrigation		Non-irrigation		Non-irrigation		Non-irrigation			
	C.V. (%)	11.9		20.6		13.5		12.6		10.2		10.3		
	L.S.D.(.05)	429		1069		1337		746		626		694		
	Date planted	15/5/78	4/12/78	11/6/79	4/12/79	18/6/80	15/10/80	14/5/81	4/9/81	25/5/82	22/9/82	7/6/83		

1) ( ) in cropping pattern : Non fertilizer application.

2) No yield was given in 1980/81 dry season, due to late planting under non-irrigation.

3) Treatment No. 2 was begun in 1980 rainy season.

Table 21 Soil analysis of long-term cropping pattern experiment, Maize Development Project Center.

	Cropping pattern No.	Maize yield (kg/ha) 1978-80 rainy (Aver.)	pH (H_2O)	Organic C%	Nitrogen		Available - P	Extractable Cation (me/100g)			
					Total%	Inorganic	ppm	K	Na	Mg	Ca
4.	Maize-(Fallow)	3940	7.16	0.87	0.073	25.3	32.4	0.02	0.09	0.64	7.61
6.	(Maize)-(Fallow)	1464	7.40	0.58	0.067	22.9	11.7	0.02	0.28	0.62	5.61
5.	Maize-Maize	3731	7.37	0.58	0.077	19.4	29.6	0.05	0.14	0.64	6.63
2.	Maize-(Mungbean)	4136	7.54	0.87	0.072	28.9	15.2	0.08	0.08	0.62	7.10

Cropping pattern ( ) : Non fertilizer application.

Soil type : Reddish Brown Lateritic Soil.

Date of soil sampling : July 27, 1981.

Analyst : Dr. T. Inoue & Miss Praphasri, C.
Soil Chemistry and Fertility Branch,
Agricultural Chemistry Division,
Department of Agriculture, Bangkok.

F – 1 Water management test, irrigation in relation to higher yield of maize

To determine the optimum irrigation frequency for obtaining a high yield of maize in the dry season.

1. **Variety:** Suwan # 1.
2. **Time of planting:** December 2, 1978.
3. **Treatment of irrigation:** Four treatments were provided as follows:

Plot No.	Treatment Frequency & Amount of water	Interval
1.	3 irrigations (25 - 70mm/time)	Three irrigations from just one week before tasseling through to one week after silking
2.	4 irrigations (25 - 70mm/time)	20 days
3.	6 " (25 - 70mm/time)	13 days
4.	8 " (25 - 70mm/time)	10 days

Remarks: 1) Amount of irrigation water was changed from the lefthand figure to the righthand one after maize was 30cm high.

2) All treatments (except Plot No. 1) received their first irrigation ten days after planting.

4. **Design:** A randmized complete block design with four replications.
5. **Plot size:** The size of each plot was seven rows, 10 m in length. The spacing was 80 × 25 cm with 1 plant/hill, or at a rate of 50,000 plants/ha.
6. **Fertilizer:** A fertilizer grade of 20:20:0 (N:P:K) at the rate of 156.2 kg/ha (25 kg/rai) was applied in rows two weeks after planting. An additional application of 156.2 kg/ha was side dressed when the plants were at knee-high stage.
7. **Soil:** Soil classification is re-brown earth. Parent material is residuum from limestone. Profile description is as follows: 0 – 20 cm, reddish-brown light clay.
8. **Irrigation Practice:** Furrow irrigation was applied at the specified intervals. The irrigation

water for each plot was regulated by gauging the water level of the tank which was set up at one corner of the plot.

The soil moisture tension (pF) was successively measured at the depth of 20 cm from the seed-bed (side of the ridge) by means of the tension meter method during the growing period of maize.

Results and Discussion

There were very little rainfall, especially during the growth stage. Therefore, irrigation was carried out as scheduled.

Soil moisture tension (pF) for the three treatments (excluding plot No. 4, see chart experiment) was succesively measured from Dec. 17 to March 16. The results obtained are shown in Fig 11. Soil moisture tension before planting was not measured due to mismanagement. Therefore, the tendency of pF before planting without irrigation and after irrigation has not been compared.

Depending on the time of irrigation, the soil moisture tension was graphed in the order of 6, 4 and 3 irrigation treatments. However, the tension in three treatments did not come down to less than pF 1.0 under this irrigation method.

The amount irrigation water and rainfall during the growing period of maize is shown in Table 22. 50 mm of irrigation water was applied just after planting to insure uniform germination.

Since the soil moisture tension was high at harvesting time, it may be said that most of the water as shown in the Table 22 was utilized by the maize in such ways as transpiration, evaporation and percolation. The amount of water used was 348 mm to 653 mm.

Water efficiency was calculated in terms of grain production (kg/ha)/ Unit amount of water (mm) during the maize cultivation. The average water use/day until maturity was also calculated, as shown in Table 22 and Fig. 11.

The analysis of variance for yield showed that there were highly significant differences in the mean grain yields. The highest mean yield (3,070 kg/ha) was obtained from Plot 3 (6 irrigation), followed by 3,054 kg/ha, 2,151 kg/ha and 1,578 kg/ha which were obtained from Plots 4, 2 and 1, respectively. However, the highest mean yield (3,070 kg/ha, Plot 3) was not significant difference between plots 2 and 1.

According to the results of this experiment, the optimum irrigation frequency for obtaining a high yield of maize was given in Plot 3 during the growing period of maize. However, we were not able to determine from this test the optium amount of irrigation water for each of the maize growing stages, such as vegetative and reproductive. Further investigation is necessary for the 3 and 4 irrigation treatments, especially as to maintaining low moisture tension during the critical growth stages, such as tasseling to silking, if water for irrigation is limited. This may be most important.

Table 22 Grain yield of maize, and water use with different irrigation treatment, 1978/1979 dry season.

Tabl

Treatment	Date of irrigation and growth stage														Yield (kg/ha)	Total water used (mm)	kg/mm of total water used	Maturity in day	Average water used (mm/day)
	16/12	26/12	29/12	5/1	11/1	15/1	21/1	24/1 Tass.	25/1 Silk	31/1	4/2	6/2	11/2	19/2 Milk	24/2					
3. irrigations					x 70 mm		x 70 mm			x 70 mm						1578	348	4.5	104	3.3
4. irrigations	x 25			x 70					x 70				x 70			2151	373	5.8	105	3.6
6. irrigations	x 25		x 70		x 70			x 70				x 70		x 70		3070	513	6.0	107	4.8
8. irrigations	x 25	x 70		x 70		x 70			x 70		x 70		x 70		x 70	3054	653	4.7	110	5.9

Date of planting:

Dec. 2, 1978

Date of harvest:

March 22, 1979

Date and amount of rainfall:

13/1	23.2 mm
14/1	1.1 "
3/2	8.3 "
28/2	55.7 "
Total	88.3 mm

C.V. = 22.0 %

L.S.D. (.05) = 866

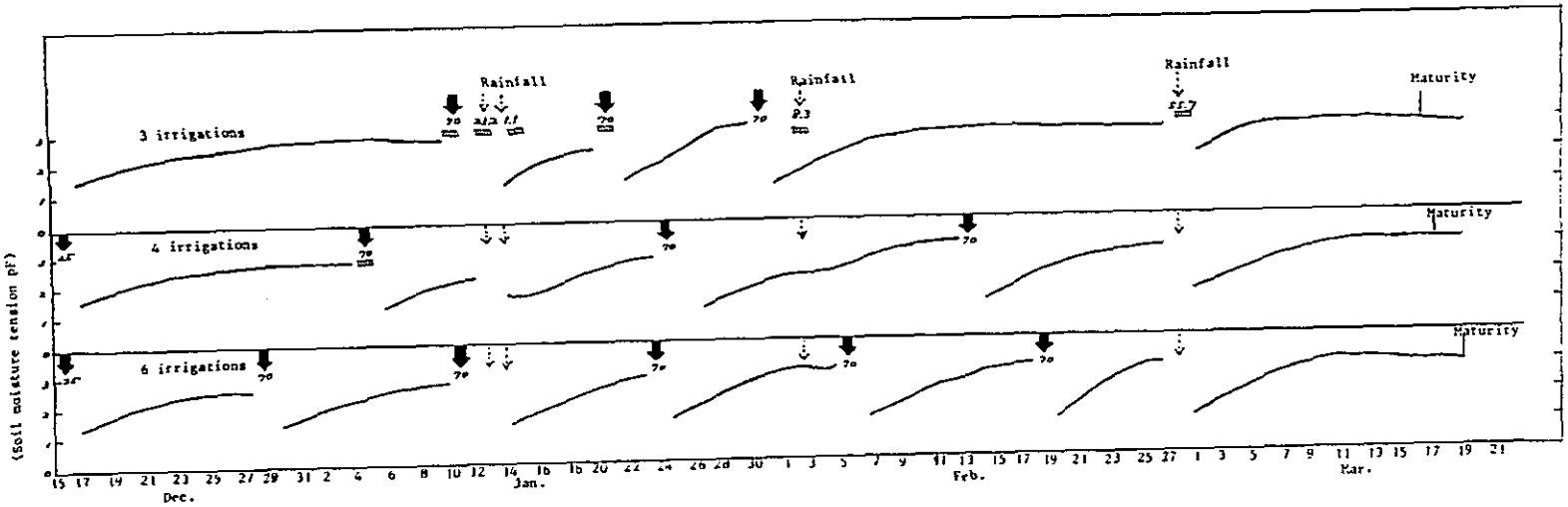


Fig. 11 Succesive changes in soil moisture tension (pF).

Table 23 Grain yield and other agronomic characteristics with regards to different irrigation treatments, 1978/1979 Dry Season.

Treatment	Grain yield in 15%moist (kg/ha)	Days to 50% silking	Maturity in Days	Height (cm)		Lodging		Length (cm)		Ear Diameter (cm)	1,000 Kernel weight (g)
				Plant	Ear	Stalk %	Root %	Cob	Ear		
3 irrigations	1578	62	104	136	66	2.7	1.3	14.3	11.5	3.8	197
4 irrigations	2151	64	105	135	68	2.2	1.3	14.6	12.3	4.0	229
6 irrigations	3070	65	107	151	80	5.8	2.1	15.3	12.8	4.2	225
8 irrigations	3054	64	110	156	82	3.4	1.6	16.1	13.8	4.2	227

F – 2 Water management test, comparison of different frequencies of irrigation and use of paddy-straw mulch on maize yield

Three different frequencies of irrigation were compared on the paddy-straw mulch and non-mulch maize fields, in order to determine the effect of the irrigation frequency, together with utilization of paddy-straw mulch on maize yield.

The maize variety used was Suwan 1. Planting was done on January 28, 1978. Experimental design with two replications was used. Plot size was ten rows, 15 m long, and 80 cm spacing between rows and 25 cm between hills of one plant. Over-head-irrigation system was used on the time of planting and two weeks after planting. 25 mm of amount water was applied on the above stages of maize, respectively. The furrow-irrigation-system was used during the period of intensive irrigation treatment (3 – 7 weeks after planting). The used amount of water at each time was 50 mm. The frequency and time of treatments was as follows: (1) One-week intervals, 9 times (2) Two-week intervals, 5 times (3) Three-week intervals, 3 times. A fertilizer grade of 20:20:0 (N:P:K) at the rate of 312.5 kg/ha was applied in rows two weeks after planting. Half of the plots mulched with 1,400 kg/ha of paddy-straw as the mulch plots after application of fertilizer.

The results are presented in Table 24. The highest grain yield was obtained at 1394 kg/ha at the one-week intervals irrigation on the mulch plot. The yield of all mulch plots gave higher than that of non-mulch plots. The differences of yield between the above two groups was 34% on the average. A total irrigation water use of 200 mm, applied 3 times (three-week intervals) gave the most efficient and the highest yield per total irrigation water used (5.4 kg/mm), and followed by 300 mm (two-week intervals) and 500 mm (one-week interval) gave 4.7 and 3.8 kg/mm of yield per total irrigation water used on the mulch plots, respectively (average, 4.4 kg/mm). On the other hand, yield per total water used on the non-mulch plots gave from 3.8 to 2.7 kg/mm (average, 3.3 kg/mm). It is evident from the data that the effect of the maize yield by irrigation is subject to the mulching, especially the limitation of water application in the dry season.

Table 24 Effect of different frequencies of irrigation and use of paddy-straw mulch on maize yield, 1979/1980 for the dry season.

Irrigation ferquency	Total water used (mm)	Mulch		No Mulch	
		Grain yield (kg/ha)	kg/mm of total water used	Grain yield (kg/ha)	kg/mm of total water used
One-week intervals	500	1934	3.8	1379	2.7
Two-week intervals	300	1420	4.7	1169	3.8
Three-week intervals	200	1095	5.4	771	3.8
Average	333	1483	4.4	1106.3	3.3
Relative to check for mulch (%)		134		100	

Planted: Jan. 28, 1978 Harvested: May 12, 1980

Fertilizer:62.5:62.5:0(N:P:K)kg/ha was applied in rows two weeks after planting.

Rainfall: Approx. 10 mm on March 13, 1980

Method of irrigation: Over-head(planting-seedling stage) and furrow.

Experimental design: Two replications.

Mulch plot: All rows mulched with 1,400kg/ha of paddy-straw after application of fertilizer.

F – 3 Water management test, effect of water conservation on maize grain yield during the rainy season

In general, it can be said that irrigation is the most effective method for growing maize and increasing its yield during draught conditions, but water resources, irrigation facilities and an uniform land level are absolutely essential. However, with regards to the irrigation of maize in the major maize growing areas, such a program can only be successfully carried out in strictly limited areas due to the lack of sufficient water resources.

Another factor to be considered is that as maize is not an economically advantageous crop, and as the price of oil has greatly increased due to the oil crisis, irrigation has therefore become economically impractical as far as maize growing is concerned.

Most of the maize plants in the major maize growing areas suffer from moisture stress with a noticeable reduction in the maize yield. Water conservation by means of a mulch or a covering crop is one way to effectively combat moisture stress. A mulch or covering crop will catch and hold any type of rainfall and prevent water loss through run-off and will also serve to prevent soil erosion.

The experiment was carried out to determine the effect of water conservation using a paddy-straw mulch and cover crops.

Materials and Methods

There were five treatments in this experiment, and their descriptions are as follows:

(1) No mulch and clean weeded.
(2) All rows mulched with 3,125 kg/ha (500 kg/rai) of paddy-straw.
(3) All rows mulched with 6,250 kg/ha (1,000 kg/rai) or paddy-straw.
(4) Interplanted with cover crop-legume "Lablab purpurcus".
(5) Interplanted with cover-crop cowpea.

A randomized complete block design with four replications was used. The maize variety used was Suwan 1. Mulching of paddy-straw, and broadcasting of legume seeds as a cover crop were carried out after maize germination. A fertilizer grade of 20:20:0 (N:P:K) at the rate of 312.5 kg/ha was applied at planting time. Plot size was five rows, 10 m long, and 80 cm spacing between rows. Plant spacing was 25 cm.

Results and Discussion

The results in Table 25 indicate that the maize yields in the different treatments were not statistically different due to the unusual amount of rainfall experienced, especially from June to September. The check plot of maize plants also did not suffer from moisture stress during their growing stages in this experiment. Thus, it could not be discovered from this experiment whether or not mulching and covering crops will have any beneficial effect on maize grown during this rainy season. Further investigations are needed.

Table 25 Mean grain yields (kg/ha) of maize at different water conservation treatments, 1980 rainy season.

Treatments	Mean grain yield
Check	4192
Paddy straw mulch 3125kg/ha	3994
Paddy straw mulch 6250kg/ha	3676
Interplanted with "Lablab purpurcus"	3916
Interplanted with cowpea	3732
C.V. (%)	9.2
L.S.D. (.05)	NS
Date planted :	June 26, 1980
Fertilizer application :	62.5:62.5:0 (N:P:K) kg/ha

F – 4 Water management test, a study on the effects of intensive irrigation on the tasseling and pollination period of maize

In general, more than 80% of the total rainfall in the major maize growing area fell between May and October, but it was quite unevenly distributed. A severe dry condition was thus experienced at times during the growing season, which resulted in severe damage to the maize. The greatest reduction of the maize yield can be observed when maize plants encounter a severe dry condition during their most critical growing, tasseling and pollinating periods* during the rainy season.

Experiments have been carried out since 1980 to determine the effect of water availability on the tasseling and pollinating periods of the maize during the rainy season. However, unexpected results were obtained from the 1980 and 1981 rainy seasons due to the amount of seasonal rainfall, which was more than ample for the growing of maize, and this rainfall did nothing to help our experiments in irrigation. This experiment was, therefore, carried out during the dry season under complete water control.

Materials and Methods

The maize variety used was Suwan # 1. Planting was done on November 12, 1981. The amount of irrigation water for the intensive irrigation treatment was determined by measuring pan-evaporation, which value is commonly used to estimate crop water requirements. A standard-pan (20 cm diameter, 10 cm depth, tin-plated inside, standardized by the Japan Weather Bureau) was set horizontally (80 cm high) on a maize field without hazards, and measurements of water loss were taken at 24 hour intervals. There were four treatments in this experiment, and their descriptions are as follows:

(1) Check: Intensive irrigation water during 45 to 66 days (for 3 weeks) after planting is not to be given.

(2) Intensive irrigation water measured at 0.5 times the amount of daily pan-evaporated water is to be given at 7-day intervals 45 to 66 days after planting.

(3) Intensive irrigation water equivalent to the daily pan-evaporated water is to be given at 7-day intervals 45 to 66 days after planting.

(4) Intensive irrigation water measured at 1.5 times the amount of daily pan-evaporated water is to be given at 7-day intervals 45 to 66 days after planting.

A randamized complete block design with three replications was used. Plot size was five rows, 8 m long, and 80 cm spacing between rows and 25 cm between hills of one plant.

The furrow-irrigation-system was used during the period of intensive irrigation treatment. Irrigation water for each plot was regulated by guaging the water level of the tank which was set up at one corner of the plot. Overhead irrigation equivalent to the daily pan-evaporated water was

*The tasseling and pollinating periods of Suwan # 1 variety were checked and determined from results of the several experiments which were carried out at Phraphuttabat Experiment Station since 1978. From planting to 75% tasseling and silking required approximately 55 – 60 and 60 – 56 days, respectively.

applied throughout the growing period of maize, except during the intensive irrigation period (45 – 66 days after planting).

The soil moisture tension (pF) was successively measured at a depth of 20 and 40 cm from the seedbed by means of the tensionmeter method during the period of intensive irrigation treatment.

Soil samples from a depth of 0 – 50 cm were taken from determined plots and analyzed by means of the soil actual volumenometer and ovendryer.

A fertilizer grade of 20:20:0 (N:P:K) at the rate of 312.5 kg/ha (50 kg/rai) was applied. Half the amount of fertilizer was applied to the rows at two weeks after planting, and the remaining half was applied when the plants were at the knee-high stage.

Results and Discussion

Grain yield (kg/ha) at 15% moisture content, implementation of intensive irrigation during the period of treatment and some agronomic characteristics for the four irrigation treatments are presented in Table 26 and 27.

A significant difference in grain yield was found between treatments. Treatment No. 4 (evapo. mm × 1.5) gave the highest mean yield of 5,138 kg/ha (155% relative to check), though its yield was not significantly higher than treatment No. 3 (evapo. mm × 1.0) and No. 2 (evapo. mm × 0.5). On the other hand, treatment No. 1 (check) gave the lowest mean yield which was statistically lower than treatments No. 3 and 4 mentioned above, but its yield was not significantly lower than treatment No. 2.

Treatment No: 3 was most efficient in the use of water. Total water used was 7.8 per mm.

Some physical properties of the soil in the experimental plot are given in Table 28. The available water was estimated and calculated from the field capacity of soil moisture (FC) 24 hours after flooding to the primary wilting point of maize plants at a depth of 0 – 20 cm, which was obtained from the ratio of consumed water in the root zone (Fig. 14).

The accumulated amount of evaporation determined by means of the water pan method, the amount of irrigation and the variation of the soil moisture content determined by means of tensionmeters for the individual treatments are shown graphically in Fig. 12. No rainfall during the period of treatment was recorded. Therefore, the irrigation treatment and evaporation data were not disturbed by any other water factors.

It is noted that tensionmeters function well at low soil moisture tensions. High tensions from dry soil will often break the internal water column of the instrument or draw in air so that the reading becomes meaningless. For example, in Fig. 12, the value of pF on the curve for the check plot at a depth of 20 cm 50 days after planting should be approximately pF 3.7 because the maize plants were already wilted. However, the actual value of pF on the curve shows only pF 2.75. Therefore, the indication of the variation of soil moisture content by tensionmeters in this experiment should be taken as an approximation only.

Fig. 12 shows that a similar increased tendency is obtained between the accumulated amount of evaporation and the value of pF when the soil moisture content is reduced. A decreasing tendency of soil moisture content can be seen after irrigation, and it becomes greater after each succeeding irrigation due to the increase of evapo-transpiration by growing maize plants from the tasseling to pollinating stages. The tendency of pF value of treatment No. 2 (evapo. × 0.5) at a depth of 20 and 40 cm was not very much changed after irrigation. It can be clearly seen especially at a depth of 20 cm, that the soil moisture content is hardly influenced at all by this amount of irrigation water.

Fig. 13 was plotted from the accumulated amount of evaporation and variation of soil moisture content for treatment No. 3 (evapo. × 1.0) at a depth of 20 cm (Fig. 12). There exists an obvious relationship between the accumulated amount of evaporation and soil moisture tension (pF). A decreasing tendency of soil moisture content at a depth of 20 cm is a little more clearly seen than that at a depth of 40 cm.

The soil moisture consumption pattern for the 7-day period from Dec. 29 – Jan. 5 is shown in Fig. 14. The figure shows that the greatest amount of soil moisture consumption for this 7 – day period occurred at a depth of 0 – 20 cm (76.4%). It should be noted that whereas the roots of the maize plants grown during the rainy season commonly grow down into the subsoil zone, the roots of the maize plants grown under the dry season irrigation system grow and develop just under the shallow surface area.

Thus, the amount of water for each irrigation is estimated and calculated as follows:

$$\text{Required water for the root zone (mm)} = \frac{\text{Available water (mm)}}{\text{Ratio of consumed water (\%)}}$$

Therefore, 43.0 mm of water would be needed to soak the root zone of soil at a depth of 0 – 10 cm to field capacity (FC) if the same root zone of this soil were at the wilting point before irrigation. The amount of water, expressed in mm per 0 – 10 cm of depth, can be changed to the value of pan-evaporation. The relationship between evapo-transpiration (ET) and pan-evaporation (EP) was investigated by pot-cultivation-method during the growth stage from tasseling to pollinating. The result of ET/Ep value was obtained from 1.4 to 1.5 (averaging 1.45). Therefore, the equivalent to the required 43.0 mm of water at a depth of 0 – 10 cm for the pan-evaporated water is 29.6 mm and the determined timing is 4.05 days (daily pan-evapo. : 7.3 mm). That is, 43.0 mm of water, the amount required, is to be given at 4.05 day intervals or at 1.45 times of pan-evaporated water when the accumulative evaporation reading is 29.6 mm (29.6 mm × 1.45) for the period of the treatment.

Summary and Conclusion

The greatest reduction of the maize yield was observed when the maize plants encountered a servere dry condition (check plot) during tasseling and pollinating period.

The highest mean yield of maize (155%, relative to check) was obtatined from treatment No. 4 (evapo. mm × 1.5), though its yield was not significantly higher than treatments No. 3 (evapo. mm × 1.0) and No. 2 (evapo. mm × 0.5).

According to the relationship between the amount of evaporation from the water pan and the ratio of consumed water and available soil moisture in root zone, applying 43.0 mm of water at 4.05 – day intervals or applying at 1.45 times of pan-evaporated water when the accumulative evaporation reading is 29.6 mm (29.6 mm × 1.45) are considered the most suitable for our purposes, the practical and efficient use of water during the tasseling and pollinating period of maize. Soil moisture consumption indicates that most of the maize plant roots grew and developed under the shallow surface zone, due to maize being grown under irrigation practice for the dry season.

In the case of the rainy season, however, the roots commonly grow into the sub-soil zone, and, therefore, more investigations, such as the consumptive-use rate, the water holding capacity of the soil, and rooting depth during the most critical growing, tasseling and pollinating periods, are needed.

Table 26 Yield of grain and implementation of intensive irrigation during the tasseling and pollination period, 1981/1982 dry season.

Treatment No.	Over-head irrigation (including rainfall) 1-38 days after planting (mm)	Intensive irrigation treatment and growth stage: 45 days after planting (mm)	Tass. 52 days after planting (mm)	silk. 59 days after planting (mm)	Total water of treatment for the period of 3 weeks and average for one day (mm)	Over-head irrigation 66 days after Planting to harvest (mm)	Total water used (mm)	Yield and relative to check (kg/ha)	kg/mm of total water used
1.	309.6	No irrigation			0	171.6	481.2	3309 (100%)	6.8
2.	309.6	29.1	24.4	23.1	76.6 (3.6)	171.6	557.8	4259 (128%)	7.6
3.	309.6	58.2	48.9	46.3	153.4 (7.3)	171.6	634.6	4999 (151%)	7.8
4.	309.6	87.3	73.3	68.4	229.0(10.9)	171.6	710.2	5138 (155%)	7.2
			C.V. (%)					11.6	
			L.S.D. (.05)					1027	

Table 27 Grain yield and other agronomic characteristics at different intensive irrigation treatments, 1981/1982 dry season.

Treatment No.	Height		Lodging		Length		Ear	Days to 75%		Weight of 1000	Grain Yield (15% moist)
	plant (cm)	Ear (cm)	Root (%)	Stalk (%)	Cob (cm)	Ear (cm)	diam. (cm)	Tass.	silk	kernels (g)	(kg/ha)
1.	125	57	13.4	2.7	12.9	10.2	3.9	60	68	182	3309
2.	166	86	3.0	1.3	14.7	12.1	4.1	57	66	200	4259
3.	172	91	0.8	3.2	14.6	11.8	4.2	57	64	204	4999
4.	182	97	0.8	2.8	14.6	12.2	4.1	56	63	219	5138

Table 28 Physical properties in the soil of irrigation field.

Depth (cm)	Texture	Three phase under Fc after 24 hrs (% by volume)			Moisture content (% by volume)		Amount of available water (mm)
		Solid	Liquid	Air	Fc after 24 hrs	Pri.W.P.	
10	Li C	57.5	34.0	8.5	35.6	15.7	19.9
20	Li C	60.3	33.2	6.5	33.8	20.8	13.0
30	C L	65.9	29.1	5.0	28.9		
40	H C	63.4	33.1	3.5	30.3		
50	H C	61.7	30.8	7.5	30.8		

Note: Great Soil Group: Reddish Brown Lateritic Soils.
Soil sampling date: December 29, 1981.
Available water: It was estimated and calculated from FC after 24 hrs to Primary Wilting Point at a depth of 0-20cm.

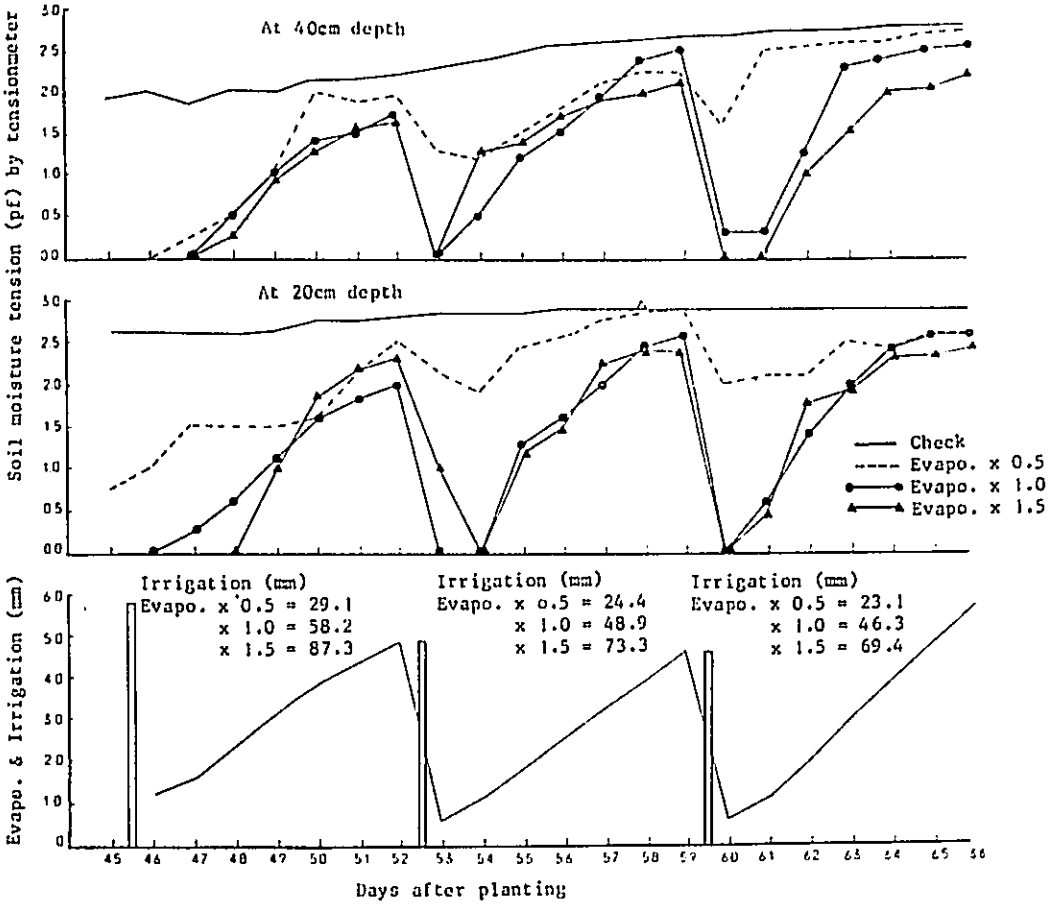


Fig. 12 The accumulated amount of evaporation by water pan, amount of irrigation and variation of soil moisture content by tensionmeter, for the dry season in 1981/1982.

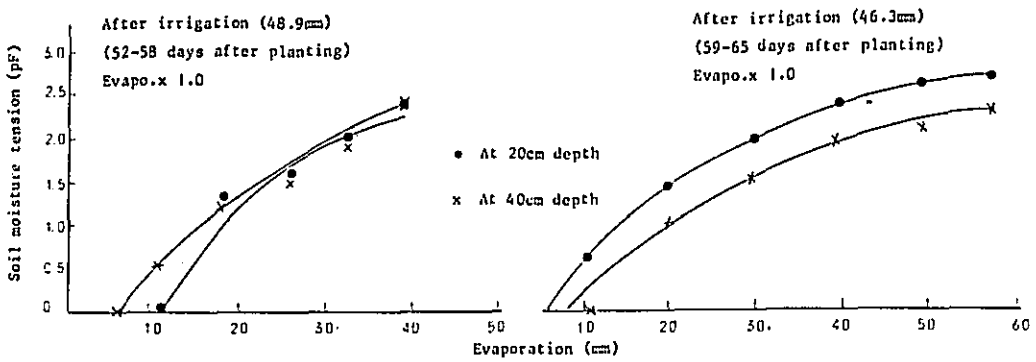


Fig. 13 The relationship between accumulated amount of evaporation and soil moisture tension (pF) by tensionmeter.

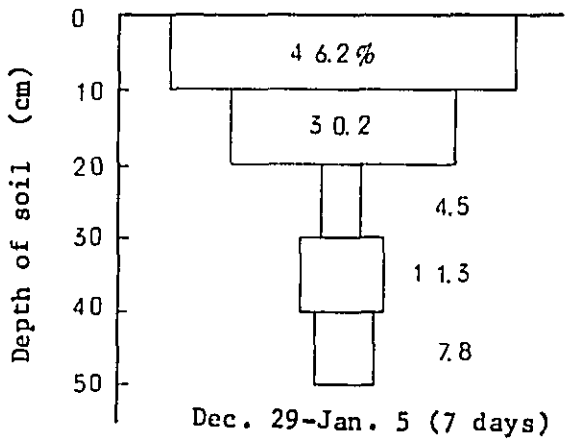


Fig. 14 The ratio of consumed water in root zone.

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References

1) KATO, I. KAMOTA, F. and NAITO, Y. (1968) Improving the field crop irrigation, Case studies on the application of an irrigation timing warning device for vegetables and fruit trees. Tokai-kinki-noshi-kenkyu-houkoku. 22:72 – 83
2) HITOSHI FUKIDA and HIKARU TSUTSUI. (1973) Rice irrigation in Japan. OTCA. 17 – 25.
3) ROGER, P. HUMBERT. (1968). The growing of sugar cane. Elsevier. 327 – 345.
4) R.H. SHAW and W.C. BURROWS. (1966) Water supply, water use, and water requirement. 122 – 136.
   D.G. HANWAY. (1966) Irrigation. 157 – 170. Advances in corn production. Iowa State.
5) D.W. THORNE and H.B. BETERSON. (1954) Irrigated soils. Tata McGraw – Hill. 29 – 57.
6) LOUIS, M. THOMPSON. (1957) Soils and soil fertility. McGraw-hill 14 – 84.

G – 1 Seed germination test, a primary study of influence of different ways and means of storing maize seed on its germination

To know the influence of different ways and means of storing mize seed on its germination.

Materials and Methods

Suwan # 1 maize seed which was produced by the Maize Development Project at Phraphutthabat, 1979 rainy season was used. The seed was treated with insectcide (Marathion 67) and fungicide (Difolatan 40) in order to protect it from insects and disease during the storage period. Variuos treatments were as follows:

(1) 50 kgs of samples were divided into four parts and put into two polyethlene woven bags, a clay pot and a bamboo basket.

One of the polyethlene woven bags was stored in a cold room (temperature 19° ± 2°c, relative humidity approx. 75%) and the other three kinds of containers were put into an ordinary room (temperature: approx. 20° – 35°C), and 100 kernels of seed were collected in a random sampling from each container every month for a period of 29 months for the cold room and 22 months for the ordinary room.

(2) 5 kgs of grain was taken out from the polyethlene woven bag stored in the cold room after 22 months, and put into an ordinary room. 100 kernels of seed were collected in a random sampling from that ordinary room every month for a period of seven months.

Seed germination for each treatment was checked every month as follows: Seeds planted on a germination plate under ordinary room conditions. The percentage of germination was computed seven days after planting.

Results and Discussion

The results presented in Fig. 15 indicate that the percentage of germination for maize seed stored in the polyethlene woven bag under cold room conditions did not appreciably change for the period of 29 months. The percentage of germinating seed from the other three kinds of containers under ordinary room conditions was reduced gradually from 8 months after storing, the seed contained in the bamboo basket being reduced more rapidly than the others. The seed contained in the clay pot was found to be the best way to store grain under ordinary room conditions in this experiment.

Storing maize seed under cold room did not appreciably change its germination for the long period mentioned above. However, its germination was reduced sharply when the seed was changed to an ordinary room after 22 months storage in the cold room.

Therefore, it may be necessary to distribute maize seeds to growers as quickly as possible under natural climate conditions, and cold room conditions which have been stored over a long-term period.

Here we only introduce the problems as a primary study. More detailed experimental research is required.

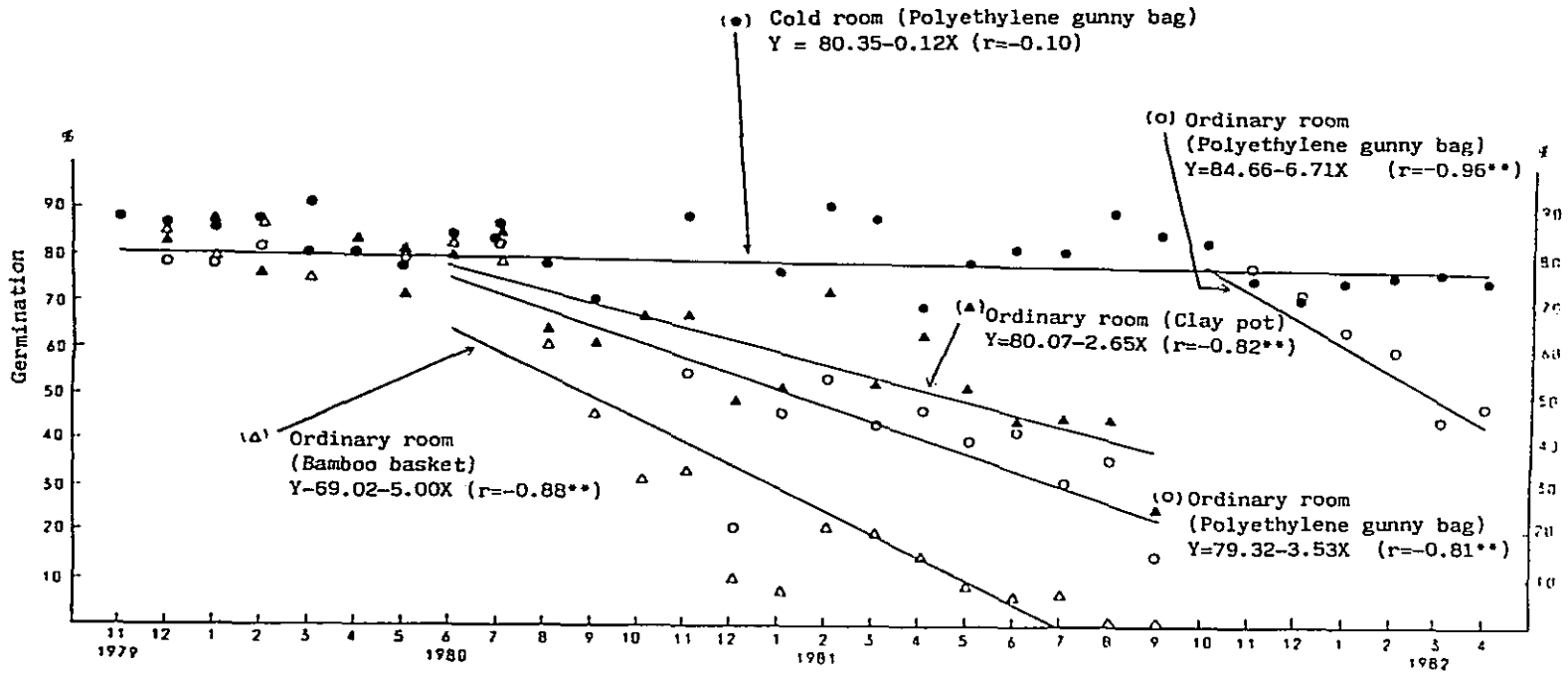


Fig. 15 Influence of different ways & means of storing maize seed on its germination.

Note: (1) Cold room: Temperature: 19° ± 2°C
Relative humidity: 75% (20°C)
(2) Ordinary room: Temperature: Approx. 20°–35°C

H – 1 Subsoiling test, a study on the effects of subsoiling treatment on yield of maize

Some soils with "hard pans" or impermeable horizons exist near the surface have presented serious problems in management of maize growing since the introduction of big tractor cultivation in Thailand. They absorb water slowly during rainstorms, but once they do take up all the water they can absorb, they drain slowly. Furthermore, root penetration may be limited because of lack of oxygen for root respiration. There is not much that a farmer can do to improve the structure of a heavy clay subsoil (B horizon). Therefore, frequent subsoiling or knifing of farmer's fields is necessary to shatter these layers and encourage deeper root.

The demonstrational experiments were conducted on several farmers' fields and at the Center during the rainy season 1983. Four of them were repetitions of the 1982 experiments in order to confirm the previous results. The titles of these experiments are as follows:

Expt. No.	Title
1.	Effect of subsoiling operation on yield of maize.
2.	Effect of different subsoiling methods on yield of maize.
3.	Effect of subsoiling operation with heavy weight tractor on yield of maize.

1. Effect of subsoiling operation on yield of maize.

A subsoiling operation was compared with conventional method (non subsoiling). The experiment was conducted in 1982 – 1983.

Subsoiling method is as follows:

Subsoiling was accomplished with John Deere's 50 Tool Bar Subsoiler (2 shanks demention $1\frac{1}{4} \times 6 \times 30$ in.) mounted Ford 6600 (75 Hp) Tractor on April 15, 1982. Subsoiling depth was approx. 40 – 50 cm on the contour at intervals of about 80 cm.

The size of each plot was 10 m width, 20 m in length. A randomized complete block design with three replication was used. The spacing of maize plants was 75 cm × 75 cm with 3 plants/hill. Maize variety Suwan 1 was sown in May, 1982 and 1983 successively. There was no fertilizer application given.

Grain yield obtained from the different treatments in the first and second year are shown in Table 29. The effects of this subsoil treatment were observed in two fields out of four in 1982, showing 13% and 27% on yield increase. However, no significant difference of yield was obtained in 1983. This might be due to increasing soil compactness in the year since the subsoiling treatment was done.

The relationship between soil group and effect of subsoiling treatment was not obtained from the data.

Table 29 Mean grain yield of Maize under subsoiling operation, 1982 and 1983 rainy season; (kg/ha).

Field No & Soil group	1982 rainy season		1983 rainy season	
	Subsoiling	Non-subsoiling	Subsoiling	Non-subsoiling
1. Reddish Brown Lateritic soil	3,022	3,252	3,496	3,618
2. Grumsol	3,168	3,003	3,026	2,794
3. Reddish Brown Leteritic soil	2,896* (127%)	2,248 (100%)	3,645	3,212
4. Grumsol	2,988* (113%)	2,625 (100%)	3,994	4,013

1) Date of Subsoiling operation: April 15, 1982.

2) Time of maize planting: May, 1982 and May, 1983.

3) Name of Subsoiler: John Deere, 50 Tool Bar Subsoiler.

4) Depth and intervals of subsoiling: 40-50cm (depth), 80cm (intervals).

2. Effect of different Subsoiling methods on yield of maize.

Two different methods of subsoiling operation were conducted at farmer's field in the 1983 rainy season. Subsoiling was accomplished with John Deere's 50 Tool Bar Subsoiler mounted Ford 6600 tractor on May 25, 1983. Treatment was as follows:

(1) Check.

(2) One-way subsoiling: The width of 75 cm row was subsoiled (35 cm depth) along with 40 m length.

(3) Crosswise subsoiling: The width of 75 cm row was subsoiled (35 cm depth) along with 40 m and 15 m length across each other.

The size of each plot was 15 m width, 40 m in length. A randomized completed block design with three replications was used. The spacing of maize plants was 75 × 75 cm with 3 plants/hill. Maize variety Suwan 1 was sown on May 25, 1983. No fertilizer applications were given. The results are presented in Table 30. The grain yield of one-way system of subsoiling treatment was 31% higher than that of non subsoiling treatment.

However, poor results were obtained from the crosswise system of subsoiling treatment, due to the muddy soil condition (unsuitable for maize growing) which was caused by the concentrated subsoiling operation under the high moisture content of the soil in the rainy season.

Table 30 Mean grain yield at different methods of Subsoiling operation, 1983 rainy season.

Treatment No.	Mean grain yield (kg/ha)	Relative to check %	Soil hardness (kg/cm^2)		
			0-15cm	15-25cm (depth)	25-40cm
1. Check	2,738	100	2.6-4.7	5.4-8.5	8.5
2. One-way Subsoiling	3,602	131	-	-	-
3. Crosswise Subsoiling	2,732	99	-	-	-
	C.V. :	9.2%			
	L.S.D. (.05)	629			

1. Date of subsoiling operation : May 19, 1983.
2. Date of Malize planting : May 25, 1983.
3. Depth and intervals of subsoiling : 35-40 (Depth), 75cm (intervals)
4. Soil group : Reddish Brown Lateritic Soil.

3. Effect of Subsoiling operation with heavy weight tractor on yield of maize.

A subsoiling operation with three rippers mounted on a heavy crawler tractor (10 t) was compared with non-subsoiling treatment at the Center on May 31, 1983.

The construction of a "hard-pan" approx. 20 cm under the surface was done in all the experimental plots with a heavy crawler tractor before experimental treatments were done.

Subsoiling depth was approx. 50 cm on the contour at intervals of approx. 80 cm. The size of each plot was 10 m width, 20 m in length. A randomized complete block design with four replications. The spacing of maize plants was 80 × 25 cm with 1 plant/hill. Maize variety Suwan 1 was sown on June 7, 1983.

A fertilizer grade of 20:20:0 (N:P:K) at the rate of 300 kg/ha was applied when the plants was at the knee-high stage (on June 28, 1984).

The results indicated no significant difference in yield of maize in the different treatments (Table 31). Poor soil structure was observed in the hard-pan and subsoiling plots, presumably due to unsuitable soil conditions for maize growing made by the construction of hard-pan and subsoiling operation on rainy days.

The maize yield was not affected, but to say whether or not this was the effect of the subsoiler treatment requires more data.

Table 31 Mean grain yield and some agronomic characteristics of maize under subsoiling operation with heavy crawler tractor, 1983 rainy season.

Treatment No.	Mean grain yield (kg/ha)	Height plant (cm)	Height Ear (cm)	Stalk diam. (cm)	Soil hardness (kg/cm^2) 0-10cm	10-20cm	20-30cm	30-40cm (Depth)
1. Check	4,282	155	131	4.5	2.0	18.0	17.0	14.0
2. Hard-Pan	4,300	161	129	4.4	5.0	25.0	27.0	38.0
3. Subsoiling	4,525	172	142	4.8	-	-	-	-

N.S.

1) Date of Hard-Pan construction : May 19, 1983.

2) Date of Subsoiling : May 31, 1983.

3) Date of maize planting : June 7, 1983.

4) Depth and intervals of subsoiling: Approx. 50cm (Depth)
80cm (intervals)

5) Soil group : Reddish Brown
Lateritic soil.

Integrated Conclusion

Problems and some aspect of improved techniques on maize cultivation in Thailand

Maize is one of the most important field crops in Thailand, and the second most valuable Thai export after rice. The acreage and production of maize has increased tremendously over the past two decades. From less than 0.3 million hectares in 1960, there are now over 1.5 million hectares of maize planted. In the same period production has grossed six times from 0.5 million tons to over 3.0 million tons. However, expansion is now limited due to shortage of land available, and also yield per hectare has been relatively low since the past two decades. Therefore, first priority should be given to increase the yield with high production techniques under consideration to limited land available.

In general, the main problems of maize cultivation in Thailand, can be coped with aspect to the possibility of technical improvement and thus may be concluded in the following techniques.

Rainfall, Planting Time and Water Management:

Generally, more than 80% of the total rainfall in the major maize growing area falls between May and October, but it was quite unevenly distributed. A severe dry conditions was thus experienced at times during the planting and growing season, resulting in severe damage to the maize.

According to the record of meteorological data for two decades stable rain fall for planting in the major maize growing area is during May and June. However, planting of maize by growers can be seen in many places even beginning of April after the rain start. To plant maize in advance is always risky and more harmful to yield than benificial. On the other hand, to delay planting of maize would certainly be disastrous if infected by Downy mildew disease* which caused to break out and rapidly spread to other maize growing fields. Therefore, suitable planting time of maize between early May and late June is recommended.

The greatest reduction of the maize yield can be observed when maize plants encounter a severe dry condition during their most critical growing, tasseling and pollinating periods during the rainy season.

Irrigation in the most effective method for growing maize and increases its yield during draught conditions, but water resources, irrigation facilities and an uniform land level are absolutely essential.

According to the experimental results, intensive irrigation water measured at 1.5 times the amount of daily pan-evaporated water for 7 days interval during the tasseling and pollinating stages resulted yield increases of 55% (Exp. F – 4). However, with regards to the irrigation of maize in the major maize growing areas, such a program can only be successfully carried out in strictly limited areas due to the lack of sufficient water resources.

Water conservation by means of a mulch or a covering crop is one way to effectively combat

*According to the experimental results, no Downy Mildew infection was obtained (Exp. B – 1, 2).

moisture stress. A mulch or covering crop will catch and hold any type of rainfall and prevent loss through run-off and will also serve to prevent soil erosion. The paddy-straw mulch plot gave 34% of higher yield of maize than that of non-mulch plot. (Exp. F – 2)

However, unsatisfactory experimental results were obtained from such another mulch and covering crops on yield of maize in the rainy season (Exp. F – 3). Further studies are needed.

Land Preparation and Supplemental Seed Sowing:

Many fields are not uniformly plowed, leaving residues from previous crops with weeds partly disposed. Generally, only one task of shallow plowing without crosswise is accomplished. These practices with poor disposal of weeds and big clods resulted poor stands during the season.

About 10 days after first sowing, supplemental seed sowing is one of the common conventional methods to improve the above poor stands. Usually, farmers do not take into consideration the time of supplemental sowing, most farmers want to obtain full use of their fields by planting more than one crop a year; hence; maize is harvested as soon as possible, whenever first sowing maize matures. This results in poor quality of maize produced and the breaking out of aflatoxin contamination on maize** due to being mixed with immature crops after harvest. Therefore, the better land preparation has the greatest effect on the quality of maize grain.

The recommended method for land preparation is to hire large farm tractors with disk-plow, disk-harrow and ridger from local merchants or custom service operators to do the job. The work may be contracted on the basis of area and charged according to the field conditions. Naturally, contractors and tractor owners would plow in the most profitable and rapid methods. If the farmers do not watch closely, the work may not be as satisfactory as they expect. Therefore, the better quality of work done by hire tractors can be achieved on the basis of operating hours, not concerning with field size and conditions.

High yield of maize are not obtained by some maize fields despite of good growing conditions on all its outer sides. Obviously, the reason lies in area that the plants suffer from excess water in the area inside the field because it is poorly drained. In this case, construction of open ditch lanes should be established around and inside the field depending on the topography which should be connected to lower planes than that of field level. Ditches can serve to drain out the excess water outside of the filed.

Some soils with "hard pans" or impermeable horizones existing near the surface have presented serious problems in management of maize growing since the introduction of large farm tractor cultivation in Thailand. They absorb water slowly during rainstorms, but once they do they take up all the water they can absorb, then drain slowly. Furthermore, root penetration may be limited because of lack of oxygen for root respiration. There is not much that a farmer can do to improve the structure of a heavy clay subsoil (B horizon). Therefore, frequent subsoiling or knifing of farmer's fields is necessary to shatter these layers and encourage deeper root.

According to the experimental results, the effect of subsoil treatment were observed in two

**Dr. K. ASANUMA (Aug. 1983 – Jan. 1984) studied contamination of Aflatoxin on maize grain in Thailand. High contamination could be seen in immature grains at their harvesting time.

fields out of four in 1982, showing 13% and 27% on yield increase, and 31% of higher yield than that of non subsoiling treatment was obtained at a farmer's field in 1983, (Exp. H). However, the maize yield in several of the fields were not affected, therefore, more data of subsoiling treatment are required.

The Rate of Plant Population:

According to the recommended practices for maize cultivation by the Department of Agriculture, the suitable rate of plant population for Suwan 1 is 53,300 plants per hectare. However, the plant population of farmers' maize fields is usually poor. Even selected key farmers, for instance, the average number of plant population on 135 maize producing competition fields in 1980 – 1983 gave only 48,000 – 50,000 plants per hectare. Many plants did not germinate and stands were lower than expected. Evidently, one of the reason is shortage of sowing seeds.

According to the experimental results, it has been found than the highest means yield was obtained from 50,000 – 75,000 plants per hectare (Exp. C – 1), and the estimated maximum-yield-population was 73,367 plants per hectare for Suwan 1 (Exp. C – 2). Therefore, sufficient quantity of seeds should be sown in order to maintain optimum plant population at least 53,300 plants per hectare. However, thinning out of high density of plant population especially too much stands per hill should be done after seeding for the maintenance of optimum population.

The present recommended rate of seed for variety Suwan 1 is only 1.9 kg per hectare (3 kg/rai). It seems a considerable small amount of seeds for the recommended plant population. According to the calculation of kernel weight (250 – 270 g/1,000 kernels), and excessive quantities of seeds where poor germination and thinning out after seeding in expected at least 25 kg (4 kg/rai) of seeds per hectare is needed.

Fertilizer Application and Soil Improvement:

The cost of fertilizers is very expensive relative to that of maize (2:1), so invesments on fertilizer applications are very high compared to other farm expenditures. As mentioned before, maize growing in Thailand is likely to be risky due to abnormal weather conditions, therefore, it is difficult to convince the farmers to risk such high investments.

Here, we only introduce the typically good results of chemical fertilizer application under the conditions of appropriate weather and Reddish Brown Lateritic soil, which generally has a significantly higher response to fertilizer application: 127% of higher yield maize than that of check plot was obtained from fertilizer application 62.5:62.5:0 kg/ha of N:P:K plot (Exp. D – 3). The highest grain yield can be realized when the 150:150:0 kg/ha of N:P:K (the optimum range) gave the greatest profit when the maize was valued at ฿ 2.5/kg and the compound fertilizer (20:20:0) was valued at ฿ 5.0/kg (Exp. D – 4).

Besides the use of chemical fertilizers as mentioned, other methods of soil improvement such as crop rotation, green manuring, soil conservation, etc. have not been well utilized by farmers. Usually, the farmers selected to plant or rotate any crops on the basis of their own needs without realizing their significant roles in soil improvement. Such management sometimes leads to the

destruction of soil nourishment, for example, maize rotation with legumes was a method of soil improvement used by Thai farmers for years. However, farmers now prefer to rotate maize with sorghum or cotton as the increase in profit of these two crops makes production financially feasible. Soil depletion is believed to be quicker with these cropping patterns.

According to the long-term experimental results, the effect of rotation by leguminous crops on yield increase of maize with fertilizer was observed clearly in every rainy season. The yield of maize in 1983 after five years rotation by mung bean and soybean was 4.6 and 4.8 tons/ha respectively, as compared with 3.6 and 3.9 tons/ha by the rotation of sorghum and maize. The difference of yield between the above two groups was about 25%. Therefore, this effective cropping pattern methods should be informed to farmers through Extension and Demonstration work.

Planting and Harvesting Time:

Generally, the harvesting period of the best planting season is between September to October, which is the highest peak of annual rainfall and relative humidity. Harvesting is difficult and drying creates many problems. It is very difficult to decrease the moisture percentage of grain below the safety point under these conditions, and the grain tends to decay and damage easily by fungus and insects. Frequently, farmers harvest the maize too early before the maturing stage in order to plant the second crops such as cotton, sorghum, mung bean, etc. It is also a serious problem of increasing poor quality of grain.

Late planting might solve most problems; however, as mentioned previously, maize plants would certainly be seriously damaged by Downy mildew disease.

It is, therefore, concluded that the suitable time of planting is the early rainy season, and release of the more shorter maturing variety of maize than that of Suwan 1, in order to plant the second crops on time after harvesting of maize is highly required.

Seed Production and Storage:

The weather conditions of Thailand are not favorable for seed storage. With high relative humidity, high temperatures all year round, and many pest insects, seed stored at normal room conditions would be deteriorated and destroyed within a few months. Since commercially good quality seed is not sufficient, the farmers have to select and save seed for their own use in their warehouses. Such seeds, despite of good care, were generally poor in quality and produced very poor stands with low yielding crops.

A primary experiment was carried out in order to improve these problems. The results indicated that the percentage of germination for maize seed stored in three kinds of containers under normal room conditions was reduced gradually from 8 months after storing. The seed contained in the bamboo basket reduced more rapidly than the others. The seed contained in the clay pot was found to be the best way to store grain under normal room conditions in this experiment. The percentage of germination for maize seed stored in the polyethlene woven bag under cold room conditions did not appreciably change for the period of experiment (29 months). However, its germination was reduced sharply when the seed was changed to a normal room after 22 months storage in the cold room (Exp. G).

At present, composit seed Suwan 1 is being produced and distributed to the farmers by Thai Government and private commercial seed companies. However, the quantity is so limited that about less than 10% of the total demand seed has been produced annually.

Currently, some private seed companies have produced and are selling the hybrid seed to farmers in the major maize growing area. Suwan 1 as a composite variety may be obstracted by this hybrid seed. That is, open-porinated variety seed Suwan 1 could be easily changed into different types of maize due to crossing with the hybrid maize especially seed produced by farmers. Suwan 1 grows in common crop fields in whole areas. Therefore, proper countermeasures for the extending hybrid seed should be taken into consideration by Government authorities.

Insect and Disease Damage:

One of the most notorious pests, locusts (Patanga succineta L.) had given serious damage to the maize plants over two decades. The main reason of locust increase is due to influence of changing balance of nature and ecology by the severe destruction of forest and natural vegetation.

Downy mildew is the most serious disease facing maize farmers in Thailand. However, nowadays this disease has been under control since the adoption of resistance variety Suwan 1 and proper time of planting.

According to our observation at present, insect and disease damage on maize is not serious under the proper field cultural practices. However, contamination of Aflatoxin in pre-and post harvested maize is a subject for future study.

Present Limitations to Maize Production:

Thai farmers, in general, know how to grow maize properly. However, the most important factor limiting production is the limited attention which the farmers give their maize fields. That is, not only improper fluctuation of rainfall, but also the low net income they get from their maize crop since the market prices are low compared to the present cost of cultivation.

2. Investigations on Quality Control for Post Harvest Maize

The improvement of maize production is the main objective of the Project. However, we should not ignore the improvement of quality of maize as pointed out in the purpose of the Project.

Aflatoxin contamination with maize grains is becoming the greatest barrier for maize export in Thailand recently. Most of this contamination was caused by the fungi (Aspergillus flavus) infection on grains from harvesting time of maize under high temperature and humidity conditions.

The investigations on quality control of post harvest maize were carried out at the Center in cooperation with the short-term experts from Japan in 1981 – 1982 and 1983 – 1984.

Firstly, the studies were screening of mycoflora and variation of Aflatoxin content in grains of many stages after harvest. Secondly, the studies focused on obtaining technical countermeasures for preventing contaminations from the practical viewpoints.

A. Studies on aflatoxin contamination with maize in Thailand:

1. The real state of aflatoxin contamination with post harvest maize (in 1981 – 1982)

In general, Aspergillus flavus which produces the Aflatoxin grows on maize grains after harvest. It is, therefore, said that the Aflatoxin contamination of maize mainly depends upon the storage conditions after harvest.

The main objective of this report is to make clear the actual states of Aflatoxin contamination with maize grains after harvest in fields and in warehouses of farmers, middlemen and silo companies.

Due to the delay of arrival of the expert from Japan, the investigations did not come into effect until October, 1981. Most of maize in Thailand is harvested from August to September. Therefore, the results of the investigations would be very limited.

I. Investigations on the Aflatoxin contamination of maize under the various stages of storage.

Purpose:

To know the actual storage system and the Aflatoxin content in grains under the various stages of storage.

Materials and Methods:

Samples were collected from fields, warehouses of farmers and middlemen in Lopburi area, and silo companies in Ayudthaya and Bangkok area several times from October 1981 to February 1982. Taking samples from farmers and middlemen in Phetchabun and Phitsanulok Provinces were also carried out twice in October and November 1981.

Approximately 20 pieces (approximate 2 kgs) of ears were used for the analysis of Aflatoxin after collecting at random from farmers' warehouses, threshing, dividing by a sample divider into 300 gr and grinding into flour.

Approximately 500 gr of maize grains was also used for the analysis after collecting at random from middlemen and silo companies' warehouses, dividing into approximate 300 gr, and grinding into flour.

The analytical method was "The Standard Feed Analizing Method" authorized for this purpose in Japan as follows:

Aflatoxin was extracted from the samples by cholroform. It was classified by thin layer chromatography as Aflatoxin B_1, B_2, G, and G_2 after clean up by column chromatography. Aflatoxin B_1 was analysed quantitatively by comparing with the standard solution with fluorescence spectro-photo-meter. The moisture content of grains was checked by the Steinlite moisture meter.

Results:

1. Aflatoxin contamination of grains in the field:

The fields for the investigations were set up at a farmer's field, and a field of the Experiment Station in Phraphutthabat area. Investigations were conducted 3 times from September to November in 1981, on the 4 samples collected from the two fields. The results are shown in Table 32.

The moisture content was considerable high, ranging from 15% to more than 25%.

However, Aflatoxin contamination was very low. A trace (less than 5 p.p.b) of Aflatoxin was observed only in one case, and no contaminations were observed in other samples.

Table 32 Aflatoxin B_1 content of grains from fields in Phraphutthabat area

Sample Number	Place	Date of Collection	Moisture %	Aflatoxin B_1 ppb
1	Farmer's field	Sep. 30	19.5	0
2	"	Oct. 8	15.2	Trace
3	Exp. Station's field	Nov. 9	16.0	0
4	"	Nov. 9	More than 25	0

2. Aflatoxin contamination of grains in the farmers storages.

The results on 21 samples are shown in Table 33.

The moisture content of grains ranged from 12.5 to 18%, and the mean value was 15%.

Deviation of Aflatoxin content was very large and there were no differences in Aflatoxin content between places and sampling dates excluding the mountain areas where a little contamination was observed.

Detection rate of Aflatoxin was 43% (excluded 0 p.p.b. and trace). Range and mean value of the content were from 0 to 82 p.p.b. and 16 p.p.b. respectively.

There were many samples with low content of Aflatoxin in the investigations, but the deviation of value was very large. There were no relations between storage term and value of Aflatoxin content. While sample No. 1 stored only for a week after harvest was 82 p.p.b., No. 21 stored about 3 months since harvest was only trace. However, it seemed that some relationships between moisture content and Aflatoxin content were observed.

Table 33 Aflatoxin B_1 content of grains from farmers' warehouses

Sample number	Location	Date of collection	Date of harvest	Moisture %	Aflatoxin B_1 ppb
1	Phraphutthabat Lopburi	Oct. 1	Sep. 23	17.0	82
2	"	Oct. 8	-	14.5	0
3	"	"	Oct. 6	16.0	36
4	"	"	Oct. 5	15.0	0
5	"	"	Sep. 30	15.6	0
6	Phetchabun	Oct. 14	-	14.6	11
7	"	"	-	14.2	Trace
8	"	"	Beg. Sep.	14.4	"
9	"	"	Mid. Sep.	14.1	0
	(Mountain) (area)				
10	Prompiram, Phitsanulok	Oct. 15	Aug.	14.3	Trace
11	"	"	-	14.5	25
12	"	"	Mid. Sep.	15.0	18
13	Phetchabun	Nov. 18	-	15.8	80
14	"	"	-	14.5	12
15	" (Mount. area)	"	Mid. Sep.	12.5	Trace
16	"	"	-	15.6	0
17	"	"	-	17.0	0
18	Prompiram, Phitsanulok	Nov. 19	-	18.2	55
19	"		-	16.0	13
20	Phraphutthabat Lopburi	Dec. 11	Beg. Oct.	12.6	Trace
21	"	"	Beg. Sep.	12.7	Trace
	Mean			15.0	16

* Sampling was taken from ears.

3. Aflatoxin contamination of grains during storage of middlemen.

Results of the investigation on 18 samples from middlemen and cooperatives' warehouses are shown in Table 34.

The moisture content ranged from 12 to 18%, and its mean value was 15%. Detection rate of Aflatoxin was 83% excluding 0 p.p.b. and trace values. Aflatoxin content ranged from 0 to 520 p.p.b. and the mean value was 122 p.p.b.

The deviation of the contamination showed almost the same tendency between places and sampling dates.

4. Aflatoxin contamination of grains in the storages of silo companies:

The investigations were carried out on two kinds of samples, one was the samples just before putting into the silos and another was under storage in their warehouses.

The results are shown in Table 35 and 36.

There were clear differences in moisture content between two cases. Samples of grains were lower in moisture content than those stored in the warehouses before.

As to the differences of Aflatoxin content, however, between these two cases, it was difficult to observe clearly. According to the result in Table 5, the moisture content on grains ranged from 12.2 to 15.4% and the mean value was 14.1%. About 30% of them were beyond the standard moisture content for export (14.5%).

The detection rate of Aflatoxin in all the samples was 94 and the content of it ranged from 0 to 240 p.p.b. with 94.2 p.p.b. as the mean value.

Table 34 Aflatoxin B_1 content of grains from middlemen's warehouses

Sample number	Location	Date of collection	Moisture content %	Aflatoxin B_1 ppb	Note
1	Lopburi	Oct. 8	15.3	12	
2	"	"	14.0	285	
3	"	"	15.0	8	
4	"	"	14.2	32	
5	"	"	15.7	15	
6	"	Oct. 14	15.0	65	
7	Phetchabun	"	16.5	102	
8	Phitsanulok	Oct. 15	18.0	520	mixed with heated grains
9	Lopburi	Nov. 9	15.5	0	
10	"	"	16.3	168	mixed with damaged grains by insect & mould
11	Lopburi	"	14.3	0	
12	"	Nov. 18	14.9	79	
13	Phetchabun	"	15.5	81	
14	"	"	17.0	313	mixed with heated grains
15	Lopburi	Dec. 11	12.4	142	
16	"		14.7	Trace	
17	"	Jan. 12	12.0	135	mixed with damaged grains by insect & mould
18	"	"	13.6	240	
	Mean		15.0	122	

Table 35 Aflatoxin B_1 content of grains just before putting into storages of silo companies.

Sample number	Location	Date of collection	Moisture %	Aflatoxin B_1 ppb
1	Bangkok	Oct. 12	14.9	73
2	Tharua, Ayudthaya	Nov. 16	17.0	91
3	Bangkok	Nov. 30	15.8	296
4	Tharua	Dec. 23	14.6	Trace
5	"	"	15.4	"
6	"	"	15.0	18
7	Bangkok	Jan. 5	16.8	85
	Mean		15.6	80.4

Table 36 Aflatoxin B_1 content of grains from warehouses of silo companies.

Sample number	Location	Date of collection	Moisture %	Aflatoxin B_1 ppb
1	Bangkok	Oct. 12	14.4	72
2	"	"	14.0	170
3	Tharua	Oct. 13	15.2	26
4	"	"	14.3	115
5	"	Nov. 16	14.1	25
6	"	"	15.4	174
7	Bangkok	Nov. 30	14.7	19
8	"	"	14.0	110
9	"	"	14.4	107
10	"	"	14.7	240
11	Tharua	Dec. 23	13.4	93
12	"	"	14.8	108
13	"	"	12.8	50
14	"	"	12.2	150
15	"	"	13.2	0
16	Bangkok	Jan. 5	14.3	48
	Mean		14.1	94.2

II. Variation of Aflatoxin content of grains during storage:

Purpose:

To determine the variation of Aflatoxin and moisture content in grains during storage.

Materials and Methods:

Thirty kgs. of ears in a bag was stored into each of 4 farmers' storages, and 20 ears were sampled at random from each bag every 10 days for the period of 1.5 months.

Thirty kgs. of grains in gunnybags were also stored in 2 middlemen's warehouses. Approximate 500 gr of grains were sampled from each bag 3 times during the period of 4 months. The methods of analysis of Aflatoxin and moisture content were those of investigations of I.

Results:

Results were shown in Tables 37, 38.

The moisture content of grains out of ear bags were 15% at first, and it did not change at all, but the Aflatoxin content increased gradually.

As to the sampling grains from middlemen's storage, the moisture content reduced smoothly, while variation of Aflatoxin content did not change.

Table 37 Variation of Aflatoxin B_1 in grains during storage in farmers' warehouses.

Sample number		Date of collection, moisture content (%) and Aflatoxin B_1 (ppb)				
		Oct. 8	Oct. 20	Oct. 29	Nov. 10	Nov. 23
1	Moist.	14.5	14.2	14.6	14.2	14.6
	Afla. B_1	0	0	0	15	19
2	Moist.	15.2	14.2	15.0	14.5	15.2
	Afla. B_1	Trace	0	5	Trace	Trace
3	Moist.	15.0	14.8	15.1	15.5	16.0
	Afla. B_1	0	13	4	0	12
4	Moist.	15.6	16.1	15.8	15.5	16.1
	Afla. B_1	0	14	17	27	82
Mean	Moist.	15.1	14.8	15.1	14.9	15.5
	Afla. B_1	0	6.8	6.5	10.5	28.3

Table 38 Variation of Aflatoxin B_1 in grains during storage in middlemen's warehouses.

Sample number		Date of collection, moisture content (%) and Aflatoxin B_1 (ppb)				
		Oct. 8	Nov. 9	Dec. 11	Jan.	Feb. 9
1	Moist.	15.3	14.1	13.2	-	11.0
	Afla. B_1	12	Trace	10	-	15
2	Moist.	15.7	14.5	13.3	-	11.1
	Afla. B_1	15	18	13	-	9

III. Discussion:

It is well known that Aspergillus flavus which produce Aflatoxin exists in the air and grows on stomata of crops, and it is also suitable for tropical area under the conditions of high temperature and humidity. Dr. M. Kakishima observed that this fungus grows on maize grains of farmer's fields in Lopburi Province in 1981 – 1982. The metrological data in Phraphutthabat area from March 1981 to February 1982 was shown in Table 39.

Many cases of the first infestation of the fungus on maize grains therefore, would begin in fields at harvesting time.

However, in the investigations on grains collected from fields, it was observed that the Aflatoxin contamination is negligible, in spite of the high moisture content of grains. This would be caused by in-sufficient growth of the fungi, because there is not enough time for producing Aflatoxin.

On the samples from farmers' warehouses, the detection rate of Aflatoxin increased, but the amount of the contamination was not so large. However, the rate of contamination was clearly increased compared with those on samples directly from the fields. This would be caused by the growth of fungi as the result of increasing of the storage periods of grains with high humidity content.

The relationships between the contamination and duration of storage after harvest and between the contamination and differences in time of sampling for the analysis could not be observed. However, there was some tendency of little contamination in samples collected from the moutain areas in Phetchabun Province. Less contamination of Aflatoxin in maize grains from the mountain areas in Phetchabun Province would depend upon the mono cropping of maize in one year, because there was enough time to dry them before selling to middlemen.

Almost the same tendency on moisture and Aflatoxin content was observed by another experiment, which was the keeping of earcorns in bags at the farmers' warehouses. Final Aflatoxin value in the samples after storage for 45 days, ranged from trace to 82 p.p.b. and the mean value was 28 p.p.b. From these results, it is suggested that more than 45 days would be necessary for producing high value of Aflatoxin in grains.

The contamination of Aflatoxin in samples from middlemen's warehouses was increased clearly both in detection rate and the amount. The moisture content of grains in this case was almost the same level of those from farmers' warehouses. This high moisture content would change the quality of grains for the worse as the result of extending of their storing periods. Some samples which were mixed with heated grains of high moisture content or grains damaged by diseases and insects showed a high level of contamination.

However, in the warehouses of silo companies it was observed that the moisture content of grains seemed to decrease, and Aflatoxin content seemed not to change during storage. We can say that the contamination value of middlemen's grains was transfered directly to the silo companies, where there are better conditions for keeping them.

This is also endorsed by another experiment of quality comparison of grains between samples collected right before putting into silos, and those under storage. There were not any different trends of contamination value in samples between the grains from two companies and those of two different sampling times.

Most of the maize in Thailand is cultivated in the rainy season and harvested from August. The moisture content of grains at maturity reaches about 25%. The harvested ears are stored in farmers' warehouses for a period after drying under the sun to the extent of about 15% of moisture content of grains.

They are stored in middlemen's warehouses after shelling by shellers at the farmers' yards, and drying again under the sun. Finally, they are transfered to silo companies for export. Almost all periods of the process mentioned above are under the condition of high temperature and humidity. It is an ideal condition for growing Aspergillus flavus in grains together with the high moisture content in them.

Therefore, it is suggested that the most important counter-measures for checking the Aflatoxin contamination in grains are to dry them enough as quickly as possible after harvest by introducing effective facilities to both farmers and middlemen's level. Furthermore, shifting the harvesting time of maize which is now too early to escape the rainy season by introduction of a new planting system.

This report made clear one aspect of the actual state of Aflatoxin contamination in maize grains in Thailand. Further investigations, therefore, will be necessary in the near future. The next step of the investigations should be conducted by using more samples at the appropriate season.

It would also important to include samples from the same sources, in order to clarify the changing process of the contamination from farmers' fields to silo companies.

Table 39 The meteorological data at Phraphutthabat Agriculture Experimental Station, from March 1981 to February, 1982.

Month	Rainfall mm (Total)	Temperature °c Max	Mini	Aver. Relative Humidity %
1981				
March	24.7	38.0	22.0	68
April	146.0	37.4	21.8	70
May	133.1	38.0	21.2	72
June	83.2	35.0	21.0	69
July	249.2	35.0	23.0	79
August	160.0	33.2	22.8	74
September	352.5	34.6	22.2	76
October	78.3	34.8	22.2	69
November	131.3	34.6	17.8	71
December	-	33.4	16.8	54
1982				
January	-	33.4	19.2	56
February	-	37.2	21.2	65

2. Relationship between aflatoxin contamination and harvesting techniques on maize (in 1983 – 1984)

Contamination of Aflatoxin has been described and examined by various authors from different points of view. This paper describes the analysis of its contamination which proves certain existing relationship between concentration of contamination and maturity of maize grain.

Materials and Methods:

Three maize fields (A,B,C) with different times of planting were selected at Koktoom, Lopburi Province. Ten pieces of ears as sample were collected from the above fields as follows:

A field: (1) The most appropriate time of maturity. (about 10 – 20 October)
(2) Approximate 4 weeks before the most appropriate time of maturity.
(3) Under raining condition

B field: (1) The most appropriate time of maturity. (about 10 – 20 September)
(2) Approximate 1 week before the most appropriate time of maturity.

C field: (1) The most appropriate time of maturity. (about 15 – 25 November)
(2) Approximate 2 weeks before the most appropriate time of maturity.

Samples which were collected from the above period, were divided into 4 treatments as follows:

(a) Undamaged earcorn.
(b) Damaged earcorn with insects and fungus.
(c) Damaged earcorn was made by scratches with iron spatula and stuck to the soil (excluding A field – (3).
(d) Mixed with undamaged (75%) and damaged (25%) earcorn (excluding A field – (3)).

All samples which were collected by the above methods, were stored in the ordinary warehouse (non air-conditioned) up to analysis after one week drying up on the concrete pavement in the sun.

Moisture content of grain was examined after threshing, and 25g of maize flour for analysis made from the 10 pieces of ear after collecting at random from samples, which were, 0, 7, 20, 30, 40, 50 and 60 days after havest. They are shown as in Table 40 – 1.

The analytical method for Aflatoxin was carried out under the A.O.A.C. method as follows.

Table 40－1 Date of Sampling

(1983)

Group of fields	Matu-rity	Matur-rering Date	Days after harvested						
			0	7	20	30	40	50	60
A	M	10-20	19 Oct.	26 Oct.	8 Nov.	18 Nov.	28 Nov.	8 Dec.	18 Dec.
	P	Oct.	14 Sep.	21 Sep.	4 Oct.	14 Oct.	24 Oct.	3 Nov.	13 Nov.
B	M	10-20	13 Sep.	20 Sep.	3 Oct.	13 Oct.	23 Oct.	2 Nov.	12 Nov.
	P	Sep.							
C	M	15-25	21 Nov.	28 Nov.	11 Dec.	21 Dec.	31 Dec.	Not Sampling	Not Sampling
	P	Nov.	3 Nov.	10 Nov.	23 Nov.	3 Dec.	13 Dec.	23 Dec.	2 Jan,1984

M: Matured, P: Prematured

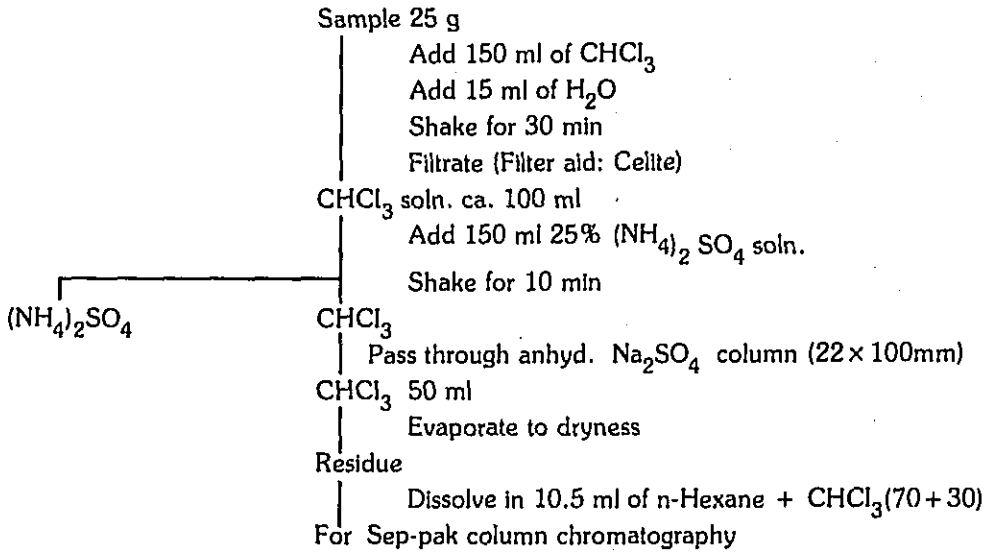
Table 40－2 Date of Sampling (Differencial from Weather)

(1983)

Group of fields	Matu-rity	Wea-ther	Matur-rering Date	Days after harvested						
				0	7	20	30	40	50	60
A	M	F	10-20 Oct.	19 Oct.	26 Oct.	8 Nov.	18 Nov.	28 Nov.	8 Dec.	18 Dec.
		R		11 Oct.	18 Oct.	31 Oct.	10 Nov.	20 Nov.	30 Nov.	10 Dec.

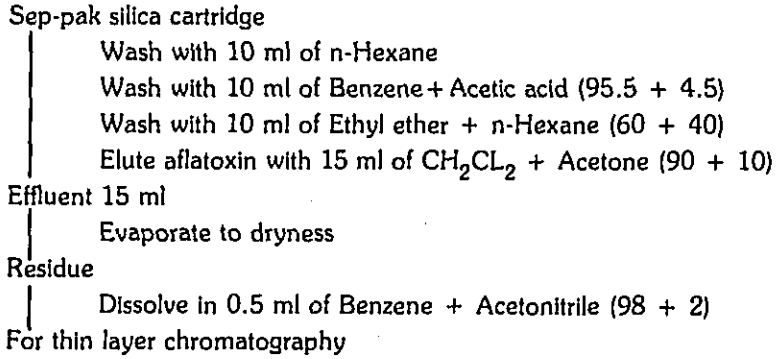
M: Matured, F: Fine Day, R: Rainy Day

Extraction Method of Aflatoxin B_1 in Grains



The Aflatoxin extracts for column charonomatography were further purified in the manner by Sep-pak Silica Cartrige as follows

Sep-pak Silica Cartridge Column Chromatography



The determination method for concentration of Aflatoxin from each sample was as follows:

20 mcl of sample extract was spotted at intervals of 1.5 cm on the Silica gel TLC plate and also 0.5, 1.0, 2.0 and 4.0ng of standard solution of Aflatoxin B_1 were spotted along the above line.

The concentration of Aflatoxin B_1 in samples was determined by the fluorescent intensities, which was compared with standard solution of Aflatoxin B_1, with densitometer (Ex 365nm, Em 425nm) after the plate was developed with mixed solvent consisting of Chloroform + N-Hexane + Acetone (90 + 5 + 5).

One of the standard curve for Aflatoxin B_1 is shown in Fig. 4.

The lower limit of detection in this experiment was 0.2ng in the standard solution of Aflatoxin B_1. Then the detection limit is calculated to be 0.6ng/g (ppb) by the equation as follows:

$$0.2\ ^{ng} \times \frac{150\ ml \times 500\ \mu l}{50\ ml \times 20\ \mu l \times 25g} = 0.6\ ^{ng/g}$$

The recoveries of Aflatoxin B_1 tested by adding 2.5 and (ng/g of standard Aflatoxin B_1 to 15g samples were 90.9% (C.V. 3.9%) and 94.8% (C.V. 2.2%), respectively.

Thin Layer Chromatography

Plate; Merck precoated silicagel 60 (Art. 11854)
Spot : 20μl
Develop; $CHCl_3$ + n-Hexane + Acetone (90 + 5 + 5) 15cm
Detector; Hitachi 610 – 10S
Ex. 365nm Em. 425nm

Results:

The results are shown in Table 41 – 43

Grains harvested at the most appropriate time of maturity were not contaminated with aflatoxin in every treatment of all fields. Grains sampled before the most appropriate time of maturity from A and B fields were contaminated with aflatoxin. Grains from A field which were sampled about four weeks before the most appropriate time of maturity were more highly contaminated than those from B field sampled one week before appropriate time of maturity. Immatured grains from C fields, however, sampled about two weeks before the most appropriate time of maturity were not contaminated at all in every treatment.

As to comparison among four treatments, the highest contamination value was detected from grains of (C) treatment given damages to them compulsorily and the lowest value was seen from a treatment given no damages externally. Grains from other two treatments showned intermediate value of contamination between C and A treatment. The differences of contamination value in grains among four treatments are as follows.

C > D > B > C

No contamination value could be seen in immatured grains from a treatment of B field. They are shown in Fig 8.

There were no differences of contamination value between grains harvested under raining condition and dry condition.

Detection of aflatoxin value could be seen at twenty days after harvest and the maximum contamination value was detected at thirty to fifty days after harvest. The reduction of contamination value of Aflatoxin B_1, was seen from more than fifty days after harvest.

There was no correlation between moisture content of grains before analysis and amount of Aflatoxin B_1 content. High correlation, however, was observed between moisture content at harvesting time and Aflatoxin B_1 contamination value in grains.

No contamination of Aflatoxin was observed in grains which were less than 22.5% of moisture content. High contamination, however, could be seen in grains which were more than 32.5% of moisture content at their harvesting time.

In some materials from 22.5% to 32.5% of moisture content could be detected in very small amounts of Aflatoxin B_1. (Fig 9)

Discussion:

According to the result of experiments, it was proved that maize grains which matured completely were very safe from the contamination with aflatoxin. This fact was well known as a result of many experiences. The recommendation ensured the full maturity time for harvesting maize. It was already issued by WHO and FAO as one of essential countermeasures for preventing aflatoxin contamination with grains. In the experiments the grains which matured completely were not contaminated with aflatoxin even in the case of suffering external damages on them and harvesting under rainy condition.

On the contrary, immatured grains suffered big contamination with aflatoxin and more immatured ones were shown more highly contaminated value.

Most of the immatured grains contained more than 30% of moisture. There were therefore clear relationships between contamination and moisture content of grains at harvesting time.

Furthermore, damages on grains accelerated the contamination with aflatoxin. A case of immatured grains from field was not contaminated at all. It would depend upon the harvesting time in November when it is already into the real dry season.

Contamination of aflatoxin was detected from 20 days after harvest and the peak value was more than 20 days after the above stage. During this period, most of the maize harvested would be stored in farmers' warehouses as earcorns. It would be an important stage to improve quality of maize by developing intellect of farmers as well as strengthening quality inspections.

In this experiment, the reduction of aflatoxin content could be seen more than 50 days after harvest. It is very difficult to explain the reason now. It would be necessary to re-investigate in the future.

As conclusion, many countermeasures should be taken into consideration:

1. Earcorns and grains should be dried up after harvest as quickly as possible. According to this experiment the equilibrium moisture content of Suwan 1 was assumed about 17.5%. Drying should be carried out up to this level. For the purpose, the development of handy drying systems for farmers level would be very necessary.

2. Maize harvest should be carried out after full maturity of all plants in the fields in the rainy season. Generally, Most of the farmers are used to filling up dead spaces without enough stands in rows based on the original planting by supplementary sowing.

The supplemental sowing was usually carried out about ten days after original sowing time. Harvesting time, therefore, should be decided following full maturity of all stands by account of the supplemental plants.

3. For harvesting maize, the operations should be done very carefully. Damages to grains will induce contamination of Aflatoxin, especially in the case of harvesting before appropriate time of maturity.

Table 41 Contentration of Aflatoxin B_1 in Maize Grains.

(ng/g)

No.	Maturity	Field	Group of grains	Days after harvested 0	7	20	30	40	50	60	Total
1	Completely Matured	A	Un-damaged	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	-
			Naturally damaged	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	-
			Mechanically damaged	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	-
			U. Dm. + N. Dm. (4:1)	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	-
			Mean	-	-	-	-	-	-	-	-
			S.D.	-	-	-	-	-	-	-	-
2	Completely Matured	B	Un-damaged	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	-
			Naturally damaged	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	-
			Mechanically damaged	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	-
			U. Dm. + N. Dm. (4:1)	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	-
			Mean	-	-	-	-	-	-	-	-
			S.D.	-	-	-	-	-	-	-	-
3	Completely Matured	C	Un-damaged	<0.60	<0.60	<0.60	<0.60	<0.60	-	-	-
			Naturally damaged	<0.60	<0.60	<0.60	<0.60	<0.60	-	-	-
			Mechanically damaged	<0.60	<0.60	<0.60	<0.60	<0.60	-	-	-
			U. Dm. + N. Dm. (4:1)	<0.60	<0.60	<0.60	<0.60	<0.60	-	-	-
			Mean	-	-	-	-	-	-	-	-
			S.D.	-	-	-	-	-	-	-	-
4	Im-matured	A	Un-damaged	<0.60	<0.60	1.42	30.06	11.14	17.61	9.33	≥ 69.56
			Naturally damaged	<0.60	<0.60	0.75	25.72	28.98	21.74	6.86	≥ 84.05
			Mechanically damaged	<0.60	<0.60	2.25	78.59	71.11	36.43	15.16	≥188.38
			U. Dm. + N. Dm. (4:1)	<0.60	<0.60	6.30	57.28	51.54	23.88	12.83	≥151.83
			Mean	-	-	2.68	47.91	40.69	24.92	11.05	≥123.46
			S.D.	-	-	2.49	24.77	26.16	8.11	3.68	56.21
5	Nearly Matured	B	Un-damaged	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	-
			Naturally damaged	<0.60	<0.60	<0.60	<2.69	2.11	<0.60	<0.60	≥ 4.80
			Mechanically damaged	<0.60	<0.60	<0.60	<8.66	8.59	11.30	7.45	≥ 36.00
			U. Dm. + N. Dm. (4:1)	<0.60	<0.60	<0.60	<4.17	4.83	0.60	0.60	≥ 9.00
			Mean	-	-	-	-	-	-	-	-
			S.D.	-	-	-	-	-	-	-	-
6	Nearly Matured	C	Un-damaged	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	-
			Naturally damaged	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	-
			Mechanically damaged	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	-
			U. Dm. + N. Dm. (4:1)	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	-
			Mean	-	-	-	-	-	-	-	-
			S.D.	-	-	-	-	-	-	-	-

" 0.60 " Means Not detected
" U. Dm. " Means Un-damaged
" N. Dm. " Means Naturally damaged
" — " Means Not Culculated

Table 42 Moisture Contents in Corn Grains.

No.	Maturity	Field	Group of grains	Days after harvested 0	7	20	30	40	50	60
1	Completely Matured	A	Un-damaged	20.2	17.8	15.7	14.1	13.1	13.2	13.4
			Naturally damaged	18.6	17.9	15.7	14.0	13.2	12.6	13.1
			Mechanically damaged	17.1	15.8	15.3	14.1	13.2	12.5	13.2
			U. Dm. + N. Dm. (4:1)	19.1	17.7	15.8	14.4	13.4	13.1	13.6
			Mean	18.8	17.3	15.6	14.2	13.2	12.9	13.3
			S.D.	1.3	1.0	0.2	0.2	0.1	0.4	0.2
2	Completely Matured	B	Un-damaged	30.5	22.6	20.3	17.6	18.1	15.6	15.5
			Naturally damaged	28.5	20.5	18.8	17.5	17.6	15.5	14.7
			Mechanically damaged	30.3	22.2	17.3	18.0	17.3	15.4	14.8
			U. Dm. + N. Dm. (4:1)	32.4	22.7	18.6	17.0	17.6	15.4	15.0
			Mean	30.4	22.0	18.8	17.5	17.7	15.5	15.0
			S.D.	1.6	1.0	1.2	0.4	0.3	0.1	0.4
3	Completely Matured	C	Un-damaged	20.3	17.4	13.6	14.1	13.4	-	-
			Naturally damaged	21.6	15.4	13.0	13.7	13.1	-	-
			Mechanically damaged	20.6	16.0	13.4	13.8	13.7	-	-
			U. Dm. + N. Dm. (4:1)	20.5	16.9	14.4	13.4	13.2	-	-
			Mean	20.8	16.4	13.6	13.8	13.4	-	-
			S.D.	0.6	0.9	0.6	0.3	0.3	-	-
4	Im-matured	A	Un-damaged	47.6	29.7	24.9	20.4	17.8	15.8	13.9
			Naturally damaged	35.7	28.9	23.5	20.6	19.6	15.5	14.8
			Mechanically damaged	37.6	27.7	22.7	18.6	17.9	15.0	14.3
			U. Dm. + N. Dm. (4:1)	41.0	22.7	21.1	18.8	17.6	15.2	15.1
			Mean	40.5	27.3	23.1	19.6	18.2	15.4	14.5
			S.D.	5.2	3.1	1.6	1.0	0.9	0.4	0.5
5	Nearly Matured	B	Un-damaged	26.1	21.6	19.2	18.5	17.4	15.8	15.2
			Naturally damaged	28.8	21.0	18.2	17.4	17.4	16.0	15.0
			Mechanically damaged	27.6	20.5	18.8	17.5	16.7	15.2	15.0
			U. Dm. + N. Dm. (4:1)	27.2	21.1	18.4	18.6	17.3	15.6	15.2
			Mean	27.4	21.1	18.7	18.0	17.2	15.7	15.1
			S.D.	1.1	0.5	0.4	0.6	0.3	0.3	0.1
6	Nearly Matured	C	Un-damaged	28.1	21.9	18.2	14.8	13.6	13.7	13.8
			Naturally damaged	29.5	20.5	16.7	14.5	13.2	13.4	13.5
			Mechanically damaged	29.4	21.6	15.7	14.8	13.4	13.9	13.2
			U. Dm. + N. Dm. (4:1)	28.3	20.1	16.4	14.2	13.3	13.6	13.7
			Mean	28.8	21.0	16.8	14.6	13.4	13.7	13.6
			S.D.	0.7	0.9	1.2	0.3	0.2	0.2	0.3

"U. Dm." Means Un-damaged

"N. Dm." Means Naturally Damaged

Table 43-1 Concentration of Aflatoxin B_1 in Maize Grains.

(ng/g)

Maturity	weather	Group of grains	Days after harvested						
			0	7	20	30	40	50	60
COMPLETELY MATURED	FINE	Undamaged	< 0.60	<0.60	< 0.60	< 0.60	< 0.60	<0.60	<0.60
		Naturally damaged	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	<0.60	<0.60
		Mean	-	-	-	-	-	-	-
	RAINY	Undamaged	< 0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60
		Naturally damaged	< 0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60
		Mean	-	-	-	-	-	-	-

Table 43-2 Moisture Content in Maize Grains.

(%)

Maturity	weather	Group of grains	Days after harvested						
			0		20	30	40	50	60
COMPLETELY MATURED	FINE	Undamaged	19.8	18.2	15.2	14.1	13.0	12.7	13.3
		Naturally damaged	18.3	17.8	15.6	14.5	13.3	12.5	12.9
		Mean	19.1	18.0	15.4	14.3	13.2	12.6	13.1
	RAINY	Undamaged	23.2	22.1	16.1	15.7	15.1	13.0	13.1
		Naturally damaged	25.7	21.9	16.0	15.6	14.9	12.9	13.0
		Mean	24.7	22.0	16.1	15.7	15.0	13.0	13.1

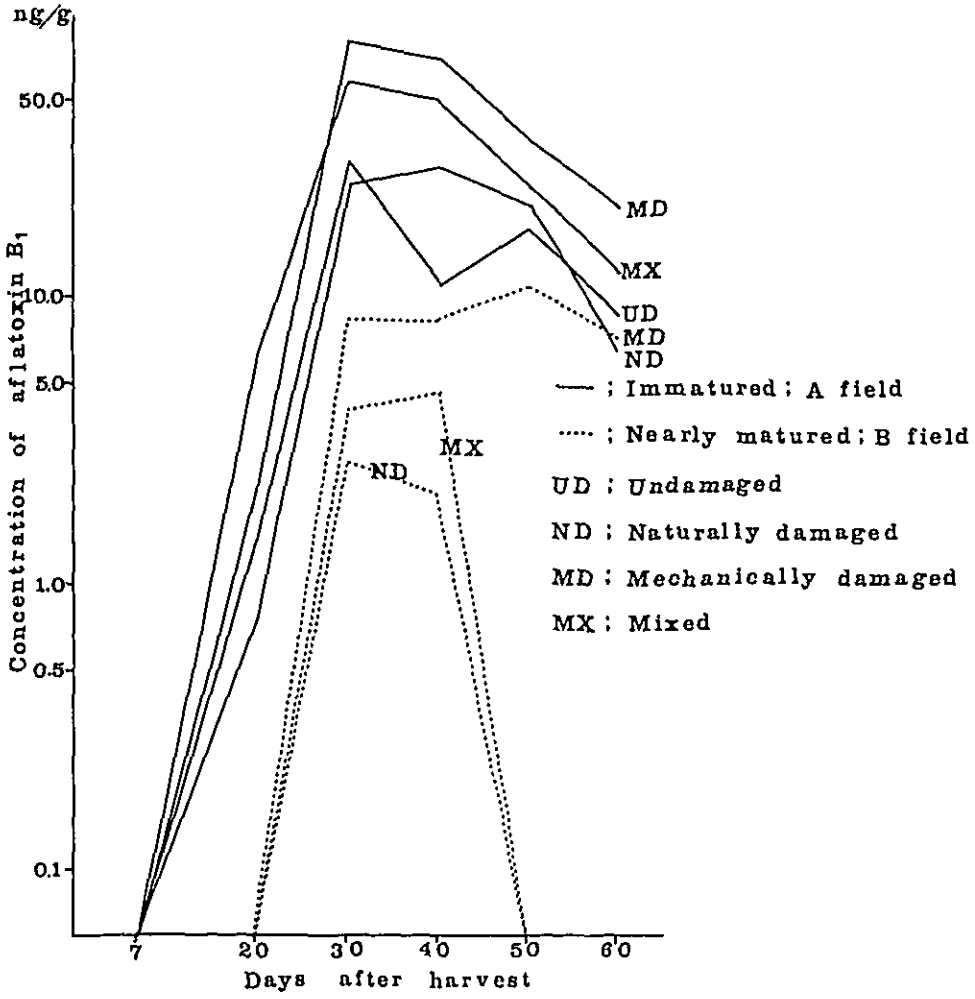


Fig. 8 Contamination of aflatoxin B_1 in maize grains

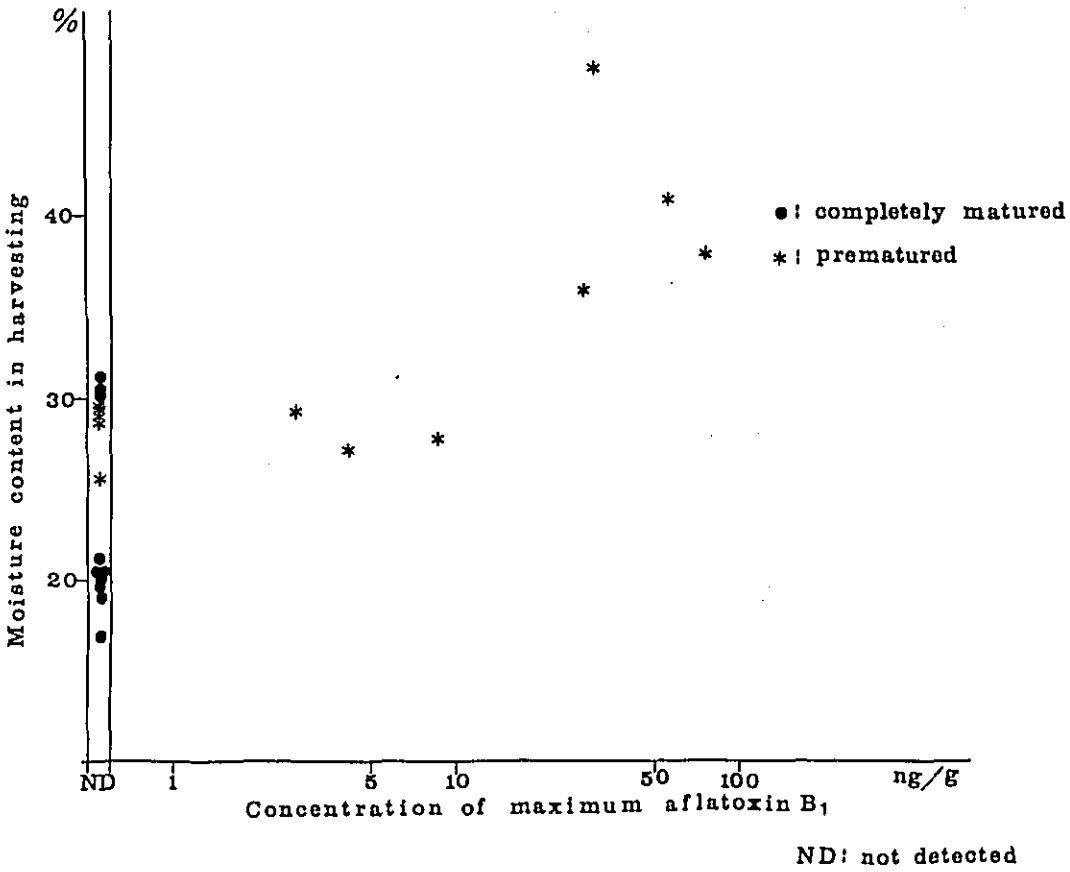


Fig. 9 Relationship between maximum aflatoxin B_1 and moisture content

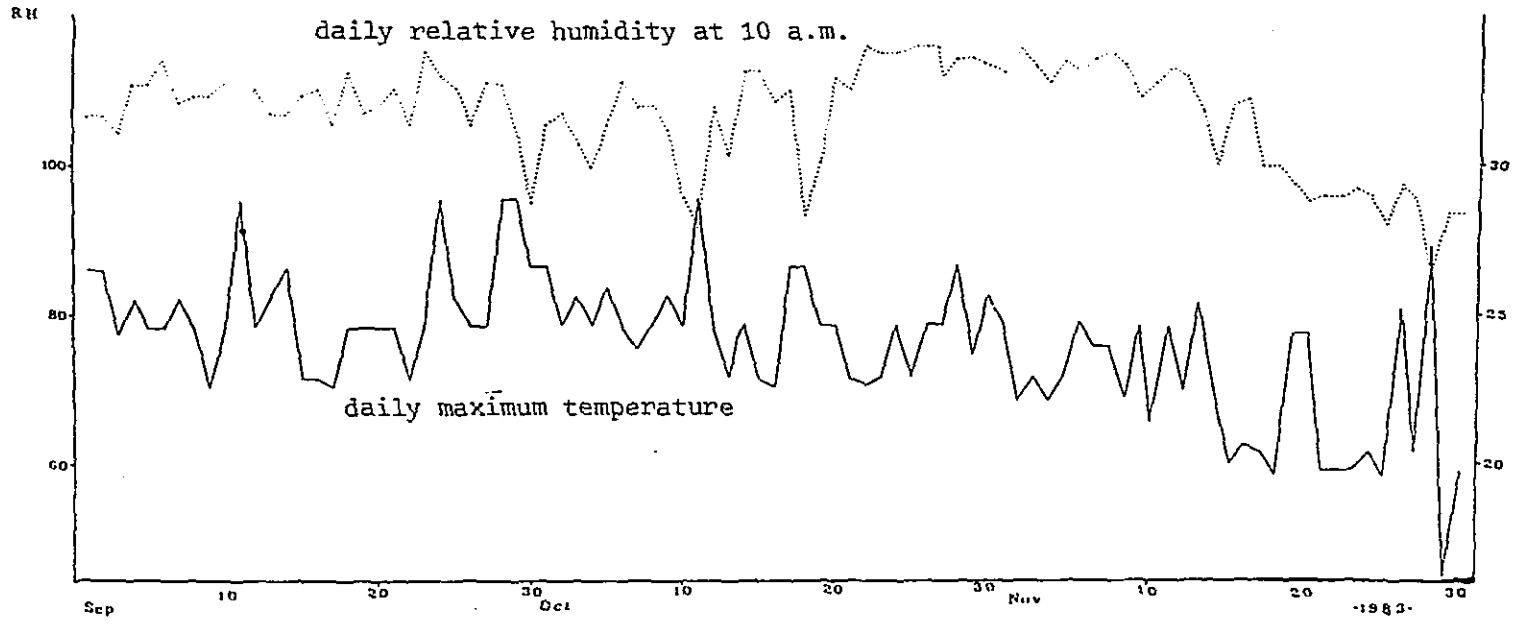


Fig. 10 Metoralogical data at the Center from *September to November* 1983

B. Studies on mycoflora expecially, Aspergillus flavas on maize grains in Thailand

1. Mycoflora on grains of post harvest maize (in 1981 – 1982)

In Thailand maize is harvested in September to October that is nearly the end of the rainy season. The climate of this season is very a favorable condition for the growth of many fungi. In this study, the mycoflora of maize grains which are collected from farmer's field, farmer's storage warehouses, the godown of middlemen and silo companies are examined.

Materials and Methods:

Samples of maize were collected from various parts of Thailand. Origin of samples, date of collections and locations of collections are shown in Table 44.

Earcorns were obtained from farmer's fields and farmer's storage warehouses. Those ears were threshed into grains and were kept in a refrigerator until used. Two samples of earcorns were stored at the center in Sept. 17, 1981. After storage sampling were carried out in Oct. 8 and Nov. 5. Samplings were also carried out for several times from the same farmer's storage warehouse in order to examine the succession of fungi. Maize grains were also obtained from the godown of middlemen and silo companies. Those samples were kept in a refrigerator until used.

Two kinds of media were used to examine the mycoflora. One of them is Potato dextrose agar (PDA) which contains potato infusion, 20g dextrose and 15g agar per one litre. Another is malt salt agar (MSA) which contains 20g malt extract, 75g NaCl and 20g agar per one litre. In PDA medium two or three drops of 20% lactic acid per one petridish were added to inhibit the growth of bacteria.

Maize grains were immersed in the 1% sodium hypochlorite solution to sterilize the surface of grains for 3 min. After sterilization they were washed three to five times in sterile distilled water and transferred to sterile filter papers except water, 5 grains per one petridish were put on the media in petridish, 40 – 50 grains were used to examine the mycoflora. These petridish were incubated at 25° – 30° C. When fungi appeared on the surface of the grains, these fungi were picked up by using needle under stereomicroscope and transferred into the test tube slant media. The cultures were incubated at 25° – 30° C and were identified.

Results:

Frequency of fungi isolated from various samples are shown in Table 45 – 48.

From the samples collected from farmer's fields, Aspergillus spp., *Penicillium* spp., *Botryodiplodia* sp., *Curvalaria* sp., *Fusarium* spp. were obtained (Table 45). *Fusarium moniliforme* was most frequently detected. In the sample 103, 100% grains were infested with *Fusarium moniliforme*, *Aspergillus* spp. and *Pencillium* spp. which are known as storage fungi already appeared.

From the samples collected from the farmer's storage warehouses, *Aspergillus* spp., *Penicillium* spp., *Chaetomium* sp., *Cladosporium* sp., *Trichoderma* sp., *Botryodiplodia* sp.,

Brachysporium sp., *Colletotrichum* sp., *Curvularia* sp., *Fusarium* spp., *Nigrospora* sp. were isolated (Table 46). *Fusarium moniliforme* was most frequently detected from these samples. *Penicillium citrinum, Penicillium islandicum, Botryodiplodia* sp. were dominantly isolated.

Aspergillus spp., *Penicillium* spp., *Chaetomium* sp., *Codinaea* sp., *Rhizopus* sp., *Syncephalastrum* sp., *Trichoderma* sp., *Botryodiplodia* sp., *Colletotrichum* sp., *Curvularia* sp., *Drechslera* sp., *Fusarium* sp., *Nigrospora* sp. were isolated from the samples collected from the godown of the middlemen (Table 47). From these samples, *Aspergillus flavus, Aspergillus niger, Penicillium citrinum, Penicillium islandicum, Botryodiplodia* sp., *Fusarium moniliforme* were dominantly detected.

From the samples obtained from the godown of silo companies, *Aspergillus* spp., *Penicillium* spp., *Botryodiplodia* sp., *Colletotrichum* sp., *Fusarium* sp., *Nigrospora* sp. were isolated (Table 48). *Aspergillus flavus, Aspergillus glaucus, Aspergillus niger, Penicillium citrinum, Botryodiplodia* sp., *Fusarium moniliforme* were dominantly detected.

Tables 49 – 51 are the results of examination of mycoflora in the same samples which were stored for some period. Samples of Table 6 were stored in the farmer's storage warehouse. From the results, *Aspergillus falvus, Penicillium citrinum* increased during storage, however, *Penicillium islandicum* decreased. On the other hand, *Fusarium moniliforme* were constantly detected (Table 49).

The sample of Table 50 was good in quality, whereas, that of Table 51 was bad in quality, these samples were stored at the maize project center. Many fungi were detected in the sample of Table 51 rather than in that of Table 50. However, in both samples, mycoflora did not change.

Frequency of occurrence of fungus genera on maize grains collected from farmer's fields, farmer's storage warehouses, and the godowns of middlemen and silo companies is shown in Table 52. *Aspergillus, Penicillium, Chaetomium, Cladosporium, Codinaea, Rhizopus, Syncephalastrum, Trichoderma* are known as the storage fungi, where as, *Botryodiplodia, Brachysporium, Collectotrichum, Curvularia, Drechslera, Fusarium, Nigrospora* are known as the field fungi. The storage fungi such as *Aspergillus* and *Penicillium* increased in the samples collected from the godown of middlemen and silo companies: however, field fungi such as *Botryodiplodia* and *Fusarium* decreased in those samples.

Table 53 indicates the frequency of occurrence of *Aspergillus flavus*, which produce aflatoxins, on maize grains. It was apparently proved that *Aspergillus flavus* increased in the samples obtained from the godowns of middlemen and silo compaines. In the samples of silo companies, 43.4% grains were infested with *Aspergillus flavus*.

Discussion:

From the maize grains in Thailand, many fungi were isolated. It was indicated that the storage fungi such as *Aspergillus* and *Penicillium* increased as the period after harvest went by and the field fungi such as *Botryodiplodia* and *Fusarium* decreased.

Among the field fungi, *Fusarium moniliforme* and *Botryodiplodia* sp. were frequently detected. It was reported that many *Fusarium* species produced mycotoxins. It will be necessary

to examine the ability of mycotoxin production of *Fusarium moniliforme*. *Botryodiplodia* sp. was usually isolated from the embryos of maize grains that change into black colour. However, life history and ecology of this fungus was yet unknown.

Among the storage fungi, *Aspergillus flavus*, *Aspergillus niger*, *Aspergillus glaucus*, *Penicillium citrinum*, *Penicillium islandicum* were dominantly obtained. In the samples of the godown of silo companies, 43.4% grains were infested with *Aspergillus flavus* which were known as aflatoxin-producing fungi. It was also reported that *Penicillium citrinum* and *Penicillium* produced mycotoxins.

It will be very difficult to control these fungi because the climate of Thailand is very favorable for the growth of these fungi. It will be important to examine the life history and ecology of these fungi before thinking out or developing any methods of controling these fungi.

Table 44 List of Samples examined

Sample No.	Origin of Sample	Date of collection	Location	Germination rate (%)
101	Farmer's field	Nov. 9, 1981	Phraphutthabat	92.5
102	"	Nov. 9, 1981	"	100
103	"	Oct. 20, 1981	"	100
201	Farmer's storage warehouse	Sept.30, 1981	"	93
202	"	Oct. 1, 1981	"	85
203	"	Oct. 18, 1981	"	92.5
204	"	Oct. 14, 1981	Phetchabun	97.5
205	"	Oct. 14, 1981	"	97.5
206	"	Oct. 14, 1981	Pairat (Phitsanulok Prov.)	92.5
207	"	Oct. 15, 1981	Prompiram	95
208	"	Oct. 15, 1981	"	87.5
301	Godown of middleman	Oct. 8, 1981	Phraphutthabat	90
302	"	Oct. 8, 1981	Phattanankhon	75
303	"	Oct. 8, 1981	Phraphutthabat	85
304	"	Oct. 14, 1981	Phetchabun	95
305	"	Oct. 15, 1981	Prompiram	85
306	"	Nov. 9, 1981	Phattanankhon	50
401	Godown of silo company	Oct. 12, 1981	Bangkok	27.5
402	"	Oct. 12, 1981	Bangkok	90
403	"	Oct. 13, 1981	Tharua	87.5
404	"	Oct. 13, 1981	Tharua	50

Table 45 Frequency of fungi isolated from maize grains collected from farmer's field under two kinds of media (%)

Fungi isolated	Sample No. and medium					
	101		102		103	
	PDA	MSA	PDA	MSA	PDA	MSA
Aspergillus flavus			27.5	22.5		2.5
A. glaucus		5				
A. niger			12.5			
A. sp.	2.5		2.5	5		
Penicillium citrinum	10	12.5	12.5	17.5	7.5	2.5
P. fumiculosum	15	10	5	7.5		
P. isulandicum		2.5		15		2.5
Botryodiplodia sp.		2.5	5			
Curvularia sp.	2.5		2.5			
Fusarium moniliforme	80	87.5	30	15	100	90
F. semitectum						5
Unidentified	5	2.5	5	2.5	5	2.5

Table 46 Frequency of fungi isolated from maize grains collected from farmer's storage warehouse under two kinds of media (%)

Fungi isolated	Sample No. and medium															
	201		202		203		204		205		206		207		208	
	PDA	MSA	PDA	MSA	PDA	MSA	PDA	MSA	PDA	MSA	PDA	MSA	PDA	MSA	PDA	MSA
Aspergillus flavus	5		2.5	2.5	2.5	2.5	10				2.5		10		2.5	2.5
A. Glaucus						2.5	5		2.5			12.5	2.5			
A. niger	2.5					10	5	2.5	17.5	12.5	5	2.5	15	15	22.5	12.5
A. restrictus						2.5	5		2.5			7.5				
A. terreus							2.5					5	2.5			
A. sp.				2.5												2.5
Penicillium citrinum	2.5		7.5	15	30	12	7.5	47.5	5	20	7.5	55	2.5	42.5	10	4.5
P. fumiculosum					12.5		5			5						
P. islandicum		2.5		10	65	87.5	5		2.5		10	15	15	12.5	12.5	5
P. purpurogenum							5									
Chaetomium sp.													5			
Cladosporium sp.								2.5						2.5		
Trichoderma sp.													27.5			
Botryodiplodia sp.				2.5			50	22.5	25	12.5	12.5		45	10	60	42.5
Brachysporium sp.															2.5	
Colletotrichum sp.										2.5						
Curvularia sp.				5		5			5							
Fusarium moniliforme	62.5	75	72.5	82.5	25	12.5	30	30	62.5	22.5	37.5	60	10	37.5	15	17.5
F. oxysporum					5											
F. semitectum									2.5	5						
Nigrospora sp.				2.5						2.5				2.5	2.5	2.5
Unidentified	32.5	12.5	20	2.5	27.5	12.5	12.5	10	12.5	27.5	20	17.5	7.5	12.5	15	25

Table 47 Frequency of fungi isolated from maize grains collected from godown of middlemen under two kinds of media (%)

Fungi isolated	Sample No. and medium											
	301		302		303		304		305		306	
	PDA	MSA	PDA	MSA	PDA	MSA	PDA	MSA	PDA	MSA	PDA	MSA
Aspergillus flavus	20	17.5	7.5	27.5	10	7.5	27.5	22.5	17.5	25	30	27.5
A. glaucus		5	2.5	15		10				2.5		15
A. niger	2.5	2.5	25	25	5		27.5	10	40	32.5	12.5	12.5
A. restrictus					2.5							2.5
A. terreus		2.5	2.5	15	5	12.5	5		2.5	2.5		
A. sp.	2.5		2.5								2.5	5
Penicillium citrinum	27.5	22.5	47.5	22.5	10	10	60	92.5	25	40	30	90
P. fumiculosum	5	5	5	5	2.5	7.5			7.5		5	
P. islandicum	5	5	7.5	32.5	7.5	17.5			12.5	22.5	10	
P. purpurogenum	2.5				2.5							
Chaetomium sp.	15				10	10						
Codinaea sp.							5					
Rizopus sp.				5								
Syncephalastrum sp.	5											
Trichoderma sp.							5				5	
Botryodiplodia sp.		35	15	12.5	15	10	5	5	22.5	12.5	30	12.5
Colletotrichum sp.			5				12.5					
Curvularia sp.		2.5	2.5							2.5		
Drechslera sp.			5				2.5					
Fusarium moniliforme	40	40	17.5	12.5	27.5	37.5	10	15	5	10	47.5	5
Nigrospora sp.						5	2.5	5	17.5	2.5		
Unidentified	15	15	22.5	5	22.5	12.5	12.5	7.5	10	22.5	12.5	12.5

Table 48 Frequency of fungi isolated from maize grains collected from godown of silo companies under two kinds of media (%)

Fungi isolated	Sample no. and medium							
	401		402		403		404	
	PDA	MSA	PDA	MSA	PDA	MSA	PDA	MSA
Aspergillus flavus	15	32.5	52.5	60	52.5	60	17.5	30
A. glaucus	20	55	2:5	7.5		10	5	35
A. niger	5	12.5	57.5	52.5	2.5	2.5	7.5	5
A. terreus		10	5	27.5	5			
A. sp.		2.5	2.5	2.5				
Penicillium citrinum	12.5	7.5	10	20	10	22.5		2.5
P. fumiculosum					5			
P. islandicum			10	5	5	5		
P. purpurogenum					2.5			
Botryodiplodia sp.		2.5	20	7.5	10	7.5	20	10
Colletotrichum sp.	2.5				2.5			
Fusarium moniliforme	15	2.5	7.5	15	27.5	35	30	37.5
Nigrospora sp.					5		5	5
Unidentified	7.5	5	10	5	12.5	15	22.5	25

Table 49 Frequency of fungi isolated from the same samples which were stored at farmer's storage warehouse in Sept. 30, 1981 under two kinds of media (%)

Fungi isolated	Date of collection and media					
	Oct. 8, 1981		Oct. 20, 1981		Oct. 29, 1981	
	PDA	MSA	PDA	MSA	PDA	MSA
Aspergillus flavus	2.5	2.5	7.5		70	77.5
A. glaucus		2.5				2.5
A. niger		10		2.5	2.5	
A. restrictus						2.5
A. terreus			2.5		2.5	
A. sp.			2.5	5	2.5	2.5
Penicillium citrinum	30	12	37.5	72.5	25	85
P. fumiculosum	12.5					
P. islandicum	65	87.5	10		10	7.5
Botryodiplodia sp.			17.5		12.5	10
Brachysporium sp.			2.5			
Curvularia sp.		5				
Fusarium moniliforme	25	12.5	40	50	47.5	15
F. oxysporum			7.5			
F. semitectum			10			
Nigrospora sp.			2.5			
Unidentified	27.5	12.5	15	12.5	22.5	12.5

Table 50 Frequency of fungi isolated from the same sample which was stored at the center in Sept. 17, 1981 under two kinds of media (%)

Fungi isolated	Date of collection and media			
	Oct. 8, 1981		Nov. 5, 1981	
	PDA	MSA	PDA	MSA
Aspergillus flavus	2.5		2.5	20
A. niger	2.5		2.5	
Penicillium citrinum	7.5	10	5	30
P. fumiculosum	2.5	2.5	2.5	2.5
Chaetomium sp.				10
Botryodiplodia sp.	27.5	27.5	37.5	12.5
Curvularia sp.	2.5			
Fusarium moniliforme	40	22.5	65	12.5
Unidentified	22.5	10	22.5	7.5

Table 51 Frequency of fungi isolated from the same sample which was stored at the center in Sept. 17, 1981 under two kinds of media (%)

Fungi isolated	Date of collection and media			
	Oct. 8, 1981		Nov. 5, 1981	
	PDA	MSA	PDA	MSA
Aspergillus flavus	75	62.5	10	10
A. glaucus		7.5	2.5	2.5
A. niger	12.5	10		
A. terreus	10	37.5	2.5	
A. sp.	15	5		10
Penicillium citrinum	35	42.5	77.5	85
P. fumiculosum			10	
P. islandicum			5	
P. purpurogenum			2.5	5
Cladosporium sp.	2.5			
Syncepharastrum sp.	2.5			
Botryodiplodia sp.			5	
Colletotrichum sp.		2.5		
Curvularia sp.		2.5		
Fusarium miniliforme	52.5	22.5	45	10
Unidentified	22.5	7.5	20	7.5

Table 52 Frequency of fungal genera isolated from maize grains (%)

	Genera of fungi	Origin of samples			
		Farmer's field	Farmer's storage warehouses	Godown of middlemen	Godown of silo companies
Storage fungi	Aspergillus	13.3	12.8	37.3	60.6
	Penicillium	20.8	37.8	45.2	20.3
	Chaetomium		0.3	1.7	
	Cladosporium		0.3		
	Codinaea			0.1	
	Rhizopus			0.4	
	Syncephalastrum			0.4	
	Trichoderma		1.7	0.8	
Field fungi	Botryodiplodia	1.3	17.3	14.5	10.0
	Brachysporium		0.2		
	Colletotrichum		0.7	1.5	0.6
	Curuvularia	0.8	0.9	0.6	
	Drechslera			0.4	
	Fusarium	72.5	48.2	22.3	21.3
	Nigrospora		0.7	2.7	1.9

Table 53 Frequency of Aspergillus flavus isolated from maize grains (%)

Fungi	Origin of samples			
	Farmer's field	Farmer's storage warehouses	Godown of middlemen	Godown of silo companies
Aspergillus flavus	8.8	2.7	20.0	43.4

2. Ecological studies on Aspergillus flavus contaminated with maize (in 1983)

Aflatoxin contamination is an important problem for maize production in Thailand. It is produced by Aspergillus flavus group. M. KAKISHIMA (1981 – 1982) examined the mycoflora of maize grains in Thailand and proved that Aspergillus flavus was already detected from the earcorns collected in farmers' fields and increased as the period after harvest went by. He also suggested that the ecological study of Aspergillus flavus in maize fields and appropriate storage conditions were important to control this fungus. This time, therefore, the ecological studies on Aspergillus flavus in maize fields and survival of the fungus for temperature and aflatoxin producing ability of isolates were examined. Furthermore, inoculation experiments with Aspergillus flavus on earcorns and grains at various stages of development were conducted. Effective, handy storage made by an expert, and a drying machine for controling contamination of fungi were examined by checking moisture content of earcorns and fungi in them.

This experiment was carried out at the Maize Project Center, Koktoom, Lopburi during Sept. 5 to Dec. 4, 1983.

Results of experiments are as follows:

(1) Samples of earcorns collected from 32 corn fields in Lopburi and Saraburi Provinces. Aspergillus flavus was detected from 14 samples (44%)

(2) Samples of surface soil were collected from 14 maize fields in Lopburi and Saraburi Provinces. Aspergillus flavus was detected from 9 samples.

(3) Air-borne fungi were examined in the maize field at the Center. Aspergillus flavus was frequently detected.

(4) Samples of insects inhabiting around earcorns in fields were collected at the Center. Aspergillus flavus was detected from 25% and 7% of samples in Sept. 20 and 28, respectively.

(5) Samples of silks were collected from earcorns at various stages of development in the Center. Aspergillus flavus was more frequently detected from the silks of milky stage maize than those of mature stage ones.

(6) Succession of fungi was examined in the same field. Aspergillus flavus was already detected from the earcorns collected at about 1 month before harvesting time.

(7) Influence of temperature on survivalbility of Aspergillus flavus was examined. Aspergillus flavus survived under high temperature (80°C) (Table 54)

(8) Aflatoxin producing ability of 134 isolates of Aspergillus flavus obtained from earcorns collected in fields was tested by the culture filtrate spot method. Twenty isolates produced aflatoxin.

(9) Samples of earcorns were collected from farmer's storage facilities, and go-down of cooperatives and middlemen in Phetchabun Province. Aspergillus flavus was detected from all samples.

(10) Earcorns at various stages of development were used for inoculation experiments with spore suspensions of Aspergillus flavus. Earcorns which were injured with a knife and moist seeds were infected with Aspergillus flavus. (Table 55)

(11) Maize grains were also inoculated with suspensions of Aspergillus flavus. Maize grains of 29.6%, 24.9% 20.4%, 17.4% and 16.2% seed moisture were used for inoculation experiments. Maize grains which had seed moisture of 29.6%, 24.9% and 20.4%, which were cut into halves were infected with Aspergillus flavus. (Table 56)

(12) Changes of seed moisture of earcorns kept in a storage facility and a drying machine made by an expert was examined. Earcorns kept in them dried up well. Fungi did not increase in them.

From the results of experiments and observations of earcorns contamination with Aspergillus flavus, suggestions are as follows:

(1) Earcorns are infected with Aspergillus flavus in fields.
(2) In maize fields, Aspergillus flavus are present everywhere.
(3) Earcorns exposed from husks are easily infected with Aspergillus flavus.
(4) Aspergillus flavus survives under high temperature and dry conditions.
(5) Contamination with Aspergillus flavus is affected by climatic conditions.
(6) Aspergillus flavus infects seeds through injury.
(7) Maize grains which have less than 17% seed moisture cannot be infected with Aspergillus flavus.
(8) Earcorns which are artificially injured or damaged by insects are easily infected with Aspergillus flavus.
(9) It may be necessary to develop new storage facility or drying machine for controling contamination with Aspergillus flavus.

Table 54 Influence of temperature on survivalability of *Aspergillus flavus* which infect maize grains.

Temperature (°c)	Period			
	30 mins.	1 hrs.	2 hrs.	3 hrs.
30°c	+	+	+	+
35	+	+	+	+
40	+	+	+	+
45	+	+	+	+
50	+	+	+	+
55	+	+	+	+
60	+	+	+	+
65	+	+	+	+
70	+	+	+	+
75	+	+	+	+
80	+	+	+	+
85	+	+	+	+
90	+	+	-	-
95	-	-	-	-
100	-	-	-	-
105	-	-	-	-

* + : growth

\- : no growth

Table 55 Results of Inoculation Experiments With Spore Suspensions of *Aspergillus Flavus* on to Earcorns.

Stage of corn development	Treatment	Replication	Date of inoculation	Infection *
Milky	no	1	Sept. 15, 1983	-
		2		-
		3		-
	injured	1		+
		2		+
		3		+
Milky	no	1	Sept. 16, 1983	-
		2		-
		3		-
	injured	1		+
		2		+
		3		+
Pre-mature	no	1	Sept. 16, 1983	-
		2		-
		3		-
	injured	1		+
		2		+
		3		+
Pre-mature (Seed moisture =31.0%)	no	1	Sept. 20, 1983	-
		2		-
		3		-
	injured	1		+
		2		+
		3		-
Mature (Seed moisture =27.0%)	no	1	Sept. 20, 1983	-
		2		-
		3		-
	injured	1		-
		2		-
		3		-
Mature (Seed moisture =20.7%)	no	1	Sept. 20, 1983	-
		2		-
		3		-
	injured	1		-
		2		-
		3		-

* - : not infected
\+ : infected

Table 56 Results of Inoculation Experiments With Spore Suspensions of *Aspergillus Flavus* on to Maize Grains.

Stage of corn development	Treatment 1	Treatment 2	Replication	Date of inoculation	Infection	Remarks
Pre-mature (Seed moisture =29.6%)	no	no	1	Sept.28, 1983	-	
			2		-	
	wetted	no	1		-	After germination slightly infected
			2		-	
	no	cut	1		+	
			2		+	
	wetted	cut	1		+	
			2		+	
Mature (Seed moisture =24.9%)	no	no	1	Sept.28, 1983	-	
			2		-	
	wetted	no	1		-	After germination slightly infected
			2		-	
	no	cut	1		+	
			2		+	
	wetted	cut	1		+	
			2		+	
Mature (Seed moisture =20.4%)	no	no	1	Oct. 17, 1983	-	
			2		-	
	wetted	no	1		-	After germination slightly infected
			2		-	
	no	cut	1		+	Dust on the surface of the grains also infected.
			2		+	
	wetted	cut	1		+	
			2		+	
Mature (Seed moisture =17.4%)	no	no	1	Oct. 17, 1983	-	
			2		-	
	wetted	no	1		-	After germination slightly infected
			2		-	
	no	cut	1		-	Dust on the surface of the grains also infected.
			2		-	
	wetted	cut	1		+	
			2		+	
Mature (Seed moisture =16.2%)	no	no	1	Oct. 17, 1983	-	
			2		-	
	wetted	no	1		-	After germination slightly infected
			2		-	
	no	cut	1		-	
			2		-	
	wetted	cut	1		+	
			2		+	

* - : not infected

\+ : infected

3. Seed Production

Extension seed production is one of the main activities of the Project. The Seed Division of the Department of Agricultural Extension has a responsibility for the activity.

There are many steps for producing the extension seeds. Firstly foundation seed of recommended varieties maintained their genetical characters carefully by agricultural researches of the Department of Agriculture are to be provided to the Project. Secondly the foundation seeds are to be distributed to contract farmers for producing extension seeds in their fields in the next rainy season.

For getting superior extension seeds, intensive training of cultivation techniques are to be given to the contract farmers at the Center as well as giving advice frequently to them by the member of the Project for protecting maize from genetic contamination of varieties and damages by insects and diseases. At harvesting time, earcorns are to be purchased by the Project and carried into the Center.

After drying and sorting good earcorns, they are to be put into processing plant for shelling, cleaning, treating with chemicals, bagging and storing into cold storages for the farmers planting in the next rainy season.

For the extension seed production, a seed processing plant, for which all equipment was donated by Japan, was completed at the Center in August 1979.

First extension seed production was carried out in the rainy season 1978. At this time, the Center was not constructed and the staff members of the Department of Agricultural Extension were not dispatched to the Center yet.

Contract fields for the seed production were set up 15 ha in Phraphutthabat area of Lopburi Province and 40 ha in Pak Chong area of Nakhon Ratchasima Province under control of the seed division of Department of Agricultural Extension.

All fields in Pak Chong area were given up for the production of extension seeds as a result of severe damages by drought. However about 20 tons of seeds were produced from the Phraphutthabat area with the cooperation of staff members of Field Crop Experiment Station of the Department of Agriculture next to the Center.

Seven tons of seeds were sold to the Phraphutthabat and Sawankhalok Cooperatives and remains were distributed to general farmers and others.

First trial of seed production in the dry season was conducted in combination with the demonstration field at the Center and the Sawankhalok Cooperative area in the dry season 1978–1979. The same trials were repeated again at the Center and Phetchabun Cooperative area in combination with demonstration fields in the dry season 1979–1980.

As a result of many trials, it was concluded that the seed production in the dry season was not economical.

Detailed results were reported in the demonstration and extension activities.

Extension seed production, on a full scale, was started from the rainy season 1979 for the first time and the scope of work was enlarged year by year.

According to original plan stipulated R/D in 1976, seed production fields will be approximately 100 ha in the first year, 140 ha in the second year and 160 ha in the third year of the Project.

The real operation of seed production, however, have been much largerly scaled than those on R/D. The result of seed production during five years was shown in Table 57.

Table 57 Result of Extension Seed Production

	1979	1980	1981	1982	1983
Foundation seed (from DA) utilized (kg)	4,976	10,000	10,020	22,600	16,663
Planted average (ha)	231	423	512	802	948
No of contract farmers	41	75	79	145	162
Purchased average of earcorn	226	321	512	703	643
No. of farmers purchased earcorn	41	58	77	129	109
Purchased earcorn (ton)	260.6	582.6	976.5	1,145.4	1,114.9
Extension seed produced (kg)	199,533	498,320	809,683	921,580	942,840

Actual planting acreages in the contract farmers fields also exceeded those of the plan of operations decided in 1979. Acreages for purchased earcorns, however, were usually less than those of actual planting ones every year. Some of them were contamination of undesirable grains such as genetic abnormality, too small size, damaged by insects and disease and etc.

According to an assumption from the results during the 5 years, this cancelled area was up to about 15 per cent for the total contract fields a year.

Amount of seeds produced by the Project was attained more than 900 tons in 1982 and 1983. The seed processing plant was designed to produce 400 tons of seeds a year according to the original plan. The production, however, was already more than 2 times for the original target.

It would be capable to produce more seeds if there were enough rooms for cold storage for which capacity had been already enlarged to double of the first plan of 400 tons.

Operation of the seed processing plant used to start at the beginning of September after earcorns were collected at the Center, and it was continued to the end of January of next year. After processing, seeds were stocked into cold storage for the distribution of seeds from February to April in the next year.

Actual result of seed distribution was shown in Table 58 and Fig 11.

Table 58 Result of Seed Distribution (kg).

		1979	1980	1981	1982	1983
Project area	Agricultural Cooperatives	3,980	195,930	167,970	54,180	172,140
	Farmer Groups	23,610	6,630	27,280	24,960	12,900
	General farmers	68,653	216,610	522,071	334,269	342,551
	Others	720	9,900	30,736	379,375	255,689
	Total	96,963	429,070	748,057	792,784	783,280
Outside of Project area	Agricultural Cooperatives	8,010	27,570	10,320	16,080	47,070
	Farmer Groups	4,020	-	-	7,050	2,010
	General farmers	540	12,840	34,755	54,635	90,280
	Others	90,000	28,840	16,551	51,031	20,200
	Total	102,570	69,250	61,626	128,796	159,560
	Grand Total	199,533	498,320	809,683	921,580	942,840

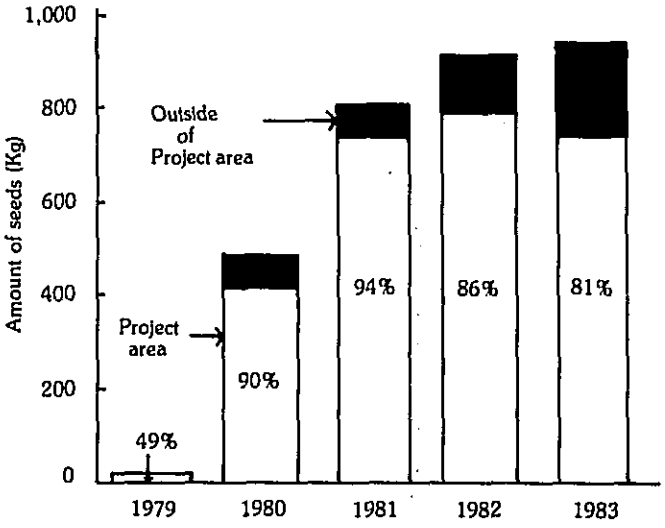


Fig. 11 Amount of Seed distributed in the Project Area from the Project

About 90% of seeds produced at the Center had been distributed in the Project area every year except in the first year of 1979.

In this first stage, as there were a considerable anxiety for selling out all seeds before next planting season, a half amount of seeds were sold to the Marketing Organization for Farmers by bulk for redistribution to farmers through it.

The reputation of Center's seeds with good quality and low price, however, was spread steadily through activities of training, demonstration, and etc. of the Project.

From the next year, in spite of yearly big amount of production all seeds were distributed within a few months without any consideration.

The biggest customers were general farmers who occupied a share of 40–70% out of total amount of seeds in the Project area every year. They used to visit the Center personally and thereby directly purchased seeds. Most of them came from Lopburi, Phetchabun and Saraburi provinces.

According to the Master Plan of the Project, the extension seeds produced at the Center should be distributed to maize producing farmers in the Project area through Agricultural Cooperatives and Farmers Groups.

Share of seeds handled by the Cooperatives and Farmers Groups in the Project area, however, were much less than that of by general farmers as shown in Table 59.

Table 59 Distribution of seeds through Agricultural Cooperatives and Farmers Groups in the Project area

		1979	1980	1981	1982	1983
Project area	by Agricultural Cooperatives and Farmer Groups(%)	28	47	26	10	24
	by General Farmers (%)	71	50	70	42	44
Amount of seeds handled by Extension bases (kg)		3,980	51,300	80,550	55,080	105,630
Seed distribution ratio (%)		2	11	10	6	11

The amount of seeds distributed to the Extension bases concerned increases year by year keeping a share of about 10% for total amount of seeds in the Project area.

However, this can be attributed as a big success of extension work of the Project because the amount of seeds handled by only nine extension bases attained more than hundred tons in 1983.

The seed processing plant at the Center is called Seed Center No. 5 following those at Phitsanulok, Chainat, Lam pang and Nakhon Ratchasima which were constructed by USAID.

Almost all equipment in the plant was provided from Japanese Government as are listed

in Table 61. Most of them were installed in 1979 excluding a series of gravity separator added to them in 1983.

Remodeling and adjusting of the equipment had also been carried out as routine work by the cooperation of Japanese experts for completion of the plant which at present operated without serious problems. Main problems and their countermeasures done during project period are shown as follows.

1. Improvement of yield rate of good seeds:

Yield rate of seeds produced at the plant was a little lower compared to those from other Seed Centers in 1979. This was mainly caused by higher round numbers of drum in the sheller. Adjustment was carried out from 1,000 – 1,100 rppm to 850 rppm in 1980 and 650 rppm again in 1982 and a screw conveyor installed to the sheller was also taken off to lessen damages for seeds.

2. Remodeling earcorn dry bins to improve their efficiency:

1) Giving floors down slopes of 12' and one more outlet for two bins out of eight ones.
2) Making new handles for opening and shutting outlets of all bins for easy operation at the ground level as it should be operated at the top of bins.
3) Remondeling earcorn bins for the combined use of dry bins for shelled grains by installing two new conveyers between two kinds of bins.

3. Installation of a unit of water softner for cooling water to packaged type air conditioners in the cold storage.

After its installation, total hardness of water of 300 – 350 ppm was reduced to less than 5 ppm. (Table 60)

A unit of water softner consisted of a water softner, a water pump, a soft water tank ($2m^2$), a salt water tank (100 litre), a water current meter and a control panel.

The softner contained ion excharge resin of 160 litre and capacity of water in take is 2 tons/hr. Each 12 tons of water intake (on a day) needed reclaim the resin by 20 kg of salt.

Table 60 Quality of cooling water (January 1981)

	Original water	Water through softner	Circulation water
PH	7.5	7.5	7.5
Electric conductivity (mU/cm)	600-700	650-700	700-900
Total hardiness (ppm Ca Co_3)	350	3-4	13-20
Total iron ion (ppm Fe)	0.07	0.02-0.10	0.03-0.08
M. alkalinity (ppm Ca Co_3)	350	300-350	350-450
Chlorine ion (ppm cl)	11-13	13-14	15-25
Sulfuric acid ion (ppm So_4)	10	10	9-13
Silica acid ion (ppm Sio_2)	30-55	30-55	4.0-7.0

4. The second cold storage and cooling system for it.

An original capacity of cold storage was 450 tons, for the production of 1,000 tons from 1981 another cold storage building for 400 tons was constructed in April, 1982.

This cold storage consisted of 4 rooms with each capacity of 100 tons of seeds. For the cold storage, 12 sets of air conditioners and 5 sets of dehumidifiers were provided by the Japanese side. This type of cooling system had many advantages compared with the packaged air conditioned ones installed into the old cold storage are as follows:

1) As each small room can be operated separately, coordinating to the amount of seeds, electricity power can be saved.
2) Consideration for water hardness is not necessary.
3) When machines are out of order, they can be repaired easily at shops.
4) As the dehumidifiers are mobile, they can be used according to the demand.

Detail of equipment provided for the cold storage are as follows:

Air conditioner: "Comet" SC – 12 & JS – 030 30,000 BTU split type for industry.

Dehumidifier: "Singer" D 20B – 35 for industry 1.7 pint/hour under 15.6' and 60% of humidity.

5. Seed processing equipment for foundation seed:

For smooth provision of foundation seeds to the Project, a series of seed processing plant was provided to the Phraphutthabat Field Crop Experiment Station in the Department of Agriculture situated next to the Center as severe deterioration of old system in 1981.

Main equipment are listed as follows:

Heater/Blower	:	Sukup Fan and heater equipped with Wayne EHA-SRI burner	1
Air-screen cleaner	:	Crippen, Model H-344	1
Belt Bucket Elevator (9m)	:	Universal, Model C3 – 175ED	1
Belt Bucket Elevator (8m)	:	Universal, Model C3 – 175ED	2
Seed Treater	:	Gustafson, Model S100 – SS	1
Gross Weight Bagger	:	Howe-Richardson, Model G17	1
Bag Closer	:	Fischbein, Model D portable	1
Drying/Storage bin	:	SCAFO, Model 1803	1
Conveyer	:	Seedburo, Model 178 – 50 (Belt type with flight)	2
Conveyer	:	Seedburo, Model 816 – 50 (Chain and flight type)	1
Corn Sheller	:	Triumph, Model 3C	1

6. Big fluctuation of electric voltage.

Electricity is provided by the Provincial Electricity Authority. The problems were frequent power cut for uncertain duration and big fluctuation of power voltage (Fig 12).

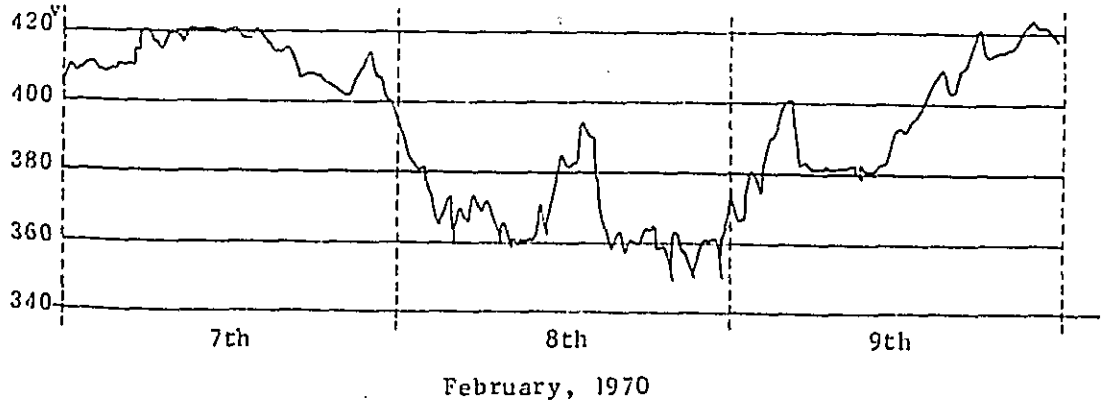


Fig. 12. Voltage fluctuation at the Seed Processing Plant (Rating : 380 V. 3 Phase)

Troubles would be expected as breakdown for switches by too high voltage, and damage for motors by too low voltage. Installation of auto switch or double safety device to important equipment is very necessary.

Table 61 A list of Seed plant equipment

NO.	DESCRIPTION	QTY.	REMARKS
1	Truck Scale	1	Cap. 15 ton (10 kg, Minimum)
2	Sorting Belt Conveyor	1	3.0 t/h × 18 m × 0.75 kw
3	Climbing Belt Conveyor	1	3.0 t/h × 15.05 m × 1.5 kw
4	Belt Conveyor	1	3.0 t/h × 5.3 m × 1.0 kw
5	,, ,,	1	3.0 t/h × 13.0 m × 1.0 kw
6	,, ,,	1	12 M/L × 50 cm/w × 1.0 kw
7	,, ,,	1	3.0 t/h × 14.8 m × 1.5 kw
8	Bins (A)	8	Cap. 5.6 ton × 8 Bins
9	Fans (A)	2	Q = 480 m3/min P = 100MMAQ 15 kw
10	Heater (A)	2	95,000 KCAL/h 10 L/h (Kerosene)
11	,, ,, (B)	2	38,000 KCAL/h 4 L/h
12	Belt Conveyor	1	2 t/h × 30.05 m x 1.5 kw
13	Climbing Belt Conveyor	1	2 t/h × 0.5 m x 1.0 kw
14	Hopper	1	60 cm/H × 80 cm /L × 45 cm/w
15	Belt Conveyor	1	2 t/h × 10.0 m × 1.0 kw
16	Corn Sheller	1	1.5 t/h (corn) 11.0 kw Kelly Duplex Model 22
17	Belt Conveyor	1	1.5 t/h × 3.4 m × 0.4 kw
18	Hopper	1	Cap. 960 kg (corn)
19	Bucket Elevator	1	1.5 t/h × 9.3 m × 0.4 kw
20	Bins (B)	2	Cap. 4 ton (corn)
21	Fan	1	Q = 230 m3/min P = 200 MMAQ 15 kw
22	Heater (A)	1	95,000 KCAL/h 10 L/h (Kerosene)
23	Belt Conveyor	1	2 t/h × 6.9 m × 0.4 kw
24	Belt Conveyor	1	6 M/L × 0.5 m/w × 1.0 kw
25	Bucket Elevator	1	2 t/h × 7.5 m × 0.4 kw
26	Tanks	2	Cap. 4 ton (corn)
27	Belt Conveyor	1	1 t/h × 8.0 m × 1.0 kw
28	Hopper	1	Cap. 960 kg (corn)
29	Bucket Elevator	1	1 t/h × 8.4 m × 0.4 kw
30	Flux Control Tank	1	Cap. 120 kg (corn)
31	No. 245 Seed Cleaner	1	1 t/h 0.75 kw Carter No. 245
32	Dust Collecting Cyclone	1	29.5 cm/H × 60 cm/w × 3.7 kw
33	Bucket Elevator	1	1 t/h × 6.6 m × 0.4 kw
34	No. 2 Precision Grader	1	1 t/h × 0.4 kw Carter No. 2
35	Bucket Elevator	1	1 t/h × 5.7 m × 0.4 kw
36	Gravity Separator	1	1 t/h 11 kw
37	Bucket Elevator	1	1 t/h × 7.2 m × 0.4 kw
38	Seed Treater	1	1 t/h × 0.4 kw × 2
39	Bucket Elevator	1	1 t/h × 7.5 m × 0.4 kw
40	Reservoir Tank	1	Cap. 1200 kg (corn)
41	Balance Scale	1	30 kg, accuracy 1/1000
42	Bag Closer	1	0.2 kw
43	Dust Collecting Cyclone	1	Motor Cyclone Q = 75 m3/min P = 200 MMAQ 3.7 kw

NO.	DESCRIPTION	QTY.	REMARKS
	AIR CONDITIONER:		
44	Packaged Air Conditioner	2 sets	27,000 KCAL/h Cooling ability 7.5 kw Freezer 3.7 kw Fan 100 L/min Amount of cooling water
45	Dehumidifier	1 set	20.6 kg. h Amount of water dehumidified 22 kw Freezer 3.7 kw Fan 250 L/min Amount cooling water
46	Cooling Tower	1	450 L/min Cooling water 1.5 kw Fan
47	Water Sending Pump	1	3.7 kw Amount of water 450 L/min × 12 MH
48	Water Softner	1	
	ELECTRIC APPLIANCES:		
49	Diesel Generator	1	48 kw 16 L/h
50	Main Switch Board	1	
51	Switch Board	1	Earcorn Drying System
52	,, ,,	1	Seed Processing System
53	,, ,,	1	Air Conditioning System

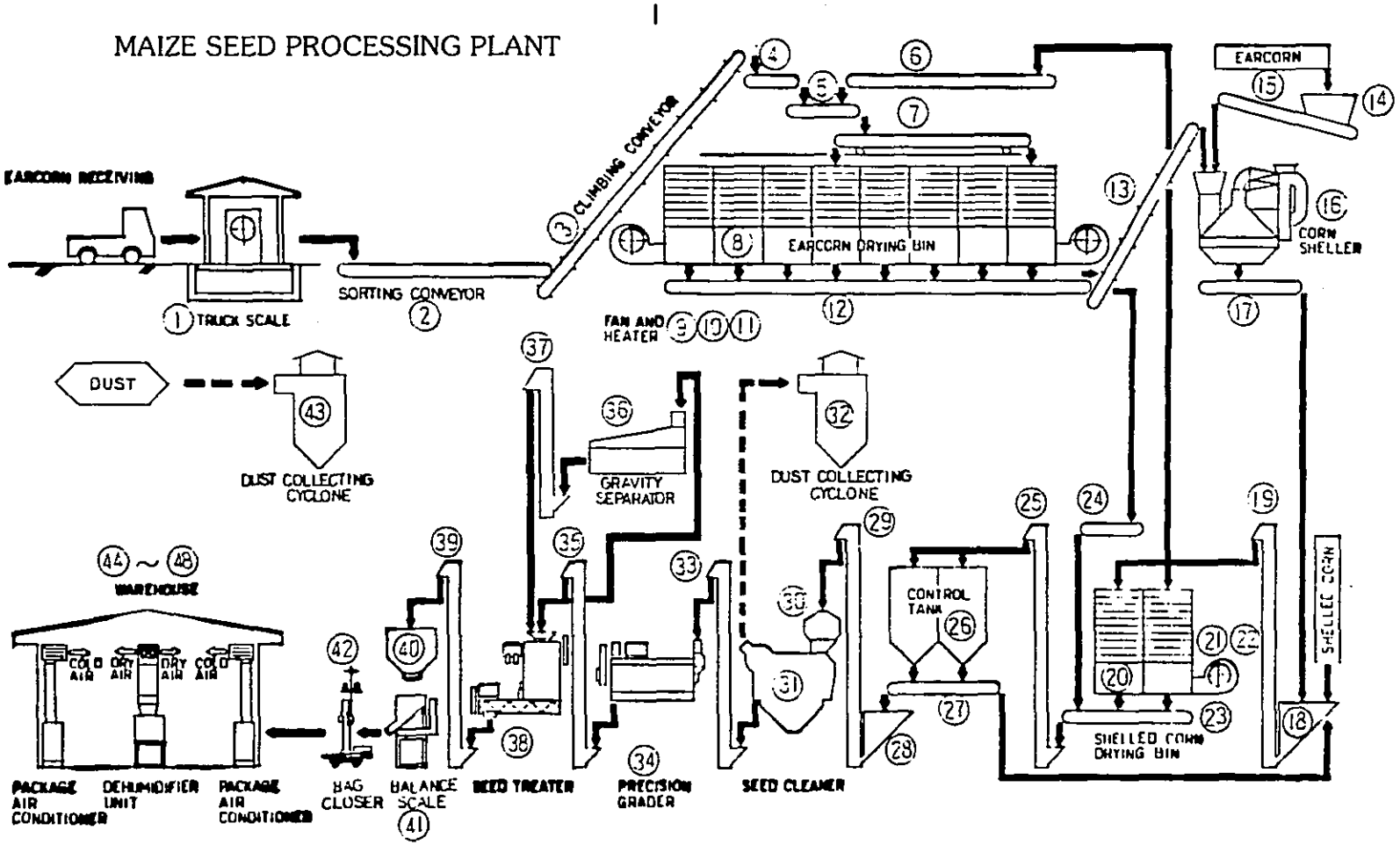


Fig. 13 The Seed Processing System of the Project

4. Disease and Insect Control

Cooperation activities of the Center will be extended to the Project on the control of maize disease and insect which will be carried out by the Department of Agricultural Extension in the Project area comprizing of six provinces according to the Master Plan of the Project.

Following the above idea, the Japanese Government provided the equipment to the Locust and Special Pest Control Center situated at Chaibadan District in Lopburi Province, and awarded the followships to staff members of the Center. The Control Center had the responsibility for protecting crops from damages by insect and disease as routine activities under the control of the Insect and Disease Protection Division of the Department of Agricultural Extension.

These activities are very necessary when damages break out on maize in the Project area. Main insects and diseases on maize fields were Downy Mildew, Locust and Rodent. Downy Mildew broke out in 1968 for the first time and the damages was increased year by year. It spread over the whole country covering about 100,000 hectare of maize fields which is 10% of the total maize area of Thailand in 1974.

Damages by locusts were extended to wide areas locally. Damaged and controlled acreages in the Project area shown in Table 62 and Table 63.

Total acreages damaged by insects and diseases was very big in 1974, and they exceeded the total acreage and most of the damages were caused by locust. Infected area of Downy Mildew was not so big in the Project area in 1974, even in the biggest year of its outbreak.

Locust outbreak was decreased rapidly year by year, and it is now negligible since 1978.

Infected area of Downy Mildew also showned a yearly decrease from 1975 and it was quite negligible since 1978. On the other hand infected areas by rodent were not reduced and repeated big outbreaks in some years.

The control activities of the Department of Agricultural Extension have covered most of the infection areas every year. The big reduction of infected areas of Downy Mildew were accomplished by Government campaigns introducing to farmers resistant varieties simultaneous with early sowing of maize as well as cleaning up of fields before sowing, using healthy seeds etc.

They also helped seed production farmers of the Project for spraying insecticides to their warehouses to protect earcorns being damaged from weevil. These countermeasures were carried out for 20 farmers in 1980, 130 farmers in 1981, 111 farmers in 1982 in the Project area, respectively.

From the viewpoint of damages of insects and diseases on maize, our Project was very fortunate because there were no serious outbreak of damages through all of the project period.

However, we will never forget effective provision against Downy Mildew outbreak by preparing new resistant varieties as well as the development of appropriate cultivation techniques for it in the future.

Table 62 Damaged Acreages and Ratio of Maize Fields in the Project Area.

unit : ha & (%)

	Downy Mildew	Locust	Rodent	Others	TOTAL
1974	27,395 (4.0)	643,413 (94.5)	48,061 (7.1)	15,548 (2.2)	734,417 (107.9)
1975	5,027 (0.7)	158,129 (21.3)	14,000 (1.9)	6,002 (0.8)	183,158 (24.6)
1976	5,623 (0.8)	60,244 (8.7)	11,088 (1.5)	8,064 (1.2)	85,019 (12.2)
1977	2,707 (0.4)	20,453 (3.0)	8,922 (1.3)	5,608 (0.8)	37,690 (5.6)
1978	-	3,402 (0.5)	6,943 (1.1)	22,650 (3.5)	32,955 (5.1)
1979	-	3,063 (0.5)	78,066 (12.0)	11,247 (1.7)	92,376 (14.2)
1980	-	4,605 (0.7)	608 (0.1)	6,000 (0.9)	11,213 (1.7)
1981	-	3,290 (0.5)	54,309 (7.7)	-	57,599 (8.1)
1982	-	416 (---)	7,419 (1.0)	868 (---)	8,703 (1.2)
1983	-	334 (---)	5,395 (0.7)	2,754 (0.4)	8,483 (1.1)

Table 63 Controlled Acreages and Ratio for Damaged Ones of Maize Fields in the Project Area

unit : ha & (%)

	Downy Mildew	Locust	Rodent	Others	TOTAL
1974	3,822 (13.9)	219,795 (34.2)	48,061 (100.0)	15,548 (100.0)	287,266 (39.1)
1975	4,867 (96.8)	99,383 (62.8)	12,416 (88.7)	5,729 (95.5)	122,395 (66.8)
1976	4,824 (85.8)	33,027 (38.2)	11,088 (100.0)	5,347 (66.3)	44,286 (52.1)
1977	1,754 (64.8)	11,786 (57.6)	8,922 (100.0)	4,222 (75.3)	26,684 (70.8)
1978	-	3,402 (100.0)	5,594 (80.6)	4,245 (18.7)	13,241 (40.1)
1979	-	2,424 (79.1)	72,717 (93.1)	3,618 (32.2)	78,759 (85.3)
1980	-	2,195 (47.7)	608 (100.1)	5,421 (90.4)	8,224 (73.3)
1981	-	3,290 (100.1)	54,138 (99.7)	-	57,428 (99.7)
1982	-	312 (75.0)	5,133 (69.2)	724 (83.4)	6,168 (70.9)
1983	-	320 (95.8)	5,394 (100.0)	2,221 (80.6)	7,935 (93.5)

5. Demonstration and Extension

According to the Master Plan of the Project, the demonstration fields about 13 ha are to be set up at each of the extension bases in the Project area for demonstrating improved cultivation techniques developed by the Center.

First demonstration fields in combination with applied experiment were set up at the Center, which was not yet completed in the rainy season in 1978.

The demonstration fields on a full scale were established from the next dry season 1978 – 1979. The trials were planned to confirm availability of seed production in the dry seasons. Because of its availability many economical advantages will be expected for the seed production activities in the Project. They are to lessen deterioration of seed quality, save seed storing cost, utilize fields and permanent labours efficiency, enlarge the operation period of seed plant etc.

It will also be contributed to farmers for effectively utilizing their idle lands and family labours too.

In the dry season 1978 – 1979 a trial was conducted at the model farm of Sawankalok Cooperative and farmers paddy fields. Total acreage of land was 16 ha and water was provided by the irrigation system from deep well newly constructed by the Government.

In this trial maize plants suffered severe damages by rodent repeatedly as well as poor drainage based on soil structure in the paddy fields. This trial, therefore, was quite unsuccessful.

Another trial was carried out under mechanized cultivation system and furrow irrigation at field of 1 ha of the Center in the dry season 1978 – 1979. Maize was planted in January and harvested in May and water was given 8 times and 556 mm in total. This trial resulted in big loss of 3,307 baht based on high cost of 9,361 baht for income of only 6,054 baht.

More trials which placed emphasis on yield increase were carried out at the Center and Phetchabun Cooperative area in the dry season of 1979 – 1980. Maize was planted on 1 ha of field at the Center in November 1979. Irrigations were carried out 7 times and about 500 mm in total with furrow and rain-gun methods by halves of the field. Four tons per ha of yield was obtained.

Another trial was carried out at a field of 0.1 ha in the Phetchabun Cooperative area. Cultivation of maize was placed in charge of the owner of the field, who had planted maize for vegetable in the dry season.

Maize was planted at the field in January 1980. Irrigation water was given 11 times and 400 mm in total. The yield of maize was 5.9 tons/ha. Gross income was 17,805 baht as price of seed was 3 baht/kg. A total of cost was 16,723 baht which included labour fee of 5,600 baht. A gross profit, therefore, was 1,082 baht.

This result would be attractive to farmers, if they wanted to utilize their idle labour. However, when they plant maize for vegetable in the same field gross profit would be attained 30 times of that of seed maize mentioned above.

As a result of many trails, it was concluded that the seed production of maize in the dry season would be quite hopeless economically.

Demonstration work of maize, therefore, should be carried out in the rainy season only from the practical viewpoint. The demonstration work in the rainy season was started from 1979. Nine fields were set up in total at the Center and the Cooperatives area of Phraphutthabat, Chaibadan and Phetchabun in 1979. The number of fields and total acreages were extended yearly following the plan of operations as are shown in Fig. 6.

The maximum number of demonstration fields was 43 in 1982, but the number of places was reduced to half in 1983 as the difficulty for setting and managing the fields extended too many numbers in wide areas. Based on the same reasons, the demonstration fields were set up intensively in the Cooperatives area of Phraphutthabat and Chaibadan for the convenience of implementation because the distance from the Center was not far.

Some demonstration fields have been managed by the staff members of the Project directly for checking yields and characters on maize strictly every year. The main techniques applied for the demonstration fields had been limited to the foundamental simple factors for easy adoption by farmers.

Because, it would take a long period to develope new techniques from the experimental work of the Project and furthermore, the foundamental techniques were still assumed to be the most effective for yield increase of maize in farmers' fields.

The techniques were only limited to a few effects such as variety, fertilizer application, plant population or combination of each of the said techniques.

The results in the rainy seasons from 1979 to 1983 were summarized as follows:

Yields of Suwan 1 provided seeds from the Center, were about 20% higher than those of local varieties including Suwan 1 for which seeds have been kept at farmers' houses from pervious year.

Comparing with two recommended varieties between Suwan 1 and Suwan 2, the growing periods of Suwan 1 were about 105 days which was 15 days longer than that of Suwan 2 but the yields were about 10 – 20% higher than those of Suwan 2.

The optimum population for highest yields of Suwan 1 was 6.7 plants/m^2 for the 8.9/m^2 of Suwan 2 with higher response on yield increase by applying densily population than Suwan 1.

Fertilizer effects on Suwan 1 for yield increase were 20 – 30% in average with high fluctuation based on differences of soil fertilities.

A study on fertilizer effects for Suwan 1 was made from the economical viewpoint based on the results of 18 demonstration fields for 3 years from 1979 – 1981. The fertilizer effects for yield increase of Suwan 1 was 28% with 2,635 kg/ha with non fertilizer and 3,376 kg/ha of with fertilizer. Value cost ratio was 1.1 when it was calculated based on the price of 2 Bht/kg of maize and 4.5 Bht/kg of fertilizer. The value would be too low to get profits for farmers, it would be needed more than 1.5 at least.

From this stand point, it would be dangerous to recommend farmers to use fertilizer uniformly and fields with high response for fertilizer should be selected for applying it.

Table 64 Number of Demonstration Fields in the rainy season

	CENTER	COOPERATIVES									FARMERS GROUPS					TOTAL	
		PB	CB	Pe Bo	PP	NT	SK	KS	TF	KT	YT	HS	SM	TG	TC	Place	Average/ha
1979	1	3	2	3												9	
1980	1	12	2		3						3					21	20
1981	1	16	7	6							1					31	26
1982	2	8	7		3						8	3	8		4	43	39
1983	1	2	2	2	1	1		2	2	2	2	2		1		20	13
Total		41	20	11	7	1		2	2	2	14	5	8	1	4	124	

abbreviated words mean as follows:
PB: Phraphuttabat, CB: Chaibadan, PeBo: Phetchabun, PP: Prompiram,
NT: Nongtom, SK: Sawankalok, KS: Koksamrong, TF: Takfa, KT: Koktoom,
YT: Yangtone, HS: Hinsond, SM: Submaidang, TG: Ta-ngam, TC: Ta-chai

As a result of many experiences on managing demonstration work, it would be concluded that the standard techniques should not be recommended unformly to every farmer. Proper techniques fitted to soil types, and farmers level on cultivation of maize should be deversified in the future.

Futhermore, we have had doubts of the effects of demonstration field work as extension techniques at farmers' level. Comparison of quantitative characters as yield, however, are difficult to let farmers recognize the effects of factors. Errors based on uneven soil fertility in a field used to be bigger than real differences based on factors.

In this case, farmers would lose interest in new techniques. In addition, there are big communication and transportation gaps for utilizing the demonstration fields effectively for farmers at many provinces in Thailand.

Irrigation was 8 times and the amount of water 556 mm in total. Cost of machinery was 62% of total cost. Cost of land preparation and irrigation were 21% and 56% of machinery cost respectively.

In this trial, cost of machinery was comparatively high as the field was too small for introducing machinery. Production costs in detail shown as Table 65. It was concluded that maize cultivation in the dry season would be hopeless economically even under machanization system.

Improved methods for promoting demonstration work should be established quickly. We are eager to establish the epock-making techniques for these activities in the future.

According to the Master Plan of the Project, demonstration work on mechanized cultivation system should be developed by the Project as well as other activities for the purpose.

First demonstration field of 1 ha was set up at the Center under furrow irrigation in combination with seed production trial in the dry season 1978 – 1979.

Each working machinery used for the field are as follows:

PLOUGHING	:	Three blade disk plow installed to Ford 6600 (75HP) Tractor.
HARROWING	:	Eighteen bade disk harrow installed to Ford 6600 (75HP) Tractor.
PLANTING	:	Four row planter pulled by Ford 6600 Tractor.
CULTIVATING		
WEEDING	:	Rotary plow installed to Kubota hand Tractor.
EARTHING		
HARVESTING	:	Track 5 ton.
IRRIGATION	:	Furrow method with water from deep well.

Irrigation was 8 times and the amount of water 556 mm in total. Cost of machinery was 62% of total cost. Cost of land preparation and irrigation were 21% and 56% of machinery cost respectively.

In this trial, cost of machinery was comparatively high as the field was too small for introducing machinery. Production costs in detail shown as Table 65. It was concluded that maize cultivation in the dry season would be hopeless economically even under machanization system.

Table 65 Production cost for 1 ha seed farm:

Input	Per ha	Remarks
Materials:		
Seed (Suwan No. 1)	฿ 150	@฿5.0, 30 kg.
Fertilizer (10:10:5)	฿ 937	@฿1.5, 625 kg.
Labor & Machines:		
Land preparation	฿ 1,200	@฿100, 12 hr. for tractor.
Planting	฿ 570	@฿100, 5 hr. for tractor.
		@฿35, 2 laborers
Thinning	฿ 245	@฿35, 7 laborers
Bedding up in furrows (cultivation, weeding, applying fertilizer)	฿ 950	@฿30, 20 hr. for hand-tractor
		@฿35, 10 laborers
Irrigation	฿ 4,509	@฿0.61, 5,557 tons of water.
		@฿35, 4 laborers x 8 times irrigations.
Harvesting	฿ 800	@฿200, 0.5 hrs for truck.
		@฿35, 20 laborers.
Total	฿ 9,361	

Another demonstration was carried out at the Center in the rainy season 1979. In this trial, two kinds of mechanized, cultivation system laying stress on big tractor and hand tractor were compared with traditional one. Cultivation methods are shown as Table 66.

Yield of maize in both mechanized cultivation system were much lower than that of traditional. They were caused by insufficient plant population and weeding by machines. As to operational hours of labour, however, the use of big tractors was much lower than that of traditional one. Cultivation cost among three systems were almost the same.

They are shown as are Table 67.

Table 66 Operation method of the demonstration field (1979)

	Acreage of field ha	Making Ridge	Sowing	Fertilizing	Cultivation weeding		Reference
					1st	2nd	
Big tractor	0.5		Seed & fertilizer	drill	Cultiva-tor	Ridger	Ploughing & harrowing were carry out by big tractor in all fields
Hand tractor	0.25	Ridger	Man-power	Man-power	Screw rotary	Man-power	
Traditional (Water Buffalo)	0.25	Plow	do	do	Plow	Plow	Harvesting was by Man-power

Table 67 Comparison of cultivation system

	Yield (kg/ha)	Income ฿	Cost ฿	Net Income ฿	Working hours		
					Tractor & Buffalo	Man-power	TOTAL
Big tractor	1,439	3,310	3,075	235	11.7	130.0	141.7
Hand tractor	1,671	3,843	3,060	783	18.5	191.3	209.8
Buffalo	2,272	5,226	2,838	2,387	18.8	192.5	211.3

6. Yield Competition:

As a step to provide sufficient motivation to farmers in maize cultivation, a yield competition was carried out for the first time in the area of Phraphutthabat Cooperatives during the rainy season in 1980.

The results were very remarkable.

The highest yield of maize was 6.6 tons/ha and average yield of 10 farmers following the highest one was 5.5 tons/ha. The areas setting up the yield competition were extended to two cooperatives areas in 1981, three cooperatives areas and one Farmers Group area in 1982 and five cooperatives and two Farmers Groups' areas in 1983.

The results were almost the same as those of the first year excluding Chaibadan Cooperative where soil productivity would be lower than other areas and some areas suffered severe damages from drought.

Yield of maize at each competition field was estimated by the method as follows:

Firstly, earcorns were harvested from a block of ¼ rai (400 m^2) out of the competition fields, and the total of them weighed at the fields. When that time, two pieces of earcorn as samples are to be taken from each harvesting basket (20 – 25 kg, approx. 100 pieces of them), and measured weight at the fields too.

Secondly, grains from the sampled earcorns should be dried on the pavement after shelling until 15% moisture content remains. Percentage of produced grain yield from each earcorn can be obtained from the weight of dry grain.

Thirdly, the estimation of grain yield per ¼ rai (400 m^2) is to be determined as follows:

Percentage of produced dry grain yield from fresh earcorn in samples X weight of fresh earcorn.

The results were shown in Table 68 and 69.

The yield level of the competition fields was very high comparing with average yield of 2 tons/ha in Thailand, and these higher yields are also expectable in wide areas in this country almost every year.

We were recognized that the potentiality of maize production in Thailand are still very high and much rooms for more development in the future. Now problem, however, would be the big differences of yields between competition fields and ordinal ones.

The investigations from technical viewpoint were carried out by hearing methods from farmers obtained higher yield of 1 – 20 places which 4.4 tons/ha of average yields at the yield competition in Phraphutthabat Cooperative area in 1980.

Data obtained are as Table 70 and Table 71.

Table 68 Maize Yield in Competition (Kg/Ha) From 1980 – 1981.

Praphuthabad Coop. area (1980)				Praphuthabad Coop. area(1981)			Chaibadan Coop. area (1981)		
1	Tonglor	Pumpuang	6,600	Ngan	Suhiran	6,705	Chamnong	Klindokkeaw	4,818
2	Prasat	Bun-anant	5,919	Prayat	Tancharoen	6,262	Chamnan	Kliadokkeaw	4,219
3	Songhram	Bun-anant	5,819	Pow	Bun-anant	5,415	Sanong	Chaikla	3,004
4	Peng	Chaisiri	5,813	Phayoa	Maneang	5,219	Phat	Saengsai	2,774
5	Lamchuan	Phutnin	5,178	Thonglor	Pumpuang	5,083	Kan	Manphrom	2,550
6	Samruay	Trai-udom	5,170	Sompong	Sukcharoen	4,831	Samlee	Uankeaw	1,965
7	Chat	Bunsongsri	5,099	Somporn	Bunrod	4,828	Suk	Butdee	1,759
8	Huan	Chakraksa	5,048	Lamchuan	Phutnin	4,447	Sompaen	Chumwamon	1,271
9	Prayat	Tancharoen	4,994	Somkiet	Wongthoa	4,410		Average	2,795
10	Ngan	Suhiran	4,838	Prasat	Bun-anant	4,256			
11	Bunserm	Sappasit	4,621	Sunthorn	Maimansomsuk	4,119			
12	Somchit	Thongkham	4,484	Somkhuan	Wongkeaw	3,918			
13	Noy	Wongthoa	4,458	Bua	Chaingam	3,917			
14	Sawang	Sangmani	4,455	Chat	Bunsongsri	3,913			
15	Chamlong	Mametta	4,316	Sawang	Sangmanee	3,888			
16	Chit	Klinchat	4,306	Bunruean	Plodkoed	3,888			
17	Pow	Bun-anant	4,250	Phae	Phromsin	3,825			
18	Sunthorn	Maimansomsuk	4,159	Prayoon	Bunkhayai	3,427			
19	Somporn	Bunrod	4,088	Samran	Intharathanee	3,258			
20	Long	Tri-udom	3,981	Chamlong	Mametta	3,188			
21	Sanit	Kongsint	3,890	Somchit	Thongkham	2,716			
22	Am	Homprasert	3,854	Phaisan	Wongket	2,713			
23	Chaluay	Chutnont	3,251	Bunsom	Sapphasit	2,433			
24	Praphat	Sapchoa	3,231	Huan	Chakraks	—			
25	Roj	Chamcharoen	3,193	Wera	Paew Thianying Thawi	—			
26	Prakat	Nutcharat	3,009	Phayom	Pumpuang	—			
27	Bunthan	Laikun	2,776	Prakat	Nutcharat	—			
28	Bunma	Chawong	2,266	Sanit	Kongsin	—			
29	Ke	Thongsamran	1,975	Nian	Arphayathat	—			
		Average	4,311	Thongbai	Chitsong	—			
				Average (except for under 24 place)		4,203			

Table 69 Maize Yield in Competition (Kg/Rai) From 1982 – 1983.

	Praphuthabad Cooperative area(1982)	
1.	Tonglor Pumpoung	6,246
2.	Chaliew Boonporn	6,078
3.	Prayao Maneing	5,519
4.	Prayad Tanchalearn	4,601
5.	Sameeing Souankeauw	4,253
6.	Lamjuan Pudnil	3,857
7.	Amnouy Imjai	3,865
8.	Ngern Suhilan	3,752
9.	Kamon Namweng	3,081
	Average	4,597
	Chaibadan Cooperative area (1982)	
1.	Wate Srilarak	2,681
2.	Yod Kethkeauw	2,655
3.	Karn Kamprom	2,488
	Average	2,608
	Petchaboon Cooperative area (1982)	
1.	Lord On-ing	5,949
2.	Lar On-ing	5,567
3.	Houng Boonmee	4,364
	Average	5,293
	Yangtone Farmers Group area (1982)	
1.	Anan Srilarak	3,248
2.	Charn Adharn	2,786
3.	Saweg Soumkratai	2,658
4.	Payon Amtest	2,204
5.	Lampeng Adharn	1,882
6.	Supat Pathanajan	1,838
	Average	2,438

	Praphuthabad Cooperative area(1983)	
1.	Raschoun Pudnil	5,062
2.	Sameeang Souankeauw	4,452
3.	Chan Srisuda	4,388
4.	Tonglor Pumpong	4,131
5.	Tongbai Charitseng	3,876
6.	Ngen Suhiran	3,658
7.	Sungwern Sangmanee	3,621
8.	Somchit Tongkam	3,434
	Average	4,079
	Petchaboon Cooperative area (1983)	
1.	Rod On-ing	3,835
2.	Klong Kethwandee	3,559
3.	Lar On-ing	3,448
4.	Yuth Boonmee	3,137
5.	Reang Sankam	3,036
6.	Pun Boontham	1,606
7.	Ngen Chanamarn	1,345
	Average	2,852
	Koksamlong Cooperative area (1983)	
1.	Yang Chalernma	4,422
2.	Peor Mychalern	4,042
3.	Reuw Nakpoo	3,914
4.	Sa-ing Klintien	3,695
5.	Sawad Srihamo	3,423
6.	Chamnong Prongsara	3,287
7.	Saman Suthiseth	3,260
8.	Sompong Kongsathan	3,192
9.	Chan Thipmo	2,178
	Average	3,490

	Takfha Cooperative area (1982)	
1.	Klap Brantap	5,614
2.	Sanguan Dangsaad	5,187
3.	Mee Phakkhao	4,742
4.	Pit Raksasong	4,379
5.	Yai whaovith	3,742
6.	Boonma Yomkeauw	2,936
	Average	4,433
	Sabmaidang Farmers Group area(1983)	
1.	Boonchoo Chana	5,196
2.	Samrarn Bantoom	4,735
3.	Cham Kamsri	4,242
4.	Ieim Keena	4,201
5.	Tongkam Nokkut	4,121
6.	Koon Sumpragsert	3,336
7.	Tongkam Nakkoobba	2,719
	Average	4,075
	Yangtone Farmers Group area (1983)	
1.	Chuan Changkrung	4,866
2.	Chan Addhan	4,656
3.	Anan Srirarak	4,535
4.	Payon Amteth	4,010
5.	Lampong Addhan	3,932
6.	Bunruang Ruanchamroon	3,841
7.	Prasit Phopok	3,757
8.	Nark Kanchai	3,637
9.	Somchai Lockin	2,791
10.	Pol Pankhuan	2,324
	Average	3,840

Table 70 Cultivation Techniques Adopted to the Yield Competition Fields.

Rank	Yield Kg/Ha	Soil type	Seed: Variety, Origin and Period of using the seed	Sowing time (No showed month)	Plant population: Plants/ha	Plant population: Ratio for ordinal fields	Chicken droppings: Competition fields	Chicken droppings: Ordinary fields	Chicken droppings: Year applied	Amount of compound fertilizer: $N-P_2O_5-K_2O$ (kg/ha)	Reference
1	6604	Grumsol	S. 1 from center	End of 5	47,000	107 %	2 m^3/ha	2 m^3/ha	4	31-31-0	
2	5919	B F S	S. 1 "	Begining of 6	67,000	159 %					
3	5818	R B E	S. 1 "	do	67,000	159 %					
4	5812	BFS or RBE	S. 1 "	do	67,000	159 %					
5	5177	Rendgina	S. 1 "	Middle of 5	67,000		12.5 m^3/ha	12.5 m^3/ha	3	162-162-250	Applied fertilizer to vegetable field before maize
6	5169	BFS or RBE	P. B5 5 year	Begining of 6	47,000					62-62-0	
7	5099	Rendgina	S. 1 ordinal	End of 5	61,000	115 %	9 m^3/ha	3 m^3/ha	4		
8	5047		S. 1 "	Middle of 4	50,000	119 %					
9	4943	Rendgina	S. 1	Middle of 6	50,000		1.9 m^3/ha	1.9 m^3/ha	5		Applied fertilizer to vegetable field before maize
10	4838	Rendgina	S. 1 ordinal	Middle of 5	53,000	88 %	300 kg	300 kg	2	47-47-47	
11	4620		S. 2 2 year	Begining of 4	57,000		0.12 m^3/ha (Bat droppings)			38-38-38	
12	4465	Grumsol	S. 1 2 year	End of 6	53,000						
13	4457	Rendgina	S. 2 ordinal	End of 5	53,000		2 m^3/ha	2 m^3/ha	3	47-47-47	
14	4432	Rendgina	S. 1 "	Middle of 4	44,000	70 %	1.3 m^3/ha	1.7 m^3/ha	2	20-25-0	
15	4316	Rendgina	S. 1 "	End of 6	44,000		2.2 m^3/ha			38-50-38	
16	4305	R B L S	S. 1 1 year	End of 5	60,000		1.3 m^3/ha				
17	4249	R B L S	S. 1 from center	do	66,000	150 %					
18	4159		S. 1 ordinal	Begining of 6	44,000		1.8 m^3/ha	1.8 m^3/ha	2		
19	4087	R B L S	S. 1 "	End of 5	44,000		3 m^3/ha				
20	3980		P. B5 5 year								
21	3890	R B L S	S. 1 ordinal	Middle of 4	44,000		3 m^3/ha	3 m^3/ha	5		
22	3854		S. 1 "	Begining of 4	56,000						

Table 71 Cropping System for Maize Competition Fields and Treatment for Residue of Crops.

Yield Ranking	Crops after Maize in 1979	1980	Crops after Maize in 1980	Usual planting system	Treatment for residiums of crops	
					Maize	Other crops
1	Rosera	Yield competition on maize	Sorghum / Mung Bean } Mixed	Maize - Mung bean, Sorghum(Mixed cropping)	Burn out	Leave as it is
2	Black Mappe	"	*	Maize - Black Mappe	Plough into-soil	"
3	Black Mappe	"	*	Maize - Black Mappe	"	"
4	Black Mappe	"	*	Maize - Black Mappe	"	"
5	Vegetable	"	Vegetable	Maize - Vegetable	Burn out	Plough into soil
6	Mung Bean	"	*	Maize - Mung Bean	Plough into-soil	Leave as it is
7	Vegetable	"	Mung Bean	Maize or Cotton - Mung Bean	Burn out	Burn out for contton, leave as it is for mung bean
8	Mung Bean	"	Sorghum	Maize - Mung Bean	"	Leave as it is
9	Black Mappe	"	*	Maize - Black Mappe or Yam Bean	"	Burn out
10	Vegetable	"	Vegetable	Maize - Vegetable	Plough into-soil	Leave as it is
11	Black Mappe	"	Sorghum	Maize - Black Mappe or Sorghum	Burn out	Burn out for sorghum, leave as it is for mung bean
12	*	"	Sorghum	Maize - Sorghum or Mung Bean	Plough into-soil	"
13	Sorghum	"	Sorghum	Maize - Sorghum or Mung Bean	Burn out	"
14	Peanut	"	Peanut	Maize - Peanut or Water Melon - Maize - Peanut	"	Leave as it is
15	Sorghum	"	Sorghum	Maize - Sorghum	Plough into-soil	Burn out
16	Yam Bean	"	Sorghum	Maize - Peanut or Yam Bean	Burn out	Burn out for sorghum
17	*	"	*	Maize - Black Mappe	"	Leave as it is
18	Mung Bean	"	*	Maize - Mung Bean	"	"
19	*	"	Peanut	Maize monocropping (Peanut from 1980)	Feed for cow or buffalo	
20	*	"	*			
21	Yam Bean	"	Yam Bean	Maize - Yam Bean	Burn out	Leave as it is
22	Sorghum	"	Sorghum	Maize - Sorghum or Mung Bean	"	Burn out

* No cropping or abandoned

In the case of the farmer who got the first place yielded 5.8 tons/ha, soil of his field belonged to Grumsol type, and he applied chicken dropping of 2 m^3/ha every year continously for four years together with chemical fertilizer.

Another farmer followed the first place introduced high population of plants which were 60% higher than those of other farmers. Many of them introduced leguminous crops as rotation of maize in the dry season as well as applying chicken dropping.

Some of them made their fields fertile by introducing vegetable crops under great amount of fertilizer in previous the year for maize planting. Results summarized from the investigations are as follows:

1) Contract farmers for extension seed production obtained the highest rank of yield from 1 – 4 places.

2) Yield level of fields was classified by soil types. Soil of fields with the highest yield group belonged to types of Brown Forest Soil and Red Brown Earth. Fields of Grumsol and Rendgina soil types were intermediate of group with yield rank 7 – 15. Many of other fields of lower level belonged to Red Brown Lateltic Soil.

3) Sowing was carried out 1 – 2 months later than those of ordinary farmers.

4) Planting population of their fields were 47,000 – 67,000 Plants/ha. They are considerably higher than those of general farmers.

According to the testimonies of these farmers, they obtained the high yields as the results of timely rainfall through growing periods, fertile soil condition of fields, applying fertilizer, high density of planting and etc.

Awarding ceremony for the winner of yield competition have been held at each extension base every year. A big number of farmers joined the ceremony for technical informations from the winners and the staff members of the Project.

The yield competition seemed to be very effective for promoting farmers interest in maize cultivation. It would also be a very efficient method of extension, because farmers would pay positive attention for integrated high yielding techniques by themselves through many informations from competitions.

An investigation was also conducted about income and outgo of maize growing farmers who joined the yield competition in the Phraphutthabat Cooperative area in 1981. Maize plantation in the rainy season was their principal occupation. Representative examples separated with different farm scale were shown in Table 72.

According to the data, total expenditure of the farmers was about 2,200 – 2,800 baht and almost 60% of it was occupied by the cost for plowing and fertilizer and remainder was labour cost. The differences of expenditure among farmers was small. From this result it can be said that, in general, the major scale of maize growers would be more profitable.

However, gross incomes among four farmers were mainly based upon yield of maize per unit area. Quick extension of the high yielding techniques would be very important for farmers.

Table 72 Income and Outgo of Maize Farmers in Phraphutthabat Area 1981.

Scale of Farm management		Each farmer	A		B		C		D	
		Planted acreage (ha)	4.0		8.0		9.6		16.0	
		No. of family workers	4		0		2		5	
		Yield of maize (t/ha)	2.9		3.2		4.2		2.5	
		Gross income (Bt)	5,890		6,563		8,719		5,156	
Cost of cultivation			Cost (Bt)	Ratio %	Cost (Bt)	Ratio %	Cost (Bt)	Ratio %	Cost (Bt)	Ratio %
	Cost of material	Land preparation	700	32	750	27	700	30	700	29
		Seed	-	-	113	4	-	-	-	-
		Fertilizer	600	27	300	11	519	22	550	23
		Others	-	-	350	13	116	7	45	2
		Total	1,300	59	1,513	55	1,385	60	1,295	54
	Cost of labour	Making ridge	188	9	150	6	156	7	188	8
		Sowing	-	-	200	7	69	3	88	4
		Weeding	313	14	200	7	313	13	313	13
		Fertilizing	-	-	63	2	-	-	-	-
		Harvesting	400	18	538	19	400	17	391	16
		Transportation	-	-	108	4	-	-	117	5
		Total	901	41	1,259	45	938	40	1,097	46
		Grand Total	2,201	100	2,772	100	2,323	100	2,392	100
		Net income (Bt)	3,689		3,791		6,396		2,764	

7. Agricultural mechanization

For promoting mechanized cultivation techniques, many kinds of activities on agricultural machinery were carried out by the Project.

Machinery services for Cooperative areas were one of the activities as well as training and repairing machine services for Cooperative member farmers in the Project.

Land preparation and shelling services by using tractors and shellers of the Project were conducted as cooperatives' own business under control of the Cooperatives Promotion Department in the Project.

The principal purpose of the idea was to make the Cooperatives to adopt it as their new service activity for their member farmers by using their own equipment in the future.

For this purpose, the estimation of loss and gain should be very important for the activity.

A) Land preparation service:

The service was started in the Sawankalok Cooperative area in 1979 for the first time.

A tractor (Ford 6600, 79HP) with three disk plow was sent to the Cooperative area for ploughing service to member farmers' fields in the period of 39 days from 1st March to 8th April 1979.

The record of the operations was as follows:

Total operational hours	:	283.5 hours
Total plowing acreage	:	379 rai (60.7 ha)
Operation cost for the tractor	:	Fixed cost ฿103.4/hr
		Variable cost ฿34.10/hr
		Total ฿137.40/hr
Operation acreage (rai)	:	379 rai/283.5 hr = 1.342^{rai}
Operation cost (rai)	:	฿137.4/1.342^{rai} = ฿102.4/rai

As general operation cost in Sawankalok area is 60 baht per rai, this plowing service, therefore, was gain loss of 42.38 baht per rai.

Fixed cost was calculated based upon the price of tractor and its attachment (total 396,000 baht in 1978) for 12 years or 12,000 hrs of depreciation periods. For parts and repairing cost was calculated based upon the method of "(A Coordinated Industry Project in Thailand (1967)". Variable cost was calculated based upon a total cost of fuel and labour in March and April.

They say that, general plowing activities in Thailand is continued for 5 months a year and average working hours per day is 18 hours. Working hours of this trial was only 7.26 hrs per day. It would be necessary to expand both field acreages and working hours per day for this operation in the future.

The same services were carried out again at the Phraphutthabat and Chaibadan Cooperatives area from 1981. (Table 73)

Table 73 Results of Tractor operation services by two Coops. 1981 – 1983.

Name of Coops.	Chaibadan				Phraphutthabat				Grand Total
Period	1981 12/3-6/5	1982 8/5-1/6	1983 1-5	Total	1981 30/4-20/6	1982 8/5-30/5	1983 4-5	Total	
Number of tractor	2-3	2-3	2		1-3	1-3	2		
Operated acreage (rai)	1,276	1,183	1,017	3,476	155	1,108	1,188	2,451	5,927
Operated hour	-	637.4	557.1		-	619	660		
Income (฿)	95,766	87,458	77,019	260,243	13,245	83,850	93,580	190,675	450,918
Expenses (฿):	71,460	48,471	52,958	172,889	7,587	34,354	39,319	81,260	254,149
Fuel & Lubricant	47,517	34,167	36,808		6,415	27,173	28,179		
Repairing & Parts	11,928	4,096	600		397	551	4,640		
Commission for operators	6,380	6,933	7,203		775	6,630	6,500		
Transportation & Others	5,635	3,275	8,347		-	-	-		
Gross profit (฿)	24,306	38,987	24,061	87,354	5,658	49,496	54,261	109,415	196,769

1) Tractor used: 3-Ford 6600 (79HP), 1-Massey Ferguson 185 (75HP).

2) Income: Tractor service charge (Plowing: 75-80/rai, Harrowing: ฿ 60/rai).

3) Wages of operators approx. ฿ 20/hr, ฿ 11/rai, allowance of officers who was concerned with this operation service fixed cost of tractors are excluded.

For the activity, four tractors with attachment, belonged to the Project were used by each Cooperative free of charge.

Most of costs for the activity, that is drivers' wages, repairing and depreciation costs for machines and etc., were covered by the Project except cost of fuel.

Total acreage of land for the period of three years were 2,451 rai (392 ha) and 3,476 rai (556 ha) for Phraphutthabat and Chaibadan Cooperatives area, respectively.

Gross profit by the tractor services given by these two Cooperatives since 1981 was ฿109,000 at Phraphutthabat and ฿87,000 at Chaibadan, respectively.

When compared, results of the activities between two cooperatives, Phraphutthabat Cooperative obtained larger amounts of gross profit based on less expenses in 1982 and 1983 as shown in Table 74.

Table 74 Comparison of profits and expenses per rai and consumption of fuel and lubricant per hour between Chaibadan and Phraphutthabat Coops. on tractor operation service, 1981 - 1983.

Coops.	1981	1982	1983
Chaibadan			
Income/rai	75.05	73.92	75.73
Expenses/rai	56.00	40.97	52.07
Gross profit/rai	19.05	32.95	23.66
Consumption of;	-	53.60 (122%)	66.07 (155%)
Fuel, lubricant/hr			
Phraphutthabat:			
Income/rai	85.45	75.67	78.77
Expenses/rai	48.94	31.00	33.09
Gross profit/rai	36.51	44.67	45.68
Consumption of;	-	43.89 (100%)	42.69 (100%)
Fuel, lubricant/hr			

Most expenses consisted of fuel consumption and lubricant. A considerably high consumption of fuel and lubricant per hour was seen on tractor operation at Chaibadan Cooperative in 1982 and 1983, especially that of 1983 was 55% higher than that of Phraphutthabat.

Operational hours are recorded by hourmeter which is based on an average engine speed of 1,570 rev/min on this type of tractor. Engine speeds below 1,570 rev/min accumulate hours at a slower rate than clock hours. Engine speeds above 1,570 rev/min build up hours faster than clock hours. That is, a registration of large amount of hours should be made rapidly by heavy duty operation.

Therefore, consumption of fuel and lubricants per hour is not always increased even under heavy conditions for tractor operations in the case of the Chaibadan area where poor topography, abounded in rocks and tree stumps, where unsuitable field shapes, etc., existed. More investigations are needed in terms of relationships between consumption of fuel, lubricants and hours on tractor operation under various field and climate conditions.

From the above reasons, discussion for economical cost and charge of land preparation services will only be given on activities of Phraphutthabat Coop. in 1982 and 1983.

Estimation of operating costs per hour at Phraphutthabat Coop. is shown in Table 74. The cost for land preparation services per rai for Phraphutthabat area in 1982 and 1983 was as follows:

2,296 rai – 1,279 hr = 1.79 rai/hr
฿177.48 rai – 1.79 rai = ฿99.15/rai

The charges of operation service (income) per rai for Phraphutthabat area are as follows:

฿177,430 – 2,296 rai = ฿77.27/rai

That is, B 99.15 – ฿77.27 = 21,88 is given as deficit on each rai of operation.

Table 75 Estimated land Preparation costs for tractor & its implement per hour at Phraphutthabat, 1982.

Year & hours of work life			12 years (12,000 hr)	Reference
Annual fixed cost (1,000 hr)	Depreciation		Tractor: 1) ฿ (410,000-41,000) x $\frac{1}{12}$ (year) =฿30,750 Implement: 2) ฿ 31,600 x $\frac{1}{12}$ (year) = ฿ 2,633	1) Thailand Farm mechanization and farm machinery market. a coordinated Industry Study Project, 1969
	Interest on capital		Tractor: ฿ (410,000 + 41,000) x 10% =฿22,550 Implement: ฿ (31,600 + 3,160) x 10% = ฿ 1,738	2) Capacity and its economical cost estimation for tractor and implements, Nogyo Gijits Kenshukai, 1965 (Japan)
	Tax of land, garage etc.		฿ (410,000 + 31,600) x 2% = ฿ 8,832	
	Maintenance & repairing		฿ (410,000 + 31,600) x 11% =฿48,576	
	Total		฿ 115,079	
Operating costs for tractor and implement per hr	Fixed cost		฿ 115.07	Variable cost was calculated from the results of 3 tractors' operation.
	Variable cost	Fuel & lubricant	฿ 42,47	
		Wages & allowance	฿ 19.94	
		Total	฿ 62.41	
	Total		฿ 177.48	

1) TRACTOR : Ford 6600 (79HP)

2) IMPLEMENT : Disk plow (26' x 3)

It can be seen that a sizable net loss is obtained in this operation. The factors causing this large net loss seem to have been the high fixed cost which is determined from a base of 1,000 working hours per year.

Therefore, the reduction of fixed costs should be done by means of expanding working hours. The expanding of working hours coinciding with tractor service charges (฿ 77.27/rai) is calculated as follows:

Operating cost for Tractor & implement.		Fixed cost	Variable cost	Working hours
Per hour	117.48	115.07	62.41	1,000
Per rai	99.15	64.29	34.86	1,000
Per rai	77.27	42.41	34.86	x

$$\therefore \quad x = 1{,}000 \text{ hr} \times \frac{64.29}{42.41} = 1{,}515 \text{ hr}$$

In Thailand, common tractor custom service operation was carried out about 5 months yearly on an average of 18 working hours per day were reported* (Approx. more than 2,000 hr/year).

As a result of the above mentioned, we can conclude that within the limit of this trial, the possibility of an economical tractor land preparation services for cooperatives member farmers may be possible with 1,500 working hours yearly less than the common tractor custom service.

In any case, lengthy and careful consideration should be given to these countermeasures in operation.

*Farm Mechanization in Thailand, The International Symposium on Farm Mechanization in Asia, 1978.

B) Corn shelling service with tractors:

Corn shelling service was carried out at the Phraphutthabat and Takfa Cooperatives in 1981 and in 1983, respectively. The results of this operation are presented in Table 76.

The priority objective of the scheme was to purchase the corn from coop. member farmers. Therefore, no profit was expected from these corn shelling services. If we consider the reduction of the fixed cost of the tractor, the corn shelling operation would be effective even if no profit were obtained from this activity.

Table 76 Results of corn shelling service with tractors at two cooperatives.

Coop.	Phraphutthabat	Takfa	Total
Period	23/11/81-18/12/81	7/9/83-26/10/83	
Operation hour	Not recorded	90.8	-
Amount of shelled corn (t)	410	516	926
Income (฿)	11,014	21,195	32,209
Expenses (฿):	11,014	20,768	31,782
Fuel & Lubricant	6,814	6,742	
Repairing & parts	1,237	1,049	
Commission for operators	2,930	6,254	
Others	-	6,723	
Gross Profit (฿)	0	427	427

As another important service procedure repairing service of agricultural machinery has been conducted at the Center and each extension base.

For the purpose, many machinery was delivered into the workshop at the Center from Cooperatives, Farmers Groups and their member farmers concerned with the Project.

The result of the activities at the Center are as Table 77.

For the service, necessary cost was paid by the budget of the Project (Cooperatives Promotion Department), excluding parts and some of the materials. Average cost for farmers with one machine therefore, was 110 baht about a half of marketing price.

These activities have gained public favour especially by farmers at the extension bases. It will be expected to develope as an important Cooperative Activities in the future.

Koksamrong Cooperative, one of the extension bases of the Project, prepared some budget for the activities in 1984. Only Sawankalok Cooperative owned its workshop in our extension bases, and have carried out the same service for members.

It would be very necessary to establish the machinery service in each Cooperative by its own workshop to let members appreciate the merit of the Cooperative system in the future.

Repairing service at the extension bases was conducted in combination with training activity using mobile car containing necessary equipment and materials for repairing. These services were given by the staff member during a period of the training course.

The result of the activities at the extension bases are as Table 78

Table 77 Number of machinery repaired at the Center.

Item / Year	Tractor	Buldozer	Vehicle	Motorcycle	Water pump	Weeder	Sprayer	Dinamo	Total
1982	11	1	18	7	3	4	6	-	50
1983	28	1	49	15	5	3	-	1	102

Table 78 Number of machinery repaired at the Center.

Place / Year	PB Coop.	CB Coop.	PeBu Coop.	Pr.P Coop.	NT Coop.	SK Coop.	Koksamrong Coop.	Takfa Coop.	Submai-Dang FG	Tachai FG	Total
1982	17	22	27	29	25	-	-	-	-	-	120
1983	13	15	21	19	15	-	32	22	16	14	167

abbreviated words mean as follows.
PB: Phraphuttabat, CB: Chaibadan, PeBu: Phetchabun PP: Prompiram,
NT: Nongtom, SK: Sawankalok,

8. Training

Training is also one of the most leading activities of the Project. The Cooperatives Promotion Department had the responsibility for this activity.

According to the original plan, cultivation techniques on maize are to be given at the Center for farmers associated with the seed production fields and maize producing farmers in the Project area.

After the training course was opened for the first time at the Center in 1979, the scope of training was magnified year after year and the subjects for it were also extended to other fields as agricultural machinery, Cooperatives management, Cooperatives accounting etc.

Furthermore, the mobile training course was added to them using a mobile car installed for necessary repairing equipment for each extension base in the Project.

Number of training courses and trainees joined them from 1979 to 1982 are shown as Table 78 and Table 79.

Training courses were held at the auditorium of the Center. One training course was composed of about 50 trainees for six days. Most of the lecturers for the training were dispatched from the Government Agencies with some specialists from private sectors including Japanese Experts sometimes.

Most of trainees were members of the Cooperatives and Farmers Groups at the extension bases of the Project. The special trainings for the management and accounting on cooperatives were also provided to staff members and members of the Board of Directors of the Cooperatives concerned.

Curriculum of typical training courses are shown in Figure 14 and 15.

Unique curriculums were contained in every course as object lessons, group discussion for evaluating effects of training by themselves, observation tour to machinery factories and advanced agricultural Project sites or model farms etc.

At night time present states of agricultural society or modern agricultural techniques in Thailand and foreign countries and others were also introduced to them by using movies and slide films at each training course at the Center.

Table 79 Number of training courses and trainees at the Center

	Cultivation Techniques	Seed Production Techniques	Information On Coops	Machinery Techniques	Accounting of Coops.	Total
1979	2 (100)					2 (100)
1980	2 (100)		1 (40)	1 (53)		4 (193)
1981	1 (30)	1 (37)	1 (40)	3 (122)		6 (229)
1982		2 (73)	4 (149)	2 (95)	3 (47)	11 (364)
1983	2 (110)	2 (92)	2 (111)	2 (97)		8 (410)
Total	7 (340)	5 (202)	8 (340)	8 (364)	3 (47)	31 (1296)

Table 80 Number of trainees for Mobile training course

	Cooperatives								Farmers Group		Total
	PB	CB	PeBu	PP	NT	SK	KS	TF	SM	TG	
1982	36	32	42	32	23	32					197
1983	22	36	37	42	37	44	45	54	38	37	392
Total	58	68	79	74	60	76	45	54	38	37	589

abbreviated words mean as follows.
PB:Phraphuttabat, CB:Chaibadan, PeBu:Phetchabun,PP:Prompiram,
NT:Nongtom, SK:Sawankalok, KS:Koksamrong, TF:Takfa, KT:Koktoom,
YT:Yangtone, HS:Hinsond, SM:Submaidang, TG:Ta-ngam, TC:Ta-chai

Fig 14 Maize Development Project in Thailand
Time-table for the Training of Cooperative committe
Men and Group Leaders
Session IV/1980, During 1 – 5 September, 1980
At Cooperatives Demonstration Center (Maize Development Project)
Koktoom Sub-district, Muang District, Lopburi Province.

Time / Date	9.00 - 10.00	10.00 - 11.00	11.00 - 12.10		13.30 - 14.30	14.30 - 15.30	15.40 - 16.40	19.00 - 21.0
Monday 1 st September,1980	Openning Session	Activities of Development (Japanese expert)	Principles and Method of Cooperatives (CPD)	L U N C H	(continue)	Marketing and Collecting System of Agricultural Products in Cooperatives (Agri. Coop. Division, CPD)		Question and answer and Feature show
Tuesday 2 nd September,1980	Foundation Seed Producing and Modernize of Agri. Techniques (Director of Field Crop Div.,DA)		The Production of Extension Seeds (Director of Seeds Div., DOAE)		(continue)	Relationships Among Board of Committee, Coop. Staff, and CPD. Staff		-Ditto-
Wednesday 3 rd September,1980	Credit Principle and Techniques on Follow up and Loan Repayment (BAAC)		Activities Service Business (Engineering Div. CPD)		(continue)	Master Plan for the Improvement of Agri. Coop. (Office of Agri. Coop. Development)		-Ditto-
Thursday 4 th September,1980	Study Tour at Muang Singburi Agri. Coop., Singburi Province							
Friday 5 th September,1980	Role and Activities of ACFT (ACFT)				Discussion	Evaluation	Break	Awarding Certificicates and closing Ceremony

Remark 1. Registeration on August 31, 1980. 8.30 - 17.00 hr, at Coop. Demonstration Center (Maize Development Project) Koktoom Sub-district, Muang district, Lopburi Province.

2. Orientation on Sunday, August 31, 1980, 19.00 PM.

Fig 15 Maize Development Project in Thailand
Time-table of the Training on Operation and Maintenance of Farm Machinery
Session IV/1981, During 29 – 30 August, 1981
At Cooperatives Demonstration Center (Maize Development Project)
Koktoom Sub-district, Muang District, Lopburi Province.

Time / Date	9.00 - 10.00	10.00 - 11.00	11.00 - 12.00		13.30 - 14.30	14.30 - 15.30	15.30 - 16.30	19.00 - 21.00
Monday 24 th August, 1981					Registeration			Orientation
Tuesday 25 th August, 1981	Openning Session	Activities of Maize Development Project	Testing		Principles of Engine, 4 Cycle System.			Feature Film Show
Wednesday 26 th August, 1981	Principles of Engine, 2 Cycle System		Machine Tools		Iginition System		Valve System	"
Thursday 27 th August, 1981	Fuel Injection Pump System (Theory)				Practical Training (continue)			"
Friday 28 th August, 1981	Study Tour at Farm Machinery Plant, Bangkok.							"
Saturday 29 th August, 1981	Cooling System and Lubricant System (Theory)				Practical Training (continue)			"
Sunday 30 th August, 1981	Repairing and Maintenance of Farm Machinery				Quèstion and answer	Testing and Evaluation	Certificates and Closing Ceremony	----

L U N C H

Trainees were very keen on the studies all the time during the training period, and they seemed to have great concern for the Project and the technical informations from the training course. Subjects of the mobile training were limited on agricultural machinery guidance and during the course repairing services for machinery were also carried out to farmers participating by staff members of the Project.

Curriculum for the mobile training courses were almost the same as that of at the Center excluding study tour. For these training activities many equipments were prepared as an audio visual system, a mobile car, a truck and buses and etc., by the Government of Japan.

According to the opinions obtained from questionaires in 1980, most of the trainees composed of general farmers or the contract farmers for seed production were satisfied with the technical knowledges on cultivation or machinery from the training course. They also preferred practice lessons to principle ones in every course.

The staff member and the member of the Board of Directors of each cooperative concerned were very interested in Cooperatives management techniques in the training course and they requested more intensive courses in the future.

The training activities would also be very valuable to trainees for making up good human relationships through their culture interchanging because they have had a few chances to contact with each other.

Some effects were gained from the training activities. Farmers occupied 1 – 5 place at yield competition of Phraphutthabat area in 1980 were trainees of our training courses on cultivation techniques of maize. Many farmers came to the Center for purchasing seeds from the Project in 1984 requesting leguminous crop seeds together with maize seeds for rotation of maize. This knowledge was mainly obtained through our training activities.

9. Guidance for the Agricultural Cooperatives

To contribute to the development of Agricultural Cooperatives through technology, improvement of maize cultivation technigues is one of the important purposes of the Project.

For the purpose, several technical guidance activities has been carried out for the extension bases as training, demonstration work, machinery service and etc.

Furthermore, positive approach for the up-bringing of core members of the Cooperatives were promoted in the Phraphutthabat Cooperatives area from 1979. As a result of these activities yield competition of maize was settled at first among the core members and it was extended to other areas.

Several trials were also carried out in the Phraphutthabat Cooperatives area as an introduction of castor bean, Japanese varieties of vegetables, Shiitake (a kind of mushroom) and etc. in addition to the main activities as training, repairing machinery, plowing and so on.

Almost all of the main activities was reported in each chapter of this report. Investigations on the actual state and main problems of activities on each Cooperative of the Project was carried out. The brief results are as follows.

PHRAPHUTTHABAT RECLAMATION AGRICULTURAL COOPERATIVE

This Cooperative was established as the Marketing Cooperative in 1971, and it was reorganized into the Integrated Agricultural Cooperative in 1974. Credit business was started by borrowing from the Bank of Agriculture and Agricultural Cooperatives (BAAC) in 1975. The number of member farmers and the ratio of membership was 1620 and 9.0 percent respectively in 1979.

A prosperous future was expected from this Cooperative as its membership and capital had increased year by year. However, as a result of failure of marketing business of maize in 1980 it got a big loss and it was incooperated into the Restructuring Program under control of the Cooperatives Promotion Department from 1983.

Now, the financial state of the Cooperative is recovering gradually and the net income is expected to go into the black in 1983. Our Project has been contributed to the Cooperative by providing tractor service and good seeds as well as many activities for member farmers of the Cooperative.

The Restructuring Program came into effect for improving way of management of primary cooperatives under a slump in business in 1981. The Program is consisted of giving subsidy for core staff members salaries and controlling business activities by the Committee members organized by the Cooperatives Promotion Department. Now the program was applied to about 400 primary cooperatives which was placed as the third class by criteria of the Committee out of about 1,000 cooperatives in total.

Table 81 Principle Account of the Phraphutthabat Reclamation Agricultural Cooperative.

(unit:baht)

Principle Account	1979/80	1980/81	1981/82
Number of farm households	7,781	9,287	9,538
Number of members'	1,847	1,862	1,900
Ratio of membership (%)	23.7	20.0	19.9
Number of employees	10	9	7
Loans	3,052,731	3,566,736	5,363,998
Account receivable	5,002,619	5,359,258	3,278,642
Interest receivable	527,252	422,905	360,815
Borrowing	19,136,533	6,798,859	7,467,686
Account payable	7,070,666	6,070,666	6,070,666
Saving	354,866	230,018	358,128
Share capital	1,306,450	1,466,750	1,699,850
Reserves	432,865	-	-
Loan recovery ratio (%)	55.67	50.98	54.61
Upper limit of borrowing from BAAC	6,000,000	6,000,000	6,000,000

Table 82 Result of Business of the Phraphuttabat Reclamation Agricultural Cooperative.

(unit:baht)

Credit business	1979/80	1980/81	1981/82
Total of loan to be disbursed	825,525	3,837,500	4,629,000
Loan interest received	737,501	813,191	692,382
Borrowing interest paid	517,855	586,804	598,525
Saving interest paid	29,678	32,363	29,295
Gross profit	189,969	194,024	64,563
Purchasing business			
Amount of transaction	3,768,536	2,091,279	2,188,159
Cost	3,299,577	1,837,114	1,879,426
Gross profit	468,959	254,183	308,733
Maize seed	24,800	41,760	203,360
Marketing business			
Amount of transaction	31,484,466	28,742,608	6,800,898
Cost	32,652,081	27,631,327	6,425,674
Gross profit	(1,167,615)	1,111,281	375,223
Maize (ton/baht)	8,328/ 27,593,213	9,005/ 26,002,820	1,743/ 4,244,088
Settlement of account			
Total business profit	(2,313,991)	(902,137)	229,351
Total administrative expenses	770,628	708,240	463,733
Net income	(3,084,618)	(1,610,377)	(234,382)

CHAIBADAN AGRICULTURAL COOPERATIVE

This Cooperative was established in 1966. In 1975, the number of members was 377 of 17 groups and ratio of membership was 5%. At that time the amount of maize transaction of the Cooperative was about 4,000 tons, and it was one of the most prosperous cooperatives in maize area.

Recently, business of the Cooperative has been very poor with a few staff members and a tendency of yearly decrease in member farmers. The basical point of the problems would be based on the qualification of members who are less honest and less intelligent to cooperate to the cooperative system. Many of them had not paid back their loan to the cooperative.

In 1982, the amount of loan was 600,000 baht by 92 members and many of them escaped to other places without repayment. Another problem of the cooperative was that there was no warehouse or other facilities and it made it difficult for the Cooperative to promote purchasing business or others.

Tractor service of our Project has been contributing to the Cooperative not only for giving some profit directly but also leting the member farmers to recognize merit of the Cooperative.

Many other activities of the Project have been carried out for the Cooperative intensively. From 1983, it got support of the Restructuring Program of the Cooperatives Promotion Department.

Table 83 Principle Account of the Chaibadan Agricultural Cooperative.

(unit:baht)

Principle Account	1979/80	1980/81	1981/82
Number of farm households	20,740	20,415	16,815
Number of members	495	479	478
Ratio of membership (%)	2.4	2.3	2.8
Number of employees	1	3	3
Loans	591,279	1,341,050	1,808,550
Account receivable	861,753	623,391	673,796
Interest receivable	242,216	276,374	317,749
Borrowing	792,971	1,789,680	1,941,196
Account payable	957,359	957,359	857,359
Saving	19,213	79,220	126,301
Share capital	232,050	285,350	234,600
Reserves	-	-	-
Loan recovery ratio (%)	59.86	44.23	39.00
Upper limit of borrowing from BAAC	1,000,000	1,100,000	1,100,000

Table 84 Result of Business of the Chaibadan Agricultural Cooperative.

(unit:baht)

Credit business	1979/80	1980/81	1981/82
Total of loan to be disbursed			
Loan interest received	166,559	127,857	262,387
Borrowing interest paid	71,274	55,730	104,856
Saving interest paid	178	2,365	11,871
Gross profit	95,107	69,762	145,660
Purchasing business			
Amount of transaction	41,300	266,798	347,010
Cost	38,950	195,432	275,495
Gross profit	2,350	71,366	71,515
Maize seed (all from the Project)	-	94,860	121,200
Marketing business			
Amount of transaction	922,701	2,152,493	1,548
Cost	914,156	2,145,415	-
Gross profit	8,545	7,078	1,548
Maize (ton/baht)	287/ 882,752	831/ 2,145,415	-
Settlement of account			
Total business profit	51,876	72,186	61,762
Total administrative expenses	50,522	53,431	58,563
Net income	1,354	18,755	3,199

PHETCHABUN AGRICULTURAL COOPERATIVE

The Cooperative was established in 1974 and became Integrated Cooperative in 1976. It owned a rice mill with a capacity of 40 tons per day, a warehouse for 1,000 tons, a truck scale and etc. Amount of maize handled by the marketing business was 12,000 tons in 1973. The Cooperative had a good reputation on business activities with more than 1 million baht of profit each year as well as having a big amount of capital and borrowing from the Bank of Agriculture and Agricultural Cooperatives.

The activities, however, have been stalemate these days, as was shown in decreasing members and profit which was mainly brought from the credit business.

The situation would be mainly caused by the management system of the Cooperative. Some would be mannerism of management; the way of Cooperative and others would be no positive stance to improve member farmers by giving new informations on cultivation or cooperative societies.

In this area, maize plantation was new increasing in the mountain area now. Maize seeds provided the Cooperative with about 10 tons each year from the Project. Marketing business of maize in the Cooperative, however, were reduced from 1981 due to too low profit at high cost.

The Cooperative, however, will be expected to get more than 1 million baht as profit a year from 1983.

Table 85 Principle Account the Petchabun Agricultural Cooperative.

(unit : baht)

Principle Account	1979/80	1980/81	1981/82
Number of farm households	23,028	23,028	25,472
Number of members'	2,350	2,356	2,273
Ratio of membership %	10.2	10.2	8.9
Number of employees	8	10	12
Loans	15,734,477	14,293,055	16,600,326
Account receivable	2,047,870	1,058,398	847,477
Interest receivable	1,042,714	1,364,669	2,026,645
Borrowing	17,240,418	19,592,094	18,114,672
Account payable	4,531,500	4,531,500	4,023,538
Saving	199,628	191,558	388,711
Share capital	2,794,650	3,051,850	3,365,150
Reserves	3,785,967	4,483,502	5,111,423
Loan recovery ratio (%)	35.90	49.08	28.27
Upper limit of borrowing from BAAC	16,500,000	16,500,000	16,500,000

PROMPIRAM AGRICULTURAL COOPERATIVE

This was established as a Credit cooperative in 1971 and became Integrated Cooperative in 1974. This has a warehouse and other facilities.

Business activities of the Cooperative have been prosperous and improving now as a result of a big support of loan from the Bank of Agriculture and Agricultural Cooperatives every year. Maize was the main marketing comodity with 1,500 tons in 1975. In 1974, it gained a profit of about 500,000 baht from maize marketing, and the new office was constructed from the profit. Now, however, maize transaction has ceased to exist following decrease of maize plantation area.

This area has changed to rice fields based on the new irrigation system constructed by the Government from 1974. Restructuring program was applied to the Cooperative as a result of corruptions in the Cooperative in 1982.

Credit business, however, has given a big profit continously to the Cooperative. Prosperous future, therefore, is expected soon for the Cooperative.

Table 86 Result of Business of the Petchabun Agricultural Cooperative.

(unit : baht)

Credit business	1979/80	1980/81	1981/82
Total of loan to be disbursed	9,058,100	7,333,900	7,532,950
Loan interest received	1,996,690	1,254,530	1,146,415
Borrowing interest paid	1,220,747	1,324,004	1,768,377
Saving interest paid	26,820	20,317	23,520
Gross profit	794,123	(89,791	(645,482)
Purchasing business			
Amount of transaction	2,465,214	1,815,906	858,515
Cost	2,007,500	1,613,097	709,806
Gross profit	457,714	202,809	118,709
Maize seed (kgs),(Total/from Project)	163,590 / 15,990	110,420 / 14,400	159,210 / 9,960
Marketing business			
Amount of transaction	6,380,840	10,629,967	3,754,843
Cost	6,153,262	9,889,104	3,766,484
Gross profit	227,578	740,863	(11,642)
Maize (ton/baht)	1,471 / 3,490,216		143 / 383,208
Settlement of account			
Total business profit	1,525,271	1,627,193	819,189
Total administrative expenses	484,250	598,343	674,042
Net income	1,041,023	1,028,850	145,147

Table 87 Principle Account of the Prompiram Agricultural Cooperative.

(unit:baht)

Principle Account	1979/80	1980/81	1981/82
Number of farm households	14,593	14,195	17,492
Number of members	2,717	3,070	2,992
Ratio of membership (%)	18.6	21.6	17.1
Number of employees	7	11	12
Loans	17,205,067	13,075,995	12,660,055
Account receivable	1,630,563	1,683,163	1,399,556
Interest receivable	2,733,627	2,622,087	2,434,605
Borrowing	18,030,753	19,677,612	19,359,117
Account payable	3,364,425	3,244,425	3,320,833
Saving	11,585	8,935	138,927
Share capital	1,880,570	2,040,750	2,666,750
Reserves	1,680,058	1,847,026	2,138,326
Loan recovery ratio (%)	9.78	39.98	45.03
Upper limit of borrowing from BAAC	20,000,000	25,000,000	25,000,000

Table 88 Result of Business of the Prompiram Agricultural Cooperative.

(unit:baht)

Credit business	1979/80	1980/81	1981/82
Total of loan to be disbursed	544,000	4,208,500	8,930,500
Loan interest received	2,210,726	2,737,568	2,505,549
Borrowing interest paid	1,482,699	1,882,240	1,838,400
Saving interest paid	2,357	2,280	16,283
Gross profit	725,670	853,048	650,866
Purchasing business			
Amount of transaction	727,678	611,104	967,209
Cost	564,032	588,584	917,371
Gross profit	163,646	22,520	49,838
Maize seed (all from the Project)	-	24,346	3,549
Marketing business			
Amount of transaction	150,197	5,432,778	630,667
Cost	49,444	5,391,528	562,311
Gross profit	100,752	41,250	68,356
Maize (ton/baht)	20.3 / 55,297	-	-
Settlement of account			
Total business profit	551,536	816,668	872,458
Total administrative expenses	257,486	332,447	560,153
Net income	294,050	484,220	222,304

NONGTOM AGRICULTURAL COOPERATIVE

This Cooperative was established as a marketing cooperative in 1966, and reorganized to Integrated Cooperative in 1974.

This area was covered by maize fields before but irrigation system using pump was expanded widely now. Plantation of maize, therefore, decreased quickly year by year. Maize transaction which was more than 1,000 tons before, therefore, has ceased to exist now.

Financial state of the Cooperative has been very bad for a long period.

This stalemate of the activities was based on selfish management of a manager or some staff members of the Cooperative as well as their corruptions. Repayment of loan to the Zenno Project was also a heavy burden for the Cooperative as it should be paid back 500,000 baht every year. The Cooperative had requested delay the payment for sometime.

It would be possible to recover the financial state soon if delay of repayment will be approved. The Restructuring Program by Cooperatives Promotion Department was also applied to the Cooperative from 1982.

Table 89 Principle Account of the Nongtom Agricultural Cooperative.

(unit:baht)

Principle Account	1979/80	1980/81	1981/82
Number of farm households	14,593	14,195	17,492
Number of members	731	741	719
Ratio of membership (%)	5.0	5.2	4.1
Number of employees	6	6	5
Loans	2,930,617	1,645,628	1,455,323
Account receivable	187,861	164,065	177,048
Interest receivable	557,045	336,312	173,386
Borrowing	10,934,858	12,519,200	11,560,410
Account payable	1,690	313,827	-
Saving	10	68,693	65,790
Share capital	452,080	525,050	689,450
Reserves	-	-	-
Loan recovery ratio (%)	17.08	62.14	59.78
Upper limit of borrowing from BAAC	2,000,000	2,000,000	2,000,000

Table 90 Result of Business of the Nongtom Agricultural Cooperative.

(unit:baht)

Credit business	1979/80	1980/81	1981/82
Total of loan to be disbursed	516,000	1,080,000	2,019,000
Loan interest received	433,134	382,672	395,528
Borrowing interest paid	51,737	69,683	224,350
Saving interest paid	71.11	-	-
Gross profit	(125,701)	(312,689)	(169,178)
Purchasing business			
Amount of transaction	42,734	46,745	148,847
Cost	37,175	35,503	104,819
Gross profit	5,559	11,242	44,027
Maize seed (kg/baht)	6,000 / 36,000	- 19,890	- 57,010
Marketing business			
Amount of transaction	1,183,059	427,653	189,240
Cost	732,432	365,993	111,194
Gross profit	450,627	61,659	78,046
Maize (ton/baht)	363 / 1,060,663	-	-
Settlement of account			
Total business profit	90,346	(136,625)	(235,208)
Total administrative expenses	411,710	439,966	295,392
Net income	(321,363)	(576,591)	(530,600)

SAWANKALOK LAND SETTLEMENT COOPERATIVE

The Cooperative was established as a reclamation Cooperative in 1941, and became Integrated Cooperative from 1975. The area of the Cooperative was 32,000 ha and 20,000 ha of it was used by the member farmers and it has been still increasing following increase of members.

The situation of the Cooperative has been very good. The credit business has obtained a big profit continously based on large amounts of borrowing from the Bank of Agriculture and Agricultural Cooperatives. Zenno Project was also given a big burden due to the financial state of the Cooperative now. Amount of repayment to the Project has been more than 1 million baht each year, but it will be possible to pay back all by 1984.

Many facilities and trucks provided by the Zenno Project will be very useful for the activities of the Cooperative now. A very prosperous future will be expected from the Cooperative.

A few years ago, maize was one of the most important crops in this area as with 2,000 tons transaction by the Cooperative in 1973. However, most of the area changed to rice fields as a result of the completion of the irrigation system by the Government. Maize transaction by the Cooperative almost ceased now.

Table 91 Principle Account of the Sawankaloke Land Settlement Cooperative.

(unit:baht)

Principle Account	1979/80	1980/81	1981/82
Number of farm households	4,887	5,080	5,164
Number of members	3,924	4,044	4,347
Ratio of membership (%)	80.3	79.6	84.2
Number of employees	7	7	7
Loans	6,622,666	10,409,715	11,618,652
Account receivable	9,262,243	9,182,724	6,673,540
Interest receivable	669,433	1,341,654	1,692,349
Borrowing	13,030,033	20,340,225	18,269,419
Account payable	5,917,080	5,930,577	6,102,358
Saving	493,279	947,433	861,371
Share capital	3,244,800	3,952,250	4,759,500
Reserves	2,166,149	1,838,414	1,711,362
Loan recovery ratio (%)	59.63	59.26	41.82
Upper limit of borrowing from BAAC	7,800,000	10,200,000	12,810,000

Table 92 Result of Business of the Sawankaloke Land Settlement Cooperative.

(unit:baht)

Credit business	1979/80	1980/81	1981/82
Total of loan to be disbursed	12,014,000	13,570,000	9,560,100
Loan interest received	1,669,953	2,493,010	2,541,748
Borrowing interest paid	617,075	1,005,986	1,245,168
Saving interest paid	39,535	54,461	70,768
Gross profit	1,013,343	1,432,563	1,225,812
Purchasing business			
Amount of transaction	5,710,710	3,727,266	2,922,334
Cost	5,366,023	3,329,553	2,426,860
Gross profit	344,688	397,714	485,475
Maize seed	-	-	-
Marketing business			
Amount of transaction	5,286,918	2,159,169	1,231,089
Cost	5,190,272	2,137,741	1,175,776
Gross profit	96,646	21,428	55,313
Maize (ton/baht)	158 / 462,460	150 / 322,741	- / 126,011
Settlement of account			
Total business profit	1,156,665	1,263,382	1,578,807
Total administrative expenses	1,353,941	1,591,117	1,705,859
Net income	(197,276)	(327,736)	(127,052)

KOKSAMRONG AGRICULTURAL COOPERATIVE

From 1982, this Cooperative was taken into the extension bases of the Project.

This Cooperative was established as the Credit Cooperative in 1974, and reorganized to the Integrated Agricultural Cooperative in 1979. At that time the number of members and the amount of capital were 260 and 3,043,600 baht.

This Cooperative obtained 7,000,000 baht of loan from Bangkok Bank every year, in addition to yearly big loans from the Bank of Agriculture and Agricultural Cooperatives (BAAC).

BAAC regarded this Cooperative as first class in business activities. Yearly profit was up to 2 million baht recently, and it has still increased gradually. Amount of saving has been specially high and increasing year by year too.

The superior management of the Cooperative will be based on the qualification of staff members and member farmers. Many of them had higher intelligence about cooperative system and they were also very keen in getting technical informations from our Project activities.

All activities of the Project, therefore, were expanded to the Cooperative area now. Marketing maize has still been one of the most important business for the Cooperative.

Table 93 Principle Account of the Koksamrong Agricultural Cooperative.

(unit:baht)

Principle Account	1979/80	1980/81	1981/82
Number of farm households	17,717	17,621	16,724
Number of members	2,848	2,819	2,820
Ratio of membership (%)	16.1	16.0	16.9
Number of employees	17	19	19
Loans	26,627,358	26,386,028	33,330,284
Account receivable	2,805,676	2,561,220	1,873,527
Interest receivable	1,760,054	1,813,491	2,181,318
Borrowing	25,838,258	33,589,833	32,714,948
Account payable	23,520	2,381	116
Saving	1,256,387	1,469,725	1,686,777
Share capital	4,600,650	5,281,550	6,386,400
Reserves	7,412,557	8,486,491	9,422,740
Loan recovery ratio (%)	44.66	54.63	45.31
Upper limit of borrowing from BAAC	20,500,000	22,550,000	34,240,000

Table 94 Result of Business of the Kok-samrong Agricultural Cooperative.

(unit:baht)

Credit business	1979/80	1980/81	1981/82
Total of loan to be disbursed	12,616,470	18,799,758	25,083,419
Loan interest received	3,874,246	4,526,094	5,317,459
Borrowing interest paid	2,111,884	2,598,807	3,040,836
Saving interest paid	95,597	125,314	155,786
Gross profit	1,666,766	1,801,972	2,120,837
Purchasing business			
Amount of transaction	4,285,218	3,341,317	2,870,343
Cost	3,623,200	2,878,408	2,180,775
Gross profit	662,018	462,909	689,568
Maize seed (ton/baht) (all from the Project)	56 / 374,280	- / 370,176	- / 197,529
Marketing business			
Amount of transaction	5,909,286	8,948,938	2,982,999
Cost	5,692,312	8,438,852	1,878,374
Gross profit	216,975	510,086	1,104,625
Maize (ton/baht)	2,686 / 5,669,422	4,427,951	1,876,077
Settlement of account			
Total business profit	2,581,157	2,959,460	4,143,802
Total administrative expenses	799,989	1,120,560	1,466,446
Net income	1,781,167	1,838,900	2,677,357

TAKFA AGRICULTURAL COOPERATIVE

This Cooperatives was amalgamated to the Integrated Cooperative in 1971. At that time the number of members and the amount of capital was 287 and 123,000 baht respectively.

From 1982, the cooperative was taken into the extension bases of the Project.

The activities of the Cooperative has been good following to the Koksamrong Cooperative in each business.

The Bank of Agriculture and Agricultural Cooperatives loan has increased year by year.

There was some corruptions in 1980 in this Cooperative. Therefore, the Cooperative was applied to the Restructuring Program from 1982.

This Cooperative, therefore, will have improved in the near future as a result of guidance by the Cooperatives Promotion Department.

Table 95 Principle Account of the Takfa Agricultural Cooperative.

(unit:baht)

Principle Account	1979/80	1980/81	1981/82
Number of farm households	7,581	7,637	7,730
Number of members	840	833	849
Ratio of membership (%)	11.0	10.9	11.0
Number of employees	3	5	5
Loans	7,490,300	8,653,600	8,871,672
Account receivable	344,524	1,066,566	1,092,885
Interest receivable	145,535	379.612	504,207
Borrowing	7,930,293	9,254,110	7,881,123
Account payable	377,045	384,685	-
Saving	273,184	273,314	1,098,501
Share capital	2,053,500	2,388,400	2,705,850
Reserves	74,990	262,800	561,639
Loan recovery ratio (%)	83.71	70.43	60.77
Upper limit of borrowing from BAAC	8,000,000	10,000,000	12,400,000

Table 96 Result of Business of the Takfa Agricultural Cooperative.

(unit:baht)

Credit business	1979/80	1980/81	1981/82
Total of loan to be disbursed	6,540,000	7,149,000	6,168,700
Loan interest received	663,502	1,025,991	1,288,721
Borrowing interest paid	527,689	683,022	873,971
Saving interest paid	16,866	18,517	29,166
Gross profit	118,947	324,452	385,584
Purchasing business			
Amount of transaction	3,011,692	3,030,538	814,529
Cost	2,668,681	2,480,124	699,919
Gross profit	343,011	550,414	114,610
Maize seed (all from the Project)	-	16,836	16,590
Marketing business			
Amount of transaction	1,124,962	823,655	151,918
Cost	1,071,041	748,584	148,511
Gross profit	53,921	75,071	3,407
Maize (baht)	885,896	823,655	151,918
Settlement of account			
Total business profit	570,408	815,637	673,232
Total administrative expenses	196,387	277,083	318,862
Net income	374,021	538,554	354,370

KOKTOOM AGRICULTURAL COOPERATIVE

This Cooperative was taken into the Project as an Extension Basis right after becoming the Cooperative from Agricultural Farmers Group in 1981. At that time, the amount of the capital was 145,250 baht.

Koktoom Agricultural Cooperative was situated next to the Project Center. Intensive advice from our Project, therefore, will be available in the future.

Credit business is not started yet in this Cooperative.

However, 80% of members have got loans already from the Bank of Agriculture and Agricultural Cooperatives.

Table 97 Principle Account of the Koktoom Agricultural Cooperative.

(unit:baht)

Principle Account	1979/80	1980/81	1981/82
Number of farm households		2,315	2,720
Number of members		354	345
Ratio of membership (%)		15.3	12.7
Number of employees		-	1
Loans		-	-
Account receivable		813,296	745,700
Interest receivable		-	-
Borrowing		-	-
Account payable		717,290	717,290
Saving		4,000	10,900
Share capital		145,250	160,800
Reserves		18,081	919
Loan recovery ratio (%)			
Upper limit of borrowing from BAAC		-	-

Table 98 Result of Business of the Koktoom Agricultural Cooperative.

(unit:baht)

Credit business	1979/80	1980/81	1981/82
Total of loan to be disbursed			
Loan interest received		-	-
Borrowing interest paid		-	-
Saving interest paid		-	1,448
Gross profit			(1,448)
Purchasing business			
Amount of transaction		870,298	672,313
Cost		802,540	601,901
Gross profit		67,758	70,412
Maize seed (all from the project)		13,650	9,705
Marketing business			
Amount of transaction		-	298,823
Cost		-	268,152
Gross profit		7,456	21,671
Maize (ton/baht)		-	281,183
Settlement of account			
Total business profit		39,846	14,991
Total administrative expenses		14,403	44,915
Net income		25,443	(29,924)

MAIZE MARKETING BUSINESS BY THE COOPERATIVE IN THAILAND

Maize is one of the most important exporting commodities in Thailand. Most of maize produced has been handled by merchants for a long time. From the view point of strengthening Cooperative, marketing business of maize would be very important. Some cooperatives had a lot of profit by marketing business of maize in some years as Phetchabun and Prompiram Cooperatives in 1974.

However, many cooperatives have obtained a big loss from this business too. Let us think about this marketing business which will be profitable or not for primary cooperatives.

Maize export to Japan through the Cooperative Society in Thailand was carried out several years ago. The largest amount of transaction was about 100,000 tons in 1971 from ACFT (Agricultural Cooperatives Federation in Thailand) and Zenno (National Federation of Agricultural Cooperatives Association in Japan).

Transaction of maize by primary cooperatives used to be controlled by the ACFT. Amount of maize transaction carried out by ACFT recently are shown in Table 99.

Table 99 Maize transaction by the Agricultural Cooperative Federation in Thailand

	A Amount of maize transaction (ton)	B Amount of maize Collected from Cooperative Society (ton)	B/A %
1979/80	61,412	34,127	56
1980/81	75,765	70,562	93
1981/82	132,697	26,419	20
1982/83	13,280	13,280	100
1983/84	210	210	100

Collection of maize through Cooperative Society in Thailand had been carried out by about 70 Primary Cooperatives under control of the ACFT. Trade of maize through the Cooperative Society were carried out between ACFT and Zenno for 15 years from 1965 to 1979.

In this case, yearly amount of maize collected by ACFT through the Cooperative Society was only 51% in average for all amount of maize. This fact showed that the ACFT used to collect almost a half amount of maize from merchants called as middlemen.

Generally, when the ACFT collects maize from Primary Cooperatives, it sends a delivery; a quota and 70% of budget for total price in advance. Based on insufficient capital of the ACFT, remainder budget of 30% will be paid after delaying for a long period, and sometimes paid after shipment of the commodity for export.

The Primary Cooperatives, after getting an allotment of maize collection from the ACFT will take action for purchasing maize from their member farmers.

From this purchasing, each Cooperative should compete with middlemen at its disadvantageous stand point under insufficient budget and inferior facilities. It would be very difficult to compete with middlemen's services.

Furthermore, quality of maize purchased by middlemen used to be superior than those by Cooperatives because middlemen used to purchase maize early and they can dry it up fully.

Many Primary Cooperatives, therefore, will be necessary to purchase good quality maize for mixing them to their collected maize for improving the quality of their maize.

Amount of maize purchased from member farmers in the Phraphutthabat Cooperative in 1980 and 1981 occupied only 25% and 76% the total amount of it respectively. The ratio of amount of maize collected from members in Chaibadan Cooperative was 56% in 1981.

Another merit for the Cooperatives would be to save purchasing costs by getting maize through middlemen. Because they can ensure a large amount of maize within limited period for the request of the ACFT.

Middlemen has been controlling many farmers economically, needless to say, by purchasing agricultural commodities in cash from farmers and giving other many routine services to them. On the other hand, many Primary Cooperatives are insufficient both in capital and staff members as well as luck in good communication and transportation facilities.

Furthermore, member farmers which are usually 10% of membership distributed separately in wide area of each Cooperative. In case of the Phraphutthabat Cooperative, total area of it is about 80,000 hectare.

Maize is one of the most important exporting commodities in Thailand. Therefore, price of maize changes susceptibly following international price. This used to add another problem for marketing maize of the Cooperative Society. There were two possibilities for getting both profit and deficit every time.

Many Cooperatives have carried out this marketing business of maize with a larger amount than the allotment by the Agricultural Cooperatives Federation in Thailand. They gained a lot of profit by the business in 1974, as the Phetchabun Cooperative succeeded construction of a main office and warehouse etc., or the Prompiram Cooperative in our extention bases.

In other years, both Cooperatives did not get big profit from the business for a long time. The Phraphutthabat Cooperative met with a big deficit from the business based on a failure of speculation for this business in 1981.

Nowaday, the amount of transaction of maize by the leadership of the ACFT showed

a big decrease. It would be caused by the limited transaction of the Cooperative Society only. Anyway, many Primary Cooperatives are still carrying out the maize marketing by themselves. Many of them do not want to cooperate with the ACFT for this business because of low price, refunding system of it and etc. From these experiences, marketing business of maize would not be very prosperous for the cooperative Society in Thailand.

When primary cooperatives want to promote this as their own business, it is requested for the staff members of the cooperatives that a circumspective behavior based upon keen insight to compete with middlemen system for the business.

III. Contribution to the Project from Both Governments

1. The Japanese Government

A. Long-Term Expert

Table 100 Long-Term Experts

Category	Field	Name	Cooperation period
Team leader		TETSUJI YAMAKI	27 Oct., 1977 — 16 Sept., 1984
Experts	Seed production	CHUZO SAIKA	26 March, 1979 — 16 Sept., 1982
	Cultivation	HARUHIKO SAKAMATO	27 Oct., 1977 — 16 Sept., 1984
	Farm machinery	TATSUJI MURAI	1 Sept., 1978 — 16 Sept., 1984
	Agricultural Cooperatives and Extension	YUTAKA OISHI	9 Sept., 1980 — 16 Sept., 1982
Coordinator	Demonstration	YOSHIHIRO SHIMIZU	26 March, 1979 — 16 Sept., 1984

B. Short-term Experts

Table 101 Short-term Experts

Name	Cooperation period	(days)	Work for assignment
TETSUJI YAMAKI	1 March — 30 May, 1977	(91)	Promotion for the implementation Project.
KEIZO KATSUYA	1 March — 20 May, 1977	(81)	
YOSHIHISA KATSUTA	17 Oct. — 6 Nov., 1978	(21)	Construction of the Prefabricated cold storage.
TOKUJI ABE	do		
SHIROO SEZAI	6 – 26 February, 1979	(21)	Consultation on the equipment for seed plant.
HIDEAKI KIMURA	6 April — 12 June, 1979	(67)	Installation and adjustment of the equipment for seed plant.
KATSUHIRO KUROSAWA	do		
KOICHI NONAKA	26 June — 30 Nov., 1979	(158)	Advice for the activities on Cooperatives and extension.
HIDEAKI KIMURA	8 – 21 August, 1979	(14)	Operation test of seed plant and installation of cooling system for the cold storage.
HIROMITSU KANEOYA	3 Nov. — 8 Dec., 1979	(36)	
HIDEYOSHI AKIMOTO	9 Nov. — 8 Dec., 1979	(30)	
KOICH NONAKA	21 March — 18 Sept., 1980	(182)	Advice for the activities on Cooperatives and extension.
HIROMITSU KANEOYA	20 August — 10 Sept., 1980	(22)	Inspection on the equipment for seed plant and installation of truck scale.
SHIROO SEZAI	20 August — 2 Sept., 1980	(14)	
HIROMITSU KANEOYA	10 April — 15 May, 1981	(36)	Operation test and checking the equipment for plant.
NOBUO KOGUCHI	do		
ISAO MATSUBARA	25 Sept., 1981 — 24 Feb., 1982	(153)	Investigation on micoflora and aflatoxin contamination for post harvest maize.
MAKOTO KAKISHIMA	23 Oct., 1981 — 24 Feb., 1982	(92)	
HIROMITSU KANEOYA	25 April — 24 May, 1982	(29)	Checking the equipment and advice for the operation of seed plant
YOSHIAKI MITSUI	do		
KENJI ASANUMA	2 August 1983 — 1 Feb., 1984	(184)	Investigation on Fungi infiltration and aflatoxin contamination for post harvest maize
MAKOTO KAKISHIMA	5 Sept., — 4 Dec., 1983	(90)	

C. Japanese Mission for the Project

Table 102 Japanese Mission for the Project

Designation	Term	Purpose	Members
Execution and design investigation for the seed plant.	from 24 January 〃 to 16 February, 1978.	Making arrangement on construction of the seed plant.	Leader MINORU KOBAYASHI (NIPPON SHAKYO CO.) KAZUO OHOMO (do) HIROSHI NISHIMURA (J I C A)*
Technical Advisory for the Implementation of the Project in 1978.	from 27 June 〃 to 10 August, 1978.	Approval of P/D for changing the Project site and the plan of operations FOR 1979.	Leader MOTONAGA OHTO (J I C A) YOSHIBUMI AKAI (M A F F)** TADASHI ITABASHI (J I C A) HIROSHI NISHIMURA (J I C A)
Technical Advisory for the Implementation of the Project in 1979.	from 1 August 〃 to 20 August, 1979.	Investigating progress of project implementation and approval for the plan of operation 1980.	Leader MOTONAGA OHTO (J I C A) YASUMASA ASHIDA (M A F F) FUMIO WADA (M A F F) TADASHI ITABASHI (J I C A) HIROSHI NISHIMURA (J I C A)
Technical Advisory for the Implementation of the Project in 1980.	from 27 August 〃 to 10 September, 1980.	Investigating progress of project implementation and approval for the plan of operation 1981.	Leader TETSUMITSU SUGANO (M A F F) KAZUO KUWAZAWA (ASHIGARA COOP.) MASASHI NOGUCHI (M A F F) YUHACHI TAKEDA (J I C A) TOSHIRO NONOMURA (M A F F)
Technical Advisory for the Implementation of the Project in 1981.	from 22 September 〃 to 7 October, 1981.	Investigating progress of project implementation and approval for the plan of operation 1981.	Leader TETSUMITSU SUGANO (M A F F) TSUTOMU TANNO (M A F F) KOICHI NONAKA (Institue of developing economy) MASANORI SATO (M A F F) TADAO SATO (J I C A) TAKASHI AOYAMA (J I C A)
Evaluation on the Implementation of the Project from 1977-1982.	from 6 July 〃 to 24 July, 1982.	Investigating and evaluating progress of project implementation and reporting its opinion about continuation of the project to the Government of Japan	Leader MOTONAGA OHTO (J I C A) YASUMASA ASHIDA (M A F F) KOICHI NONAKA (Institue of developing economy) MASASHI NOGUCHI (M A F F) YUHACHI TAKEDA (J I C A)
Technical guidance for the Implementation of the Project in 1983.	from 3 April 〃 to 12 April, 1984.	Investigating progress of project implementation during the follow-up period.	Leader YOSHIFUMI AKAI (M A F F) YASUMASA ASHIDA (M A F F) TAKASHI MIZUNO (J I C A)

* Japan International Cooperation Agency

** Ministry of Agriculture, Forestry and Fisheries

D. Budget for the Project in Japan

Table 103 Budget for the Project in Japan

(Unit : 1000 Yen)

Item / Year	Equipment & Materials	Experts & Missions	Experts' activities	Others
1976		4,225	774	
1977	86,680	14,042	1,565	
1978	85,393	36,740	7,001	4,449
1979	59,740	54,231	2,876	2,456
1980	42,925	55,719	3,480	
1981	72,290	64,747	3,480	
1982	68,201	54,582	4,632	
1983	7,702	30,179	5,112	687
1984		24,379	1,216	50
Total	422,931	338,874	30,136	7,862
GRAND TOTAL	799,803			

E. Technical training and study tour in Japan for the Thai counterpart officers

Table 104 Technical training and Study tour for Thai officer.

YEAR	PERIOD	NAME	TRAINING COURSE
1977	29 Sept. – 20 Dec.	Mr. Vallop Nisadol	Agricultural Cooperative
1978	1 Jun. – 6 Nov.	Mr. Permsak Ratanaubol	Agricultural Machinery
	12 Sept. – 25 Aug.	Mr. Petcharat Wannapee	Study tour
	do	Miss Peerarat Aungrurarat	do
	4 Sept. – 16 Dec.	Mr. Somrak Noradechanonta	Seed production techniques
	do	Mr. Paiboon Ploylearmsang	do
	29 Sept. – 20 Dec.	Miss Rachaphon Tangyangyune	Agricultural Cooperative
1979	1 July – 22 July	Mr. Wanllop Wittayaprapat	Study tour
	do	Dr. Chamnarn Chutkaew	do
1980	31 Mar. – 30 Sept.	Mr. Sirilert Punnoi	Seed processing techniques
	24 June – 23 Aug.	Mr. Kriangsak Singtop	Marketing of Agri. Product
	10 July – 12 Aug.	Mr. Vera Kentapath	Plant protection
	5 June – 4 Dec.	Mr. Prawit Puddhanon	do
1981	11 Oct. – 21 Oct.	Mr. Chaisop Sopsam	Study tour
	do	Mr. Ampol Senanarong	do
	do	Mr. Prawat Chartikananich	do
1982	24 Feb. – 23 Oct.	Mr. Klarob Phungyoo	Seed processing techniques
1983	30 Jan. – 12 July	Miss Lily Nemsung	Aflatoxin analysis
	12 May – 11 July	Miss Rachaneewan Prathomthong	Agricultural Cooperative
	25 Aug. – 20 Sept.	Mr. Chakgree Sujaritthum	do
1984	12 July – 25 Dec.	Mr. Sukkapong Vayuparp	Aflatoxin analysis
	not yet fixed	Mr. Sune Kasisareewong	Study tour for seed production techniques

2. The Thai Government :

A. Officer who participated for the Project.

Table 105 – a. Cooperatives Promotion Department

No.	Name	Position	Activity duration	
			From	To
1.	Mr. Surin Cholpraserd	Director General	1976	1983
2.	Mr. Adul Niyomvipard	Director General	1976	1983
3.	Mr. Chern Bamrungwong	Director General	1980	1984
4.	Mr. Prawat Chartikavanich	Deputy Director General	1980	1981
5.	Mr. Wanllop Wittayaprapat	Cooperative Technician 7	1977	1984
6.	Mr. Vallop Nisadol	Agriculturist 6	1977	1982
7.	Mr. Kriengsak Singtop	Cooperative Promotion Officer 5	1980	1984
8.	Mr. Chakgree Sujarithum	Chief, Coop. Demonstration Center (Maize Development Project)	1981	1984
9.	Miss Ratchaporn Tangangyuen	Cooperative Technician 5	1980	1983
10.	Mr. Pourpand Chuthaporn	Cooperative Technician 5	1984	—
11.	Mr. Preecha Pandsond	Cooperative Technician 3	1984	—
12.	Mr. Sawad Ukachanchainon	Cooperative Technician 3	1983	1984
13.	Mr. Montree Pokasamrit	Clerical Staff 2	1982	1984
14.	Miss Ubon Suksumate	Supply Staff 1	1983	1984
15.	Mr. Banchu Loikumfa	Mechanical Officer 1	1984	—
16.	Mr. Ruangchai Boonyananda	Training Officer 6	1976	1981
17.	Miss Peerarat Aungurarat	Analyst for Policy and Plan 7	1976	1984
18.	Miss Ratchaneewan Prathomthong	Analyst for Policy and Plan 6	1976	1984
19.	Mr. Witaya Chinchantharawong	Analyst for Policy and Plan 4	1980	1983
20.	Mr. Nikom Insee	Mechanical Officer 5	1980	1984
21.	Mr. Sangked Kangwand	Mechanical Officer 3	1983	1984
22.	Mr. Niran Maynaparn	Mechanical Officer 3	1983	1984
23.	Mr. Sawate Tipsumontha	Mechanical Officer 3	1983	1984
24.	Mr. Karoon Sannapiban	Mechanical Officer 4	1983	1984
25.	Mr. Adisak Suksatit	Mechanical Officer 4	1980	1984
26.	Mr. Apiwat Wongsomboon	Engineer 4	1980	1984
27.	Mr. Sak Ratanakarn	Agricultural Engineer 4	1981	1984

Table 105 – b. Department of Agriculture

No.	Name	Position	Activity duration	
			From	To
1.	Dr. Yookit Sarikaphuti	Director General	1982	1984
2.	Dr. Ampol Senanarong	Deputy Director General	1976	1984
3.	Dr. Arwooth Na-Lampang	Agriculturist 9	1976	1984
4.	Dr. Vichitr Benjasil	Director of Field Crops Research Institute	1976	1983
5.	Dr. Chamnan Chutkaew	Lecturer (Kasetsart University)	1976	1982
6.	Mr. Thamnong Tuntataemee	Agriculturist 7 Leader, Phraphutthabat Field Crops Experiment Station	1976	1984
7.	Mr. Somrak Noracechanon	Agriculturist 7 Leader,	1976	1984
8.	Mr. Pravit Puddhanon	Agriculturist 4	1976	1984
9.	Mrs. Lily Kaveeta	Agriculturist 4	1982	1984
10.	Mr. Sukapong Vayuparp	Agriculturist 4	1982	1984

Table 105 – c. Department of Agricultural Extension

No.	Name	Position	Activity duration	
			From	To
1.	Mr. Pisit Sasiphalin	Director General	1976	1984
2.	Mr. Taveesak Sasavej	Deputy Director General	1976	1984
3.	Mr. Narong Minanandana	Deputy Director General	1976	1984
4.	Mr. Chaisap Sappayasarnd	Deputy Director General	1976	1984
5.	Mr. Petcharat Wannapee	Director of Seed Division	1976	1984
6.	Mr. Pipat Kaewplung	Chief, Seed Multiplication Section	1978	1979
7.	Mr. Charan Vansanit	Chief, Condition System Development Section	1980	1984
8.	Mr. Sirilert Pannoi	Agriculturist 5	1980	1984
9.	Mr. Udom Dechmani	Director of Plant Protection Service Division	1980	1984
10.	Dr. Billy Ray Gregg	Expert	1977	
11.	Mr. George M. Dougherty	Expert	1977	

B. Budget of Thailand

Table 106 Budget for the Project in Thailand

Item No.	Item	1978 F.Y.			1979 F.Y.			1980 F.Y.			1981 F.Y.			1982 F.Y.			1983 F.Y.			1984 F.Y.			Total
		CPD	DA	DAE	CPD	DA	DAE	CPD	DA	DAE	CPD	DA	DAE	CPD	DA	DAE	CPD	DA	DAE	CPD	DA	DAE	
1.	Official salary	-	-	-	-	-	-	135,960	-	278,900	364,700	-	351,000	185,200	98,600	839,200	228,800	66,400	944,400	221,600	66,400	1,312,800	4,890,660
2.	Salary for employee	-	-	-	122,040	77,820	67,800	231,360	165,800	178,900	284,500	211,000	231,100	305,800	158,200	215,900	374,600	203,900	224,600	387,700	295,100	183,800	3,772,500
3.	Wages	-	-	-	7,650	93,900	237,300	68,100	267,800	133,800	81,500	365,600	272,100	117,900	118,700	208,500	136,560	26,500	241,900	136,560	134,800	67,800	2,752,970
4.	Expense for lecture	-	-	-	12,400	-	-	12,400	60,000	-	12,400	60,000	-	15,800	57,000	9,900	12,000	-	6,400	12,000	-	-	270,300
5.	Operation cost	-	-	-	385,200	274,800	252,900	545,000	266,000	377,700	574,800	136,000	503,000	450,420	167,000	784,400	733,600	207,500	765,500	344,600	268,500	552,800	6,858,500
6.	Expense for water-supply, and etc	-	-	-	-	-	-	21,200	28,000	63,000	22,500	37,000	75,600	27,000	40,000	128,800	27,000	161,000	142,600	110,000	108,000	142,600	1,236,100
7.	Supplies	-	-	-	282,100	58,500	198,200	437,600	80,700	416,900	560,500	288,700	418,800	581,900	254,100	632,500	966,100	80,500	780,200	525,200	247,500	977,400	7,414,400
8.	Equipment expenses	-	-	-	90,300	26,200	160,300	79,000	144,600	116,000	-	121,000	134,100	38,300	44,000	151,100	81,700	250,000	34,500	48,100	-	348,400	1,876,600
9.	Land and construction cost	1,871,600	-	2,418,400	2,849,000	1,517,000	3,008,000	637,600	1,300,000	494,850	-	61,000	2,989,000	784,000	382,300	2,268,100	42,600	1,000,000	631,300	85,200	-	73,700	22,879,950
10.	Others	-	-	-	-	-	300,000	-	-	50,000	-	-	-	-	-	-	323,500	-	-	161,800	-	-	835,300
	Total	1,871,600	-	2,418,400	3,558,690	2,048,820	4,224,300	2,169,200	2,334,900	2,058,050	2,517,900	1,296,300	4,974,700	2,027,900	1,249,200	5,026,460	1,995,800	3,771,400	2,026,760	2,020,300	4,315,600	-
	Grand Total	4,290,000			9,831,790			6,562,170			7,726,900			9,083,400			7,793,660			7,364,660			52,724,320

IV. Postscript:

The technical Cooperation of Japan for the Project was carried out 7 years ago will expire in September, 1984. There are still many technical problems to be solved in the future.

Here, we would like to point out some of them with reflection to lack of our effort.

1. Cultivation techniques on maize:

The detail was explained in Chapter II – 1 already.

We want to comment upon need of the new varieties of maize.

To bread and release superior varieties with the charactors of earlier maturity, resistant to new type of Downy mildew fungi infection on grains and etc., will be urgently needed.

Establishment of quality control techniques on post harvest maize putting priority on agronomical viewpoint would also be needed.

2. Seed Production activities:

We are very satisfied with completion of maize seed processing system from foundation level to extension one at the Center. Seed production of leguminous crops in combination with maize seeds will be very important for promoting maize production in farmers' fields.

We do hope that the seed plant will be useful continously with the greatest possible care.

3. Service activities for the Cooperatives and Farmers Groups:

It was fully recognized that many cultivation techniques penetrated quickly to farmers through training or other activities in the extension bases. Many kind of service activities, that is seed distribution, tractor plowing, yield competition, repairing agricultural machinery and etc. through Cooperatives and Farmers Groups would be very valiable for farmers. All of these activities should be developed more in the future.

This Project could be said an unique one carried out by the cooperation of three Departments with multidisciplinary. As pointed out by the Japanese Evaluation Team July, 1982, "the Project as a whole made a good progress as planned in the original Master Plan.

The most important factor for this success was human relation : among the Thai officials who participated in this Project from three Departments and between Thai staffs and Japanese experts."

We are very proud of the results of the Project and heartly appreciate the cooperation of Thai staff members concerned hoping that the project will continue more successfully for a long time.

APENDIXES

I. RECORD OF DISCUSSIONS

ON THE RECORD OF DISCUSSIONS BETWEEN THE JAPANESE AGRICULTURAL SURVEY TEAM AND THE AUTHORITIES CONCERNED OF THE GOVERNMENT OF THAILAND CONCERNING TECHNICAL CO-OPERATION PROJECT ON MAIZE DEVELOPMENT IN THAILAND

The Japanese Agricultural Survey Team, organized by the Japan International Cooperation Agency and headed by Mr. Motonaga Ohto visited Thailand from August 31 to September 17, 1976, for the purpose of formulating concrete co-operation plans for the Technical Co-operation Project on Maize Development which will be carried out with the Co-operative Demonstration Center as its core.

During its stay in Thailand, the Team exchanged views with the authorities concerned of the Government of Thailand on the necessary measures to be taken by both Governments to successfully implement the Technical Co-operation Project on Maize Development. The Team also conducted necessary survey for the implementation of the project.

As a result of the exchange of views and survey, both parties agreed to recommend to their respective Governments to carry out the matters referred to in the attached Record of Discussions.

Bangkok, September 17, 1976

Motonaga Ohto
Head of the Japanese Agricultural
Survey Team
Japan International Cooperation
Agency

Surin Cholpraserd
Director-General
Cooperatives Promotion
Department

in the presence of

Wanchai Sirirattna
Deputy Director-General
Department of Technical
and Economic Cooperation

RECORD OF DISCUSSIONS

I. (1) Both Governments will co-operate with each other in implementing the Technical Co-operation Project on Maize Development (hereinafter referred to as the "Project") with the Co-operative Demonstration Center as its core for the purpose of promoting the enhancement of the productivity of maize, and contributing to the development and strengthening of the agricultural co-operatives and the modernization of agriculture through the quality improvement of maize and its production technology.

(2) The Project will be implemented in accordance with the Master Plan as stipulated in Annex I and in close contact with the maize development project between Thai and Japanese agricultural co-operatives.

(3) The Project will be implemented in accordance with the annual operational work plan to be formulated annually by the Joint Committee referred to in VI. The annual operational work plan will be submitted to the authorities concerned of both Governments for their approval.

II. (1) In accordance with laws and regulations in force in Japan, the Japanese authorities concerned will take necessary measures to provide at their own expense the services of the Japanese experts as listed in Annex II through the normal procedures under the Colombo Plan Technical Co-operation Scheme.

(2) The Japanese experts referred to in (1) above and their families will be granted in Thailand the privileges, exemptions and benefits no less favourable than those accorded to experts of third countries working in Thailand under the Colombo Plan Technical Co-operation Scheme.

III. (1) In accordance with laws and regulations in force in Japan, the Japanese authorities concerned will take necessary measures to provide at their own expense such equipment, machinery, implements, vehicles, tools, spare parts and other materials required for the implementation of the Project as listed in Annex III through the normal procedures under the Colombo Plan Technical Co-operation Scheme.

(2) The articles referred to in (1) above will become the property of the Government of Thailand upon being delivered c.i.f. to the Thai authorities concerned at the ports of disembarkation, and will be utilized exclusively for the implementation of the Project in consultation with the Japanese team leader referred to in Annex II.

IV. (1) In accordance with laws and regulations in force in Japan, the Japanese authorities concerned will take necessary measures to receive the Thai personnel engaged in the Project for technical training or study tour in Japan through the normal procedures under the Colombo Plan Technical Co-operation Scheme.

(2) The Government of Thailand will take necessary measures to ensure that the knowledge and experience acquired by the Thai personnel mentioned in (1) above through technical training and study tour in Japan may be utilized effectively for the implementation of the Project.

V. The Government of Thailand will take necessary measures to provide at its own expense :

(1) the services of the Thai counterparts and other personnel as listed in Annex IV;

(2) land and buildings as listed in Annex V. as well as incidental facilities;

(3) foundation seeds of good varieties needed for the extension purposes;

(4) supply or replacement of equipment, machinery, implements, vehicles, tools, spare parts and any other materials necessary for the implementation of the Project other than those provided by the Japanese authorities concerned under III (1);

(5) suitably furnished housing accommodations for the Japanese experts and their families;

(6) transportation facilities and the grant of the travel allowance for the Japanese experts for the official travel within Thailand.

Annex I
Master Plan for the Project

A. Composition of the Project

1. The Co-operative Demonstration Center (hereinafter referred to as the "Center") which will include fields for trials, training, seed production and demonstration, will be established in Chaibadan, LOP BURI Province.

Trials, training and extension services, demonstration and other related activities in respect of technology for the improvement of maize production will be conducted at the Center.

2. For the purpose of effective extension of technical co-operation to the following five provinces, key extension bases will be established within these provinces.

Lop Buri Province
Sara Buri Province
Phetchabun Province
Phitsanulok Province
Sukhothai Province

(1) The following six agricultural co-operatives and five farmer's groups to be designated from each of the provinces mentioned in A2 above by the Joint Committee will be the key extension bases.

Chaibadan Agr. Co-op.
Phraphutthabad Reclamation Agr. Co-op.
Phetchabun Agr. Co-op.
Prompiram Agr. Co-op.
Nongtoom Agr. Co-op.
Sawankalok Land Settlement Co-op.

(2) Demonstration fields of about 13 ha. will be set up at each of the eight key extension bases, excluding the Petchabun Agricultural Co-operative, Nongtoom Agricultural Co-operative and Sawankalok Land Settlement Co-operative.

3. To ensure the smooth supply of extension seeds, seed production fields will be set up within the Center and at appropriate places in its vicinity.

The area required for the seed production fields will be approximately 100 ha in the first year, 140 ha in the second year and 160 ha in the third year of the Project.

B. Activities under the Project

1. Applied Experiments for Production Techniques

The following experiments will be conducted at the Center for the purpose of identification, utilization, confirmation of local adaptability and other items of specific techniques developed by agricultural experiment and research institutions.

Applied experiments for production techniques
Varieties adaptability tests
Fertilizer tests
Water management tests
Disease and insect control experiments
Cropping system experiments

2. Seed Multiplication

In collaboration with the Department of Agricultural Extension, the foundation seeds which are to be supplied by the Department of Agriculture will be multiplied to produce extension seeds at the seed production fields.

The extension seeds thus produced will be distributed to maize producing farmers in the five provinces mentioned in A2, through agricultural co-operatives and famer's groups.

3. Disease and Insect Control

Co-operation activities of the Center will be extended to the projects on the control of maize disease and insect which will be carried out by the Department of Agricultural Extension in the provinces mentioned in A2.

4. Extension and Demonstration

Improved cultivation techniques developed by the Center will be demonstrated at the demonstration fields mentioned in A2, and experts will conduct round trip guidance activities to promote their effective extension to the key extension bases.

5. Technical Training in Seed Production and Improved Cultivation Techniques

Technical training in seed production and Improved cultivation techniques will be provided at the Center for the farmers associated with the seed production fields mentioned in A3 and also for the maize producing farmers.

6. Agricultural Mechanization System

To establish a system for the mechanization of maize cultivation and to promote its extension, applied experiments for the systematization of agricultural mechanization as well as training activities for agricultural machinery operation and repair will be conducted at the Center. At the same time, the agricultural mechanization system will be demonstrated at the Center and at the demonstration field mentioned in A2.

7. Guidance on the Management of Agricultural Co-operatives

To develop and strengthen agricultural co-operatives and farmer's groups, staff officials of agricultural Co-operatives and other personnel will be trained and educated at the Center, and experts will conduct round trip guidance activities to the key extension bases.

Annex II
List of Japanese Experts

Category	Field
1. Team Leader	
2. Experts	Seed production
	Cultivation
	Farm machinery
	Agricultural co-operatives and extension
3. Coordinator	

Notes: Short-term experts may be dispatched, when necessity arises.

Annex III
List of the articles to be provided by the Government of Japan

1. Equipment, machinery, implements, spare parts and fertilizer for crop production.
2. Equipment, machinery, implements and spare parts for seed processing and storage.
3. Equipment, machinery, and chemicals for insect and disease control.
4. Machinery and tools for repair work at the Centre.
5. Equipment, instruments, spare parts and other materials for laboratory work.
6. Vehicles.
7. Teaching materials including audio-visual aids.
8. Other necessary equipment, tools and materials to be mutually agreed upon.

Annex IV
List of Thai Counterpart Officials and Other Personnel

Category	Field
1. Project Manager	
2. Counterpart Officials	Seed production
	Cultivation
	Soil and fertilizer
	Pathology and insects
	Farm machinery
	Irrigation
	Extension
	Agricultural co-operatives
	Farm management
3. Clerical and service employees	
4. Labourers	

Annex V
List of Land and Buildings

1. Land

(1) Land for the Center	about 16 ha
(2) Seed production fields	about 160 ha (in the third year)
(3) Demonstration fields	about 104 ha (total area for the eight key extension bases)

2. Buildings in the Center

(1) Office
(2) Garage
(3) Guest house
(4) Classrooms
(5) Laboratory
(6) Fuel storage
(7) Storage for farming materials
(8) Shed for agricultural machinery
(9) Workshop
(10) Seed drying station
(11) Seed processing station
(12) Seed storage
(13) Dormitory

Annex VI
Composition of the Joint Committee

Chairman Under-Secretary of State, MOAC

Japanese Side	Thai Side
1. Team Leader	1. Director-Generals of CPD, DA and DAE
2. Expert (s) designated by the team leader	2. Project Manager
3. Coordinator	3. Coordinator from Foreign Relations Div, MOAC.
4. Representative of JICA	4. Representatives of DTEC, Budget Bureau and NESDB.

Notes:

(1) An official of the Embassy of Japan may attend the meeting of the Joint Committee as an observer.
(2) MOAC : Ministry of Agriculture and Cooperatives
(3) CPD : Cooperatives Promotion Department
(4) DA : Department of Agriculture
(5) DAE : Department of the Agricultural Extension
(6) DTEC : Department of Technical and Economic Cooperation
(7) NESDB: National Economic and Social Development Board
(8) JICA : Japan International Co-operation Agency

II. SUMMARY REPORT AND RECOMMENDATION OF THE JAPANESE EVALUATION TEAM

To: Mr. Yookti Sarikaphuti,
Chairman of the Joint Committee for
Technical Cooperation Project on Maize Development.

From: Motonaga Ohto,
Leader of the Japanese Evaluation Team for
Technical Cooperation Project on Maize Development in Thailand.

Subject: Submission of Summary Report.

Date: 22 July, 1982.

I am submitting herewith the record of my summary report of the evaluation which I presented orally at the Fifth Meeting of the Joint Committee held on 21 July 1982, for distribution to the agencies concerned and for inclusion in the minute of the meeting.

Motonaga Ohto

(Motonaga Ohto)

Summary Report and Recommendation

The Project has been carried out in accordance with the Master Plan which was attached to the original Record of Discussion of 17 September, 1976. The actual implementation of the Project, however, delayed due to the change of the location of the Center from the originally planned site in Chaibadan to the present site which locates in Muang District of Lopburi Province, adjacent to the Experiment Station of the Agriculture Department.

Although the change of the location caused delay in starting the project activities, the present of the Center seems to be much better in all aspects. The progress of the activities after the completion of the Center was fast and caught up the delay.

The costs of the project were met by the government of Thailand and Japan. The Thai portion consisted mainly of the costs for land and buildings, salaries, wages and other operational expenses and Japanese portion covered mostly the costs of equipment, farm machines, vehicles and other materials, and the expenses for experts services. The disbursement of Thai portion amounted to Bht. 44,291,810, and Japanese portion —624,360,000 (approximately Bht. 63 million).

The activities of the project were carried out under the 7 categories as specified in the original Master Plan.

I. Evaluation on activities under the Project.

1. Applied Experiments for Production Techniques:

Applied experiments on 8 items have been carried out in the experiment plots in the Center.

Some of them, already have produced definite results, such as those on time of seeding, and seed preservation method, but some other experiments such as the cropping pattern experiment requires longer period until useful result is obtained. Such long-term experiment needs continuation for some years. The experiments which have been started recently such as the experiment on post-harvest quality control should also be continued.

2. Seed Multiplication:

The production and processing of certified seeds progressed rapidly. Last year's production was about 800 tons and the production for this year is estimated at 1,000 tons. As the quatity increases and the processing plant operates in full capacity, the proper operation, maintenance and repair of the plant become increasingly important. The technical staff of the plant should be strengthened both in number and quality and transfer of technology in this aspect to the technical staff, which is not yet satisfactory, should be continued.

3. Disease and Insect Control:

Before this project strated in 1976, locust and downy mildew were major damages on maize, but since the inception of the project the damages almost disappeared, owing to the active DAE's plant protection and perhaps the change of natural enviroment in case of locust and the development of resistant varieties in case of downy mildew.

The Team noted with great concern the damage on maize of rodent. The production of maize seed in dry season under the Project at Sawankalok in 1978/79 completely failed by the rodent damage. Since rodent damage is not only on maize but also on other major crops in various parts of Thailand, effective control measures have to be developed as a national project.

4. Extension and Demonstration:

In order to extend the techniques confirmed by the applied experiment in the Center, field demonstrations were conducted. The cumulative number of places where demonstrations have been done in 121 fields totaling 687 rais in acreage. This activity attained the planned target as far as number of places and acreage are concerned, but the actual effect of the demonstration is difficult to evaluate. It seems, however, that, due to the poor transportation system in rural areas, the visitors to the fields were very few. The extension activity of the Project might better be concentrated on a smaller number of demonstration fields not far from the Center and utilize the demonstration combined with the training program in the Center.

5. Technical Training in Seed Production and Improved Cultivation Techniques:

Training courses on cultivation techniques were conducted at the Center. The number of courses and the participants were 6 and 250 respectively.

The effectiveness of the technical training is clearly proved by the fact that all of the prize winners and the farmers who showed very high yield at the yield competition, as referred to later, were the graduates of the training courses.

6. Agricultural Mechanization System:

Training courses for the operation, maintenance and repair were conducted in the Center. The cumulative number of courses was 7 with 320 participants in total.

In addition to the special courses for mechanisation, mechanical training was included in curriculum of the various courses for cultivation techniques mentioned above.

Training on mechanization was also conducted at various places in the Project area by the "Mobile-Unit". The number of farmers participated in the mobile-unit training amounted to 210.

As the use of tractors and other machines for maize cultivation is widely spread and still increasing, the need for training seems to be large. The task of the machine workshop in the Center, at the same time, will increase its importance.

7. Guidance on the Management of Agricultural Cooperatives:

The main activity in this field was the training of Cooperative personnel and member farmers on the theory and practice of the management of Cooperatives. Five training courses on this subject were conducted in the Center with participation of about 200 trainees in total. Beside these specialised courses, cooperative management was included in the curriculum of many other training courses.

The round-trip guidance by the Center's staff was conducted frequently at the Phraphut-thabat Reclamation Cooperatives and Chaibadan Agricultural Cooperatives. The guidance was focused on specific activities of the Cooperatives rather than general guidance.

The general meetings and monthly Committee Meetings of each of the six "designated cooperatives" were always attended by the staff-members of the Center.

As a new activity of agricultural cooperative, tractor services were provided on trial basis by three cooperatives, e.g. Sawankalok, Chaibadan and Phraphutthabat. Tractors were made available to these cooperatives from the Center for this activity. It appears that cooperative tractor service is an attractive activity to member farmers. However, more study is necessary to establish economic feasibility of tractor service as the cooperative business. The data concerning the fuel consumption, operation hour, labuor requirement, etc., recorded in the course of this trial activities will be useful for such study.

Another new activity performed by the cooperatives under the guidance of the Center's staff is yield competition. In 1980, the Phraphutthabat Reclamation Agricultural Cooperative held the competition with participation of 22 member farmers. The yield of the first prize winner was as high as 6.6 tons per hectare, the farmers who yielded more than 5 tons were 5 in number. In 1981, the competitions were held again by the Phraphutthabat Co-op and by Chaibadan Co-op. In addition to these two Co-ops, Phetchabun Agr. Co-op and a farmers group in Lopburi are now carrying out the competition this season.

This activity was very effective not only in motivating farmers to improve their cultivation techniques, but also in promoting interests of farmers to the cooperative activities. The cultivation records (planting time, spacing, amount of fertilizer applied, varieties, etc.). submitted by the participants provided very useful data for analysis of high yield elements.

In connection with the cooperative promotion activities under the project, we noted with concern the fact that only a small portion of the certified seed were sold to farmers through cooperatives, despite the effort of the Center's staff to encourage the cooperatives to deal with more seeds. And, we understand that there are various difficulties which are beyond the scope of this project, such as the lack of funds on the part of the cooperatives.

We consider that this problem might better be considered from the viewpoint of overall and integrated cooperative development. More specifically, the cooperative distribution of seeds under this project might well be linked with, or imcorporated in, the "Total System Cooperative Development Model Project", which is now being formulated by CPD, basing upon the result of the "Thai-Japan Joint Feasibility Study for the Cooperative Development Project in Thailand", conducted in 1980–81.

II. Conclusion and Recommendation

There are differences among the activities under the project in the degress, but the project as a whole made a good progress as planned in the original Master Plan.

Moreover, some activities, such as the mobile unit training and yield competition, which were not envisaged in the original Master Plan were carried out with success.

Various factors may be attributable to this success of the project, but we consider that the most important factor was human relation: among the Thai officials participated in this project from three different departments and between the Thai staff and Japanese experts. And in the later aspect, we highly evaluate the value of "Counter-part training" in Japan.

Priority and during the Project period about 20 Thai officials came to Japan in connection with the project. The counter-part training was valuable not only in raising their knowledge and technique, but also contributed greatly to the good understanding among Japanese experts and the counterparts.

From these observations, the team considers that the project should be continued basicaly on the same organization, i.e., the joint undertaking of the three Departments. On that assumption, the team recommends that following activities should be continued as priority activities for Japanese, Cooperation.

1. The applied experiments which are unfinished and some experiments started recently due to the new needs, such as post-harvest quality control.
2. Technology transfer on operation, maintenance and repair of seed processing plant in the Center.
3. Yield Competition.
4. Mobile unit training on mechanization and the technology transfer in operation of workshop in the Center.

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